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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION
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162ND MEETING
ADVISORY COMMITTEE ON NUCLEAR WASTE
(ACNW)
+ + + + +
TUESDAY, AUGUST 2, 2005
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ROCKVILLE, MARYLAND
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The Advisory Committee met at 8:30 a.m. in T2B3 of Two White Flint North, Rockville, Maryland, MICHAEL T. RYAN, Chairman, presiding.

PRESENT:

MICHAEL T. RYAN, Ph.D.	Chairman
ALLEN G. CROFF, Ph.D.	Vice Chairman
JAMES H. CLARKE, Ph.D.	Member
WILLIAM J. HINZE, Ph.D.	Member
RUTH F. WEINER, Ph.D.	Member
ASHOK C. THANDANI	Deputy Executive Director, ACRS, ACNW
LATIF S. HAMDAN, Ph.D.	ACNW STAFF
MICHAEL L. SCOTT	ACNW STAFF

PRESENTERS:

KEN PICHA	DOE/EM
ANNA BRADFORD	NMSS/NRC
PAUL MURRAY, Ph.D.	AEA TECHNOLOGY ENGINEERING SERVICES, INC.
BARRY BURKS, Ph.D.	TPG APPLIED TECHNOLOGY
DAVID KOCHER, Ph.D.	SENES/ACNW CONSULTANT
KEN GASPER, Ph.D.	DOE ORP, Ret.
JOHN PLONDINEC, Ph.D.	DIAGNOSTIC INSTRUMENTATION AND ANALYSIS LABORATORY
LES DOLE, Ph.D.	OAK RIDGE NATIONAL LABORATORY

I-N-D-E-X

I-N-D-E-X (Continued)

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

(8:38 a.m.)

1) OPENING REMARKS BY THE ACNW CHAIRMAN

CHAIRMAN RYAN: This is the first day of the 162nd meeting of the Advisory Committee on Nuclear Waste. My name is Michael Ryan, Chairman of the ACNW. The other members of the Committee present are: Allen Croff, Vice Chair; Ruth Weiner; James Clarke; and William Hinze.

During today's meeting, the Committee will conduct a working group meeting on waste determinations. Latif Hamdan is the designated federal official for today's session.

The meeting is being conducted in accordance with the provisions of the Federal Advisory Committee Act. We have received no written comments, requests for time to make oral statements from members of the public regarding today's session. Should anyone wish to address the Committee, please make your wishes known to the Committee staff.

If we have overflow in this room from attendees, we have the capability to broadcast to other rooms that will be available in the building and I believe in the other building. And if that becomes necessary, Mr. Brown will help us make that hookup and announce to everybody when our session here goes live to other parts of the building.

We had one request to hook somebody up by telephone, but evidently that individual is not available at the moment. And if we do make that connection, we will also advise when that telephone participant hooks in if he is available by phone. He doesn't seem to be available at the moment.

It is requested that speakers use one of the microphones, identify themselves, and speak with sufficient clarity and volume so they can be readily heard. It is also requested that if you have cell phones or pagers, kindly turn them off or place them on mute.

I will now turn the meeting over to Mr. Croff, Vice Chair, for the remainder of the day. Allen?

VICE CHAIRMAN CROFF: Okay. Thank you, Mike.

SESSION 1: INTRODUCTION AND BACKGROUND

2) INTRODUCTION TO WORKING GROUP MEETING AND SESSION 1

VICE CHAIRMAN CROFF: On behalf of the NRC Advisory Committee on Nuclear Waste, I would like to welcome the Committee members, the ACNW staff, our many speakers who have kindly shown up, as well as the many observers here to this working group meeting on DOE tank waste determinations.

Briefly stated, this working group meeting was organized by the ACNW in consultation with NMSS staff members to provide both organizations technical insights relevant to preparation of a standard review plan to determine the classification of waste in DOE tanks by the NMSS staff and subsequent review of this plan by the Committee.

To be clear on one point, this working group meeting is not intended to focus on any specific tank waste determination that has been or might be developed by the Department of Energy.

The working group meeting is planned to take two full days. And with the number of questions I anticipate, I think we are going to need to be somewhat ruthless about trying to keep people on schedule here. We may get lucky, but I doubt it.

The working group meeting is divided into an initial session that will provide background information concerning the Department of Energy's tank wastes and their plans for waste determinations and then a discussion of criteria and historical NRC activities concerning waste determinations.

This will be followed by a number of speakers in three sessions, who will elaborate the status and prospects of various scientific and technical aspects of waste determinations.

Before we are introducing the first speaker, I'd like to request we try to allow the speakers in the first session to complete their presentation with minimal interruptions for clarification questions. After each of the first two speakers, we will then entertain questions from the Committee, NRC staff members. And then if any of the other presenters have any questions, we will entertain those.

To begin the meeting at the beginning, our first speaker will provide an overview of DOE's activities in planned waste leading to the need for a waste determination.

I am pleased to introduce Ken Picha from the Department of Energy, who is well-qualified to provide such an overview. He has over 20 years of experience in engineering, operations, and project management for the government and the private sector.

He was previously the DOE's headquarters program manager for radioactive start-up of high-level waste immobilization facility at Savannah River and has performed writing his reviews on a number of other facilities.

More recently, he has coordinated the complex-wide activities for the department's tank waste program. In this capacity, he served as sub-team leader for the development of the high-level waste chapter in a revision of DOE's directive on radioactive waste management.

Ken, the floor is yours.

3) OVERVIEW OF DOE'S APPROACH TO MANAGING TANK WASTE

MR. PICHA: Good morning. Unfortunately, I was delayed in the rush of people coming up, and I didn't get a chance to do the logistics. How do we forward the slides? Thank you.

Good morning. For some of you, you have heard probably this presentation if you were there at the first kickoff meeting of the National Academy of Sciences study on certain radioactive waste back in March. And for that, you may be bored. I'm sorry.

I've just got a few new slides to address West Valley at the end, but other than that, it's pretty much a repeat of that presentation because I think it does set the stage for some of the specific discussions that are going to come later today and tomorrow.

We basically have four sites that the department manages. That number up there of waste represented about what was there prior to beginning some of our mobilization efforts, tank waste retrieval and mobilization efforts.

Basically we have three DOE-owned sites, one at Hanford, one at Savannah River site, another at the Idaho National Laboratory, and one site that's owned by the State of New York: the West Valley demonstration projection.

Our tank waste management strategy is actually something that was developed pretty much in the early '80s. So a lot of the activities that we have been doing over the past few years was something that started in the early to mid 1980s through National Environmental Policy Act documents and decisions resulting from those documents.

And so the fact that we had planned and are implementing processes to basically take tank waste, retrieve tank waste, treat some tank waste and dispose of them as non-high-level waste have actually been part of the department's plans for at least 20 years.

Of course, we certainly want to safely

store any waste that we have in our tanks to get it to some form for disposal. We have to retrieve those wastes. And then we have ended up pretreating waste or planning to pretreat waste at Savannah River, Hanford, and West Valley.

The low-activity waste stream, which is we have separated the bulk of the radioactivity but kept most of the volume, is intended to be disposed of on site at the sites except West Valley. And then the higher activity that contains the bulk of the radionuclides but lesser the volume is intended to be disposed of at a geologic repository.

At Savannah River, Hanford, and West Valley, we intend to treat that high-activity waste through the vitrification process. As I get to the individual sites, I'll talk about the progress of each of those sites.

The other thing I wanted to mention is I think we have representatives from each of the Savannah River, Hanford, and West Valley here, who may be able to answer more specific questions if you have any. I'm not sure there's anybody here from Idaho. I don't see any familiar faces off the top of my head.

At Idaho, as I will talk about later, they pretty much kept their waste in an acidic form. And they basically denitrated that waste, the bulk of that waste, and put it into a calcine form -- it's a dry powder -- and have kept that in some storage bins located on site while they made preparations to get that ready to be packaged and disposed of at a geologic repository.

And then, finally, as the speakers will talk about today and tomorrow, there are going to be some residues in the tanks that we will not be able to retrieve. And we will have to disposition the tanks and associated components.

At Savannah River and Idaho, we have completed the environmental documentation to address the alternatives associated with dispositioning of the tanks and associated components.

We have not done a record of decision at Idaho. And at Hanford and West Valley, the NEPA documents associated with analyzing the alternatives for handling the tanks and components are still in progress.

At Savannah River site, we have about 130,000 cubic meters of waste. You can see the bulk of that is -- somehow my math is wrong there. It's about 38 million gallons. And so I have to get the conversion. But obviously 11 in 127 and 130. So something is off a little bit, but the proportions are correct.

Most of the waste is in a salt or liquid form and a lesser amount in sludge. It's about 430 million curies divided approximately equally between the sludge and the salt and. supernate

It's alkaline waste. And it's generally more homogenous than Hanford because they had less reprocessing technologies that they use and less variance in the fuels.

They have 51 tanks, 3 active evaporators, which they use for controlling the volume and minimizing the volume that they need to safely store. They have active sludge pretreatment facilities that they have been using since I guess about the mid 1990s to prepare the sludge for vitrification in the vitrification facility, the defense waste process facility there.

And then at the DWPF, they have processed and created over 1,500 cans of vitrified waste. Those are stored in a separate facility adjacent to the DWPF in an underground below-ground storage configuration.

The site is currently in the process of designing and constructing facilities to handle the salt waste portion of their tank waste. The cornerstone of that will be a salt waste processing facility that will basically separate out most of the cesium, strontium, and the actinides at the site.

They're working on some other interim processing facilities at this time. And their major -- I'm not sure you can see that down here, but their milestones for completing their process are 2019 for immobilizing all of their high-level waste and the early 2020s for closing all of the associated facilities, high-level waste facilities, on the site.

We put these slides together. There's one of these for each of the four sties. And it's basically trying to simplify the waste management strategy at each of the four sites. And I don't want to belabor this a whole lot, but I'll just point out some of the major aspects.

This represents all of the tanks down here. The orange nominally represents a facility associated with I'll say high-level waste. The green facility, green shading, is for the low-activity waste that we would then manage as low-level waste, dispose of on site as low-level waste.

And the violet is -- basically that's a facility for treating things like evaporator overheads and some other related very low activity stuff that eventually allows that waste stream to be discharged through an NPDES permitted outfall on the site.

Some of the other aspects on this are the dotted lines represent facilities that are in construction or being designed. They don't exist at this time. And if it's the solid, it does exist.

I probably should have dotted lined the repository there, but, at any rate, one of the other things you can see here is the division of radioactive waste relative to what's going to be the high-level waste going to a geologic repository and the low-activity waste that would be disposed of on site.

It gives you a rough breakdown of both the curies and the volume. I don't want to stress the exact numbers, but that's a pretty representative cut on the numbers. And then down here is an estimate of the residual waste that would be left in all of the facilities on the site.

Current status. As I mentioned earlier, we have been operating the DWPF since 1996. The planning for basically the retrieval and the processing of salt waste through some interim salt-processing facilities that we hope to begin, either later this year or early next year, those will be dependent upon a waste determination through a process that was in the National Defense Authorization Act of 2005, section 3116; and then a full capability salt waste-processing facility that will hopefully come on line in 2009.

Basically I mentioned that there. And then the stabilization of residual waste in tanks via grout was analyzed as one of the alternatives in a NEPA document. And the actual disposition in that regard would be dependent upon a waste determination that would be prepared in accordance with section 3116 of the NDAA.

We had two tanks at Savannah River that were closed in 1997, prior to DOE's order on radioactive waste management and through consultation process with the Nuclear Regulatory Commission. And I think Anna or somebody will talk a little bit about, touch on that later.

At our Hanford facility, we have a separate office that was created in I think 1998, the Office of River Protection, to manage the tank farms and associated activities there to treat and disposition the tank waste. There are about 200,000 cubic meters of waste, about 200 million curies in the tanks.

Back in -- I can't even remember the time frame, Bill -- '60s, '70s.

MR. HEWITT: Nineteen sixty-five to --

MR. PICHA: Okay. They processed out some of the cesium and strontium and placed those into capsules that are stored at their -- what was it, the waste encapsulation storage facility on site.

This is certainly the bulk of the tanks in the system, 177 tanks that are divided up into 149 what we call single shell tank, where there is not a double containment kind of a system or confinement system. Twenty-eight are double shell tanks.

They have constructed a high-level waste canister storage building, which is going to be used for storing both high-level waste and spent fuel. And I believe some spent fuel is in there already.

One of the major drivers of the activities at Hanford is a tri-party agreement, an agreement between the state, the EPA, and the DOE, which contains a number of milestones. In fact, I'm always astounded at the number of milestones. But some of the more significant ones are at 2024 to close all the single shell tanks and 2028 to complete immobilization of all the high-level waste, not the low-activity waste. I'll talk a little bit about how this differs a little bit from what is being done at Savannah

River.

This again shows the tanks. There's a little bit of a different waste stream in here than there was for Savannah River. At Hanford, a number of tanks -- I think it's on the order of about 10 to 20 tanks -- contained some waste that resulted from, as I understand it, plutonium purification activities. And we would certainly propose that an argument could be made that those were not associated directly with reprocessing. And so, therefore, they were not waste resulting directly from reprocessing. And so we are looking at whether or not we could disposition those as transuranic waste and send that to WIPP.

The other aspects are similar to Savannah River. As I'm sure many of you know, the cornerstone at Hanford is the waste treatment plant. It's a facility or set of facilities that include both pretreatment facilities, a laboratory, a low-activity waste melter, vitrification melter building, and a high-activity waste vitrification facility.

That's in construction now. And it will receive waste directly from the tanks and then process it as accordingly and do a separations process and then either go to the high-level waste melter or to the low-activity waste melter and then be disposed of in an integrated disposal facility on site.

The other piece that is part of the Hanford strategy is that the low-activity waste melter vitrification capability is not sufficient to get them to be able to complete their activities in a very timely manner. I don't remember the date, but if you relied only on that, it would send it out to I'm going to say 2040 beyond.

So what they're looking at is some alternative technologies to augment the low-activity waste melters in the waste treatment plan. And, actually, that will end up processing as much or more of the low-activity waste than the low-activity waste melters will be.

They are currently conducting a demonstration project using an approach called bulk vitrification. And I'm not sure exactly where they are in that process, but some of the folks here from the Hanford site can probably give you more details if you are interested in that.

And, again, that waste will also go to the integrated disposal facility on site; again, the breakout of approximately what we're looking at in terms of curies and volume in each of these disposition paths.

And one thing I didn't mention, -- I did globally but not specifically for Savannah River; I probably should have -- the plan for the disposition of Savannah River I mentioned was through a NEPA process. And I think that was done in the early '80s, '81-'82 process. I believe this was '85, something like that.

Well, this strategy, this general strategy -- I don't want to say all the specifics -- were generally mapped out prior to any recognition in the DOE sphere of an incidental waste process, but it was clear that that was our intent at that time frame. In fact, there are some words that I have in an environmental impact statement from that time frame that talks about that. I guess that's about it for Hanford.

Current status is they have basically completed the bulk of -- the transfer of the bulk of the liquids and the single shell tanks to minimize risk of leaks that are completing construction of the waste treatment plant.

I already talked about this a little bit, that approximately 50 percent or so will go through the low-activity waste melters. The remainder will be through the supplemental technologies, one of which they're looking at is the bulk vitrification process.

They have completed retrieval and cleaning of tank C-106. The site is currently in discussions with the NRC here on a process that was included in their tri-party agreement if they couldn't reach certain retrieval milestones. And they're in the process of working out some details of having the NRC take a look at what they have come up with in terms of the capabilities demonstrating that they have retrieved what they can technically and economically achieve. NRC needs some additional documents from them to be able to complete that review.

As I mentioned in one of the earlier slides, the environmental impact statement on closure of single shell tanks is in process right now. And then this last bullet refers to the pathway for certain of the tank wastes to be dispositioned as transuranic waste at WIPP.

At Idaho, I guess they had a good idea back when they initiated processing by not neutralizing their waste and storing waste in stainless steel tanks. They have certainly less volume of waste, both the stuff that has been calcined and the liquid waste that still remains in the tanks, about 25 million curies on site.

The facilities that they have there primarily are 11 primary storage tanks, stainless steel tanks, since they didn't neutralize their waste, 4 smaller auxiliary tanks. And then they have a high-level waste calcine facility. And then they have seven calcine bin sets, where they have stored the calcine, one set of which has not been used yet.

They have several agreements with the state in terms of when they need to complete their activities. Probably the more important one is to complete treatment of the remaining liquid wastes in the tanks, of which is about 900,000 gallons, by 2012.

And then sort of associated with that is ceasing use of the tanks by 2012 and then to treat the calcine waste, which is normally the high-level waste, to be road-ready for disposal by 2035.

Again, a similar diagram that's for Hanford and Savannah River. Probably the one exception here is that there they had some NEPA work done in 1995 associated with spent fuel, actually, where they had also looked at some of their -- an early look at their high-level waste disposition. But they didn't really complete their NEPA work until I guess it was 2002 when they completed their final EIS.

And because they already pretreated,

treated their waste in some manner to a calcine, they don't have the separations process in a low-activity waste stream, like we do at Hanford and at Savannah River. We have the calcine that would be nominally packaged or treated as necessary to meet whatever requirements that we ultimately have for a repository. And then it would be sent to a repository. Again, that's the bulk of the radioactivity. An estimate right now is it would be about 5,000 cubic meters in volume.

We have this what we call sodium-bearing waste stream as primarily decontamination solutions that were used throughout the facility there at Idaho, the Idaho Nuclear Technology Engineering Center. It included both the tanks. It included the reprocessing facilities, the calcine facilities, that type of thing. And that contains primarily, as I said, decontamination solutions.

And then they have actually two evaporators, but they all have this kind of effluent treatment facility that will allow some on-site flow of discharge of fluids that are very low in activity.

I think I probably covered most of this. The second item here is that in, I want to say, May, the department basically awarded a contract at Idaho for management of these wastes and some other associated activities and that one of the ways that the contract was set up was to allow the contractor to choose a technology for treating the sodium-bearing waste.

And they have identified initially a technology that we were in the process of trying to make public through a Federal Register notice. And I know that is in concurrence in our department right now.

If we end up sending that waste to WIPP as transuranic waste, it will require some kind of a determination to be determined. As I'm sure many of you know, waste that would be disposed of off site at Idaho and Savannah River, for that matter, is not covered under section 3116 of the National Defense Authorization Act. So we would not do any kind of a determination under that, but we're looking at other approaches.

I think this number is a little low. I think that number is now seven. I didn't go back and update this slide. I think they've completed cleaning and characterization of 7 of the 11 tanks that they have done.

Again, because they have acidic waste,

they don't have the harder sludges that we have at Savannah River and Hanford and West Valley. And, as you can see, they were able to get down to a level of less than 500 gallons in a tank that's nominally -- I'm not sure of the size. These are smaller tanks and typical at Savannah River and Hanford, but that's I'll say nominally a half an inch, an inch or so at the bottom or even less.

The State of Idaho has approved -- I think they used the term "partial RCRA closure plans" for addressing those seven tanks. And then the stabilization of the residual waste via grout was analyzed in the alternative in their NEPA document. And they have not issued a record of decision on that. And certainly we would have to do a determination under section 3116 of the NDAA to allow that to proceed.

I was not intending to talk specifically about any waste determination. Allen mentioned something about that. I can answer some questions later if you have some questions about where we are in terms of planning for doing those, but I was not intending to talk about that specifically. And I'm just giving an overview of the department strategy in managing the tanks and how we were just going to disposition the waste.

Unfortunately, I put these slides together and sent them to Latif before I had a chance to get some review by the West Valley folks yesterday. So there are some errors in here that I'll point out as we go.

Originally they had about 2,300 cubic meters of waste primarily in one tank at West Valley, about 25 million curies. Again, primarily it was alkaline waste. They did have some thorex acidic waste that they had stored in a separate stainless steel tank there. And they ended up blending it through a very rigorous engineering analysis and safety analysis that has now been primarily retrieved with the other waste and treated, which I'll get into here in a minute.

They had two primary tanks, storage tanks, and two smaller stainless steel tanks. They had a vitrification facility that operated from 1996 through about 2002. That's in the process of being dismantled. I'll talk to that a little bit more later.

They have a high-level waste canister storage facility. It's basically a set of racks that were installed in the old chemical process cell that was operated by the folks who operated the reprocessing facility. They did a lot of D&D, took a lot of the components out of that and put these racks and storing the canisters there.

They have a separate drum cell, a shielded drum facility for storing their low-activity waste that they created as part of the tank waste disposition process. I'll talk about that a little bit later. And then they also had a pretreatment facility that they used for pretreating the liquid waste.

And there are several, I'll say, unresolved issues with the State of New York on various things: ownership issues, the waste, who is going to pay for disposal, how much has to get cleaned up by the department under the act, those kinds of things.

Let's see. Similar slide as before. One of the things that's wrong here is this has now been done. And I'll talk about that waste stream in a minute. This is not 20 cubic meters. It would be nice if we could get it down to that level. It's about 250 cubic meters. I'll say roughly .7, .8 cubic meters per canister. There are 275 canisters.

The bulk of the radioactivity, though, is in the canisters. This number is I am thinking about a third of that. It had about a little less than 10,000 curies in their low-activity waste stream.

And what they did at West Valley is they operated their pretreatment facility. They used a zeolite ion exchange process. And then they ended up dumping the ion exchange through the bottom of one of the tanks using a grinder to mix it with the sludge and sending it over to the vitrification facility.

The low-activity waste, they got very good DFs through that process. And they ended up with I'll say almost 20,000, a little bit short of 20,000. What they did, rather than use faults, they ended up using drums. And they are roughly 71-gallon. They are actually steel square drums so they could put them on an edge. And they're in this drum cell I showed on the previous page awaiting an off-site disposal. And there are my understanding is about 10,000 curies associated with that.

The sodium-bearing waste water when they were doing retrieval and transferring waste from one tank to another, they only retrieve waste to go to the vitrification building out of one tank. They ended up with some pump seal water that was leaking into the tanks. That's primarily what this is. And it's been treated, and it's stored on site.

And I'm trying to recall the volume. I want to say it was 5,000 gallons is the volume, but the West Valley folks maybe can give you a better number on that. I forget the curies. I think they were on the order of perhaps what was in the low-activity waste drums.

Because they are complete with their high-level waste treatment, they're in the process now of trying to do some things that they can do ahead of completing their environmental impact statement for long-term stewardship and decommissioning of the entire site.

So they're dismantling a number of the components there on site, the vitrification cell that is there. They have pulled out some of the major components and have those stored on site. And it may be that some of those end up in concentrations that would be above our transuranic waste classification and may need to go to WIPP. There are some issues associated with that in terms of defense waste that would need to get resolved. So we have shown that as a possibility. Most of it is going to go here and off site.

As I mentioned, most of the pretreatment activities were completed in the mid 1990s. They completed vitrification in 2002. And they have started initial project facilities cleaning and dismantlement. And I mentioned the environmental impact statement that is ongoing now to determine final disposition of the tanks and some other components on site. And I believe that's it.

VICE CHAIRMAN CROFF: Great. Thanks. Let's try some questions here. Bill?

MEMBER HINZE: I'm interested in the status of your vitrification process. Where do you stand? Have you got all the problems taken care of with -- thank you. I'm sorry. I tried to keep the straight face. I just like to know where you are.

MR. PICHA: At DWPF, I showed that we had over 1,500 canisters completed there. We have already done a melter change out there. So we have demonstrated that technology and that capability. I'm not sure how many canisters we're on on the second melter, but there have been some operational hiccups with that, particularly with poor streams in terms of wicking to the size of the walls and that kind of thing. I think most of those have been ironed out.

I probably can't tell you too much more of the specifics. I know we have been able to increase waste loading. Some folks here could probably give you more specifics on that. Ramp that up from I think the high 20 percent or so to low 40s. So we have had some success in that.

Again, we're not processing salt waste component, which has the bulk of the radioactivity, the nonactive ion radioactivity. At West Valley, we had quite a bit of a success there. We were able to complete that on the single melter over a six-year time frame. And I think they're in the process of doing some of the analysis to verify the little small samples that they took are in agreement with the projected performance that they suspected based upon doing some of the projections.

At Hanford, we're in the middle of constructing the vitrification facilities there for both the high-activity and low-activity waste melters at Hanford.

Did you want --

MEMBER HINZE: Well --

MR. PICHA: If you need something more specific, I think we'll have to defer to some --

MEMBER HINZE: I'm sure we're going to learn more as the program goes on. Let me ask you, is there a difference between the vitrification process for low-level waste and high-level waste? I was surprised to see you going to the vitrification for the low-level waste.

MR. PICHA: That was a process that was ironed out with the states. And in I think the environmental impact statement in the mid '90s, when they went with that technology, in terms of the actual differences, whether or not the feed process, whether you use chemicals or whether you use FRIT, I can't speak to that.

And I guess I would defer. I don't know who the right person. Bill?

MR. HEWITT: Yes. The low-activity process.

VICE CHAIRMAN CROFF: Come to a microphone. Identify yourself.

MR. HEWITT: I'm Bill Hewitt with YASIC. We support the Office of River Protection.

We're looking at two low-level processes. Really, at the low-level waste, it's kind of the junk end. It takes the stuff that we can't get in to high-level waste, but it turns out of borosilicate glass. And it ranges from 12 percent sodium to 20 percent. But it's similar glass.

MEMBER HINZE: And a similar process. Let me ask you one more question, if I might. What are the plans for the canisters on the glass blocks, glass logs going into the high-level waste repository?

MR. PICHA: Well, as I showed, for instance -- well, maybe it's not here. This happens to be West Valley. I talked about the racks. Those are being stored right --

MEMBER HINZE: Right. But I'm speaking about them to the geological repository.

MR. PICHA: Well, the plans are there, at least as far as I knew -- they were actually being proposed to be co-disposed with spent fuel. And there were different configurations being looked at.

I think at Hanford, where the canisters were going to be 15 feet, the fuel assemblies from the end reactor I think were comparable length. They were proposing I think two fuel assemblies from end reactor and two canisters from -- there's better, more information --

MEMBER HINZE: Basically, alloy 22 can --

MR. PICHA: Oh, yes. Oh, yes.

MEMBER HINZE: Okay.

MR. PICHA: Absolutely.

MEMBER HINZE: Thank you.

VICE CHAIRMAN CROFF: Thanks. Mike?

CHAIRMAN RYAN: I guess this might be just a comment. There may be a question in here somewhere. When I think about these kinds of processes that you have outlined for all of the facilities, the question comes to my mind, "How much of the processing is done because it's the way to do the chemical engineering and the process to get it in the right waste form? And then how much of it is aimed at meeting a waste acceptance criteria?" And there's always that balance in there.

And maybe that's such a global question it's hard for you to answer now, but I guess as we think about these couple of days, that's the sort of thinking I'm focused on. And if you want to make an opening comment on it, then we'll hear more about it as we go along. That would be great. But what do you think?

MR. PICHA: Well, it's sort of a chicken and egg thing, I think. But, frankly, those decisions were substantively made prior to me even getting involved. And I'm not sure exactly how it evolved. I'm pretty sure that it was probably -- let me strike that.

I am going to guess that certainly some of the chemical aspects drove to the selection of the waste form, but I can't speak to that, whether --

CHAIRMAN RYAN: Fair enough. But, again, as we kind of go through, I think that's -- you know, when you think about the NRC's view of how they are going to create a guidance document in this area, both of those questions I think are at least intimate with these whole processes.

And I think that's maybe one of the focus points that the Committee will be thinking about as we go through the two days. So I'd ask maybe the other speakers and you as we participate to think about that and maybe help us understand your insights there as best we can.

Thanks.

VICE CHAIRMAN CROFF: Okay. Ruth?

MEMBER WEINER: I just have a couple of questions. What is your curie loading going to be like in 2024, 2028, in that kind of time frame? Some of this stuff has been sitting in these tanks for a while.

MR. PICHA: That's right. Well, if you think, for instance, for cesium and strontium, which have half-lives of about 30 years, if you're talking almost a complete half-life, the bulk of this radioactivity, well, I'm not sure how much -- it's still I think primarily driven by cesium and strontium in terms of bulk radioactivity. So it still, you know, could be half that.

MEMBER WEINER: Have you looked at this in terms of ultimate disposal, temporary disposal. I mean, some of this stuff if you just let it sit long enough at this point, the activity will decay away.

MR. PICHA: Actually, one of the things that we're looking at in some early analyses here for this liquid waste at Idaho is that to try to do, if you will, a curie balance.

And one of the things is to try to start with what was actually created as a result of reprocessing and just looking globally at different disposition paths. And certainly some of it is decay since I'm not sure when they started, maybe late '50s or early '50s, mid '50s in Idaho. That's almost two half-lives. So, I mean, there's been a fair amount of decay.

Now, whether or not you are asking a technical question as to whether or not we would make an -- or maybe a legal question or regulatory question whether we would make an argument that towards the end of our processing campaigns, that activity would be low enough to say, "Maybe this doesn't warrant geologic disposal." We're not in that mode right now.

MEMBER WEINER: Thank you.

You've mentioned several times disposal at the WIPP. The rH TRU component at the WIPP by the Land Withdrawal Act is five percent of the million-barrel equivalents can be rH TRU.

What determinations are still required before you can go through with that? Because basically isn't the rH TRU the same stuff as high-level waste? I mean, physically it's about the same thing.

MR. PICHA: Well, I don't know necessarily all the waste streams that were envisioned that would make up the rH TRU process. But certainly some of the waste streams are going to be isotopically probably similar to high-level waste.

I do know that for this waste stream, for the one on ORP, this waste stream here, that those are part of the -- I forget the specific title of the document, the EPA recertification document. Those have been included in there for analysis. And I'm going to say that some attempt has been done to look at how that might stack up against the five percent.

We have actually backed off on doing anything here vigorously until we get the remote handle waste permit at WIPP because we don't want to jeopardize that by pushing these things simultaneously.

MEMBER WEINER: I see. Thank you.

What are you doing with the empty tanks? What is going to be the final disposition? I remember this has been a matter of discussion at Hanford for I will say decades.

MR. PICHA: Sure. Well, at Hanford, you're probably aware they are in the middle of doing an environmental impact statement on looking at alternatives for dispositioning the single shell tank components and associated components. And we're not at a draft -- we haven't issued the draft yet, right, Bill? Yes.

So, as you might imagine, there are a lot of regulatory issues as well as technical issues in looking at alternatives there. And so I don't remember exactly how many alternatives are being evaluated -- I want to say three or four -- to look at how we might disposition those tanks and associated facilities.

But it's certainly to be determined in terms of officially based upon any kind of NEPA documents. However, clearly we're looking at trying to get the bulk of the waste out that we can using whatever measures are technically and economically practical.

At Savannah River, for instance, the preferred alternatives in the record of decision was to close the tanks using grout as a stabilization matrix after you have done the retrieval to the extent practical.

At Idaho, we haven't issued a record of decision, but that was the alternative there, preferred alternative there. And at West Valley, we're doing the NEPA to decide how we proceed at West Valley.

In general, I was saying from an overall Complex Y perspective, we're looking at closing tanks with some residuals left. But at individual sites, it may vary depending on how the NEPA turns out.

MEMBER WEINER: Is that also your preferred alternative for Hanford, closing them and grouting them?

MR. PICHA: Well, certainly we have done a fair amount of effort there. I wouldn't say we -- until we do the NEPA, I don't think we can say we have a preferred alternative. Is that --

MEMBER WEINER: Don't you have one in the

NEPA?

MR. HEWITT: There isn't a preferred alternative.

MR. PICHA: Right.

MEMBER WEINER: Okay. Thank you.

Finally, how do you stabilize the calcine, the INL calcine, physically? I mean, it's a very fine powder.

MR. PICHA: It is. And I know that I've not been involved in much of that. There are some issues associated with that. I think they're looking at different approaches, including, for instance, whether or not you could use some kind of a fixative to basically allow it to maintain some kind of I would say assorted solid properties, if you will, for purposes of shipping and disposal, but then we have to demonstrate that that could satisfy the waste acceptance requirements of Yucca Mountain.

Plus, there are some issues with the hazardous aspect of that waste form that would have to be resolved as well. And that's being looked at as well.

So we haven't determined exactly what needs to be done with that waste form to get it to Yucca Mountain.

MEMBER WEINER: Thank you.

VICE CHAIRMAN CROFF: Jim?

MEMBER CLARKE: I was interested in the ultimate disposition of the tanks as well. And I guess we're going to hear more about that later. For example, the cover systems that might --

MR. PICHA: Yes. I think throughout the day today and tomorrow, you're going to hear different aspects of the tank waste disposition program. And I think there's one or two discussions by Barry and John that are going to talk about characterization and retrieval approaches that we have investigated and used at the different sites.

Oak Ridge, I didn't talk about Oak Ridge here, but they had some tank waste that they used some innovative approaches to retrieving tank waste and getting it prepared for disposal.

MEMBER CLARKE: Are there any design requirements for ultimate covers if tanks are stabilized and left in place?

MR. PICHA: For covers like a --

MEMBER CLARKE: Cap.

MR. PICHA: -- cap? Yes. While I won't say there are final design requirements, there are certainly some considerations. We actually had to look at that for one of the waste streams at Savannah River with regard to something similar to this disposal facility at the vaults that would be nominally used for disposing of salt stone.

If you want a specific answer at specific sites, I think I would ask somebody to talk about, for instance, at Savannah River. Sherry, can you answer that?

MEMBER CLARKE: That's okay. We probably need to keep moving, Allen. That's fine. Thank you.

VICE CHAIRMAN CROFF: Okay. I guess I've got a couple of questions. First, it's going to be maybe a bit of a lengthy one, but I'm trying to get some idea of the range of wastes for which DOE may be submitting waste determinations.

Now, we have talked about the closed tanks. And we have talked about immobilized low-activity waste that's disposed on site. And those seem to be fairly generic. But I'm wanting sort of to know, you know, what else may need to be considered in the standard review plan. And let me give you some examples.

MR. PICHA: Okay.

VICE CHAIRMAN CROFF: You can -- well, I hope not run away screaming, but failed equipment, such as a used high-level waste melter, piping that connects tanks together and connects tank farms together, evaporator systems, the cesium and strontium capsules up at Hanford.

And, lastly, just to maybe really vex you, at least at Hanford, there have been significant leaks of tank wastes into the soil. How are you going to deal with that soil?

MR. PICHA: Let me take the last one first. I was not part of that, but a couple of weeks ago, there was a meeting here at the NRC, announced meeting, with regard to some technical topics. And one of those was, how do we address contamination spills and the like in our waste determination process?

And I can tell you that the slides that we use because I was on vacation when that was done. So I don't actually have the specific outcome of the discussions, but basically what we had proposed was that those are nominally covered under other environmental activities, like CRCLA, like primarily CRCLA, I think, because those are not wastes that we typically manage or actively manage and can have control over. Those have been, unfortunately, released to the environment. And they're part of a cleanup action.

VICE CHAIRMAN CROFF: Okay.

MR. PICHA: So with regard to that. With regard to you're right about the low-activity waste is a major one that we look at doing waste determinations. Residuals in high-level waste management facilities would be another set of waste determinations.

Contaminated equipment. I haven't shown it on all of there. I did show it, though, in West Valley because we are at that point where it is starting to become an issue.

Certain of the components will clearly require some kind of a waste determination, things like melters, where we actually have obviously some certain amount of waste left in the melters or, you know, at least would be candidates for a waste determination process, maybe some of the major vessels associated with the vitrification process.

With regard to interconnecting piping and evaporators, we're sorting that out right now at the various sites. At Idaho, what we are considering right now is a waste determination that covers these components as well as the piping, the diversion boxes.

VICE CHAIRMAN CROFF: So you're going to

sort of bundle the piping and some of this closely connected --

MR. PICHA: That is what we are looking at right now.

VICE CHAIRMAN CROFF: Okay.

MR. PICHA: Savannah River I think is looking at something comparable to that. And I think Hanford is in the early stages of scoping their determination process.

With regard to the cesium and strontium capsules, I'm going to take a pass on that and let maybe the Hanford folks address. As far as I know, that's not something that's on our scope right now for being looked at in terms of a waste determination.

VICE CHAIRMAN CROFF: Okay. On the -- go ahead.

MR. PICHA: Did I miss anything?

VICE CHAIRMAN CROFF: No.

MR. PICHA: Okay.

VICE CHAIRMAN CROFF: On the soils, you mentioned that DOE had I'll call it floated this idea a couple of weeks ago. Who gets to say whether the idea is a thumbs up or a thumbs down; in other words, treating contaminated soils under CRCLA, for example?

MR. PICHA: Well, good question. Do you

mean --

VICE CHAIRMAN CROFF: Do you just sort of say, "We're going to do this," and if nobody objects, you go ahead?

MR. PICHA: I'd say that would be the nominal plan. You know, we're not necessarily going to go out proactively and say, "Okay. Is this okay."

VICE CHAIRMAN CROFF: Okay.

MR. PICHA: As part of the CRCLA process, I think that that would be a way of getting to some of that.

VICE CHAIRMAN CROFF: Okay. A second question. In the West Valley tanks that have been I guess retrieved as far as you intend to, about how much waste is left in that in the bottom?

MR. PICHA: In terms of volume and --

VICE CHAIRMAN CROFF: I was thinking more in terms of a thickness kind of a thing, you know, I mean, half an inch, five inches.

MR. PICHA: The tank structure at West Valley, particularly at the bottom, is very complicated with a bunch of stiffeners throughout the bottom of the tanks. I'm going to say it's probably varied but less than an inch. Can you all carburet that?

VICE CHAIRMAN CROFF: Roughly an inch. Okay. All right. Thank you.

I guess do any NRC staff members -- Latif?

DR. HAMDAN: My question is, is there any effective communication of knowledge, technology information among the four sites or the issues are so site-specific that everyone is a project by itself?

MR. PICHA: Well, the answer is yes, sort of. From about I'd say mid 1990s through I'll say 2002, 2003, we had something called a tanks focus area. It was a technology development and assessment group that basically represented the four high-level waste sites and Oak Ridge, where they really were a technology integration group.

And we actually had champions. I think we called them technical integration managers. And we had one for each of the various functions associated with managing tank waste.

We had one for retrieval. We had one for characterization. We had one for mobilization. John was the mobilization guy. Barry was part of that. Were you one of the technology integration managers, Barry?

DR. BURKS: Yes, robotics.

MR. PICHA: Robotics. Unfortunately,

through whatever means and thought processes, that group was abandoned. And we don't have those focus areas anymore.

So we're trying to figure out how we can replace that function through other means. One of the ways that has been doing is I know particularly at Savannah River and Hanford, they have been very proactive in establishing their own technology.

How would you characterize that, Sherry? Technology, not transfer but technology sharing. What do you call those meetings?

MS. MEADOR: Actually, I'm not involved.

MR. PICHA: You're not involved? Okay.

MR. GASPER: I was involved.

MR. PICHA: Okay, Ken.

MR. GASPER: I'm Ken Gasper from Hanford.

Just to supplement your comments, Ken, prior to the tank focus area, we had an integration organization with high-level activity, low activity, low-level activity D&D.

And Bill Lawrence from West Valley chaired the high-level. Don Woodrich and I represented Hanford and our counterparts from Savannah River, for example, and Oak Ridge were involved.

In the period since the tank focus area, we have maintained the technical integration activity. I was technical integration manager for the tank farms at Hanford. And my counterparts at Savannah River were Savannah River National Lab and the Savannah River operations activity, were involved.

And we have had annual meetings, technical exchange meetings. We had biweekly telephone calls. And we focus on the processing activities, the safety activities, the technology activities.

We published reports that were available and still are available of those meetings, those annual meetings. And this year we also began involving Idaho Falls. In previous years, we had involved Oak Ridge and Los Alamos because of their technology support for the operations activities.

So we have tried to continue the same communication that was facilitated by headquarters with the tank focus area subsequent to the closing of the tank focus area activity. So the same people at the sites are participating.

And the field offices and headquarters staff, such as Kurt Girdus or his representatives, have participated in the meetings. And they are always available to participate in the telephone calls, the biweekly telephone calls, as are Pat Suggs and Billy Moss, for example, at Savannah River and Hanford.

So we're trying to continue that on an organized, regular basis. And it seems to be working quite well.

MR. PICHA: Thanks, Ken.

VICE CHAIRMAN CROFF: Thank you.

As a general comment before we go on with any more questions, this entire session is being recorded. And there will be a transcript produced. So if you're back in the audience, you know, if you're over here and wanting to respond to a question, please identify yourself so we know who is speaking and then go ahead and give a response.

With that, were there any other --

MR. THADANI: Yes. Ken, I look at this as a somewhat complex set of plants, if you will, various facilities. That means you have to build in design considerations for these facilities, you have to presumably postulate some potential things that might go wrong and deal with those.

How do you go about establishing design considerations? Is it done on the basis of some predetermined state of conditions or is it some probablistic thinking is brought into play here in establishing design considerations?

MR. PICHA: Well, I'll tell you a little bit. And if you need more information, I think you're going to have to talk to some of our experts.

There are sort of I guess two primary aspects that feed into the design considerations. Certainly one of them is the technical aspects. You had the waste. And you needed treated or pretreated or whatever. So it has to meet certain requirements in that regard.

And you've got to set limits. You're not going to accept waste that has a molarity beyond *X* or whatever. And certain constituents you don't want to include at all perhaps. And so you may need to separate those out.

And then you have the more driven ones from an authorization basis, where okay. If you have that, then you do a hazards analysis. And then you start doing your safety analyses, your preliminary to support construction and then your final safety analyses.

I'm not sure where exactly. I sort of lost track of that where we are in the department, whether we're using probablistic or deterministic. I think we use a little bit of both depending upon what the various contractors decide. And if somebody in the department has a better, more current thinking, they can.

But I think it's not that dissimilar to what the private sector would do in terms of as they prepare licensing documents to submit to the NRC.

MR. THADANI: Thank you.

VICE CHAIRMAN CROFF: Thank you.

Seeing no more questions, thank you very much, Ken.

MR. PICHA: Okay.

VICE CHAIRMAN CROFF: I think at this point, what I'd like to do -- we're running a little bit ahead. We show a break, but I'd like to postpone that until after this talk. I think they fit a little bit better together, but since we're doing so well, Anna willing, our next talk is to get an overview of what the NRC has done regarding previous waste determinations and a summary of the current waste determination criteria and some understanding of how the NRC is proceeding.

I'd like to introduce Anna Bradford, who is well-qualified to do this. She's a senior project manager in the NRC's Division of Waste Management and Environmental Protection.

She was in private industry for seven years before coming to the NRC, where she has been for five years. And within that, for the last three years, she's been the project manager for waste determination issues.

She is presently leading the ongoing waste determination evaluation for the Savannah River site and the development of the standard review plan for waste determinations that we're focusing on here.

Anna, proceed when you are ready.

4) HISTORY AND BACKGROUND ON NRC INVOLVEMENT IN WASTE DETERMINATIONS

MS. BRADFORD: As Allen said, my name is Anna Bradford. I'm the senior project manager for waste determination reviews at the NRC.

The Committee asked me to talk about our historical involvement with waste determinations as well as any upcoming activities that we see on the horizon. So I am going to talk about the background of waste incidental to reprocessing, or WIR; previous NRC reviews for DOE draft WIR determinations; the legislation regarding waste determinations. And I'm going to talk about what we have accomplished recently as well as what we see coming up in the future, both programmatically and technically.

The first few slides go over some background. At the most basic level, the idea behind WIR is that certain wastes can be managed based on the risks that they pose to human health and the environment, rather than based on the source of the waste. And the idea is that for some wastes that result from the reprocessing of spent nuclear fuel, some of it requires disposal in a geologic repository while some of it does not. And the WIR process is used to determine which of that waste does not require disposal in a geologic repository.

Some general information about WIR. Examples of potential WIR are the pumps and the high-level waste tanks; waste removed from the tanks that might be disposed of elsewhere, either on site or off site; and residual waste remaining in the tanks that may be disposed of in place.

WIR is not high-level waste, but it is low-level waste or transuranic, or TRU, waste. And, as Ken mentioned, there's potential WIR at four sites: Hanford, Idaho National Laboratory, Savannah River site, and West Valley.

The history of WIR goes all the way back to 1969, when the NRC first published a draft policy statement in a proposed appendix D to Part 50, which involved the siting of reprocessing facilities. But the first sort of modern WIR criteria that people refer to were issued in 1993 in a denial of a petition for rulemaking regarding Hanford.

Those criteria are listed here on this slide. And they are that waste process removed key radionuclides to the maximum extent technically and economically practicable, the waste should be incorporated into a solid physical form at concentrations not exceeding class C concentrations, and the waste should be managed so that safety requirements comparable to the performance objectives at 10 CFR Part 61, Subpart C, which are low-level waste regulations, are satisfied.

And then in 1991, DOE included essentially the same three criteria in their radioactive waste management program, which is in their DOE order 435.1.

Then in 2000, during a WIR review that we were conducting for the Savannah River site tanks, the NRC dropped that second criterion regarding concentration limits. And the commissioners decided that concentration is not really a direct measure of risk and that it would be adequate to use the criterion one, which was removal of key radionuclides to the extent practicable; and criterion three, which was meeting the performance objectives of 10 CFR Part 61. And using those would be adequate to protect public health and safety.

So then in 2002, along those same lines, those two criteria were the ones included in NRC's West Valley final policy statement, which set the decommissioning criteria for that site.

And then most recently, at the end of 2004, new legislation was passed that set the waste criteria for Savannah River and for Idaho. And that gave NRC staff new responsibilities regarding waste determinations. I'll talk more in detail about that a little bit later.

One thing to note here is just because of the wording in the legislation, DOE often refers to these as non-high-level waste determinations or section 3116 determinations. So you'll hear WIR, non-high-level waste section 3116 depending on which process you are talking about.

In the past, DOE has asked NRC to provide technical advice and consultation on its methodology in the conclusions of their WIR determinations.

It's important to note that we did not have any regulatory or oversight role in these. We conducted them at the request of DOE. They were conducted on a reimbursable basis. DOE was the one responsible for making the waste determinations. And we were just providing technical advice.

The WIR determinations usually involve demonstrating compliance with the applicable WIR criteria. And it often included a performance assessment.

We would assess the WIR determinations for the soundness of the technical assumptions, the analysis, and the conclusions. And we have conducted four of those so far: one for Hanford for waste that was removed from the tanks and meant to be disposed of on site. That was completed in '97. Savannah River tanks that were to be closed in place, that was completed in 2000.

And we have done two for INL, one for sodium-bearing waste removed from the tanks. That was meant to be sent to WIPP. We completed that in 2002 and then a review for tank closure that was completed in 2003.

And, in general, we concluded that the performance objectives of 10 CFR 61, Subpart C could be met. And, therefore, this was going to be protective of public health and safety.

We offered recommendations for improvement as DOE moved forward. For example, we might recommend that they sample the waste as they remove it to make sure that it confirmed the inventory estimates they had made in their WIR determinations.

In case Ken didn't give you enough flow charts, I included a couple in here also. This one shows the major steps of our past NRC reviews. And, like I mentioned, it would start with DOE requesting the review. After that, we would develop an interagency agreement to provide a funding mechanism because these were done on a reimbursable basis as well as a memorandum of understanding that would describe the work we would be doing.

MOU and IA were then prior to signature sent up to the Commission for approval so that they saw we were doing this work and they approved it. Once they issued an SRM saying essentially, "Yes, staff, go ahead and do that," DOE would submit their draft WIR determination. We would review that submittal during a technical review of all of the information they provided us and issue a request for additional information in most cases, which is essentially a list of questions for which we need responses before we can complete our review.

DOE would respond to that RAI. In many

cases, they would revise their actual WIR determination according to the comments that we gave them. We would review that response, any revision to the determination, any additional information, and develop a draft technical evaluation report which contained our findings.

That draft TER was sent up to the Commission for their review and approval. And they would issue an SRM, which either approved the TER as it stood or gave us some comments from the TER and we would revise the TER accordingly. And only after all of that was the final TER sent to DOE.

One important thing to note here is under this old process, we did not conduct any follow-up activities. Once the TER was provided to DOE, because we are only in an advisory role, we did not follow up to see if they carried out any of our recommendations. We provided our report, and that was the end of our involvement.

The next two slides give a quick look at the last four reviews that we have completed. I will hit the highlights, but if you want the details, I would suggest you look at the technical evaluation reports, which maybe you already have. They are about 40 to 50 pages long, so not too bad, but the highlights are captured here.

The first one was for Hanford: waste removed from the tanks and disposed of on site. Like I said, we completed that in '97. For that review, we reviewed to all those of those original waste criteria that were established in '93 with regard to Hanford.

But at the time, DOE was at a very preliminary stage of their planning. Their performance assessment was not complete. They called it an interim PA at the time. They knew they planned to revise it. I don't think they had picked their waste disposal location on site yet. I don't think the waste form was completely decided.

And so we looked at the information we had and said, "Well, based on this, it looks okay," but we couldn't -- you know, there was no numbers for the final performance assessment. That's why it says, "Not provided in the NRC report" for the doses here. So it was a very sort of provisional agreement and review on our part that it looked like they could meet those criteria.

The next review was for Savannah River, tanks closed in place, which we completed in 2000. Originally the staff reviewed all three of those incidental waste criteria again. And this is the case that I mentioned previously where the Commission then came back and told us, "Actually, staff, we want you to focus only on criteria one and three."

So the draft TER that went up to the Commission included some evaluation of that criterion two, but the final TER that went to DOE emphasized one and three in that final report.

The doses are given there in the third column. And, as you can see, for the public and for the intruder, they're well below the Subpart C performance objectives.

This last half of the table talks about the two INL reviews. The first was for the sodium-bearing waste that was to be removed from the tank and disposed of at WIPP. Since this was expected to be TRU waste, for which we did not have a WIR criterion -- remember, ours was for class C concentrations -- and because it would be disposed of at WIPP, we only looked at criterion one in that review.

So, again, in the doses section, the public and the intruder are not applicable because we didn't look at a performance assessment for WIPP. And the worker dose was not provided in the determination. And that was actually one of our recommendations back to them that they should include those worker doses in their future evaluations.

Last, with the INL tanks to be closed in place completed in 2003, in accordance with the West Valley policy statement, which was issued in 2003, we looked at criteria one and three. And, again, the public and intruder doses are listed there as well as the worker dose. And they're all well below the standards of 10 CFR 61.

So, as I mentioned earlier, legislation was passed that affected waste determinations. South Carolina Senator Graham introduced legislative language that would allow a process similar to the WIR process at the Savannah River site only.

And the wording subsequently underwent several revisions. We provided our input by responding to two letters that we received from senators requesting our reviews on incidental wastes.

And then in October, the President signed the Ronald Reagan National Defense Authorization Act for F.Y. 2005, which I'll go into more detail on the next two slides.

NDAA requires DOE to consult with us for all of its non-high-level waste determinations for Savannah River and for Idaho. And the act itself sets the criteria that should be used in these reviews. And they are somewhat similar to the criteria we had used previously. And they are that the waste does not require disposal in a deep geologic repository.

The waste has highly radioactive radionuclides moved to the maximum extent practicable. And if the waste is class C, its disposal must meet Subpart C. And if the waste exceeds class C, its disposal must meet Subpart C and DOE must consult with NRC on the development of its disposal plans.

It also requires that NRC in coordination with the state monitor DOE's disposal actions to assess their compliance with Subpart C. And we have to report any noncompliance to Congress, the state, and DOE.

And this is a new activity with regard to the staff. So we're right now planning how we intend to go about that. And although we do monitor them, we still do not have any enforcement authority over DOE. So there is some distinction there.

A few more points about the NDAA. It does apply only to Idaho and Savannah River, does not apply to West Valley or Hanford. You were asking about the melter at West Valley. Although, like Ken said, they may do a waste determination for that, they're not required to send it to us for review since the NDAA applies to Savannah River and Idaho. They may elect to, and we may elect to go ahead and review that, but it's not required under this act.

And it does not apply to waste shipped out of those states but only applies to waste that will remain in the states. The act also requires DOE to reimburse us for our activities in F.Y. '05. And for following years, we have to seek appropriations through our normal budget processes.

And then section 3146 of the NDAA requires a one-year study by the National Academy of Sciences of DOE disposal plants for waste that will exceed class C and that they do not intend to dispose of in a geologic repository. And that Committee has met several times already and plans to issue the interim report very soon, possibly by the end of this week, beginning of next week.

The next several slides cover what we have accomplished recently as well as what we see coming up. We developed a SECY paper, the numbers given here, that describes in detail the staff's plans for implementing our new responsibilities under the act. Essentially we think the technical review will be similar for those we perform for WIR determinations except, of course, obviously we will be reviewing whether they meet the NDAA criteria.

But the SECY paper went to the Commission on April 28th of this year. And June 30th, we got the staff requirements memorandum back in which the Commission approved the staff plans. They had a few comments, things like the staff process should be open and transparent to the public and that the staff should take the time necessary to complete its review to help protect public health and safety.

So given the new volume of work, the Division of Waste Management and Environmental Protection established a new section within its organization, which will handle the waste determination reviews as well as low-activity waste activities and some other things that sort of naturally go together.

We have begun development of the standard review plan. This will help guide our reviews. It will help provide consistency across reviews. It will also help DOE see the kind of information that we need to have to be able to evaluate their submittals.

We plan to have a public scoping meeting on the SRP this fall. And then we'll issue it for public comment it looks like in the Spring of '06.

And then to help us conduct all of this work and provide some technical expertise, we established a contract with the Center for Nuclear Waste Regulatory Analysis for technical assistance. They assisted us on some of our previous WIR determination reviews also.

Since January, we have met with representatives of both South Carolina and Idaho to talk about roles and responsibilities under the act as well as schedules and how we can interact efficiently. We have notified the states of meetings we have had with DOE, and they have participated in many of those meetings.

We also established an IA with DOE to provide funding for F.Y. '05 as required by the legislation. And we're currently drafting a memorandum of understanding that will lay out the rules and responsibilities of each agency. And that MOU will need to go up to the Commission for approval prior to signature.

And then we had some interactions going on with the NAS committee. We have provided three presentations to them so far: one at the kickoff meeting talking about our role in waste determinations; and then, two, presentations at subsequent meetings talking about the previous WIR reviews that we have done.

Okay. This slide shows how we envision the process under the NDAA, the review process. It is somewhat simplified from the previous one, as you can see. And the biggest two subtractions from this slide are that we no longer have to develop an MOU and an IA for each review and don't have to send those to the Commission for approval. The other difference is removal of the need to go up to the Commission for approval for each TER prior to issuance.

What we proposed in that SECY paper was to have the Commission aware of our SRP and once they signed off on that approach in the SRP, we could go ahead and do these TERs without needing to go back to the Commission for each one.

The other addition here is up toward the right-hand corner, this do-loop of RAIs, where just if the RAI responses are not adequate or complete, we may need to go back and ask some more questions, but our goal is always to be as efficient and complete as possible and just do one round of RAIs there.

So Savannah River submitted the first draft determination under the NDAA for salt waste disposal. This is essentially low-activity waste in some tanks that they would like to remove mixed with some grout and pump and bulk volumes over to some vaults on site where it would solidify. And that would be the disposal area.

They submitted that to us at the end of February, this past February. We reviewed that. We transmitted our RAI on May 26th. The RAI consisted of 80 questions total. Twelve were clarification, editorial-type questions. Sixty-eight were technical questions.

DOE responded on July 1st to 61 of those 68 technical questions and on July 15th to the remaining 7. They also gave us a significant amount of supporting information along with those responses. So we are in the process right now of conducting our technical review of all of that information.

The other thing on schedule for them is it is my understanding they expect to submit determinations for the tanks in September. Again, this is the latest information I have. And it's up to DOE, really, when they submit these to us.

In Idaho, we met with DOE and the state to talk about activities under the act. And DOE expects to submit a draft determination for the tanks sometime this month.

Prior to the new legislation, Hanford asked us to review the adequacy of their waste removal from one of their tanks, tank C-106. As Ken mentioned, they have a tri-party agreement there with the State of Washington and the EPA that requires them to consult with us if they cannot remove 99 percent by volume of the waste from their tanks.

So we entered into an interagency agreement. DOE sent us the documents that supported their belief that they removed as much waste as possible from that one tank.

We reviewed that. We transmitted our RAIs in January. We met June 1st to discuss proposed draft responses to those RAIs and are currently waiting for the formal RAI responses and part of that performance assessment.

West Valley is a special case. We already have responsibilities there under the West Valley Demonstration Project Act. That site will use the decommissioning criteria in NRC's West Valley policy statement, which, as I mentioned, had that criteria 1 and 3 in it.

And we are expecting that WIR information will be in DOE's draft EIS, which will be sent out for cooperating agency review in August or September, and also in the decommissioning plan, which we think will be issued probably Summer of '06.

This last slide is really just some references. You may already have many of these: the SECY paper; the SRM; the Commission vote sheets on the SECY, where each commissioner sort of gives their opinion; the Saltstone RAIs; DOE's responses; the letters to Congress that I mentioned.

And the one thing that I wanted to point out on this slide is that we did recently establish docket numbers for the sites because there is a large amount of information in documents. And these are solely for ease of tracking and finding documents for members of the public or stakeholders or the staff to be able to go into ADAMS and search on these docket numbers and find any relevant documents.

That's all I had today. I'm happy to answer any questions.

VICE CHAIRMAN CROFF: Okay. Thank you.

Jim?

MEMBER CLARKE: If I understood you, Anna, you have done four determinations in the past. And you have used either one, two, or three criteria.

MS. BRADFORD: Right.

MEMBER CLARKE: The Commission asked you

to drop one criteria. So you were left with two. The act gave you four. What's the major difference from where you sit from how you used to do these and how you will be doing them in the future?

MS. BRADFORD: Right. Let me go back to where those criteria are listed. The act, this first one, the waste does not require disposal in the geological repository, is really brand new, at least being explicitly spelled out like that. You could argue that all of these criteria are used to show that it doesn't need to go to a geologic repository.

So that will be new, a new criteria that we assess, a new section of our TERs, how I sort of think about it when we're getting ready to issue our TER.

The waste has had highly radioactive radionuclides removed to the maximum extent practicable. It's somewhat similar to previous criteria of key radionuclides removed to the maximum extent technically.

MEMBER CLARKE: You had an economic consideration --

MS. BRADFORD: Right.

MEMBER CLARKE: -- which doesn't appear here.

MS. BRADFORD: Right. But we would consider it part of that maximum extent practicable, consider the economics of their various alternatives.

And then the second one, I sort of think of it as a 3A or 3B. You're either less than class C or you're more than class C and you're forced into one of those bins, which means we'll have to assess the concentrations, which we had previously dropped.

But in terms of meeting the performance objectives, that will be similar to our previous reviews.

MEMBER CLARKE: Okay. Thank you.

CHAIRMAN RYAN: Just a quick follow-up while you're on that slide. To me this is kind of the real interesting center point of how you're going to proceed in that it's a real opportunity to drift away from what is an operationally based definition of what WIR is, a real sort of risk-informed environment.

Of course, you're working on that as you develop the standard review plan now. And thinking through that in these couple of days will help you, you know, gather information to do that.

Can you give us any insights at this point or is it really too preliminary to think about it? And is that point that we're really kind of moving toward a risk-informed approach correct?

MS. BRADFORD: Yes, but I think I would say that our previous reviews also tried to be risk-informed and performance-based.

CHAIRMAN RYAN: Oh, sure.

MS. BRADFORD: There's a large amount of information supporting all of these. And, you know, our staff wanted to focus on the things that were most important and really drove the results and could change the conclusions. In terms of --

CHAIRMAN RYAN: Yes. Those are probably very good foundational evaluations for moving forward. I didn't mean to say they weren't. But I just think it's exciting to recognize for probably the first time explicitly that concentration isn't risk. It's kind of related, but it's really not the only part of the story here.

You're broadening your view to account for other things that, you know, can also be probably better or, you know, augment your percent or evaluation and risk. And that's to be applauded, in my view.

Thanks.

VICE CHAIRMAN CROFF: And I'm going to, as Mike, follow up on this slide since we're here. In what you called 3B, this phrase, "DOE must consult with NRC in development of its disposal plants," what does that mean? This whole thing looks like DOE is consulting with NRC on its disposal plants.

MS. BRADFORD: Right.

VICE CHAIRMAN CROFF: What specific is there?

MS. BRADFORD: Well, as of yet, we haven't been forced into this criterion 3B sort of space. But I think we have been thinking about that. I know DOE has been thinking about that. I know both of our general counsels have been thinking about that in terms of interpretation of statute and how do you go about interpreting it at this point. I'm not sure of the answer to that.

VICE CHAIRMAN CROFF: Okay. Thank you.

Ruth?

MR. HODO: My name is Wayne Hodo. I'm from the Engineering Research and Development Center. I have a question about your program removal of salts.

CHAIRMAN RYAN: We will call on you first.

MR. HODO: Oh, I'm sorry.

CHAIRMAN RYAN: Thanks.

MEMBER WEINER: How and by whom is maximum extent practicable determined?

MS. BRADFORD: In our -- well, I should back up. DOE in their Saltstone submittal talked about what they believe the maximum extent practicable was. And they think it's broad. It can include economic considerations, technical considerations, programmatic considerations that DOE may have, risk analyses, things like that, workers, a wide range of things that DOE should and does consider when it makes decisions for things like that.

And I think we would agree with that. I don't think that this wording drops out the economic and technical evaluation but probably just broadens it further.

MEMBER WEINER: So it is really done on a case-by-case basis?

MS. BRADFORD: Yes.

MEMBER WEINER: Mike alluded to another question I had. Where do you consider worker doses in disposition of any of the tank material? I notice you didn't mention compliance with 10 CFR Part 20.

MS. BRADFORD: Right.

MEMBER WEINER: You do comply with ALARA.

MS. BRADFORD: Yes.

MEMBER WEINER: What's the NRC's take on worker doses in this whole process?

MS. BRADFORD: Protection during operations is one of the performance objectives in Subpart C. And it refers I think back to Part 20. DOE usually refers to their own worker radiation standards to show that they are protecting the worker.

MEMBER WEINER: Finally, what is the NRC's view of disposition of the empty tanks?

MS. BRADFORD: What is our view?

MEMBER WEINER: Well, what do you think should be done? Have you considered this? What do you think should be done with the empty tanks?

MS. BRADFORD: Well, I guess I would go back to those letters that we sent to Congress, where they asked us what do we think about the WIR process in general. And I think we said it might not make sense to expend large amounts of federal funds and incur large worker doses and transportation risks to dig up those tanks and transport them elsewhere if, in fact, you can safely dispose of them in place. Again, it is very case-specific.

MEMBER WEINER: Yes. Thank you.

VICE CHAIRMAN CROFF: Mike, any more?

CHAIRMAN RYAN: No. Thank you. I'm done.

VICE CHAIRMAN CROFF: Okay Bill?

MEMBER HINZE: Referring to the last

bullet on that slide 12, what is the NRC's view of the word "monitor" here? What can we envision will be the monitoring stance of NRC towards DOE's compliance with 61?

MS. BRADFORD: First of all, I need to change this slide so you guys will ask me questions on something else.

MEMBER HINZE: No. That was the word that stuck out to me in your presentation.

MS. BRADFORD: Monitoring?

MEMBER HINZE: Monitoring.

MS. BRADFORD: Again, that would also be conducted in a risk-informed performance-based manner. And we're still thinking about how we'll implement that because it is a new activity for us. But I think the general process will be in that technical evaluation report, we will identify the factors that are important to showing compliance with Subpart C. And those would be the types of things we would monitor.

For example, if the reducing grout was very important in meeting the performance objectives, we might follow up on that to see if, in fact, the reducing grout performed the way that DOE thought it did in its draft determination.

And then there might also be an environmental monitoring component to that, reviewing site environmental reports, things like that.

MEMBER HINZE: So would this include doing your own PAs on this, reviewing more than their regulations, doing physical reviews, any or all of the above?

MS. BRADFORD: We do often develop our own models during the TER portion to inform our review and make sure we don't get wildly different results. But in terms of the monitoring stage, I don't know. I don't think we have thought about that yet.

MEMBER HINZE: How will this monitoring be coordinated with the states?

MS. BRADFORD: I think if we were visiting the site, for example, to do a monitoring visit, we would invite the state along. I would expect they might invite us along if they were doing a monitoring visit that they thought we might be interested in.

If we had -- the states are very familiar with those states. And they know the important areas. They know what has been going on in the past, what is going on in the future. So we really want to work closely with them on the monitoring.

I think if we maybe found a possible

non-compliance, we might talk to the state and say, "Hey, we're finding this. What do you think about this or is there anything we haven't considered here?"

So I think we'll be working with them all along, not just up at the end when we're ready to issue a report.

MEMBER HINZE: Thank you.

VICE CHAIRMAN CROFF: I had one additional question, a confirmation question. As I understand it, waste determinations leading to classification of a waste as transuranic don't play in the 3116 arena. This has nothing to do with it because it would presumably be disposed of off site in WIPP, for example.

MS. BRADFORD: Yes. If it was going to be disposed of off site, this doesn't apply. It's just for waste remaining in the --

VICE CHAIRMAN CROFF: Okay. Thank you.

NRC staff? No? Any of our other speakers her? Dave?

DR. KOCHER: David Kocher. I want to beat on the class C business again because I just get this feeling in my bones that there is a tendency to forget what was behind these class C limits when they were developed.

And I guess I would caution people to not forget history. For example, when this rule was developed, there would be very small

VICE CHAIRMAN CROFF: Thanks. I think we might be able to entertain a limited number of questions from the audience. And I think somebody had stepped up here. Your name and then --

MR. HODO: Excuse me for interrupting earlier.

VICE CHAIRMAN CROFF: That's all right.

MR. HODO: My name is Wayne Hodo from the Army Engineering Research and Development Center. I am currently working on a project under Jacob Phillips. But when you said the removal of odium and placing it in grout, are you referring to cement grout?

MS. BRADFORD: Yes.

MR. HODO: Okay. I'm not sure if you are aware. Even with placing sodium in cement, it will begin to leach out over time. And it will affect your soil mineralogy.

Are there going to be any studies done?

MS. BRADFORD: Ken, did you want to answer that about the formulation of the cement?

MR. PICHA: I'm not sure I do, but I think we have somebody who might be able to. Can we call on members of the public to answer a question?

VICE CHAIRMAN CROFF: That's good if we've got somebody who can answer it.

MR. PICHA: Jim, can you answer that question, Jim Cook? Is he there?

MR. COOK: Hi. I'm Jim Cook from Aiken, South Carolina. And all I can say is that we have done formulation and leach tests on our cement-based waste forms.

In particular, sodium and nitrate are things that we look at. We recognize it does come out, but we try to formulate it so that it comes out at small quantities at a time.

MR. HODO: That's based on soil type. Have you done any studies on various types of soils?

MR. COOK: What I just said had to do with the waste form, not with the soils. Our soils don't particularly absorb sodium. And we haven't looked at other soils. That is sort of a non-answer, but that is the truth.

MR. HODO: I would like to go on and say that is dependent on soil type. In particular, it is known to the geotechnical community that if you bury even a grout mixture within a cohesive or a clay soil, you will have ion exchange. And you will have dramatically changed the soil mineralogy. And it would be detrimental to your whole burial process.

MS. BRADFORD: Thank you.

VICE CHAIRMAN CROFF: Okay. Thank you very much. I think at this point I don't see anything else. So we're going to declare a break here until 10:35. That's about 15 minutes. During the break, what I'd like to do and do throughout the workshop is rotate the next panel of speakers up onto the main table here so they can be here.

And the current groups of speakers, I would like waste determinations to get them back at the second tier of tables if at all possible with a microphone to allow them to participate if they can.

So with that, about 15 minutes.

(Whereupon, the foregoing matter went off the record at 10:22 a.m. and went back on the record at 10:39 a.m.)

VICE CHAIRMAN CROFF: Thank you. I'd like to move on into our first -- what I'll call technical session. And this concerns waste retrieval and processing.

Before introducing our next speaker, I'd like to note a slight change in protocol on how I'd like to try to run this. And that is we've got our next panel of speakers up here. There are five of them.

I would like to try to get through all five speakers with no more than clarification questions. And then have you sit as a panel for about an hour of questions and answers just sort of across the board if my committee members will tolerate. So that means we'll get into the Q&A sometime later in the afternoon.

If that's not any problem, I'd like to --

MEMBER HINZE: Before lunch?

VICE CHAIRMAN CROFF: No, not before lunch, Bill. Only for you. You're on a diet.

I'd like now to introduce Dr. Paul Murray who will be the first speaker in this second session on waste retrieval and processing technology.

Paul has over 25 years of experience in the field of nuclear waste retrieval and handling. For the last 18 years, he's been employed by AEA Technology, initially working at reprocessing facilities at Dounreay and Sellafield.

He transferred to the U.S. nine years ago and has been working on waste retrieval projects around the entire complex.

His presentation will focus on fluidic approaches to retrieving waste from tanks.

Paul?

DR. MURRAY: Thank you very much. I have a funny accent so I apologize now.

Okay. My presentation today will talk about power of fluidics. During the presentation, I will just talk about pulse jet mixers, RFD pumps for pump immobilization, a little bit about tank grouting, and then a consolidated system for mobilizing waste, recovering the HLW, and then grouting the residual HLW in place.

Power fluidics was invented over 25 years ago. It is a prudent technology with multiple deployments in the British nuclear arena. It has no moving parts in contact with the fluid. It is designed to be completely maintenance free. And it is installed into all modern reprocessing plants.

Plant lifetime costs, it's ALARA because it is no maintenance and it generates no secondary waste. Okay?

The key components of the pulse jet mixer are a jet pump pair, a charge vessel, and a nozzle. I'll explain each of the components. The jet pump pair consists of two air-driven jet pumps, one connected up to the charge vessel and the other side connected up to the vent side of the system.

For the purposes of everything that I'm going to talk about today, everything from that point downwards is considered active. Everything upstream of the jet pumps is considered inactive. This is what a jet pump pair looks like. It just looks like chunks of steel.

So in the suction phase of a jet pump, you put compressed air through the top ejector here. We create a region of low pressure from Bernoulli's equation, just like you see in your shower every time you turn your shower on and the shower curtain moves towards you. This region of low pressure allows us to suck air from the charge vessel up to that region of low pressure.

During the dry phase when we want pressurize the charge vessel, we put compressed air down the other jet pump. This jet pump is designed so it doesn't create a region of low pressure here. But actually causes a small leak back of air into the vent system.

So pulse jet mixer, this is a really, really simple piece of equipment. It's jet pumps, charge vessel, and a nozzle in the waste. When we put the vacuum on this side of the jet pumps, the region of low pressure, pull the air out of the charge vessel, the sludge and liquid moves into the charge vessel.

When the charge vessel is full, we put compressed air down this jet pump, pressurizing the charge vessel, forcing the sludge and liquid back out into the tank. Now air comes out of the charge vessel. The system is designed so that no air comes out of the charge vessel.

This is the C-tank system at Oak Ridge. We vent the numerous tanks around the complex using this system. The C-tanks are 62 feet long. They had two manways in the hypervent and had cooling coils along the base of the tank.

We installed charge vessels and manways at the base of the tank. These are the charge vessels, one went at either end of the tank. These are the charge vessels during installation. And they're just -- as I say, just charge vessels. No moving parts down in the tank. That's the size of the nozzle we put on the end of a charge vessel.

I hope this plays -- oh, it's playing. It's not playing on the screen. This is the inactive demo. What we're doing is we're looking down and along the tank. This is the charge vessel discharging with 60 psi in the charge vessel.

You can see the cooling coils here. So there is not much that is going to stand in front of that jet in the way of waste.

This is typically what the sludge looks like in a tank before we start. And this is what the tank looks like when we finish. The endpoint of a tank is determined by DOE or the site operator before we start.

The RFD pump, which I'd like to talk about now, takes the concept of the pulse jet mixer one stage further. You've got the jet pumps, the charge vessel, now we've got a device called an RFD. It's called a reverse flow diverter. And this acts like a three-way valve. So one side of it is connected up to the charge vessel. The other side is connected up to a delivery line.

And all it is is basically two nozzles housed in the teepee. This is just a cutaway view of it. But it really is all it is.

This is a production unit. That side is connected to the charge vessel. That side is the delivery line. That side is open to the tank.

There are over 400 of them installed in

British nuclear plants. The longest has been running for 25 years now. There are 480 components went into the waste treatment plant at Hanford. These are the high-level waste tanks at Sellafield. These are cooling coils. These are the two RFD pumps down here.

So the RFD pump works, we put the suction on the charge vessel again. We suck liquid in between the two nozzles which fills the charge vessel. When the charge vessel is full, we pressurize the charge vessel, forcing liquid across the nozzles, up the delivery line, and out. And the pumps will literally pump anything.

They have minimum water requirements. They can pump right down to hardly any water left in the tank. There are no moving parts so you can't break them.

We built a system, a demonstration system for Hanford where we took the RFD system and we connected it up to two stable nozzles. So now we could take the waste from the tank and pump it back in. I've got slides to show this, in fact.

So we can force the liquid out of the charge vessel up, down through the stable nozzles, to knock the waste back to the pump to pump it out. So we literally keep recirculating the waste in the tank without adding extra water into the tank to mobilize the waste. Or we can send it through the outboard nozzles to knock more waste down and send it back.

And I'll skip that one.

For the million-gallon tank retrieval, we decided we need three independent systems working with two nozzles each to cover the base of the tank and return the waste. This is the size of the system here.

We demonstrated that this system could work on debris, which you typically find in a tank, pieces of string, wood, gloves, plastic bags, sample bottles. We demonstrated the system would not block when it encountered these wastes. At Los Alamos when we emptied the tank, we encountered a dead cat. So we managed to retrieve that I'm afraid.

I hope this is going to play. So one of the things -- I turned the volume down -- one of the things we did last year was we showed that the system could be used, once we got the bulk of the waste out of the tank, we could put grout in and we could use the system to mix the grout in the residual HLW. We put a uniform mix in the tank.

So instead of just pouring the grout into the tank, now we can mix the grout into the tank. And this tank is about 25 foot long to give you some idea. And the test proved very, very successful. The only comment we got back was our tanks are cylindrical and not horizontal.

This year, in September, we have built a 28-foot diameter tank with cooling coils across the bottom. We have two pulse jet mixers operating underneath the cooling coils. We have an RFD pump feeding two external nozzles. We will demonstrate we can recover the HLW from the tank and then jet grout the residual HLW in the tank.

And if anybody wants to come to that demonstration, my e-mail details are in the pamphlet. You are more than welcome.

So in summary, we've had multiple deployments around the complex. It's a very stout system capable of adaptation. One of the things we found is when you start recovering a tank, you come across problems you don't expect. We've proven that our system is capable of adapting to overcome those problems.

It is a reusable, skid-mounted system so once it has emptied one tank, you can move it on to empty other tanks. You have a minimum water requirement in the tank so if there is a problem with the tank leaking, we just have to have a really small amount of water there.

It is capable of bulk waste retrieval, HLW recovery, and jet grout in the tank. And as I said, there is this big demonstration in September in Charlotte. And that's it.

VICE CHAIRMAN CROFF: Okay. Thank you very much. People are being uncommonly brief this morning.

Right now we show a lunch, having anticipated we'd run quite a bit longer. And I don't plan on going to lunch right now. So I think what I'd like to do is just continue with the agenda and ask Barry to come up and get him set up while I introduce him.

And then I may make a liar out of myself and entertain at least some retrieval questions before we do lunch. And group those together before we move on to a slightly different topic.

With that, thank you very much, Paul.

DR. MURRAY: Okay.

VICE CHAIRMAN CROFF: And the second speaker in this section will address a different aspect of waste retrieval technology. I'd like to introduce Dr. Barry Burks, who is currently President of TPG Applied Technology.

TPG was responsible for waste removal operations from 25 underground storage tanks at Oak Ridge National Lab. Barry was formerly the Robotics Technology Integration Manager for the DOE tank focus area, the Tank Waste Retrieval Product Line Manager for the DOE Robotics Crosscut Program, and the Tank Waste Removal Operations Manager for the gunite and associated tanks remediation project.

As you might expect, Barry is going to focus on the use of robotic devices for waste retrieval.

DR. BURKS: Okay. Thanks, Allen.

Okay. There are three basic ways to retrieve waste from tanks. And Paul talked about an approach where you mix and pump. But you can also mix and pump using remote systems. And I'll talk a little bit about that.

The other two ways that you can remove waste, depending on the form of the waste, is what I call mechanical removal where you might scoop or excavate, or drill, auger, you know remove the waste in a more solid form rather than a slurry.

Then the other thing, you may have waste, for instance, with ion exchange resins or something like that that you would like to remove -- maybe burn up those ion exchange resins before removing the rest of the waste and treating it.

So three approaches. And I'm going to talk primarily about mixing and pumping mechanical removal but the way I look at retrieval is that you have positioning tools and then you have the retrieval tools themselves. The remote systems are what you use to position your tools.

Typically what we're talking about are vehicles and arms. And you deploy a variety of tools. Those tools might be water jets used to create a slurry, mechanical agitators, there might be pumps, it could be the scoops, drills, augers, those sorts of things that you use for mechanical retrieval. Or you could be deploying a chemical reagent of some sort.

Okay. There have been a number of large arms designed, some of them built, a few actually deployed for tank waste retrieval. And this is not a complete list by any means. I left off the ones that only got as far as the drawing pad. If there wasn't somebody that at least funded a conceptual development activity, then I didn't include those.

But the arms, large arms include the light-duty utility arm. Three of those were built --

and I'll talk about this on a later slide and elaborate -- for Hanford and INEEL, a modified version of that arm which was used at Oak Ridge National Lab and then a companion arm for the MLDUA that was used at ORNL.

And I will apologize to the folks who are here from West Valley, the Tarzan manipulator, we called it that, that's the nickname for this manipulator. But it was politically unacceptable at West Valley to call it a Tarzan manipulator so they came up with an acronym that is totally unrememberable -- or unmemorable, whatever you want to call it. And so I just ignore that six letter, six word acronym and call it what it really is. It's the Tarzan manipulator.

West Valley also had a simpler manipulator, just a telescoping mast with an arm that folded out. And then the Fernald site had two of the more novel approaches. Neither one got built but both the development was pretty far along, something called ReTRIEVR and EMMA that I'll talk about more.

And at Hanford, there is a fairly simple arm that is an articulated mast that has been used here recently. And they've completed cleaning up one tank so far and have other deployments planned.

In addition to these large boom systems, there are a number of companies that offer smaller manipulators that can be attached to the end of a large boom. And provide a more dexterous working system for handling those retrieval tools.

Okay. The light-duty utility arms, these were built by Spar Aerospace, Ltd. And if you are at all familiar with the shuttle arm, this is very similar technology, built by the same company that built the shuttle arm. And it looks a lot like it, a long skinny arm with several joints in it.

In this case, the LDUAs were customized for tank environments at Hanford and at Idaho. These arms were built primarily for characterization and inspection. And the emphasis was on tools that could be attached to the end of the arm, go through a 12-inch diameter riser, and do sampling, inspection, physical and chemical property measurements.

So the emphasis was on being able to reach to the bottom of those 50-foot deep Hanford tanks. Because of the limitation of going through a 12-inch riser, they were only able to get about an 11-foot horizontal reach with those systems, limited payload of about 100 pounds.

And the LDUA system was originally

deployed at Hanford for characterization inspection activity and then used at Idaho to support the retrieval activities that they are doing. The retrieval work is being done by water spray technology but some of the sampling and surveillance oversight activity that they're doing is being performed with a light-duty utility arm.

At Oak Ridge, we didn't have the 12-inch constraints that they had at Hanford. So what we did was to modify the basic LDUA design so that we could have a longer reach and a higher lift capacity. And that higher lift capacity allowed us to handle big enough tools to actually do retrieval, not just characterization, sampling, inspection.

The original LDUA design was mounted on the back of a truck so that at Hanford you could back up over top of the riser and deploy the system. I'll show a picture of that in a minute.

At Idaho and Oak Ridge, what we wanted was an arm that was mounted on a skid that we could life with a crane and place in position and move from place to place on the tank farms.

The modified light-duty utility arm was used at Oak Ridge to clean seven large underground storage tanks between 1997 and 2000. This is a cartoon that was drawn by folks at Hanford about 1996 now I guess it was.

But what it shows there's that truck-mounted light-duty utility arm. This is the containment structure. The arm would be driven to the site, housed in that structure, which would be laid in that yoke. And then once you got to the site, you upright the arm, deploy through a containment structure that had glove ports. And that's where you would attach tools on the end of the arm.

And then the arm would then proceed down into the tank. And you see the long, skinny arm like the shuttle with a variety of tools on the end. And there are other support systems, decontamination, the analysis facilities for those, and characterization tools for instance.

And there is a picture of the LDUA at Hanford. You had a little bit better view of that containment structure and the outriggers. There's the truck.

And then this is the arm itself. Rather than in a tank, this was in a test setup. Again, you can see it is a multilink arm, seven degrees of freedom. So it's highly dexterous with high-positioning accuracy, .05 inches.

And that was needed, in part, because of going through the risers at Hanford, which are not true vertical, there are some off-vertical, and so you're trying to put something that is 11 and a half inches in diameter through something that is only 11.6 inches diameter. And not straight. So positioning accuracy was required not only for the work being done in the tank but also just to get into the tank.

The modified light-duty utility arm at Oak Ridge had a similar enclosure for transport. And you see we had some working platforms up here for certain maintenance activities, connection to a glove box for attaching tools, and then the arm could be deployed into a tank.

In testing, we initially used the yellow plastic enclosure for contamination control and decided after a while that it was better to go clear so that we could see if there were oil leaks from the system. So in the actual tank deployments, we used a clear cover.

What you also see in this picture is the Houdini remotely-operated vehicle and our confined sluicing end effector. And that that is attached to something not very easily seen. But that's the waste dislodging and conveyance system that we used at Oak

Ridge.

The tanks at Oak Ridge had gone through an initial retrieval campaign where sluicing was used back in the ‘80s. And what we were faced with in the late ‘90s was a HLW that varied from six inches to five feet deep. The bulk of the waste had been removed.

And we used the arm, handling this confined sluicing end effector to bring the level down so that we could then get the Houdini vehicle in the tanks and use the plow blade on the Houdini vehicle to help move sludge to where we could reach it.

That confined sluicing end effector is like a high performance carpet cleaner. Three rotating heads that can put out water jets set up to 10,000 psi, which could break up hard waste, create a slurry, and then we had a jet pump in the arm back here that was attached through a pipeline and a conveyance hose to an intake here at this confined sluicing end effector. So as we broke up waste, we were also evacuating it from the tank.

West Valley -- Ken Picha mentioned earlier -- they've got a more complicated interior space in their tanks. They have vertical supports that are spaced ten feet apart. And then on the floor of the tank there are girders that are several feet high. And it is just a more complicated geometric obstruction to work around.

What they have been able to do is to use a telescoping mast system which then has an articulating arm for spraying water to help move waste HLW toward their retrieval pumps.

The more interesting work for folks interested in robotics anyway, is this Tarzan manipulator. And the concept there was that they wanted to deploy a manipulator which could grasp one of those pipes and be suspended from the pipe, hold a spray nozzle or other tool from its other arm, and assist in the HLW removal.

And in another version of that, which I'll show you a cartoon of, had two arms that could grasp two of the vertical supports and have a smaller, say a Schilling TITAN manipulator in the middle of that structure to help with retrieval.

Unfortunately, they weren't able to finish that project. Found alternate means to get the work done. And there were some prototype components that were built but the full system was not built. And this is just a cartoon showing how you could grip one of those vertical support beams and then have an arm out at the end handling a spray hose, for instance, or for getting around in that more complicated support structure, you might attach to two vertical supports and then lean over with a dexterous manipulator.

Okay. I mentioned that Fernald with their aboveground silos had two different projects that featured design of large manipulators. The ReTRIEVR, which was designed by Framatome, was a very large multilink arm designed for Silo 3. And the way that was going to be built, sections, eight- or ten-foot sections of arm were to be assembled inside the containment structure above the silos.

So you would insert the lower wrist and gripper. And then stick in a section. Lower that, stick in another section. So multi sections to build up an arm that would be able to reach over 40 feet down and across in those silos.

It got to the point where they had come components fabricated. But then the project was cancelled.

A similar application, the EMMA system, developed by Grey Pilgrim, in this case it was a cable-driven arm. And I'll show a picture of that shortly. The tanks focus area or actually the predecessor, Underground Storage Tank Integrated Demo, actually funded a prototype system development. And that was demonstrated and evaluated for tank waste retrieval. But the full-scale version was not constructed.

Okay. Another example of an acronym, the Revolving Turret Reeled Cable Incremental Link Extending Vacuuming Robot. ReTRIEVR is a whole lost easier to say. See the large concrete silo and these links that I was talking about, the multilink arm. Again, it was a large cable reel down the inside. This was designed to position a smaller manipulator at the tank walls or silo walls and along the floor to support waste retrieval.

And then EMMA, these are cylinders that have about a half a dozen cables running through them and back up to a cable management system up here. But you could turn that arm up, down, sideways by pulling on the cables one way or the other.

Okay. Neither of those fancy arms were deployed at Fernald but there was a system that I have some pictures of that was designed by our company and operated by Fluor Fernald, a hydraulic mining system where we had telescoping articulated masts with water jets.

And then the WD&C System, the point there was we have this three million dollar very precise arm, a modified light-duty utility arm, and it was going to be handling waste retrieval tools. But we didn't want to bring the pipeline of waste up either through that arm or attached to that arm.

So we built a half-million dollar arm simpler, four degrees of freedom, which was basically a pipeline. And the pipeline had motors in it to articulate and place the end effector across the tank.

So we would lower the waste dislodging and conveyance system into the tank. The MLDUA would grasp the end effector and then lower the rest of the arm into the tank and operate what is called a scara position for that simple arm.

So all of the hammer effect of pumping with that confined sluicing end effector was actually taken up by the simpler arm. And the expensive arm just had to deal with some simpler dynamic forces of the jets rotating. So it kept the maintenance on the more complicated arm much simpler. We weren't having folks doing maintenance or attaching tools to that arm right beside a pipeline that had waste going through it.

Okay. And then this articulated mast from Hanford, I've got a cartoon of that coming up. Oh, I guess while I've got it there, in addition to the confined sluicing end effector, we also had what we called the gunite scarifying end effector in use at Oak Ridge.

And every site is going to have different criteria for what is clean enough to close a tank. At Oak Ridge, the regulators wanted not only all the visible sludge removed but they also wanted the walls to be high-pressure washed to remove any loose contamination that there would be on the walls.

So a similar tools was developed to the confined sluicing end effector that simply had rotating jets that we could operate at up to 50,000 psi. And that the MLDUA could then use to clean the walls.

Okay. And this is the pump module for the Fernald Advanced Waste Retrieval System. And there's the pump itself, 600 gallon per minute sludge pump. And it is being shown in a mock up that we built -- TPG built an 80-foot long, 20-foot wide, 15-foot high swimming pool at our test facility. And did testing and operator training for the Advanced Waste Retrieval System.

And then Fernald had us take that down and set it up there. And they set it up on site and continue to use it there.

And there is a picture of the spray nozzle which was a 3,000-gallon-per-minute nozzle. So pretty healthy spray.

Okay. And I talked about that waste dislodging and conveyance system arm. Just some pictures showing the containment structure that you would attach tools through or do maintenance. And then the arm in its stowed configuration. And this would be lowered down into the tank and then unfold at that joint, operate then in a horizontal plane.

Okay. At Hanford, they are using an end tank remotely operated vehicle along with an articulated mast where a pump is located at the end of the mast system. And the vehicle is used to push waste and spray waste and help it move towards that pump.

Okay. Now as far as manipulators go, there have been several large complex systems designed but only a couple that have been actually built and deployed for tank waste retrieval, the MLDUA, in particular. And then there are some simpler arms that I mentioned that have been built.

For vehicles, actually there was a bigger selection of vehicles for tank waste retrieval than there are arms. And more of them have been deployed.

The Houdini vehicle, the primary feature of the Houdini vehicle is that it can fold up so that you can get a thousand pound mini bulldozer through a 20-inch riser. So it folds up, goes down in, and then it can open up on the tank floor. And you have a very versatile work platform.

We also deployed at Oak Ridge a modified version of a Scarab vehicle. The vehicle that is being used at Hanford is from Non-Entry Systems, Ltd. And then there is a system that was custom developed at SRTC for Savannah River. It deploys a water cannon.

And then there are some other systems also evaluated by the Underground Storage Tank Integrated Demo that were never deployed. And I've got some pictures of those sorts of things.

Liquid Waste Technology built something called a Pit Hog. And, unfortunately, this is a picture from the days before digital cameras were widely used. But you can see a track vehicle with an auger and a suction to an off-board pumping system. And that's used in dredging ponds, for instance.

An ARD scavenger, wheels covered with mud, you know, this was a picture taken from a test environment where the vehicle got pretty well covered with mud.

And then there is the track pump which of all the vehicles that were explored by the Underground Storage Tank Integrated Demo, this is probably the one that had the most promise that didn't go on to get deployed. And this is a vehicle that is commonly used for cleaning out petroleum sludge tanks. So it can handle a pretty thick sludge material.

It has got an auger in the front and then there is a sludge pump here in the center. So between the tracks and the auger, you could chew up the sludge. And then suck it. And it could operate completely submerged. So you didn't have to do bulk retrieval by some other means.

Okay, Scarab III, ROV Technologies uses those Scarab vehicles. It is a family of models for power plant applications. And we worked with them to build a stainless steel version that could be deployed in the harsh environments that we find in storage tanks. And did a deployment at Oak Ridge.

It was designed so that it could handle retrieval tools but only deployed for sampling and characterization activities.

The Houdini vehicles, we had a Houdini I at Oak Ridge. And deployed it in three tanks. And learned a lot about how to make it better. And had that rare opportunity to actually build an improved version and deployed it in four tanks, four large tanks at Oak Ridge.

Again, versatile work platform, basically a 1,000-pound mini bulldozer with a dexterous arm on the end of it that could handle up to 250 pounds. Did all sorts of useful things with that besides handling the waste retrieval end effector and sampling.

We could also do things like if our confined sluicing end effector got plugged with tape and wire and plastic and those sorts of things, we could basically pick the nose on the end effector and clear it out if back flushing didn't work.

This is a picture of the Scarab, actually Scarab III. And this is the glove box that was used to deploy it in one of the tanks at Oak Ridge.

All right. Some pictures of Houdini. We had an aboveground contamination control enclosure. And the vehicle could be stowed in this compartment and then deployed through a riser, work with the LDUA or MLDUA, or it could handle that end effector and do retrieval on its own.

Okay. At Hanford, the vehicle was

developed by CH2M HILL Hanford Group along with Non-Entry Systems. And this is a very recent activity, deployed in 2004, completed in 2005. In its first deployment used to remove a HLW of over 3,000 gallons. And additional deployments planned, as they say.

I'll show you some pictures of that. It is a track vehicle with a tether to operate the hydraulics on board. And you actually can see a little more -- this is not a Hanford picture but this is the commercial version before it was customized for Hanford. But it is a more clear picture of the track vehicle.

And you can see at that time, instead of plow blade on front, they had an auger. This was used for dredging operations.

Okay. For Savannah River, the folks at SRTC developed a small track platform that could be lowered into a tank. And then they could lower a water cannon on top of it and remotely join the water cannon to the vehicle. And it has been sufficiently tested but it turned out not to be necessary yet.

Okay. So for vehicles, the Houdini systems and the Non-Entry Systems, Ltd. vehicles are examples of successes. Vehicles deployed for successful tank waste retrieval applications.

A number of others that I showed you, depending on the requirements, are technologies that are available. And the vehicle, and it is true for the arms, too, having deployable systems is really an engineering challenge, not a science challenge. The technology is mature. You just need to put the pieces together for a specific set of requirements.

Conclusions, we've had some successes. Usually the successes involve use -- well, usually you either use the mixing system like a fluidic system or a sluicing system to remove the bulk waste. And then you could remove the HLW with remote systems.

You could use vehicles for HLW removal by themselves. I showed you some examples. But generally you have a more efficient operation if you are playing pitch and catch where your pump is relatively stationary and the vehicle is able to be mobile around the entire tank and help bring the waste to that pump.

And then the last line here says that although many companies have contributed to remote technology development for tank applications, there has really been very little funding or activity in that direction here lately. So there are not that many folks active right now.

But if DOE, and I say, you know, I say get serious -- they're very serious about tank waste retrieval. The problem is you don't have anything yet to -- where to dispose and store the waste. You don't have the treatment facilities in place. And so it doesn't make sense to pull waste out of the tanks until you are ready to process and store.

But when DOE is ready to process and store tank waste, the techno community has material solutions that we can put forward. Thank you.

VICE CHAIRMAN CROFF: Thank you, Barry.

I think at this point what I'd like to do is go ahead and entertain questions on the retrieval issue, if you will, to both Paul and Barry. So, I guess, Barry, you know, you can stay there with that microphone or sit down over here with Paul as you wish.

Bill?

MEMBER HINZE: Well, all this is very fascinating. And it shows a lot of ingenuity.

A couple of questions. Barry, you talk about using the vehicle system for removing of the HLW and this is with a pressurized system associated with it I assume.

DR. BURKS: That's correct.

MEMBER HINZE: And yet we hear from Paul, can your system also get the HLW out without a vehicle system associated with it?

DR. MURRAY: It depends on the HLW.

MEMBER HINZE: Well, that was also another concern of mine. You are obviously losing pressure as you move away from your arm that goes down. So you must have a fairly high pressure to remove a HLW or even to move the sludge. What kind of dissipation of pressure do you get? And how do take that into account?

DR. MURRAY: The pressure we use is really low. It's about 60 psi. And what we rely on is the mass of water coming out the nozzle. So the nozzles themselves are inch and a half diameter.

MEMBER HINZE: Okay. So it is the momentum of the water itself that -- okay.

I guess that really gets at another question that I had that relates to the problem associated with causing leaks in tanks with all this equipment. And how do you know that you are not causing leaks or how do you know you are not pressurizing the fluids through minute cracks in the tanks? How do you monitor all of this?

DR. BURKS: Let me respond to your first

question also. The tank geometry is partly what drives the solution for retrieval. If you've got a tank, a Hanford tank, with a limited number of penetrations. And you've got 15 feet of dirt over top of your tank. It's very expensive to add penetrations.

So if you can remove the waste using the existing penetrations, then that is going to save a lot of money and perhaps exposure. And the best way to do that may be an arm or a vehicle.

Whereas those horizontal tanks that Paul was showing, if you've got horizontal tanks with a row of penetrations or spargers down the center, you know it may make a whole lot of sense to just use a fluidics mixing approach because the geometry, the rounded bottom on that tank favors that approach.

Whereas a large, flat-bottom tank may be difficult to clean using -- it takes a lot more jets or a lot more directional control, for instance, on that.

Now could you be creating leaks? Potentially, you could be unplugging some piece of waste that has been plugging a leak for a period of time.

MEMBER HINZE: Right.

DR. BURKS: You know that is certainly a possibility. And in the tanks like at Savannah River where you have an annulus, you have some opportunity to monitor that. At Hanford, the single-shell tanks, it's not going to be as easy.

And what you are counting on there is that you are bringing the waste, the contamination, down to the bottom of the tank and pumping it out. You are not maintaining a large amount of free liquid in the tank.

As soon as you create that free liquid, you want to evacuate it, which helps minimize the potential for migration through a leak, which is an advantage for these minimum added water approaches compared to the traditional sluicing where you are putting a lot of water in and you are counting on keeping a large volume of water with waste suspended in it.

So you minimize the potential by minimizing the free liquid.

MEMBER HINZE: And not necessarily any monitoring system associated with it?

DR. GASPER: I'll try to address -- Kenny Gasper from Hanford. I'll try and address your question, Bill.

And that is in the case of retrieval on single-shell tanks where we're dealing with 75-foot diameter flat bottom tanks basically, Washington Department of Ecology, working with the Department of Energy, reached agreement that we would put some demonstration monitoring capability around our tanks to try to determine whether there was any leakage occurring.

And the way we did it was in separate technology development activities, evaluated competitive techniques. But we ultimately used electrical conductivity probes surrounding the tanks using the monitoring wells that already were in place. And we basically monitored the conductivity of the soil grid surrounding the tank.

And that proved for the demonstration that was done this past year to be able to pick up moisture that was coming from rain. And we don't get heavy rainfalls in the desert of Hanford. And so the monitoring system was able to pick up that kind of moisture difference. And we were not seeing from our retrieval operations any leakage associated with the retrieval operation.

But your point is well taken that you may have to put in sophisticated leak detection capability if you are dealing with the large diameter, single-shell tanks at Hanford that don't have the annulus to sense and don't have the rounded bottoms of some of the horizontal tanks.

So that becomes a separate technology evaluation activity that we've had to go through.

MEMBER HINZE: Thank you.

One of the things that is very appealing about Paul's system that he described as simplicity, when you get into something like the vehicles, these are highly complex systems. I'm wondering are you concerned about any explosive in the tank? Do you pump inert gas into the tank so that there are no explosions that could come from static electricity or from metal to metal scraping?

And I'm also wondering with those robotic tanks, how you do the decontamination after retrieving that vehicle. That must be a lot more difficult than with a simple device like Paul was describing.

DR. BURKS: I'll address the last one first because it is easier.

MEMBER HINZE: Okay.

DR. BURKS: They are all designed -- if they are designed for tank waste retrieval, then they are designed for decon. And like that LDUA with the plastic sleeve on it, it was designed so that you are cleaning a plastic sleeve rather than cleaning the metal arm that has maybe exposed screw holes or that kind of thing. So there are techniques to avoid getting or to simplify the decon process.

But then you see on these track vehicles, there are nooks and crannies. And there's places for waste to become embedded. So what we did at Oak Ridge and also it was done at Hanford and Idaho is to design a spray ring so that when we pull the vehicle or the arm up, we pass it through a high-pressure wash. In our case it was 2,000 psi.

And it did a pretty good job of cleaning off the vehicle or the arm when it was pulled up into its containment structure. But, again, our emphasis was on clean enough to move to the next tank and continue operations in a production line kind of a mode as opposed to trying to release it for, you know, free release afterward.

They are more complex than piping, than the fluidics. You have to look at the requirements. At gunite tanks, we had to take three-inch cores in the gunite walls before and after cleaning. And then cut those into slices to demonstrate that we had cleaned sufficiently and that there wasn't contamination that had migrated deep into that concrete structure.

You know you can't do that with something designed just to remove waste. You need a multipurpose system. So in addition to the retrieval, if you have other requirements, you may still end up after cleaning a tank with fluidics having to go in and do some kind of sampling or characterization activity with a different system.

You are driven by the requirements. And every site is different.

As far as the explosive potential, we always operated with a negative pressure in the tanks when we were doing operations at Oak Ridge. And so if we -- and we started out with an atmosphere in the tanks that was not potentially explosive. But we operated with a negative pressure.

At Hanford, I know that they have some tanks that are on the watch list for potential hydrogen concentration. And if you are doing retrieval from those tanks, then you are going to aggressively ventilate to try to avoid a threshold concentration of potentially explosive material.

But the other thing you can do is design the systems with intrinsically safe electronics --

move as much electronics as possible off board, which is what we've done, use some intrinsically safe materials. So you can minimize that risk.

MEMBER HINZE: It's just a potential concern. And that's why I wanted to raise it.

DR. BURKS: It is.

MEMBER HINZE: Thank you.

VICE CHAIRMAN CROFF: Okay, Mike?

CHAIRMAN RYAN: I second Allen's comments, creative and innovative engineering. You both ought to be applauded for looking at tough problems and coming up with innovative solutions. It is really interesting to hear your presentations.

I think a little bit down the road a bit, I took one note of 50,000 psi out of a hydrolaser. That's pretty aggressive cleaning. And it kind of leads me to the question that I think about. At the end of the day when the tank is "done", whatever done is and I know that is going to vary a bit, have you left it in a state that you can really predict how it is going to behave in performance assessment?

And I raise the question. For example, you attack something with 50,000 psi. You can back up. I mean you could create holes in the thing you think is intact. And things like that. Have you gotten into those kind of assessments? I know I'm asking a tough question because maybe you are not there yet. But tell me what your thinking is on how do you decide when to stop.

DR. BURKS: Well, for the gunite tanks, we went through a cold test program that included our EPA and DOE and the people who were going to be involved in the readiness reviews and they just wore me out doing demonstrations basically. And wore out the Houdini I practically. That's why we had to have a second one.

What we did there was to demonstrate the limits of the technology in a cold environment. And the regulators used that cold environment result to help define what the end state would be.

In that case, we were able to remove all visible sludge and, again, the loose contamination on the wall through that scarifying. So that was our criteria. Remove all visible sludge. Remove the scale. And there were other sampling guidelines along the way.

But what we left behind in the gunite tanks -- and these are large, flat-bottom tanks, what we left behind was typically a half inch to three-quarters of an inch of our decon water. You know that last pass cleaning the systems as you pull them out of the tank generated some dirty water.

But the disposition of those tanks was to grout. So having a half inch of dirty water in the bottom of a tank that is going to be grouted was perfectly acceptable.

CHAIRMAN RYAN: Yes. I guess the point I'm trying to make, and I know you've given us specific examples, it would be an interesting goal to not only think about criteria that are operational, like no visible sludge and some decon standard or some number of disintegrations per minute per 100 square centimeters or micro arc per hour per square meter or whatever you want to do.

But it would be interesting to think about leaving it in such a way so that it has a high predictability as you go to the next step of predicting performance in the longer haul for determining that it is okay to leave it behind. Have you ever thought in that way about it? Or not?

DR. BURKS: Well, I know that both Hanford and Savannah River have clean-up criteria based on the number of curies that they are able to leave behind in a tank. And that is based on a, I guess, a risk model.

CHAIRMAN RYAN: Okay.

DR. BURKS: And our acceptance criteria at Oak Ridge is also based on a risk model. The bottom of our tanks were below the water table because of the hydrology in Oak Ridge. We have creeks that are nearby. So the risk numbers had been run. The model had been run to see what would be acceptable.

And, you know, one of the alternatives was remove the tank shells altogether. But it was determined that if we could remove a sufficient amount of the radioactive material and then stabilize the shells and material that might be left remaining in the shells and on the floor, that that would be acceptable from the risk model perspective.

Other folks are going to have different drivers. And probably be allowed to leave a whole lot more in the tanks.

West Valley has a different situation. They were getting down to the millimeters of material left in places on the bottom -- in terms of solids, millimeters of solids on the bottom of their tanks because they started with a material that was so much hotter than our sludge that it took a whole lot smaller volume to get to an acceptable residual.

Hanford and Savannah River are more like

West Valley in that regard. Not as extreme.

And a part of what you are asking about is the condition of the shells. At Fernald, those silos, you know the analyses tell you they should have collapsed 20 years ago.

At Oak Ridge, the gunite tanks are really in very good shape except for one where we see rebar. There's obvious spalling that has occurred inside a tank. So stabilizing with grout worked just fine there.

At Hanford, it's going to be so expensive to pull those tanks out of the ground, they need to find a way to stabilize them in place and make them acceptable.

CHAIRMAN RYAN: So I guess in that sense it really is a one off situation. Each one has its own unique features. Is that really where you are now?

DR. BURKS: Yes, different geological or hydrogeological constraints. And what is acceptable to their regulators.

CHAIRMAN RYAN: Thanks. That's a helpful insight. I appreciate it.

MEMBER WEINER: Again, I think this is fascinating. And I'm so happy to see this technology developed because I remember 20, 25 years ago, we were told oh, you'll never do this. You'll never clean those tanks out.

My question is you mentioned that you only decontaminate them enough to use the instrument on the next tank. So at some point, it must become so contaminated that you can't use it any more. Is that the case? And if it is, what do you do with it then?

DR. BURKS: Actually, we ran out of tanks before we got to that point.

MEMBER WEINER: Well, good for you. That's great.

DR. BURKS: And actually at the conclusion of the gunite tanks project, I tried to interest other sites into using the equipment. And there were several reasons why we weren't successful in doing that.

One of the prominent reasons was because of the level of contamination. Most folks would rather start with a cold system that they can go through a cold testing program and operator training on than deal with the hassles of starting with a contaminated system.

MEMBER WEINER: What do you do with your contaminated instruments? Your contaminated robots and arms and things?

DR. BURKS: The two Houdini systems and the modified LDUA are in a scrap yard, contaminated scrap yard at Oak Ridge.

MEMBER WEINER: So they become low-level waste.

Paul, what do you do?

DR. MURRAY: Our systems, the small mobile system we built at Oak Ridge, after it finished emptying tanks at Oak Ridge was moved to Mounds and it continued to empty tanks at Mounds. Because it was used on plutonium contaminated wastes, it could not go to any other place.

And so it is disposed of completely apart from the control head and the off gas system were given back to us and we're about to reuse that equipment for some tanks at Idaho.

We generally abandon the nozzles in place in the tank. The big charge vessels I showed you, after they finished emptying the C-tanks at Oak Ridge, were picked out and permanently deployed on the CIP tanks, capacity increase tanks at Oak Ridge. And they'll be used for the next 20 years at that site.

In other systems, once we've emptied a tank, people tend to fill them up again after us. So they are in continuous operation.

MEMBER WEINER: Oh, I see. Thank you.

VICE CHAIRMAN CROFF: Jim?

MEMBER CLARKE: Yes, just picking up and let me fifth what everyone has said. Very creative, innovative technologies. Fascinating presentations.

A couple questions on some of the details. And this may not be a fair question. But is there an average time it takes to do something like this? For example, Paul, your cycle time on your charge and drive, you know, can you give us a feel for that?

DR. MURRAY: About two to two-and-a-half minutes on the big charge vessels to fill and cycle. Obviously, it depends on altitude. And when we get up to Los Alamos, it takes a bit longer. But it is generally about two, two-and-a-half minutes to fill the charge vessel before it discharges.

MEMBER CLARKE: And I think, Barry, you said that you really target the tool to the tank. So depending on the configuration of the tank, you'd use one approach or another.

I guess Hanford might be an example. But are there sites where you have encountered different designs for different ages of tanks? And you really need to use different approaches?

DR. BURKS: Again, the geometry and the waste form itself are the two big drivers for what the tool is going to be. And there have been a number of different systems evaluated for use at Hanford that have different strengths applicable to the various problems.

You know I showed you the Tarzan manipulator.

MEMBER CLARKE: Yes.

DR. BURKS: There is only one site that has that kind of constraint to drive you to that complicated a system.

MEMBER CLARKE: You know this is more of a question, I guess, about the tanks themselves. But do you encounter different designs on the same site?

CHAIRMAN RYAN: Yes.

DR. BURKS: Different numbers of penetrations, different sizes of penetrations, different depths, diameters.

DR. GASPER: Even at Hanford -- this is Kenny Gasper -- even at Hanford on our single-shell tanks, some are flat bottom, some are slightly dished. That is between the center of the 75-foot diameter tank and the rim at the bottom, there may be a one-foot slope to it. And that's what I mean by the dish.

The other problems that we have with regard to evaluating the technologies as Barry says is the kinds of waste. We have such a variety. I'm not talking about chemically. I'm really talking about physically. That is the waste in some cases is very soluble.

And to the extent that it is either soluble or it is somewhat mobile in terms of pumping and sluicing, even with the limited volume sluicer, kind of like a shop vac, versus if the material has aggregated more into course gravel or cobble, when we encounter that kind of material and we hit it with a sluice nozzle, it just moves.

And our C-106 problem was not that we ended up with solid concrete-like material but rather that we had cobble that we chased around the bottom of the tank. It's kind of like trying to wash coarse gravel off of your driveway with a garden hose. Well, we were using a fire hose in a sense on a couple different penetrations through the top of the tank and trying to wash it over to where the collection pump was.

The pump was fully capable of pumping it if we could get it there. It's just that how do you -- when you've got a 75-foot diameter and you've got this hose coming down through this end, your probability of with two hoses getting it to your collection point, we exhausted our resources and basically found that we were not quite achieving the 99 percent number to the plus or minus accuracy that was required by our agreement.

We were at -- let's say we were supposed to be at 360 plus zero minus whatever we wanted on cubic feet and we calculated that we were at something like 345 plus or minus something. And what do you do?

Well, we didn't meet the criteria. And we weren't sure -- it was definitely the law of diminishing return of how much resources you spend to chase this material where the material was so insoluble that it wasn't releasing anything.

And so that's where we're at with C-106 with talking with the NRC and talking with ecology about what do we do on a tank like that?

In the case of S-102, well S-112 dissolved well down to a certain point where the salt cake was so reconstituted that it basically quit dissolving and we could hit it with hot water or cold water and we were running out of ability to add water, let it sit, pump it out and get any degree of removal.

In the case of S-102, we had just enough sludge around the material at the bottom of the tank that it was clogging the inlet to the pump that we were retrieving with. And we're working that problem right now.

So when Barry says it really depends on a combination of the configuration of the tank and the constituency of the material, that's --

DR. BURKS: And the requirements of your regulators.

DR. GASPER: Yes. But even with a common set of regulators, we are just having a difficult time projecting how a particular tank is going to retrieve when you begin using a particular technology to do it.

MEMBER CLARKE: And if I could just interject one more, this is the last one.

I assume you are visually monitoring this during the course of the clean out so you've got a record of every stage of it?

DR. GASPER: Yes, we have TV cameras down in.

VICE CHAIRMAN CROFF: Okay. I've got a question or two or four.

I guess first on the fluidics technology, are you proposing that for bulk waste retrieval, you know the first 20 or 25 feet kind of stuff?

DR. MURRAY: It depends on the tank. If it is salt cake like Ken was talking about, then just past practice sluicing will dissolve the waste up. And it is a very, you know, viable and efficient way of doing it.

And fluidics then comes into its own at the end to recover the HLW and potentially grout the HLW in place.

VICE CHAIRMAN CROFF: For the -- well, let me call it massive amounts of mobile stuff, not just the salt cake but the, you know, sludge that can be moved around by a mixer pump, is it more efficient to use the mixer pump, you know I mean down to a certain point?

DR. MURRAY: There are two ways of looking at it. You can try and completely homogenize the tank with your mixer pump and then feed forward from that. Or you can use a set volume for the charge vessel and suck so much sludge into the charge vessel, dilute it with supernated water, pump that forward, monitor what you pump forward, and then adjust your amount of dilution the next time.

So instead of trying to mix the entire tank, you're trying to control a 300- or 400-gallon volume. You see what I'm saying? It gives you a different option.

VICE CHAIRMAN CROFF: Yes.

DR. MURRAY: Because you've got to turn the mixer pumps off at some point because of minimum submergence of the mixer pumps.

VICE CHAIRMAN CROFF: Right. As I understood what you said, with the fluidics technology, you can get down to on the order of an inch or a half an inch kind of stuff --

DR. MURRAY: Yes.

VICE CHAIRMAN CROFF: -- if I'm going to assume there is not a bunch of stuff on the bottom of obstructions, which is about the same, I think, as some other technologies.

Is it your belief that this fluidics thing is just a more efficient way to get down to that level if you will?

DR. MURRAY: It will use much less water to get down to that level. We can continuously recirculate the water in the tank to concentrate up the sludge before we pump it out. Past practice sluicing, you have to have recirculation loop and stuff like that.

VICE CHAIRMAN CROFF: Okay. You mentioned this demonstration in September. Has a date been picked?

DR. MURRAY: It's going to be the week after Labor Day.

VICE CHAIRMAN CROFF: Okay. But not a specific day in the week yet?

DR. MURRAY: No. If anybody is interested, as I said, if they'd e-mail me, we'll make sure you get invitations.

VICE CHAIRMAN CROFF: Okay. Barry, on some of your stuff, I gather autonomous vehicles for in tank, nobody has -- it's not worthwhile going that far?

DR. BURKS: No, the environment is unstructured enough that you are better off just to go with a tele-operated system.

VICE CHAIRMAN CROFF: Okay. At West Valley, you mentioned getting down to very low levels. What technology did they use to get down to millimeters?

DR. BURKS: They used water jets and mixing pumps.

PARTICIPANT: On the walls, they burnished.

DR. BURKS: Yes. But for their HLW removal, they were using water jets to move the sand basically to where their mixer pumps could pick them up.

VICE CHAIRMAN CROFF: Okay.

DR. BURKS: But it was -- Ken talked about reaching diminishing returns. They were really way out on the end of the curve as far as what you are picking up per amount of time you are spending.

VICE CHAIRMAN CROFF: I guess I should say by way of background, you know, that what I'm focused on is this maximum extent practicable thing and what is practicable. And it seems that in a nice open tank you can get down to just about nothing. And maybe with some debate on whether all of the remote systems are really worth it or not depending on dilution.

But in some other tanks, it can be a good deal tougher. And the economics, like the curve starts to go up fairly quickly from what I think I'm understanding.

Again on the remote system, there were a lot of midstream cancellations. You know for defined applications like Fernald and West Valley, why did they get, you know, part of the way in and then just say we're not going to do that?

DR. BURKS: Variety of reasons.

VICE CHAIRMAN CROFF: Okay.

DR. BURKS: The contractor, for instance, on Silo 3 bailed out. You know they defaulted on their contract.

VICE CHAIRMAN CROFF: Yes.

DR. BURKS: That was Rocky Mountain Remediation Services.

There was -- Foster-Wheeler had the contract to do Silos 1 and 2. And after getting about 80 percent of the way through design and fab, they entered negotiations on a large change order with Fluor Fernald and DOE. The decision was made to terminate for convenience. And Fluor finished the contract.

They picked up all of our stuff that we were building for Foster-Wheeler. But they eliminated the EMMA arm, for instance. And decided they would just rely on hydraulic mining.

VICE CHAIRMAN CROFF: Yes.

DR. BURKS: So there's contract management issues that have entered.

For the Tarzan system, design progressed pretty well until a certain point. And then they got to a point where there was some question about whether those vertical supports could handle the stress. And when those questions came up, the cost to resolve those questions versus continuing with the approach that was working but working minimally at that point, the decision was made to keep going without the Tarzan.

VICE CHAIRMAN CROFF: Okay. Final question. Savannah River has -- I don't know -- on the order of 50 tanks, the inside of which is basically a forest of cooling coils, vertical cooling coils in this case. What are your thought on -- what can you do to retrieve that kind of tank to get the waste out from amongst all those coils? What is practical or reasonable in there?

DR. BURKS: Well, mixer pumps, mixer systems are going to get you a long ways. And then it is just a question of how much of the HLW do you want to retrieve. And you're going to have to deliver more energy into that HLW to get it mobilized. Whether that is with a vehicle, an arm, or a pulse jet, that's determined -- the deployment system is really determined by the number of access penetrations.

VICE CHAIRMAN CROFF: Yes.

DR. BURKS: And my feeling anyway, you can come up with an arm, you can come up with a vehicle. The real question is how much can you leave behind.

VICE CHAIRMAN CROFF: I take it from what you are saying, you know, it would be very costly to maneuver in around all those coils.

Paul, do you have any thoughts on that?

DR. MURRAY: Yes, we looked at Tank 48 at Savannah River. And we concluded we could retrieve most of the waste from the tank using free penetrations into the tank. And then we were proposing a chemical solution to basically finish off the tank.

VICE CHAIRMAN CROFF: Okay. In this case, how much was most? I mean in inches or something like --

DR. MURRAY: It is hard to say. It's hard to quantify what is in the tank --

VICE CHAIRMAN CROFF: Okay.

DR. MURRAY -- to begin with. That's always a problem. In our experience, whatever data we're given to begin with about the tank, you know, nod and smile and put it on one side and design for the worst case because you never know what is in that tank.

VICE CHAIRMAN CROFF: Okay. So that's just basically sort of an unknown at this point.

DR. MURRAY: Yes.

VICE CHAIRMAN CROFF: Until you get there.

DR. MURRAY: Yes.

VICE CHAIRMAN CROFF: Okay.

DR. BURKS: Well, let me comment. Although I really enjoy the more complicated systems, in practice what I push is the simplist approach that meets your requirements. And so in some cases, it is an articulated mast that only has two joints.

VICE CHAIRMAN CROFF: Okay. Anybody? Latif?

DR. HAMDAN: Yes, Barry, you did not discuss this. What kind of information do you collect? Major items in your checklist, if you like, that you have before you receive the waste, during the waste retrieval, and afterwards? The things that you worry about the most.

DR. BURKS: Well, system requirements is the waste composition, pH, the RAD levels, I've mentioned the access penetrations that really drives the size of things you are putting in there, constraints such as explosive environments, walls that maybe can't take 50,000 psi.

Floors could also be an issue because at Hanford, the leaks may be from the bottom of the tank, not the sides. Who knows? So there are lots of constraints that have to do with the tank itself and the waste.

Beyond that, where is it going to go and how do I get it there. At Oak Ridge, we were using one of our tanks -- the last one we cleaned out was the one we used as our mixing tank. And then from there, we transported over a mile away to the Mountain Valley storage tanks where a treatment facility is being built or has been built at this point.

I was going to have to dilute the sludge to pump it a mile across site. So it didn't make sense for me to spend a lot of money to recirculate contaminated water when I had to add water sooner or later anyway.

We had evaluated using contaminated water supernate, in our confined sluicing end effector for the nozzles. It didn't make sense because we were going to have to add water to dilute it anyway.

Other sites, a minimum added water approach may be more important to you than a lot of other aspects. Savannah River and Hanford, they have a water management problem right now.

And when I said at the end of my slide, you know, when DOE is ready to get serious about waste retrieval, the tools are there. By get serious, I mean have the treatment, processing, storage facilities in place so that you can go forward.

The retrieval approach is just the front end of the process. You want to retrieve the waste in the form that is going to be most easily treated.

We've got work that we're going, and Paul is part of this project as well, at Mountain Valley. And they want a particular feed stock into their treatment process. So the retrieval process is matched up with that treatment process.

The other thing, you know, operational issues. I want to know what kind of debris are in the tank. Am I dealing with dead cats? Or aircraft cable? We had a lunch box in one of the tanks at Oak Ridge. If you know you are going to have plastic tape, you know, wrenches, gaskets, all kinds of stuff like that, then you have to design for that.

Rotating pieces of equipment, for instance, don't do well with ropes and wires. So there are operational issues.

Decon issues, you know at Oak Ridge, I could leave a half an inch of dirty water in the tank. Can I do that at Savannah River? Hanford?

I can go on and on as far as the design issues. But those are some that come to mind quickly.

VICE CHAIRMAN CROFF: Okay. Thank you

very much Barry and Paul. If there are any more questions, we'll go ahead and take them a little bit later in the day.

Mike, did you have something?

CHAIRMAN RYAN: Yes, actually Mike Scott is over here. And he and other members of the NRC staff will help all of our visitors get downstairs. You must be escorted if you wearing a visitor's badge. So if you can help on that.

MR. SCOTT: Yes, the other thing is I'm a bit of a bearer of bad news. With the current heightened security requirements, you need to -- if you are a visitor, you need to be escorted anywhere in the building, Security informs me. Which means that even if you want to have lunch in the NRC cafeteria, you need to have a staff escort.

Not to be inhospitable but my recommendation would be to you, if you are a visitor, you might want to consider going next door to Eatsies where you don't have to deal with these escort issues.

Hopefully we'll work our way through this. There have been some discussions internally about it as to whether this is the right way to go. But that's what Security is saying now.

Thank you.

CHAIRMAN RYAN: Okay. And we'll restart at one o'clock. Thank you.

(Whereupon, the foregoing matter went off the record at 12:05 p.m. to be reconvened in the afternoon at 1:02 p.m.)

VICE CHAIRMAN CROFF: Mike Ryan will be out for a couple of minutes, so he said we should get going, and let's try for an on-time departure here, so we have some time to talk later in the day.

The third speaker in this session continued over from the morning is Dr. Dave Kocher. Dave spent 30 years at Oak Ridge National Lab, and is presently a Senior Research Scientist at SENES Oak Ridge. He's been actively involved in issues of waste classification for the past 20 years, was a member of the committee that produced the NCRP report on risk-based classification of radioactive and hazardous chemical waste.

In this presentation, Dave is going to talk about highly radioactive and what it means. Dave?

DR. KOCHER: A couple of really important disclaimers at the beginning. I'm expressing my opinion, nothing more, nothing less. The second thing is that I'm not going to spend 15 minutes talking about what this term in the law means or how it should be interpreted for specific sites and specific waste.

This is basically a history lesson from a personal point of view about what this term has meant in the past and what it may or may not have to do with how it's interpreted at present.

Basically, three discussion topics. What's the meaning and quantification of this term "highly radioactive" in the historical context of defining high-level waste? And once we understand what highly radioactive has meant historically, what is the importance of that to long-term performance of waste disposal systems? And, third, and very little -- I'll say a little bit about this strange term, "highly radioactive radionuclides," that appears in this law. It troubles me.

As far as I could tell in my looking into the matter, the term "highly radioactive" first appeared in the definition of high-level waste in the Nuclear Waste Policy Act. And to me, one of the keys is it refers to highly radioactive material, not highly radioactive radionuclides. That's important.

You all are familiar with this. There's two problems here. One, there's no quantification of what highly radioactive means, but more important to me I think is that there is ambiguity about, well, obviously, the radionuclides that are included. I would describe the ambiguity this way: is "highly radioactive" a defining characteristic of high-level waste or is it the defining characteristic of high-level waste?

These words are ambiguous, and there's a big difference between one of several characteristics or it's the only characteristic.

So we go back in time and see how all of this got started. Really, the first extensive writings on high-level waste appeared in the timeframe of around the mid-1950s, and high-level waste was always described as having high levels of decay heat and external radiation. This is what made this stuff high level.

And, of course, these attributes were due mainly to high concentrations of shorter-lived fission products. And as you all know, if you age the waste for a few years -- basically this is strontium and cesium -- are contributing to waste having high levels of decay heat and external radiation.

This waste was liquid and it either -- it required some kind of active or passive cooling and extensive shielding to protect workers during waste operations and storage. It's really, really important to remember that all this got started because of waste definitions that had nothing to do with disposal. It was only about protecting workers on the job.

So what they really were worried about was boiling waste that would release aerosols and high levels of external radiation that would zap the workers. Nothing to do with disposal.

Well, there were early quantifications of this term, and, again, these are operational definitions to let people at AEC sites in those days do their job in a way that stored the waste safely and protected their workers. You see descriptions in terms of external exposure rate. Let me skip this one for a second. Total activity concentration was a favorite. MPC stands for maximum permissible concentration back in the old Part 20 days.

The IAEA -- this 10 -- greater than 10^4 curies per cubic meter, the early IAEA recommendations never really talked about high-level waste. They had Category 1, 2, 3, 4, and 5 -- a whole new terminology, which mercifully did not catch on. This highest category of cooling of the stored waste was necessary in their Category 4 waste, which went down to .1, five orders of magnitude lower, required shielding.

Now, all of these, including MPC, this -- these quantifications were driven by the concentrations of shorter-lived fission products. The concentrations of longer-lived alpha-emitting transuranics in these wastes were only marginally important, if at all important, in determining whether these criteria were met. This was driven by short-lived stuff.

So, to me, this in essence quantifies highly radioactive as it was thought of in the early days. A useful thumb rule -- 100 curies of fission products is on the order of one watt of thermal power. So this is all about short-lived stuff was -- determined these quantifications and classifications.

Well, there was further subclassification. This liquid high-level waste, some of it was toastier than others, so at the Hanford site -- and, actually, some of the other AEC sites as well -- they had two subcategories of liquid high-level waste.

The first category was called self-heating waste. And if the thermal power density was greater than numbers in this ball park, the waste was capable of boiling, if you did not take active cooling to mitigate that. So you see all these cooling coils in some of these tanks, that was the whole idea. Nonheating waste had lower thermal power density, and all you needed was passive cooling.

Again, this is determined by the shorter-lived stuff in the waste, similar subclassifications elsewhere.

This is actually a bit of a diversion, but I'm just kind of gathering information to show how this term was used in various arenas. Early quantifications of solid high-level waste. Now, let me make it perfectly clear, this is not solidified high-level waste from AEC tanks. This is solid waste that came from other things.

Remember back in the '50s and '60s there were no -- back in the '60s there were no commercial burial grounds for low-level waste. And so as the commercial power industry got going, they needed low-level waste sites. Oak Ridge was the eastern regional burial ground for commercial low-level waste during that period of time, and they had their own little language about what was high-level waste for their purposes.

And you see exposure rate criteria concentrations. This one was admitted by Bill to be arbitrary for various purposes. 2R per hour, we saw that before. This is the IAEA Category 3 of solid waste, requiring special precautions for handling and transport.

But, again, the idea of high-level stuff was external exposure, lots of activity -- again, driven by short-lived stuff.

The first regulatory definition of high-level waste was Part 50, Appendix F, in 1970. This was strictly a source-based definition. What was in it was not mentioned. The radiological properties of this material was not mentioned. It contained the term "concentrated waste," but that term was not defined. So this is really vague, but it's clear that it was, you know, waste from a certain source, fuel reprocessing.

But there were companion reports that the AEC put out -- and I have a reference list at the end if you want to go look these up -- that this definition implied that high-level waste had two attributes. One was that it produced high levels of decay heat and external radiation, again due mainly to the fission products, shorter-lived stuff.

And the second attribute was that it required long-term isolation from the biosphere to protect public health, due primarily to the long-lived transuranics. It was well known by this time, it had been known by the late '50s, that a geologic repository was probably going to be required for this stuff.

But my reading of this early work is that these two properties were considered separate and distinct. That's my interpretation. I could be wrong, but I just don't believe in the early days that they thought that high concentrations of fission products such as existed in tank waste would, by themselves, require a geologic repository. I think they -- they clearly viewed this, in my estimation, as two separate and distinct properties.

Gosh, I could spend two hours talking about this one. The NRC in the mid '80s undertook an effort to quantify the clause B definition in the Nuclear Waste Policy Act, and they published the staff report. This is Dan Fehringer's work. They evaluated the clause B definition in the Nuclear Waste Policy Act. They focused only on the "requires permanent isolation" part. They did not consider the meaning of "highly radioactive."

But they came up with basically two conclusions. One was that the Class C limits that had been promulgated in Part 61 three years previously, they were not appropriate for defining waste that requires permanent isolation. In other words, there was a lot of room between acceptable near surface disposal and require a repository up here, and they definitely had in mind, you know, greater confinement disposal, something like that.

They needed to -- needed room, and this report suggested that something like 30 times Class C might define "requires permanent isolation." But I would emphasize that this was not based on any kind of risk analysis. It was just based on looking at compositions of selected waste. They looked at five different waste streams, and they said, "Ah, you know, 30 times Class C appears to describe this stuff." It would be candidate reprocessing waste, commercial spent fuel, things like that.

Thirty times Class C for strontium and cesium is about a kilowatt per cubic meter. Again, they did not consider what "highly radioactive" meant, only looking at "requires permanent isolation."

I think transuranic waste acceptance criteria are a useful piece of history for sort of getting at what "highly radioactive" has meant in the past. Remote-handled waste at WIPP, there's acceptance criterion of three watts per package. A package is about one cubic meter in round numbers.

And this is based on a certain thermal loading per area and a prescribed aerial density of the waste. And there's a five times safety factor built into there.

External dose rate, 100 rem per hour at the surface based on provisions for what kind of shielding can they actually do at that site, and what can their waste hoist lift? That's a pretty high dose rate.

Contact-handled waste even has some useful ideas. Less than 15 watts per cubic meter in stacked containers at WIPP. No credit taken for space. Based on considerations of what would the -- what would that thermal loading do to salt? 40 watts per cubic meter in transport containers. What kind of levels of heat generation were important to container designer? was the basis for this. A very -- a rather low external exposure rate for handling and transport.

Again, the very idea of contact-handled waste means you shouldn't need a lot of shielding to handle it. You kind of defeat the purpose.

Allen and I got involved in an effort for DOE back in the mid to late 1980s, again to quantify this clause B definition, the part that NRC could define as other than reprocessing waste could be included in high-level waste. We quantified both terms. We quantified "highly radioactive" and "required permanent isolation" separately. We treated these as two separate and distinct attributes of high-level waste.

Our definition of highly radioactive was greater than about 50 watts per cubic meter, external dose rate greater than 100 rem per hour at one meter. It turned out sort of by accident, but also it's quite convenient, that this 50 watts per cubic meter is the strontium 90 Class C limit. I mean, the correspondence is there. We did not base it on that, but that's a very convenient metric to use.

The 100 rem per hour is approximately equal to the Class C limit for cesium, depending on what you assume about the waste form in the package, of course.

There was a lot of history behind this 50 watts per cubic meter. It's clear that above a certain level you have to remove heat from waste for purposes of safe storage or disposal. So to us that was a reasonable criterion. The dose rate is clearly more arbitrary.

It was supported by the remote-handled waste limit at WIPP, but it turned out that for almost every radionuclide of concern, except for cesium 137, the thermal power density would dive the definition of "highly radioactive." Only for cesium was this number more restrictive. And, again, we also quantified "requires permanent isolation" separately.

CHAIRMAN RYAN: Just a quick point.

DR. KOCHER: Sure.

CHAIRMAN RYAN: The dose rate in part 2 is much easier to correct.

DR. KOCHER: Oh, sure. Yes. I think in hindsight, and I'll speak for Allen out of turn, that criterion basically has no use and is not really meaningful. I mean, you're going to protect your workers. Period.

The IAEA, again, has weighed in. The 1970 Category 1, 2, 3, 4, 5, made way to terms that we recognize today. Their current system in 1994, their definition now includes a thermal power density greater than two kilowatts per cubic meter. Again, this would be driven by shorter-lived stuff.

But this number was not based on any kind of consideration of impacts of heat generation. They just looked at typical levels in various kinds of waste 10 years after discharge and said, "You know, two is at the lower bound of that, so we'll define high-level waste as greater than two."

But hopefully coming down the pike for you all fairly soon will be some very interesting draft recommendations where they have dropped this criterion. Now they just refer to high-level waste as something that has significant quantities of decay heat, and they let significant kind of just sit there by itself.

What to make of all of this? Well, the original description of high-level waste as highly radioactive, it clearly meant high decay heat and external radiation. And it was based originally on the need to protect workers during waste operations and storage. It was not based on requirements for safe disposal.

However, if you interpret highly radioactive as being these attributes -- big "if" -- then it's clear that thermal power density is a reasonable criterion to take into account. When you put waste into the ground, the amount of heat that it gives off is an important consideration in terms of ensuring the long-term safety of that disposal facility after you zip it up and go away. You don't want to boil water in the rock -- that kind of thing.

So thermal power density is a reasonable criterion to consider, and values somewhere on the order of 10 to 100 watts per cubic meter generally need to be taken into account in designing disposal facilities. So that -- if you think of highly radioactive this way, that's a useful criterion.

I think it's clear -- and I already said this to Mike -- external dose rate is -- is not a useful criterion to define "highly radioactive" for purposes of waste disposal. It's very important for purposes of getting it into the ground, getting your workers up above ground again. But when you zip it up, it has no meaning.

It takes humongous photon dose rates to significantly affect leeching of radionuclides from waste form. It takes humongous doses of alpha radiation to cause significant damage to waste forms. This is lala land. So that's not useful.

What radionuclides make waste highly radioactive? Well, it depends on what you mean by the term. If you look at highly radioactive in the historical context, which I have done here, highly radioactive clearly includes waste with high concentrations of these shorter-lived fission products, and something on the order of greater than Class C limits for strontium and cesium.

Why? Because at this level, you're talking about thermal power densities, which you have to take into account to ensure safe waste disposal. You've got to have a way to dissipate that heat without harming the host environment or impacting the ability of the facility to limit releases.

Two is a throwaway for your amusement only. I got curious about commercial spent fuel, and what about the transuranics in commercial spent fuel. By themselves, it's about a kilowatt per cubic meter. That would be highly radioactive according to these definitions in any man's language. That's just for amusement, because DOE reprocessing wastes are much cooler.

Typical -- this is round numbers -- typical tank waste at Savannah River is about .1 watts per cubic meter, you know, way -- four orders of magnitude below this. But I thought this was fairly amusing.

Well, what about this? The term "highly radioactive radionuclide" does not make sense to me. I would put it this way. A radionuclide is not inherently highly radioactive, lowly radioactive, or intermediately radioactive. It just is. It all depends on how much. Okay?

This may be harmless language, but it's new. It has never been anywhere before. Where did it come from and why? So much funny has happened in the waste business, I just am suspicious. The intent of this is not clear. Are radionuclides that are not highly radioactive excluded from the requirements of this law? I suppose so.

To me, the language in the DOE order is reasonable. It refers to removing key radionuclides, and I think everybody has a common understanding of what "key" means. My opinion -- and I think most people in this room would share that opinion -- that the goal for these -- all these tank wastes, the stuff that you leave behind, and the stuff you take out of the tanks and then process, the goal should be to remove radionuclides that significantly impact risk from disposal. Period. Don't give it a name. It's just stuff.

I just foresee all kinds of problems, and we can talk about that in the Q&A if you're interested. But it's just me ranting.

Now, if you define "highly radioactive" as I did in the previous slides, in terms of its historical context, this term has no importance to any of these residual tank wastes. The stuff is not highly radioactive as defined historically. It's clear that this term has an entirely different meaning in this current law, and it remains to be seen how this will work out. And I'm not going to tell you what I think the answer is, because I've been on the job here two weeks. This is all new to me.

But this is -- I guess the message I want to leave you with is that the way we're being forced to interpret this term has nothing to do with the historical antecedents of what highly radioactive meant in the past. So it's new ground. But it should be focused on risk reduction, risk control.

I think NRC and DOE have been trying to do the right thing historically, and I just hope we don't get tripped up over language like this.

CHAIRMAN RYAN: So what you're saying, Dave, is that your Rosetta stone just got a little bigger -- of definitions and so forth?

DR. KOCHER: Well, yes. What clearly has been lost -- and there may be good reason for it. I haven't thought it through. The historical idea that highly radioactive was a separate attribute from "requires permanent isolation," that distinction has now been smushed into a blob, as I see it. That may be a good thing. That may be a poor thing. We'll have to see. But we've kind of lost the history.

CHAIRMAN RYAN: Well, but as you said earlier, I mean, the idea that there's a worker dose protection requirement, and then there's, you know, maybe somewhere in the '70s, the first view of long-term performance once disposed. You know, we've sort of taken it maybe a half-step backward and --

DR. KOCHER: Yes.

CHAIRMAN RYAN: -- something that seems to foster that old separation.

DR. KOCHER: Yes. My bias throughout all of this was -- my concern was permanent disposal, and I'm assuming that workers will be protected, because they will be. And my whole concern was: what's the impact on safety of waste disposal?

CHAIRMAN RYAN: Thank you.

VICE CHAIRMAN CROFF: Okay. Thanks, Dave. We'll corner all these fellows here in a panel discussion later on for -- and we'll hear what Dave really thinks then.

(Laughter.)

So --

MEMBER HINZE: You want to find out whether he has any strong opinions, right?

VICE CHAIRMAN CROFF: Right. That's it.

You got it.

I'd like to move on to -- our next speaker is Dr. Ken Gasper. During the '80s, Ken served as the Program Manager at Hanford's B plant for separating hundreds of millions of curies of cesium-137 and strontium-90 from the Hanford tank waste. That begat the capsules.

In the 1990s, Ken served as the Program Manager for the initial pre-treatment module, the precursor for the large tank waste treatment and immobilization plant currently under construction at Hanford. And for the last several years until his retirement, Ken has been responsible for supplemental pretreatment activities being developed from removing cesium-137 and other isotopes from selected tank wastes and integration of these activities, with similar efforts underway at Savannah River and Idaho.

And today he's going to discuss the prospects of technologies to remove key radionuclides.

DR. GASPER: I'm going to be talking about the removal of key radionuclides from tank waste, and in that context I'm going to be talking about all of the tank waste, the constituents being the liquid or supernatant, the salt cake, and the sludge.

The key radionuclides that I'll be talking about are the cesium-137, and throughout the presentation I'll talk about cesium-137. I recognize that there's associated barium. Technetium-99 and iodine-129 and strontium-90 and the transuranics.

Let's start with the cesium-137. That normally occurs in the liquid aqueous phase, and that is the -- the phase that is either the supernatant sitting in the free liquid above the waste or as the interstitial liquid in the saturated salt cake or the saturated interstitial liquid in the sludge.

For Hanford, just to refresh your memory -- and I'll get into it -- all of our single-shell tank waste has had the cesium removed once. That is, in this campaign that we referred to earlier today that started in the second half of the '60s and ran through 1979, we did a cesium and strontium -- cesium-137 and strontium-90 removal primarily to allow us to concentrate the waste and eliminate the high heat problem.

But at the same time an equal argument was that those were potentially useful byproducts. So you had those two camps aligning to result in us removing a significant amount of the cesium. So you're going to see me talking about salt cake at Hanford single-shell tanks as being considerably lower than our double-shell tank waste, and even our double-shell tank waste is quite old compared to some of the Savannah River waste, since we -- we did know fuel irradiating after the early '80s.

For the Hanford double-shell tank waste, the curie content of cesium is the third to a half a curie per liter at seven molar sodium. For the single-shell tank waste, the interstitial liquid has a tenth to two-tenths of a curie per liter at seven molar sodium. The molarity of the sodium may be a little higher or a little bit lower, and so I've normalized it to that.

By the way, we don't have any supernatant in our single-shell tanks. What we did was we -- we first ran all of the single-shell tank waste through that cesium-strontium campaign, and then we took the -- removal campaign, and then we took the waste and we ran it through an evaporator and boiled off as much water as we could. And we sent the waste out to the tank, and it cooled off and the salt crystallized out of it, and there was some supernatant sitting on top.

And then, we drilled a hole down through the center of the salt cake and installed what we call salt wells, and we inserted basically a sump pump down to the bottom of the tank and we pumped out all of the drainable liquid to the extent that was technically practical, which was as long as the pump was working and the flow rate was .05 gallons per minute or less.

So we -- we definitely still have interstitial liquid, but it is not pumpable liquid. It's not drainable liquid. And it -- it sits at one to two-tenths of a curie per liter.

The technetium, what we have learned through the extensive characterization programs conducted in the '90s to support our tank safety program is that most of the technetium sits in the tank, in the single-shell tanks as pertechnetate. That's the chemical species. It's the oxidized state, and it's in the aqueous phase.

And so what we're going to be able to talk about is that for the most part the technetium moves right along with the cesium. So whatever we do with the cesium it -- we also do with the cesium. And by the way, the iodine -- total iodine, and, therefore, iodine-129 also falls -- flows along with the cesium, because it's in the aqueous phase.

The strontium-90 and the transuranics normally occur in the solids and in the solid phase. So it's in the sludge and it's in the solids of the sludge rather than even in the interstitial liquid of the sludge. It's only sparingly present in the liquid aqueous phase at Hanford, perhaps a little bit more with the higher hydroxide concentrations in the Savannah River waste.

And so the treatment to make sure that you are removing all of the TRU from the liquid becomes a little bit more important at Savannah River, and they've got a treatment step inserted into their plan.

It's present in the liquid aqueous phase in the presence of organic complexants. We have a couple tanks at Hanford -- we call them complexant concentrates, or CC waste -- and those tanks come from the strontium recovery operations that took -- that we conducted in the '70s and early '80s at B plant, and so those complexants do result in some strontium and TRU being in -- in solution.

The cesium removal technology -- I'm going to take you through cesium removal technology and then strontium removal technology. And the question will be both in terms of proven technology and developing technology.

What's proven? Well, clearly, our B plant operation is proven technology where we -- we removed 146 million curies of cesium-137 using ion exchange for the most part. We also used phosphotungstic acid, precipitation for acid heat. In other words, after we had processed a lot of our tank waste, it was neutralized waste, alkaline waste, using ion exchange.

We did install a stainless steel pipe from Purex over to B plant, so that we could run current acid waste we called it -- that is, waste coming directly out of the Purex plant before neutralization, and so that acidic waste we ran over to B plant and used a slightly different process for taking out the cesium. Namely, we precipitated it with phosphotungstic acid.

Now, I'm only dealing with the recovery operations these activities had following the purification operations that resulted in high purity cesium and high purity strontium for purposes of putting it in the capsules. But the recoveries are as quoted, and here you see that we were dealing with cesium concentrations up to 220 curies per liter.

And we over -- over this more than a decade campaign -- recovered grossly over 90 percent of the cesium using the ion exchange process and over 95 percent using the phosphotungstic acid process.

The ion exchange process was subsequently used at West Valley. Their mechanism for using it was a little bit different, but they did use ion exchange material and absorb the cesium on it, and then do a different kind of separation. But, so that -- that ion exchange process was well developed.

Strontium removal during this time -- we recovered 68 million curies of strontium. There were more strontium to be recovered than we recovered. You see that we recovered only half as much strontium as we did cesium, and the reason for it is because even in the '60s and '70s, since the strontium is sitting in the sludge, the sludge was becoming hard pan. It was baking. It was becoming difficult to remove, to retrieve, and so we only recovered half as much cesium or strontium as we did the cesium, all of which was in the liquid material.

The concentrations of the strontium-90 that we retrieved were up to two curies per liter after dissolving the strontium-bearing solids. You know, we had to work at it to get the solids into solution, and then we were then dealing with two curies per liter.

We recovered 80 to 90 percent of the strontium in the solids into the -- the 80 to 90 percent of the strontium that we got dissolved and into our solvent extraction columns. Eighty to 90 percent of that strontium we were able to recover.

The strontium recoveries in the solvent extraction process were over 97 percent.

So I broke those out so that you understood what were demonstrated efficiencies for this timeframe.

Cesium removal technology continued to evolve, and in the '90s Savannah River developed the tetraphenyl borate precipitation process with the intent of precipitating cesium that way for recovery and sending over to DWPF with the resultant decontaminated material being available for salt stone.

I might back up and comment that we also at Hanford had used a ferrocyanide precipitation out in our tank farm with no recovery intended, but in order to -- to cause precipitation of cesium-bearing compound. And then, we decanted the solution off of it, and those were pre-B plant days. And I -- we don't have the quantitative information to share with you.

And as far as commenting about the use of that kind of technology, which, by the way, is the technology that Russia used for doing its cesium separation, we -- we encountered quite a bit of problems with having ferrocyanide in our tanks in terms of being concerned about the safety problems associated with potential uncontrolled energy release from the decomposition of the ferrocyanide in the '90s as part of our safety program.

So we have ruled out using a ferrocyanide-based process for cesium recovery, and I chose not to give you details on -- on it quantitatively.

At Hanford, we continued to pursue the ion exchange approach while Savannah River was pursuing the tetraphenyl borate in the early '90s. We continued to base our ongoing plans for further pretreatment on our experience with ion exchange. And in cooperation with Savannah River, we evaluated resorcinol formaldehyde resin in those days, which was an eludable resin, and crystalline silicotitinate, which was a non-eludable resin.

The difference between those is you can use an eludable resin over and over again by acid stripping off the radionuclide in a separate operation and then recycling. In the non-eludable, you have to take the cesium-contaminated crystalline silicotitinate and plan on a disposal of that particular material.

And John, in fact, at Savannah River led a team to evaluate how -- how you might incorporate such loaded CFC into glass.

A little later in the '90s, as the waste treatment plant activity moved forward, they looked at alternatives to those ion exchange resins and settled for cesium removal on a SuperLig 644 resin. And that continues to be the current technology approach planned for cesium removal in the waste treatment plant.

At Hanford, during the '90s, in the laboratory we also investigated and demonstrated the ability to remove cesium from salt cake waste solution using fractional crystallization. This is roughly the same kind of process that's used for purifying table salt, purifying sugar.

The particular problems that we encountered were that we had to do it on the acid side, we had to dissolve and work on the acid side. And since we are now dealing with neutralized waste, that meant reacidifying it. But with a multi-stage fractional crystallization, we were able to get clean salt.

What I mean by "clean salt" is that the decontamination was such that the resulting salt product was -- had no detectable radiation. That was a multi-stage acidified process, and we -- we remember doing it and we'll revisit that later.

CHAIRMAN RYAN: Ken, before you leave that, I just want to ask about less than Class A. There is no lower limit to Class A, so nothing is less than Class A.

DR. GASPER: I understand, and that -- that was, incidentally, the --

CHAIRMAN RYAN: Much less than the limit of Class A going to B, I understand.

DR. GASPER: I definitely mean less than the limit of Class A. And if there were ever a de minimis declared for releasing something that was -- that came through this chain, our intent was that we apply for -- for getting a release of this material such that it could be used, for example, as fertilizer on Hanford's grass that we grow.

I appreciate the clarification. Part of the reason why this died as a process was because we had no path for disposal of it in anything other than low-level waste. And because it was sodium nitrate, it was a very soluble material that was going to have to be fixed in order to make it non-leechable.

CHAIRMAN RYAN: Just to --

DR. GASPER: It's a good clarification.

CHAIRMAN RYAN: I want to make sure that

everybody releases there is no --

DR. GASPER: There is no lower limit.

CHAIRMAN RYAN: There's nothing below Class A. Class A goes to this --

DR. GASPER: Yes. And we -- we worked with DOE to petition to get a de minimis ruling, and we couldn't get there.

At Savannah River, as time progressed, the tetraphenyl borate approach for in-tank precipitation was abandoned because it could not be safely operated at the necessary production rates. And so Savannah River evaluated alternates, and in 2001 selected caustic-side solvent extraction and -- as the mainline approach to move forward.

And the conceptual design associated with using that technology into equipment has been completed and the design is moving forward, they plan on using a -- a modular version of this in the 2006/2007 timeframe, and they plan on completing the construction of the full-scale system such that it will be deployed in 2009. And the Nuclear Regulatory Commission has participated in the -- in the waste determination discussions as was mentioned earlier today.

The caustic-side solvent extraction

product will meet Class A such -- for example, a curie per cubic meter, or I'm using now also .001 curies per liter for cesium-137. I'm doing that so that when I go back and compare to Hanford where I'm talking in curies per liter -- just refresh your memory on that conversion. And this reflects a decontamination factor for the Savannah River waste of greater than 40,000.

They are also in the period before 2009 moving forward with a deliquification/dissolution and adjustment process which will separate the concentrated supernate liquid and the associated interstitial liquid from the solid salt cake, separate that, and then dissolving the remaining salt cake matrix and sending that dissolved material to the salt processing facility. And they estimate that they'll be able to achieve 27 curies per cubic meter, or .027 curies per liter concentration.

Again, I want to set the stage for showing you a comparable process at Hanford. Capability to process is currently available. That is, they have the capability to -- to move forward with this that can produce this -- this kind of decontamination.

And it's important to them to be proceeding because of, one, their need for tank space, and this will free up some tank space so material fits this category, and also it will enable them to provide feed for their DWPF, defense waste processing facility.

At Hanford, to continue at -- the waste treatment plant flow sheet settled on the ion exchange material being SuperLig 644, and the flow sheet that is a part of this pre-treatment plant that's being constructed currently will use two stages of ion exchange, each with a decontamination factor of about 100. So they'll get a 10^4 decontamination.

Now, the contract limit that they are obliged to meet with this capability is .0017 curies per liter at seven molar sodium. And that corresponds to a waste loading in the glass of 14 percent, or something like that.

If the waste loading in the glass goes up, the concentration allowable that they must deliver would go below the .0017. But they have a technology that in their laboratory work, both at Hanford and support that they receive from Savannah River National Lab, suggests that that's readily doable with the SuperLig 644.

The waste treatment plant is now anticipated to begin processing in 2011. As a backup technology to the use of the SuperLig 644, the waste treatment plant is continuing to fund evaluation of the resorcinol formaldehyde resin that we began work with them on in the early 1990s.

Meanwhile, as Ken Picha mentioned, one of the things that we're looking at at Hanford is a way to offload the low activity waste vitrification plant to the tune of about half of its workload, in order to be able to finish up the processing of the waste in the 2024 timeframe.

So we have been pursuing a supplemental treatment program where the vitrification work would be done with both vitrification, in-container vitrification, and the liquid that would be used as feed would be the dissolved salt cake. Some of the dissolved salt cake, by virtue of draining off -- first of all, remember, we removed the bulk of the cesium in the 1967 to 1979 timeframe, and then we put salt wells down in each of the solidified salt cake and pumped out all of the drainable liquid.

Now, as we begin adding water on top of the salt cake, as we begin the retrieval operation, if we pump off that first liquid and send it off to the waste treatment plant, and now that will wash out the interstitial liquid that's left in the salt cake, and what's left behind, then, as we begin the bulk dissolution of that salt cake becomes analogous to the Savannah River process of their DDA, where the first deliquify. We've already deliquified, and then they dissolve.

And so we are able to achieve concentrations on the order of .007 curies per liter, and we have already demonstrated that on S-112. We have now retrieved 99 percent of the waste from that tank, and we're actively doing it on S-102 right now. And we're planning on doing it with S-109 beginning this fall.

So that's -- that's available feed potentially for meeting the criteria that would be such that we could have contact-handled containers of bulk vitrification.

On the other hand, there's still a lot more waste that's a little bit higher in curie content in the salt cake that really needs additional decontamination of the cesium, if we want to achieve the same kind of decontamination that the waste treatment plant is planning for the waste that they're processing through their pretreatment facility before going to their low activity waste at their plant.

So we went out with a competitive contract funded through the Office of Cleanup Technologies to explore what was available technology. And we opened it to all technology options, and we did this a year ago. We also internally went ahead with fractional crystallization on the alkaline side, much as we envisioned we might use on the salt cake material.

And a competitive contract was let. Georgia Tech, Swenson Technologies, Cogema, and Framatome were the winning contractors, and so we have in place a program going on to see if they can meet the waste treatment plant's pretreatment spec for cesium decontamination -- .0017 curies per liter -- and how well can they do on separating the sodium, and how well can they do on separating the sulfate, because sulfate impacts the ability of the vitrification plants. It limits their waste loading that they can have.

And so far, a year into it, and our internal work, have all supported that we are able to achieve the cesium-137 decontamination of -- the desired decontamination corresponding to the waste treatment plant spec of .0017 curies per liter.

And we can do it with both the single-shell tank waste -- that is, recovered salt cake -- and we can also do it with the double-shell tank salt solutions that currently exist which basically are of the same type, and some of them have come from our retrieving solution out of the single-shell tank such as S-109, S-112, and S-102.

So that looks good. Is that demonstrated technology? Well, it's only demonstrated at the laboratory, our laboratories and the contractors' laboratories. The deployment concepts -- right now, the current plan is that they could be implemented in the 2009 timeframe. We don't have it in our current baseline plan. We're going ahead with further lab and full-scale design concept work funded by the Office of Cleanup Technologies in fiscal year 2006.

Strontium removal -- Savannah River, in the '90s, established crossflow filtration as the preferred approach for doing the solids/liquids separation to remove the insoluble strontium and actinides.

The B plant activity of the '60s and '70s used centrifuges. So centrifuges were a demonstrated technology. Savannah River did an extensive evaluation and concluded crossflow filtration was the way to go. They have put that capability into place at Savannah River to support their feed to the DWPF.

The waste treatment plant -- well, first of all, the initial pretreatment module at Hanford, and then out of that, the waste treatment plant currently at Hanford have gone ahead and done further evaluation and accepted the crossflow filtration as the preferred approach for solids/liquids separation to support the pretreatment activity at Hanford going to the waste treatment vitrification facilities.

I mentioned that particularly with the higher hydroxide content material at Savannah River that there is a small amount of solubility of strontium and TRU in their waste. And the way that they have identified to treat that, and every indication is that it just works fine, is monosodium titinate, MST, addition to remove the soluble radioactive strontium and actinides by sorption.

And so they -- they have that capability in place, and the kinds of concentrations that result in the liquid are as noted there, and the waste determination at Savannah River sent out in -- at the end of February contains this information.

So Hanford accepted the crossflow filtration, and instead of using monosodium titinate for our particular waste streams to remove any soluble radioactive strontium and actinides, on a case-by-case basis as the feed moves through the waste treatment plant, this is the plan. They will sample, and if need be they will add strontium nitrate and permanganate to get the desired decontamination.

For the supplemental pretreatment, our demonstration that's going forward -- and Ken referred to we're going forward with S-109 with a demonstration of full-scale bulk vitrification. We have done sampling such that we know that if -- that our liquid solution is -- meets the strontium and permanganate -- the strontium and actinide requirements, but we are adding a -- at the tank retrieval a hydrocyclone to ensure that all particulate matter goes right back into the tank and none goes over to the bulk vitrification.

We haven't made a determination, and we're letting the contractor in the conceptual design work for the fractional crystallization make the determination and make their recommendations to us as to what -- what kind of solids/liquids separation they might employ for that. At this point, there are several options open to them that seem to work well.

Let's move on. I talked about cesium and strontium. Now I'd like to touch on technetium-99, which our performance assessment, as part of the total process of identifying what were the important radionuclides to consider, given that the waste -- large volume of the waste that's going to be buried at Hanford and the high level sent off to the deteologic repository.

Technetium-99 was a primary item, and so the Department of Energy and the Washington Department of Ecology have been particularly interested in what we were doing about technetium, particularly as we move forward with supplemental treatment.

All of our work to date continues to say that the bulk of our technetium is in the pertechnetate state, and, as such, the waste treatment plant identified that SuperLig 639 resin was a potential ion exchange media approach for removing the technetium-99 after the material went through the cesium ion exchange with SuperLig 644.

Subsequently, DOE and the contractor determined -- that is, in the early 2000s -- that this separation process was not viable for the current project, and that the requirement to conduct the technetium-99 separation was deleted from the waste treatment plant current contract.

For supplemental treatment, all of our work -- that is, where we might use fractional crystallization -- all of our work supports that the pertechnetate follows where the cesium goes. And it tends to stay in the aqueous phase exclusively in the salt cake dissolution and retrieval process, and can be sent to the stream going to the waste treatment plant.

In the fractional crystallization process, it stays in the cesium-rich phase. And it can be separated from material which is going to bulk vit. So to the extent that we are decontaminating the feed going to bulk vit, the same decontamination is occurring for the technetium. In that sense, fractional crystallization treats technetium the same way as it treats cesium.

At Savannah River, the caustic-side solvent extraction, being a different technology, it, in fact, selectively decontaminates the cesium, so the technetium does not get decontaminated.

Same thing -- next slide. The same thing happens with iodine. The iodine goes the same way as the technetium and the same way as the cesium in fractional crystallization. On the other hand, just as caustic-side solvent extraction is selective for cesium and doesn't do anything about technetium, it doesn't do anything about iodine either.

So the caustic-side solvent extraction

will selectively take out the cesium and leave behind the iodine and the technetium.

So, in conclusion, Hanford and Savannah River, supported by lab studies at Savannah River, at Battelle, at Oak Ridge, at Los Alamos, have provided experience and offer insight and potential possibilities for removal of cesium-137, strontium-90, transuranics, technetium, and iodine.

Dr. Croff?

VICE CHAIRMAN CROFF: Okay. Thank you very much. I think we're going to go on and catch our last presentation here, and then we will open it up for probably a long session of Q&A to everybody involved.

Our last speaker in this session is Dr. John Plodinec. John is a recognized expert in nuclear waste characterization and disposition. He works at Savannah River site for about 22 years, and there was involved in many aspects of tank waste processing and mobilization.

His technical studies of glass and grout waste forms provided the basis for decisions to vitrify high-level waste in the tanks at Savannah River. More recently, he has been Director of the Diagnostic Instrumentation and Analytical Laboratory at the Mississippi State University.

John?

DR. PLODINEC: Thanks, Allen. I didn't even have to die to get that nice introduction.

VICE CHAIRMAN CROFF: Well, it's coming up. Today John is going to discuss basically characterization of what's left in the tanks after Paul and Barry finish doing their thing in the tanks, if you will. So that's where this enters in, we hope.

DR. PLODINEC: Okay. What I what to do is start talking about the general requirements, talk a little bit about what each of the sites has done in terms of characterizing what's left behind in a tank after they've got done cleaning it, and then talk about some new technology and wrap up with some fairly general conclusions.

First, requirements for the methods that you use to characterize what's left in the tank. You need two things, of course. You need, first, what's the volume of material left behind, and that's an important point -- part of determining the source term, but then as well you have to know the radionuclide content of what's left behind. So the methods have to be able to provide quantitative information about that.

We live in an open society. Therefore, there has to be a certain amount of acceptance by the stakeholders in terms of -- is the data complete enough, are the errors small enough for the consequences of the decisions. And, of course, all of the typical data has got to be traceable, defensible, reproducible.

We can't forget that the methods also have to be safe and operator-friendly. We can come up with some pretty high-tech solutions that won't work, because we can't find anybody to actually perform the operations. Of course, all of this, we're talking about remote environments, and ideally whatever we do we need it to be simple, reliable, and ideally reusable.

Now, this is a very general picture of a tank. And I use this to illustrate some of the problems that make this a very non-trivial exercise. First, you're going to have in general a liquid level, and you'll have solids mostly -- well, depending on the tank, mostly immersed in that liquid. But how much is below there?

Secondly, though, you will have hills sticking up out of the liquid level. You'll have pillars, cooling coils, you'll have material -- in some cases gridwork on the bottom of the tanks, and the idea of the shadow here is to say if you're using an optical technique, it's going to be awfully difficult to see through this mass of stuff that's down there.

In addition, of course, you have high radiation fields. And as I think Barry quite appropriately pointed out, that for most of the tanks that we're concerned about it's not very practical to consider an in-tank, i.e. something under the bottom kind of a rover, particularly if you've got cooling coils there.

So you're going to have to deal with the fact that you -- you're, you know, looking at very long distances from the top of the tank to where you're trying to see down at the bottom.

I'm going to talk about the four major tank sites. I will quickly say, of course, that the Oak Ridge gunite tanks in a sense are not part of this discussion in terms of incidental waste or waste reclassification. However, they do provide I think useful experience in terms of characterization of what's left behind.

Okay. The process at Oak Ridge has been described pretty well. Essentially, what we're talking about is on the order of about an inch heel, roughly 1,000 gallons. Now, in the case of Oak Ridge, they used the robotic systems to give them pretty good ideas of the residual depth, and the accuracy -- plus or minus one inch, that's probably an overstatement.

But it was, you know, fairly significant because you're basically working with an end effector and a ruler. And, you know, how well do you stand it up and that kind of thing.

The source term estimate that they were using took into account the tank heel as well as, in their case, the concrete wall. Barry alluded to the fact that the gunite tanks -- cores were taken of those walls. The reason was that, in fact, there was concern about how far had radionuclides migrated into the gunite.

What they found was that, in point of fact, 90 percent of the activity was within the first eighth of an inch. So it hadn't gone all that far into the concrete. But for tanks, for example, that have an annulus or a partial annulus at other sites where, in fact, they have a concrete secondary as opposed to a full metal, this is a similar consideration.

Now, they make some assumptions in

determining the curie content. Assume the material was 50 percent sludge. They used the sludge curie content as the heel source, and then they actually had the analytical results on the core samples. I will mention -- or should mention, as I do here in the slide, that the amount that was left behind in the wall was insignificant for all but two of the tanks.

Okay. This is one of the examples at Hanford, C-203. Remove the material with slurry pumps up to about 100 gallons in the smaller tank, and an estimate of about 38 gallons on the tank wall. In this case, the residual waste volume was calculated as the heel volume plus the material in the tank along the structure. Plus, they tried to do some determination of how much was left in equipment, things like pumps that might have been left behind, piping, and so forth.

As is going to be a continuing theme, essentially it's an optical technique for determining the volume of the heel, looking at how much have we pumped out, where are we in the tank, looking at known features to try to pick up levels. Using those -- that information, and in comparison, as I said, to known locations in the tank and the as-built drawings, they developed a 3-D model of the heel.

The estimate of the material left on the wall was intentionally biased high in terms of aerial coverage of the wall. The estimate of the average thickness on the wall -- of the waste on the wall was about a sixteenth of an inch, and that was estimated based on the contrast of shadows in the video. So source term then was, okay, what's in the heel, what's in the wall.

Idaho -- a couple of the smaller sodium-bearing waste tanks have been empty. Again, volume of the residual waste estimated by comparison of the video views of the solids, to features of known height in the tank -- cooling coil brackets and things like that. They estimated in these particular cases heights between zero and half an inch.

Again, they developed a 3-D model by computer ledger domain, and ended up with -- you know, using that volume to calculate the source term. Now, in their case, that source term was the activity of the liquid plus the activity of the solid. They were able to get samples of the liquid, basically what I call soap on a rope. You drop a thing -- you know, a cup in and pull the sample back out.

They couldn't get samples of the solid. They were able to get samples of solids from a companion tank, and they used that radionuclide inventory to basically calculate what the -- was left in the other tank. Again, they used Origin-2 to get a more complete radionuclide inventory.

I'm leaving out all my editorial comments about what they did.

CHAIRMAN RYAN: We'll get back to those.

DR. PLODINEC: Yes. Savannah River -- I think you're going to be there next week. So any mistakes I make are my fault, and what they tell you next week is probably, without a doubt, more accurate.

But essentially on the two tanks that are, you know, completely documents on the closure, basically it's the same process, the big slurry pumps, getting it down. Roughly five inches or so of the supernatant liquid covering a thinner layer of sludge, but, again, as I indicated the mounds protruding through it. So it's a non-trivial problem to calculate how much sludge do you have, for example.

What they -- the way they went about this was to -- they're continuously looking via cameras, three cameras in the tank, at the liquid as it's being taken out. When they first see a mound protrude out the top of the liquid, they basically go one time step before that and say, "Okay. That's where we were at that point." And they have -- they're taking real tape measurements of the height.

And that gives them, then, the height of the feature. The area of the feature is much tougher, as you -- if you remember back to my cartoon, because how far does it extend underneath the liquid? Well, that's tough to tell. And certainly in their case they'll be the first to tell you that that's a big source of their errors.

Again, as with the other sites, they use known features in the tank to go back and calculate areas, particularly areas, but also to doublecheck heights.

And then, what they are basically trying to do is to, as they keep going down, they -- of course they're exposing more and more of a particular mound, and that gives them some idea as well as to how the ultimate area may look.

So then, again, the source term -- they sample the material to determine the curie content, and then use the volume to determine the source term.

Explicitly, they don't consider wall deposits, but a correction to what I've said here is that in the performance assessment they take into account -- I think they give about a 20 percent correction factor, which is probably way, way high given the cleanliness of the tanks.

What are some of the potential problems? In a sense, the biggest one may be the optics, and I don't mean that in the strict sense. There's no independent verification of the calculation methods. each one, you know, a little bit different. They're all doing it the same way, which -- and I -- frankly, I don't see any inherent difficulties with it, except that we don't know just how good or not good they are.

CHAIRMAN RYAN: Isn't that an inherent difficulty?

DR. PLODINEC: Yes.

CHAIRMAN RYAN: Okay.

DR. PLODINEC: No question. Further, it's difficult to discern the depths below the supernatant liquid. The contributions of wall deposits have not been handled consistently. You know, in one case they actually try to measure them. In another case, we throw in a correction factor.

Nobody right now is looking at the annualae in terms of how do we take that space into consideration. For one thing it's -- you know, it's a constrained space. You can look at it. It's pretty difficult to get at it and make some kind of a measurement.

As I mentioned, the bottom-dwelling robots aren't going to be generally useful, particularly because of the additional superstructure like cooling coils most specifically. And the other part of it is that the uncertainties themselves in general just aren't real well defined. They're probably bounded, and probably the values that we have are biased high. But they're open to questioning, bottom line.

CHAIRMAN RYAN: For clarification on that point, that seems contradictory to me. Put that back up. I'm certain these are not well defined, yet they're satisfactory. How can you determine a conclusion if you don't have it well defined?

DR. PLODINEC: I think that's more than a clarification. We might want to talk about that more in Q&A.

CHAIRMAN RYAN: Okay. All right. Fair enough.

DR. PLODINEC: I will give you the quick answer that the "probably" is a subjective on my part. But I stand ready to try to defend it.

Okay. Emerging technologies. Work has been done to try to do a laser range-finding technique. It works. It has some operational difficulties, particularly if you've got a lot of obstructions in the tank.

We've been -- we -- folks at Mississippi State have been developing a technique called Fourier transform profilometry that has a lot of promise, at least in addressing some of the problems with the current methods. And I'll come back to explain that in a moment.

From the source term standpoint, when I -- when I say "source term," I mean here specifically the radionuclide inventory problem. There is ongoing work, both at PNNL and at Mississippi State, looking at laser-based techniques to identify the radionuclide inventory, as I'll -- as is said here, these are far from deployment in terms of remote technology.

Spectral imaging is an interesting one that I personally think has a lot of potential. But, again, the equipment has just not been developed for deployment.

FTP, real simple technique, long name. Essentially you have a light source, you have a camera, and in front of the light source you put a line pattern. And it's -- anybody who has had to do image analysis knows that it helps solve that one problem we all have had who have had to do this, which is, okay, I'm looking at a picture, I see a feature, a -- you know, in the third dimension, is it an innie or an outie?

Well, simply by whether the lines are being contracted or expanding, you can -- and knowing the direction of the light, you can quickly determine, okay, this is a hill or a valley. But the neat thing about this is that you can take a two-dimensional image and, in fact, then calculate a three-dimensional map of the surface.

It's not perhaps as apposite in this application, but, in fact, what the folks at DIAL are doing is, in fact, matching this up with video speed. So this is really real-time video camera in the tank. And as it sweeps the tank, you get the map back out in virtually real time.

Nice technique. But does it work? Well, this is not a tank, but this is work done by the Corps of Engineers using the algorithms we developed to do close to the shore mapping. This was done for black-type applications. But you can imagine, you know, why would you want to know whether -- what the sand is around different shorelines.

But you can see that things sticking up can be quantified quite nicely. And, in fact, you can even do the profile underneath. So it begins to provide an absolute measurement of areas that -- where you could only kind of relatively pick out before.

This is what the hardware looks like. Assume this is the tank top. There's a mast, and then a long arm that gets inserted. This is the end of the arm, and these holes are the light source and where you have the camera. And this will tilt up and down, and it allows you to look at the complete interior of the tank, as long as the view is not obstructed too much.

It's also able to be deployed in any riser four inches or larger. So it's pretty robust in that sense. And this is sticking it in the tank.

What's the error? Again, one of the nice things about this technique is that it is -- you can quantify how well you're doing. In this case, the inherent errors are on the order of about one to two percent.

Now, this is with ideal conditions. What we found is that these numbers go up to four or five percent when you put it into a -- you know, a long arm configuration. And as opposed to some assumed bias, these are -- these are, in essence, truly random errors.

Now, one of the problems, you know, you get into is if you're looking through water you have to correct for the refraction effects. And folks have done that, and you can see now we're talking errors on the order of 10, 15 percent for submerged objects. And it doesn't really matter if you're talking about the peak height or the peak area, the errors are about the same.

I don't have a slide on this, but do let me say a word about radionuclide inventory. From a worker dose standpoint, any time you've got to go into a tank and pull a sample you're exposing a worker to risk. So I think there's real value in developing techniques that can easily, reliably determine the inventory in situ.

Further, one of the things that clearly is -- we're all open to question to -- question on is we know that the materials in these tanks in many cases have been layered. If I take a sample here, is that going to be the same as the sample over there? In other words, how consistent is the source term throughout the tank? And that's kind of an unknown.

One of the nice things about techniques such as spectral imaging is that they allow you to get -- well, like the FTP as well -- a full view of the --

the full field of view for whatever the camera can see, and it can pick out differences in that whole field of view.

And I think there's a lot to be gained by trying to deploy -- develop those techniques, so that ultimately the operator doesn't have to be pulling samples.

Okay. Quick summary. The methods currently being used are providing quantitative information. We'll deal with the "probably" later, in terms of data being completed, not the size of the errors, however with the current methods are open to the criticism that they're not completely characterized, nor have they been independently verified by some other technique.

I think one of the things that the NRC, looking at all this data, is going to do is to push the whole system to a more common method of dealing with things like wall deposits and annular spaces.

One thing that I'm particularly concerned about is that the -- there hasn't been a lot of thinking through I think of the QA requirements for the data, the data quality issues. And as an old operational type person, I worry about that, because I -- I've been on a couple of panels that have had to look at the WIPP mess, and I use that term advisedly, where you're forcing way more work than is justified by the risk.

There are some alternative techniques being developed. There's a -- the FTP technique will be going to large-scale testing this year, this coming year -- fiscal year. But I don't think that the techniques will be available for deployment for radionuclide inventory for another three to four years.

Okay? Any clarifying questions?

VICE CHAIRMAN CROFF: Okay. Thanks, John. You might want to consider a seat. We may go on for a bit here. The agenda showed a break before our discussion, but I think we're far enough ahead, I think it's prudent to at least begin the Q&A here, and if it runs too long we need to clear a break in a while, but with that -- well, I'm going to start in the middle. Let's let Mike go. And any of the five are fair game here. If we got redirected, Paul and Barry, that's here too.

CHAIRMAN RYAN: John, let's start where we just finished up a bit. A couple of things strike me as you made your comments. One is, you can't conclude that something is not a problem if you haven't done the analysis to demonstrate that. That's a problem. I understand that judgment comes in and experience comes in, but the systematic approach would be to do some kind of analysis of the error.

For example, and I'll give you a way that I would approach it, is to try and figure out what the end point of the data is I'm collecting. For example, I want to now radionuclide inventory. Well, I want to know that for a couple of reasons. One is, I'm going to create a waste and I have to know it's compliant with some probably concentration limit. Well, you can test this system you used to make a calculation and measurement statistically and say if the errors are in these ranges and those ranges, do I have enough statistical power to do decision-making that I'm claiming I can do? And that rigor, I think, is what you ought to use to decide whether the sampling that you are doing makes sense or not, and that's kind of the first step toward risk informing this approach, what's important and what's not.

DR. PLODINEC: I would agree, basically, and that was kind of the thrust of what I was saying, was I think when that analysis is done, that it will be -- ultimate conclusion will be that the sites have erred on the side of conservatism enough that they come to an answer that's --

CHAIRMAN RYAN: But you'll have to agree right now on your part that's an educated guess. That's not --

DR. PLODINEC: Absolutely. That's why I made the point basically leading to the conclusion that needs to be done.

CHAIRMAN RYAN: And I guess what I'm trying to emphasize is making that educated guess is a potential step into scuba diving in oatmeal. You really don't know where you're going or why, so it's a strong caution I'm offering that judgment of 20 years or 30 years of conventional wisdom might bite you. You know the use of ORIGEN calculations, for example - everybody knows ORIGEN was designed as what kind of code, fuel burn-up. It was designed to accurately predict the residual Uranium 235 or Plutonium 239 content, not fission product inventories. And while there's been lots of efforts to upgrade the cross-section sets, et cetera, and so on, we don't know how good it is. So again, that's not to necessarily discount it, but I think in order to use it, you have to at least evaluate, propagate, or theorize what the uncertainties in those results are. One element of the system.

DR. PLODINEC: I think the real key there is, for example, if you look at Hanford, they've done a pretty good job of looking at what I'll call the random errors. And, Ken, you correct me if this is incorrect, but I think it's bounded around 20 percent, is the nominal uncertainty of the random errors. However, they have --

CHAIRMAN RYAN: I'm not sure what nominal uncertainty of the random errors exactly is, but --

DR. PLODINEC: I think basically, having gone through propagation of error, of those things that are truly random, you end up with a sigma of about 20 percent, relative sigma. On the other hand, they have also, two or three places, big systematic biases where they have - and they quite honestly own up to it - they have over-estimated, or at least they think they've over-estimated, but the degree to which they've over-estimated is unknown.

CHAIRMAN RYAN: It likely dwarfs the known systematic 20 percent errors. That's like saying well, my instrument error is 1 percent.

DR. PLODINEC: I agree.

CHAIRMAN RYAN: My sampling error could be two orders of magnitude, so again, I think a real true evaluation of this is somehow to go through it and rank it, and understand it in a systems approach, not necessarily side wind yourself with individual errors.

DR. PLODINEC: We're in violent agreement here.

CHAIRMAN RYAN: It's not so violent. It's something that I think we tend to worry about. Yes.

MR. THADANI: I just want to be sure that you're talking about also epistemic uncertainties in the model that you're using, trying to understand how that might influence your --

CHAIRMAN RYAN: Epistemic?

MR. THADANI: Well, that's a term that's used. Alliatory and epistemic, they are the popular terms.

CHAIRMAN RYAN: At least in some places. But to me, the kind of key point in all this risk discussion is that two things are happening. One is, you're trying to understand that inventory of radioactive material for a couple of purposes. One is to make sure that you leave residuals that are acceptable by some measure, and make sure that you put that waste in a format and form that's acceptable to somebody that's taking it away. And it would be interesting to think about, for example, your example of 20 percent random error, whatever those are. And so okay, well, I can test that. I'm going to go in that tank and take 10 samples and see what the sample standard deviation is. I'm going to bet you it's more than 20 percent in some cases, perhaps.

DR. PLODINEC: Well, in fact, in the cases like, for example, actual measurement of radionuclide content, there they were using pool standard deviations of several different sampling events into the same tank. Now one could talk about well, how representative are the samples, et cetera, et cetera.

CHAIRMAN RYAN: And should.

DR. PLODINEC: But from the standpoint of the statistical development, in that case they tried to do it. In other cases, for example, at Savannah River, they have not used ORIGEN, but there they have done -- Ned Bimler has done some very elegant work, where he's looked at ORIGEN and ORIGEN-like calculations versus what you actually find in the waste, and has come up with some big discrepancies that are explainable based on the nature of the irradiated materials. And so Sumarium is one of them that's either -- I think it's way low in terms of what's actually there. And again, it's one of these self-absorption type things.

CHAIRMAN RYAN: Again, I think when we

think about NRC's role of making determinations, I think the issue that you've raised of data quality and accuracy - I mean, quality can be a precision question or an accuracy question, or a data management question. Let me focus my point on the idea of accuracy; that is, is it true or not. It ought to be part of what's covered in the standard review plan, and I think some of these things that we're kicking around as more formal approaches to uncertainty analysis is going to be something we'll consider in a little bit more detail, but I think it's a critical question to get at, other than oh, we think it's okay.

DR. PLODINEC: Well, the other thing, though, to remember, and I'm certainly not disagreeing, but as a cautionary note back, taking those 10 samples so that you can get better statistics, some wise guy once said that statistics are people with the tears washed off. Real people have got to take those samples, and take a risk associated with that dose.

CHAIRMAN RYAN: And I sure appreciate that being an operational guy myself. On the other hand, I think that if you end up with a gazillion dollar project where you've created a waste that can't be disposed, you've got a much bigger problem. So somewhere in the middle there's a balance, and I think if you even do kind of theoretical thinking about error and error analysis for the purpose of decision-making with whatever guidance you can derive from your data, it's worth pushing the pencil around and the paper a while to do that. Thanks. I think I made enough comment. Ruth.

MEMBER WEINER: I have a number of different questions for a number of different people. Dr. Kocher, I'm very intrigued by having wrestled as a teacher with those definitions. I'm very intrigued by your statement. What do you think we should do regarding the definition of high-level waste? And the reason I ask the question is, your talk was very illuminating, but we are where we are right now, and we're with a definition that is in tuned, if you will, in regulation and law, and so on. What would you suggest that we do? What would you suggest that we advise?

DR. KOCHER: Oh, that's two different questions.

MEMBER WEINER: Well, okay. It's two different questions.

DR. KOCHER: What should we do is obvious. But the whole system into the garbage bag and start over with a risk-based waste classification system that has nothing to do with where it comes from.

MEMBER WEINER: Okay.

DR. KOCHER: But the truth of the matter, apparently, is that you can't do that. You can't get there from here.

MEMBER WEINER: Okay. How do we get there?

DR. KOCHER: So it's patch and fix, patch and fix, get more string, get more bailing wire, get more wax, patch and fix. This language in this law - I think I said this before - in my opinion, is kind of uncharted territory, so you're going to be feeling your way as you go along about what it means. And I'm not going to sit here and advise you about what that should mean.

MEMBER WEINER: Can't even give us the first patch?

DR. KOCHER: Well, I think the sensible approach is what's important to risk, and I can't think of anything else that's sensible.

MEMBER WEINER: Thank you. That is, in fact, a very good starting point.

DR. KOCHER: From what little I have read, that appears to be the way the agencies are thinking about this problem, is they tap-dance around.

MEMBER WEINER: For everybody else who spoke up, we're going to get some liquid waste, or waste anyway from reprocessing, and we're going to continue to generate in one form or another radioactive waste. Any or all of you, what do you think should be done as far as using tanks, not using tanks, other methods of storing the waste until some disposal methods is found. I mean, we've had a lot of experience now with tank waste, and we're faced with these tank wastes that are difficult and dangerous, and expensive to remove, and to dispose. So again, where should we go from here with newly generated liquid waste?

DR. PLODINEC: Fools rush in where wise men fear to tread, so I'll be first in line. I think clearly there's a theme that's run through a couple of the talks, and I think those who were involved early in the AEC processes realize that the preferred route was stainless steel tanks. Hanford and Savannah River couldn't get enough stainless steel at a reasonable enough cost to have stainless steel tanks.

I think smaller stainless steel tanks, better segregation of waste, clearly would be the direction that you'd want to go. I'm going to put words in Ken's mouth, not for the first time, but one of the reasons why the problems at Savannah River have been, I think, a lot easier to solve than some of the ones at Hanford has been that the folks at Savannah River historically (a) have fewer processes, but (b) segregated the waste more. And as a result, it's made life a lot easier, and easier to get the retrieval going and the processing up and running. But I think those are the two things.

You're almost forced to use tanks, because where are you going to go with this stuff? You just don't have the capacity in the system many times, but the other thing that I think is an overriding issue that's probably also extremely important for what you all are doing, is that you have to look at this as an overall system. If you just look at the question that the NRC is faced with, the maximum extent practical, or whatever words you want to use, that's not simply a tank-by-tank issue.

If you look at Savannah River, they have a severe constraint just simply because they could probably, in theory, discontinue to pump the water down and slew stuff back up. Unfortunately, they don't have any place to put the water, and so it's a system -- again, it's a system problem that you have to deal with. And it becomes a very big issue in terms of determining the practical aspects of how far down to go.

MEMBER WEINER: And when you say segregating the waste, you're implying that as part of the process, since these are waste from separation processes, you could carry on and separate out other radionuclides, or separate out the waste, segregate chemically, or whatever.

DR. PLODINEC: Yes. I think specifically, for example, by fuel type.

MEMBER WEINER: Oh, okay.

DR. PLODINEC: That would be the first line of segregation. Again, it's a question of how money you've got, how much you've got, how many tanks you can afford.

CHAIRMAN RYAN: Let me just ask John a quick question, if I may. It follows on exactly with what Ruth has asked. What do you think about Dave's idea as to the maximum extent practical, and all your examples should have -- the common currency to me is risk, whether it's Hanford, or Savannah River, or whatever. Important to risk is a phrase I don't want to lose, we kind of raced through that, but it seems that whether it's the technology of taking stuff out of tank, or whether it's thinking about in terms of ultimate waste form and what you leave behind, the important to risk, that needs some further definition, but that seems to be the common theme that I could string through all the presentations. Sorry, I just wanted to jump on --

MEMBER WEINER: No, that's a very good comment.

CHAIRMAN RYAN: I would agree, certainly. And so would David, since he said it.

MEMBER WEINER: David.

DR. KOCHER: To me the analogy here is that to the extent practical is kind of ALARA for the waste extraction business, and you can't quantify it, but you sort of know when you get there, and it's an overall general touchy-feely cost benefit kind of a situation, but no differential equations, please.

CHAIRMAN RYAN: Or it could be Option A or Option B, and just look at relative measures.

DR. KOCHER: Yes.

CHAIRMAN RYAN: Right?

DR. KOCHER: You don't want a universe of a thousand choices.

CHAIRMAN RYAN: No, maybe three. But then the point is that there is a framework that has some structure that we could lean on.

MEMBER WEINER: I'd like to ask Ken to comment with all of the experience with Hanford and with separating our Cesium and Strontium, and dealing with all those single shell tanks.

DR. GASPER: If I take John's comment, I have to be a qualifier, but we're here. If I could replay the record, we might not have got here, but we're here. And we have the variety of waste that we have in the tanks. We can't go back and separate and segregate, and so it's the path forward that is the critical one for us. I certainly agree with the two of them that it makes sense to do it on a risk basis, but at the same time that I say that, there are regulations in place that for us to say that we're going to go ahead on a risk basis can mean that some of those really ought not to be constraints upon us.

I'll give you an example. An example is that we are forbidden to use any of our single shell tanks for addition of liquid, and yet we have no other processing vessels other than our double shell tanks, which are nearly full. And they will remain nearly full until the waste treatment plant, or possibly supplemental treatment, begin to provide an outlet for them.

At the same time, we have reasonable confidence that some of our single shell tanks that are more or less empty would be vessels that would enable us to do something, such as segregate some waste, so that we can facilitate overall risk reduction perhaps by retrievals or otherwise, that we're not permitted to do. So it's a concept to say that we want to do something that minimizes risk, at the same time the question is what ground rules are we able to tamper with?

MEMBER WEINER: I think you've raised a very good point, and I would hope that one of the things that we can do is to focus on those areas where the wording of a regulation or an agreements gets the soonest kind of fix, where you can't do something that would, in fact, minimize risk.

DR. BURKS: Ruth, you asked a question about what do we do with liquid waste as we generate it going forward. One of the comments I'd make is that if we're going to put it in tanks, let's put it in tanks that were designed to be emptied. When Fernald cleaned up Silos 1 and 2, and moved that material into temporary holding tanks while waiting for their treatment facility, they stored that material in tanks that also when the tanks were being built had retrieval systems built in, so now when their treatment system is ready, they can flip the switch and start moving material immediately. So if we're going to use, or use more tanks, then let's at least do a better job of designing them to be cleaned. Put those mixing systems in at the beginning.

DR. MURRAY: I think it's fair to say that I've been working recently with the Italians, the Canadians, Beckford, BNFL, and Dounreay, and their wastes are segregated, kept in acidic waste forms, and they don't have sludges in their tanks. And you can see this in Idaho in the sodium barren waste tanks, basically a pure feed going into those tanks, and hence it's much easier to retrieve the tanks.

MEMBER WEINER: That's it. Thank you.

CHAIRMAN RYAN: Jim.

DR. CLARKE: Just to follow-up on that, and Barry spoke to something I was going to ask. And I think if we were going to do this again, people are reprocessing. As Ruth mentioned, what the lessons learned? I mean, the tanks, if you have to use them, are now part of a process, they're not the end of the process, so how do you put them in the tanks? How do you get it out of the tanks, and how long do you leave it in the tanks? I mean, all of those questions - I think there would be merit to thinking about that. I'd sure like to see us capture these lessons learned, if for no other reason, just their intrinsic value.

The phrase highly radioactive waste reminds me of another troublesome phrase that I've wrestled with for a long time, and that's called toxic chemical. And these terms just have no meaning. They obviously have meaning only within the context of an exposure scenario. There's a public perception issue that's really difficult to deal with. I guess, Dave, when you say risk-based classification system, you've inherently built into that the exposure scenario.

There's a friend of mine back in the early days of hazardous chemicals said that every time somebody asks me if a chemical is hazardous, I have to ask them what they want to do with it. Do they want to eat it, do they want to transport it? What do you want to do with it? That's really I think where we have to get to from where we are with these definitions, and source-based definitions, and other kinds of definitions. I guess that's more of a comment than a question.

The last thing I wanted to ask, John, I guess you, is taking a data quality objectives approach where you're going out to get data, and you really shouldn't do that until you know what you want to do with the data. And one usage would be, obviously, to know what's in the tanks as best you could before you started doing anything. The other would be to try to figure out what would be left when you finish doing that.

How useful is information you could get from what you take out of the tanks to answering the question of what you've left behind?

DR. PLODINEC: That's a great question, and one that I'm not going to give you a great answer to. The data we have isn't really quite on point, but here's what we think we know. When we process what we call in DWPS space a macro batch of waste, which is waste from a bunch of tanks, it is surprisingly uniform. I mean, we're talking about something that truly is like what you might get for a single mixture of chemicals that was just a single batch. It's amazing how over months, maybe even years of time, that sludge will have the same composition. And, in fact, will have the same composition as a grab sample that was pulled before they actually began processing. So that would indicate that maybe there's a lot of probative value of those samples.

I indicated an example, I think it's

Idaho, where they had used a sister tank, where they could, in fact, sample, and they used that so the implicit assumption there was, in fact, that you could transfer those kinds of information across.

The niggling worry, though, is that those of who've been involved in waste characterization know that those tanks have been stratified, or the waste I should say has been stratified. And so what we have is this indirect body of evidence, but we don't have pluperfect evidence in all cases that says yes, it's uniform.

Now I have to say, though, I think you probably are going to be in a much better position to get an answer to that question, because when you go to Savannah River, in particular, I know with Tank 11 they've got a series of data that ought to be able to address that question. And they would be the best people to answer it.

CHAIRMAN RYAN: Thank you. Bill.

MEMBER HINZE: Well, I wanted to ask John, in terms of this FTP procedure, we've gone a long way in terms of subsurface acoustical imaging techniques, as you're probably more than aware. I sense that from your description that this was largely a surface measuring technique, but you also when you talked about refraction through the liquid. And is your wave lengths of the light sufficient to give you penetration? Is this transparent enough?

DR. PLODINEC: Yes. We've done - the folks that are actually doing the work - have done testing on the order of the same depths as Savannah River, five inches or so of liquid, and various types of objects. The Army, if you remember that slide that I threw up there, in their case they had gone down to about plus or minus a foot, foot and a half. So yes, it's quite doable.

MEMBER HINZE: With using the right frequencies you can get a little further than that, and still get very good resolution.

DR. PLODINEC: Yes.

MEMBER HINZE: And I'm wondering if your layering problem -- I'm very sympathetic to your sampling, and layering, and representative samples and all, and I wonder if you can't actually develop a three-dimensional image, rather than two-dimensional image.

DR. PLODINEC: Well, this is actually a three-dimensional image. But you're right, you don't get any further beyond the --

MEMBER HINZE: And the --

DR. PLODINEC: But the other problem you run into is that application of acoustic techniques in tank environments, particularly when you've got that super structure is going to be a bear. And unfortunately, there's not a great answer to how you're going to deal with this even optically because again, you've got a lot of obstruction.

MEMBER HINZE: You can do a lot with multiple sensors, though.

DR. PLODINEC: Yes, and that's, in fact, what they've done with --

MEMBER HINZE: It's a nice reaction problem that should be able to be -- well, this is a correct path to what apparently is a significant problem, but I think the technologies are even further that are available, that should be at least considered.

Dave, I had a question that came up in my mind when you were giving your discussion, and that regarded the risk-informing in relationship to the heat generation. Heat generation as I interpreted your comments were used as, number one, a surrogate for radiation, if you will. And number two, that this is a problem in itself, the heat is a problem in itself. And you spoke about boiling of the water in the subsurface. Has there been any risk analysis done on the problems of heat generation associated with radioactive decay?

DR. CLARKE: Well, there certainly was Project Salvault many years ago.

MEMBER HINZE: Okay. You've got me. What --

DR. CLARKE: I was still in knickers, so I --

MEMBER HINZE: This was the --

DR. CLARKE: The first proposal for a salt repository --

MEMBER HINZE: Oh, the Texas work.

DR. CLARKE: Lyons, Kansas.

MEMBER HINZE: Right. It was Lloyd Bennett --

DR. CLARKE: Yes.

MEMBER HINZE: But I just wonder how much of a problem heat really is.

DR. CLARKE: I don't really know the extent to which detailed risk analyses have done, but it's generally considered not good form to have water boiling in your rock.

MEMBER HINZE: I'd like to see what the risk is from it.

DR. CLARKE: There's some feeling that geochemical processes are enhanced at higher temperatures. That may or may not be true. I think it's -- my impression is that yes, it's been looked at, but as much as anything else, it's kind of a boundary condition. It's kind of something that since it's an easy problem to avoid, just don't go there. You're not severely impacting your ability to dispose of waste if you kind of take thermal power loadings into account in designing your facility and placing the waste.

MEMBER HINZE: Well, if we're going to have risk-informed, we ought to go all the way.

DR. CLARKE: Fair enough.

MEMBER HINZE: I think that boiling water is not a good idea in a repository but I can't tell you why.

VICE CHAIRMAN CROFF: Bill, let me take a crack at your question by example, and that's the Yucca Mountain Repository where for years there was a raging debate of hot versus cold. And in my view, there was never really anything -- a definitive process to go through to attach it quantitatively to risk. There was a lot of judgment used to decide the way they were going, and I think that's sort of what

Dave's saying. It's so complicated, they haven't been able to get there, so they made it a judgment call. That's observation, not saying it should be.

I've got a couple of questions. I think at least to start with, directed at Ken. You reminded me of the ferrocyanide business in the Hanford tanks, and sort of recounted some of the history there. And I sort of remember the flap it caused at the time, but ultimately, a bunch of people did some science and studied the tanks, and my memory of the final outcome, which was -- I thought the final outcome was that it never was a problem.

DR. GASPER: The final outcome was that the ferrocyanide had been radioactively degraded so that the bulk of the organics in the tank now were down to oxalates predominantly.

VICE CHAIRMAN CROFF: It's gone a long way.

DR. GASPER: In other words, they've gone a long way. And the energy content, therefore, of the residual material in the waste was very low. But that's quite different than saying that we want to use a ferrocyanide process with fresh chemicals, and then have to worry about handling the process of waste multiplication, and what we do with the residuals from it. So when the competitive bids went out, one of the competitive bids that came in - three of them that came in were for fractional crystallization, and one acid site, two alkaline, one of them was we're using the ferrocyanide process. And, of course, it wouldn't be in large tanks, it would be in process vessels. But it's kind of like the tetraphenylborate, we just didn't want to have to deal with the complex organics again as derivative waste products.

VICE CHAIRMAN CROFF: Okay, thanks. I wanted to go on to a somewhat larger picture concerning this maximum extent practicable, I guess separation of radionuclides - let me put it in that terms. I don't want to talk about retrieval at this point. When I sort of look at what you described up there, and think about it, I see three sites that have relatively similar waste; West Valley, Savannah River, and Hanford being neutralized alkaline waste for the most part. And then when I look at the processes, let me call them the mainline processes they want to use for radionuclide separations into the future, they seem to be going or have gone very different directions, solvent extraction, ion exchange, and then a, I guess, what would you call West Valley absorption precipitation kind of thing.

DR. GASPER: It's an ion exchange.

VICE CHAIRMAN CROFF: Of a sort, I guess. And then when you look at some of the nearer term proposals or interim operations, if you will, at the site, there's not so much separation there at all, or a much lesser degree of separation because they're using more physical kinds of separation. And I'm sort of struggling with, first, how do they all end up going in different directions when the waste aren't that dissimilar, and can all of this represent to the maximum extent practicable? I'm not asking you to defend DOE's position, understand, but some technical insights as to how do we get here.

DR. GASPER: Ion exchange is an approach that Hanford had a lot of experience with because of their separation, so they had built an infrastructure and their familiarity, they used that infrastructure to support getting West Valley going. It was Hanford people working with West Valley people and importing the ion exchange technology that they use there.

At the same time, Savannah River had maintained a solvent extraction familiarity that Hanford had not maintained, so in the 90s we were comfortable continuing where we had left off with our ion exchange work, B-plant, and that train of thought has continued for Cesium removal.

The solids/liquid separation step is a step that we're lock-stepping with Savannah River on. We're doing it the same way. Then you move to whether or not we -- to the extent that we need to treat any of the waste to reduce the Strontium and the actinides from the solids, there's a case where using monosodium titanate at Savannah River has been underway for a long time, and we certainly could use that. We found that it was a bigger hammer than we needed, and we could co-precipitate just by adding some inert chemicals and drive the equilibrium sufficiently over, and that's what we're doing when we add the Strontium and Permanganate.

Caustic site solvent extraction is a major new facility for Savannah River. If we were to adopt that for supplemental treatment, for example, we'd have to stand in line funding-wise behind Savannah River. I don't know what the current estimate was, but last November the estimate was $500 million in 2009 for finishing the design and completing the facility. If we want to get in place for doing some supplemental treatment, we need to do something that doesn't require a major new capital facility. So those are the kinds of factors that cause us to not necessarily stay in lock-step, certainly vitrification. We're staying with the DWPF flow sheet for high level waste. Having diverted from a salt stone base in 1990, and gone with low activity waste vitrification instead of salt stone, and that was a change, that change came as the Department accepted the ground swell to deal with all of the single-shell tank waste. Up until then, when they were planning on grouting, they were planning on grouting just the double-shell tank low activity waste portion, but when they made the determination to retrieve all of the single-shell tank waste, the volume grew too much.

VICE CHAIRMAN CROFF: Ken, I was wanting to get to it a little bit more in a forward looking sense.

DR. GASPER: Okay.

VICE CHAIRMAN CROFF: At some point, there's going to be the need -- I mean, determinations are going to be submitted that will require some kind of an analysis to show that whatever is being done is the maximum extent practical. And you've recounted some of the historical thinking, but it sort of seems to me to be leading to a very interesting decision-making problem on a forward looking sense that there's existing plans that sort of have to be reconciled with a new regulatory framework, and how in a standard review plan to articulate all of these considerations.

CHAIRMAN RYAN: Just a follow-on to that, Allen, I think you've summarized it really well. To me, again, the common currency is not chemical engineering Case A, chemical engineering Case B, C, D, and E, and F, and G across the complex. It's how important is any of that to risk in any given case. And the risk, to me the focused risk that the determination addresses is not disposal at a waste outlet. That's determined by the disposal outlet typically translated into their waste acceptance criteria in one form or fashion. The risk context is what's left behind. So all this about processing and clean-out, and all the rest, at the end of the day you have to have an accurate inventory of what's left behind, and how it's going to behave, and what your prospective view of protecting public health and safety from the first bullet that was in Anna Bradford's slide - that is the currency. So I guess what I'm trying to suggest, Allen, is that there's a component of all the engineering, and all the chemistry, and all of that gets you to a confidence judgment about what do I know about what I'm leaving behind?

DR. GASPER: Well, let me suggest that what we're leaving behind is -- the amount that's being left behind in the tanks is a trivial amount compared to the amount that's being left behind at the site, either in the material that we've converted to low activity waste, whether it be salt stone or low activity waste vitrified. That's a major component. It dwarfs the amount left behind in the tank.

CHAIRMAN RYAN: Well, I hear you and I appreciate the difference, but by the same token, that's an independent question from the WIR determination. What I'm trying to focus on --

DR. GASPER: I don't know that it is. Why is the amount of radioactivity that we take out of the tank and put in the ground four miles over not a WIR determination?

CHAIRMAN RYAN: Well, I guess I see it as an independent component of the same process, clearly.

DR. GASPER: Oh, yes.

CHAIRMAN RYAN: That much I agree, but that's evaluated on its own merit.

DR. GASPER: Well, that's what your WIR determination for your Savannah River was all about this year.

CHAIRMAN RYAN: You've all done very well to describe how they're all different. My point, I guess, that I'm trying to focus on is that risk evaluation of some assessment of dose to the public health and safety is the common currency of all of it.

DR. GASPER: We agree to that.

CHAIRMAN RYAN: All right.

VICE CHAIRMAN CROFF: I think in this there may be an issue that the committee will need to talk about after we finish the working group meeting, and the issue I see -- well, the Subpart C objectives have dose limits, ALARA, and this kind of thing in them, and then there's this maximum extent practicable business. And should the maximum extent practicable recoveries, if you will, be interpreted in a way that essentially duplicates the Subpart C objectives, or is there something else in there that either the law will force you to consider; in other words, a more technical or engineering consideration?

I'm not necessarily advocating that, but there's these two provisions, and if you look at them one way, they're basically driving toward the same end, but if you look at them in another, they can drag you in a different direction. And maybe there's something you want to say about that.

DR. GASPER: Allen, as you asked the

question and the information that I gave you in the presentation was intended to give you, as a committee, input that suggests that what is to the maximum extent practical, is a moving target. I can tell you what has been demonstrated thoroughly such that you can evaluate the economic aspect, among other aspects, and that information has long ago been transmitted to you for Hanford, but what is maximally extent practical for right now, or for 2007, or for 2010, or for 2012, I tried to give you some benchmarks of what has been done and what is being done, but none of those newer things have, in fact, been demonstrated to the extent that we can provide you with the confidence that the goals will, in fact, be achieved, or to what extent those goals will be achieved with yet to be determined economics.

VICE CHAIRMAN CROFF: Ken, I understand that, and what we asked all of you to do is basically give us technology status. And the job we're faced with in NMSS staff in our various roles is trying to abstract that into what goes into a standard review plan.

DR. GASPER: Yes. A difficult job.

VICE CHAIRMAN CROFF: So to tell what kinds of considerations go there, and that's what I'm trying to ferret out here. We're running a bit long. I'd like to ask one final question, I think mainly of the retrieval people. Somebody, maybe it was John brought this up, but he may have a role in it, and that is, in particular at Savannah River, a number of the tanks have annuli, and some of them have some amount of leaked waste in them. Has there been any thought given to technologies for retrieving that material that's sort of in the sauce or around the teacup, if you will?

DR. MURRAY: Yes, we're doing a demonstration this year as part of a cow sign bin retrieval. We're designing technology to retrieve the cow sign bin by pneumatic conveying. That technology is very applicable to recovering any waste that's been spilled annuli of Savannah River tanks. Savannah River is completely aware of that work and what we're doing, and there will be a separate demonstration on that work later this year, and Savannah River will attend that.

VICE CHAIRMAN CROFF: Okay. And thoughts, Barry?

DR. BURKS: Yes. When the tanks focus area was active, there was a development project focused on retrieval from the annulus at Savannah

River. The project was never completed, but there was a concept that got off the ground, anyway.

VICE CHAIRMAN CROFF: Okay. I didn't know that. John, any thoughts on characterizing stuff in an annulus?

DR. PLODINEC: We've had some discussions with Savannah River about using the complete -- the situation that's more likely to obtain is that you're not going to go into the annulus unless you absolutely have to. But we know that on a -- I don't know about Hanford, but I know at Savannah River, a lot of the cracks are sealed over with high level waste solid.

VICE CHAIRMAN CROFF: We have no leakage in the double-shell tanks, and our single-shell tanks have no annuli.

DR. PLODINEC: So what you need is something to characterize the amount that's there.

VICE CHAIRMAN CROFF: Okay. Are there any questions from staff here? Latif.

DR. HAMDAN: Yes, I have a question for John, and maybe one for Ken. John, these methods to calculate the HL levels(3:24:19), whether it's radioactive volume, do you use more than one method on the same tank to compute the results from the first?

DR. PLODINEC: Well, realize that I'm

talking about other people's livelihoods here, which makes it easy for me, I guess. No. I think that's one of the weaknesses, is that there hasn't been an independent verification of the calculational methods. And that's what I was trying to lead you to conclude. Thank you for being led.

DR. HAMDAN: And actually, you don't have real data to compare the calculation, any one method with real data --

DR. PLODINEC: Well, now having said that, let me say the flip side, which is that they are trying to compare their assumptions, if you will, not assumptions but their calculations against known locations in the tanks, so to that extent there is a certain amount of de facto verification, even if it's not de jure.

DR. HAMDAN: One question for Ken now.

VICE CHAIRMAN CROFF: Go ahead. Try and keep it short.

DR. HAMDAN: Yes, one more question. The change in efficiency in the technologies that you mentioned is a different volume of efficiency or the cause, or both, and the other question that I have really is, does the cost go down with this new technology as you improve efficiency?

DR. GASPER: The historical efficiencies I report as what they were. The efficiencies for the future, more technologies, I think we're at too early a stage to tell you what we expect will be the results. Fractional crystallization, for example, versus Caustic Site Solvent Extraction, there are ground rules that we wanted a process that didn't require a new capital facility, major new capital facility, so we expect it to be a much cheaper process, and we recognize it will come with a somewhat lower decontamination factor.

VICE CHAIRMAN CROFF: Okay. Thank you. Let's go ahead and take a break now. We've been sitting for a while. Come back at 3:45, if we can.

(Whereupon, the proceedings in the above-entitled matter went off the record at 3:27:32 p.m. and went back on the record at 3:49:45 p.m.)

VICE CHAIRMAN CROFF: I'd like to begin the third session of the workshop. We're running a little bit ahead, but in fairness of people who might have planned to show up tomorrow morning to listen to our first speakers, we're not going to bring any of them up today, so we're going to have one more presentation here. I think maybe take some Q&A on that presentation given we're going into the overnight, and then we'll call it quits for today. So we're moving into this third session. The second session revealed two major, let me call them waste streams or end-points. One is a tank in the ground mostly empty, filled with some kind of material like a grout, and the other is an immobilized low activity waste, again potentially in material such as a grout. And this session is going to address a couple of important aspects of disposing of these wastes. One is how to stabilize them, and then performance assessment, and decision-making concerning these wastes.

The need to fill the tanks and immobilize the waste has led to considerable activity concerning cements and grouts, and they seem to be the materials of choice in many instances. As a consequence, the durability of these materials has come to the forefront as an area of interest, and to begin to address this, I'd like to introduce Dr. Les Dole. Les has studied corrosion and radionuclide propagation in Westinghouse nuclear power plants, directed research on engineered barriers for some predecessors to the Office of Civilian Radioactive Waste Management, and led a group at Oak Ridge National Laboratory for about 10 years that developed and tested waste forms for various hazardous and radioactive waste across the BUE complex. Those are hazardous chemical wastes, of course. And he served as Technical Director of Qualtrek, a major super fund remediation contractor. Les, it's your's.

DR. DOLE: Mike talked earlier about scuba diving in oatmeal. We're going to scuba dive in cement right now. Okay. Cement is one of those issues, how many people here have cement sidewalks, patios or driveways. Okay. How many of you have cracks in them? Everybody. I do, too, so that's going to be tough room.

Basically, as I explained to Ed, my counterpart from this is that there's dirty water cement chemists and clean water cement chemists, those guys who civil engineering and structural work with cements, and they use clean water. And then there's the rest of us poor souls that mix cement with all kinds of things that should never have been used.

So basically, I'm going to talk about hydraulic cements. Basically, they're a powder and you mix it with water and it ends up like a stone. And the ones I'm going to concentrate on are the first three on the list, which are the ones that are most commonly used in waste management. There are others and they have their niches, but most of the waste is treated with Portland or a variation with a lime slag silicate, and I'm not going to say anything about the organic ones. Most things have their niche, some are still looking for it.

Basically, I could spend the rest of the day on this talk because it summarizes so many aspects of what we're talking about when we deal with cement chemistry, is that we start out as a slurry, in which the contiguous phase is water, and it goes through a phase where it forms these tendrils of CSH which is calcium silica hydrate, and eventually that locks together slowly. You notice the time scale is non-linear, over 28, 90, and even hundreds of days to thousands of years, the reactions continue to evolve so it's a sequence of reactions. So you can imagine that if you mix these with dirty water, things that would affect the slurring properties, affect the processability and the flow characteristics, things that steel calcium or silica from the system interfere with the cement reactions and get these all out of sequence. So when you start to deal with waste, you have to deal with the interferences from the constituents of the waste.

Now cement material is basically taking

clay and lime, and roasting it, and then grinding it into a fine powder, and that's really a product that's made from the crust of the earth, so it has a lot of elements in it. The principal ones are, of course, calcium silica, aluminum and iron, but what's in the crust of the earth, you find in cement.

Basically, the basic reaction is you take like tricalcium silicate, reactor it with water, it forms a calcium hydrate, usually at first it's a very non-differentiated amorphous gel, and the reaction releases calcium hydroxide. Now I'm going to foreshadow because if you add glass silica to it, fosilon, that silica then will react with the tree hydroxide and make it disappear. We'll see later that might be important. So basically, we have complex alumina silicates that first form a very fine texture. It's very difficult to analyze, the spots are usually bigger than the fabric so it's hard to isolate individual phases. And it starts out with a large fraction of amorphous material that continues to differentiate itself into possibly a large number of different phases.

Okay. These components react at different rates. And particularly when they interact with the ground water, because different components of the system lead to different rates, and they interact with the ground water, and you get reprecipitation, and so these interactions will be interesting.

Basically when you mix it with a waste, the waste comes with a variety of compounds, elements, anions, and they tend to accelerate or retard the cement reactions. And realistically, when you look at a real waste using this glueous complex, you can't a priori predict what wins in a particular case. You almost always have to start at least at some point treatability studies to see how interaction between the waste and spent chemistry behaves.

Second, you've got other things in the waste, particularly when you talk about surfactants, kelating agents, hydrolysis products like tributylphosphate, they also influence the rheology in the cement chemistry. Furthermore, since it starts out to be a slurry, it's very sensitive to ionic strength, and so the ionic strength has a large impact on this processability, how fluid it is, how thick it is, and how you replace it. And so you can manage it, for instance, with low ionic strength you tend to use a series of things like bentonite, ilite, and kaolinite. If you have very high ionic strengths, you use netolite, minerals such as attpulgite and fly ashes and other materials.

So when we consider formulating a waste form we've got a broad spectrum of cement types that are usually characterized by its constituency and its set, and then you can modify the behavior of that catalogue of cements by adding silicates and other additives. Silicates are -- everybody saw "The Greek Wedding" where the father says whenever he gets a little burn he puts Windex on it - okay. I'm going to start to sound like about silicates, because all the problems we have - well, not all of them, but many of the problems are mitigated by adding reactive silica. So reducing the calcium silica ratio, the aluminum silica ratio, and you reduce the permeability and its susceptibility to permeation and reactions that would degrade the matrix.

Also, you add additives to increase the internal the best. You may use clays in one aspect to control viscosity and the processability of the mix, but adding clays to it also highly modifies the internal ion exchange capacity, and we'll see how that reduces the diffusion coefficients. And then the effect of reducing -- certainly, one of the tricks for controlling Technetium is to add a reducing agent, reduced to a very immobile Technetiumoxide. For instance, blast furnace slags are a classic mechanism to add sulfur and reducing iron into the mix, so it's very effective in controlling Technetium.

One other issue is how to predict the long term behavior of this. That's one of the major issues, is that once you've found a mix that meets, that's compatible with the waste stream and compatible with the processing equipment, then you start to worry about how durable is it in a sense of being a long-term waste run. And the first impulse is to test these at elevated temperatures to accelerate reagent reactions. And as I pointed out, the cement systems are fairly complex series of sequential and parallel reactions, so the real essence of changing the temperature is to change the reaction paths. So here are some common minerals that cement matrices evolve to over very long periods of time. And you can see that their free energies change value significantly by raising the temperature from 25 to 100 degrees C. So you have to be very careful when you look at the idea of trying to accelerate aging tests by elevating the temperature because it just doesn't evolve in the same way.

So where does that leave us? Well, the other option is to look at anthropologic and natural analogs. Now the problem is that the Romans didn't put Plutonium in their grouts, but the other problems is that they used materials that were different than us. And we can't always determine what was used in the first place, and we certainly can't always deduce the conditions it's seen over the last 2,000 years while were looking somewhere else.

There are also natural formations, Texas, Israel, Ireland, where magma has intruded into formations and made cement linger in situ. And we can go back and look at these, and unravel ten thousands to maybe a million years of it in environmental exposure. Now there's great difficulty in using natural analogs, but they are good at bounding things, they are good at looking at systems that evolve at more ambient temperatures for very long periods of time, and gives us some idea of where to look when we examine modern cements.

Now if we can't accelerate the reactions reliability by temperature, that means we have to age them in real laboratory time, and so the hope there is that perhaps some of the modern microprobe tools will be able to look at the phases forming on the surfaces and get an early indication of where the system is going to. And then try to link them to the agent systems using some mass transfer coupled thermodynamic model. Now again, much of the thermodynamic data is missing for many of the key cement phases, and the models have difficulty handling some of the metastable intermediates because in the end the systems end up as - after they form first as amorphous systems, there's still a solid diffusion control reaction, so they're very slow. And so you can get microsystems within the matrix that have one composition versus another, and so one part of the system is evolving in a different direction. But given all these difficulties, it's really the only place we have to go to really unravel the very long term, if we're going to look at certainly transuranics when we're looking at hundreds of thousands of years of performance.

Now let's talk about the leach performance, which is really the risk. The whole idea of this is you have a waste stream, because of its chemistry and its liquid, it represents a risk, and you mix it with this stuff, and you reduce the risk, so how do we assess that reduction in risk? We really have two extremes to look at; one, a quasi-static system where you have a waste form in very low flowing water where it comes to equilibrium with the water adjacent to it, or near equilibrium. I mean, in some cases the waters in Yucca Mountain are a thousand years old and it's still not in equilibrium, but here you have a case where you have a very low, so you would design for a very low solubility, very low flow. That would be an optimum risk, that would be a good risk case.

The other case is where you have a dynamic system where you have an advection of ground water that flows passed the waste stream fast enough that it never reaches saturation in the fill, and you have a diffusion control release from the waste run.

Now in practice, probably familiar with those, but basically one aspect of the waste form in a dynamic system is you make a case that if you have a model that's embedded in a geochemistry, and if it is 100 times less permeable than the surrounding geology, that an affected particle of water goes around rather than through. So a threshold is if you build a waste form that's 100 times less permeable than its site, then you've eliminated advection as a mechanism by which it can release its activity to the biosphere.

Now then we come to diffusion control. So now we start looking into our bag of tricks on how we design a matrix of a waste form for diffusion control.

And this is an idealized occasion when, in fact, you can never really isolate all the variables, but it at least gives you a sense of what you're trying to do. You're trying to increase the virtuosity, in other words the fineness of the structure. You're trying to induce a material into it that has a high exchange capacity for the individual, and you're trying to reduce the porosity, so these are all the kinds of things you can do to silicates and clays. And so we know how to do that, except that that model really only works for Cesium. When you start looking at Strontium and other -- especially the transition metals and the Uranium, Plutonium, there's a whole complex silicate chemistry that's going on, so it's not a simple exchange matter. So perhaps only for Cesium, and maybe Iodine-129 you can make a case for an exchange model, but at least these gives you some sort of guidance what you want to do when you try to design a waste form.

So I just luckily picked examples from the W-9 gunite tank at Oak Ridge, in which we measured the effective diffusion coefficient for Strontium of 10 to the minus 13 square centimeters per second, and so what's that going to mean? Basically, in the first 20 percent of dilution from a body, geometry is not important. You just use an in finis slab model. This is a simple in finis slab model where you have the ratio of the surface to volume, the square root of the diffusion coefficient times the time. And when you get beyond 20 percent, then you have to introduce an equation that accounts for the geometry of the system, and this has been a very effective model for us. I won't go into details, but basically these are the results.

You have decay for Strontium, then you have the diffusional release from the body of the model, about the size of a W-910, and so when you combine diffusion and decay, you see that the DF is .05, and that's a maximum release, and that's without any dilution for ground water. That's the amount of curies in time that it released, so you can see for the things like Cesium, Strontium, and Cobalt-60, the combination of decay and diffusion is really a minor risk. So certainly in the case of the case of the gunite tanks and the case of many of these fields, if you fix them in place and you have that kind of diffusion coefficient in the waste form, you're essentially never going to get it to diffuse fast enough to be a hazard to the local surroundings.

Talk about some of the issues with doing leach tests, and I've been in rooms arguing about leach tests for 30 years. And the only thing we've ever resolved in those 30 years is we've agreed on a surface-to-volume ratio as a standard part of the test. But the interpretation of these tests gets a little wild.

The whole idea is that you have a static system, you close your waste formula and you measure the constituents concentration in the leaching, and it takes off. Well, it reaches saturation, but then there are other elements in the cement that are also leaching, particularly the hydroxide. If it's OPC, Ordinary Portland Cement, you have hydroxides, carbonates in the water, and they start to precipitate. So now the concentration is determined by this partitioning with the precipitate. Then later on as the calcium, and the silica, and the aluminum leach, they start to reprecipitate and form secondary minerals which then greatly reduce it more, so you end up certainly in a cementitious systems, if you do a closed leach you end up consistently with a Volkswagen isothermacite, if I may refer to it. One variation is, is that sometimes this film is very tight and there's an osmotic rupture as you get little Volkswagens reproducing themselves as time goes on.

But the other point of this is how do you interpret this as a leach rate, because if you take this period you get this one result, but as you can see, as you choose different time periods - I thought that was a French program. They'd always wait until they got to here and then pick that as a leach rate, so it's very subjective.

So then to some extent design of the waste form is about controlling how it interacts with the local geochemistry. Certainly one thing you can do to help yourself right away, and again put silica on it, if you adjust the calcium silicate ratio, you get in this regime where you cannot have three hydroxides and that helps you in several ways. One, it makes the matrix more dense, less permeable, lower porosity, and you don't have the leaching of the calcium hydroxide, it opens the internal pore space so there's a lot of advantages to going to that type of system.

But there's an other thing that happens, is that also this has a decrease in calcium silicate ratio, if you increase the silica going this way, you increase the amount of soluble silica, and if that interacts with the ground water, particularly like in the case of Uranium, you start forming very, very insoluble uranium silicates. We're moving pretty quick, and there's a quiz afterwards. But this gives you some idea of the power limits of uranium silicates that can form, and so very rapidly you get the shoepite, and it modifies, it evolves Sunnite, but it eventually goes to the hematite, so you find these very, very ersalite, very stable uranium silicates, so we've tried to make a case that certainly in Yucca Mountain they ban cements, but they did consider that if you use high silica cements you can actually greatly reduce the mobility of Uranium. And their current model doesn't account for that. And so if you look like waste like spent fuel adjacent to cement, the cement then can promote these protective layers on the Uranium, and it's very dense. And even in a case where you have radiolysis and oxidizing conditions adjacent to the Uranium, its solubility is greater reduced by the -- we've done tests like this.

This is a centered urania and GI water for six months, this is the same sample in a cement core solution in six months, and you can see that the surface is almost complete occluded by calcium silicates that were spawned by the cement. Okay. So it's really difficult to interpret these tests, particularly, as Yogi Bera says, it's hard to predict things, especially when they're in the future. But short term leach tests are conservatives if you have the quality there. You don't form a second -- if you can assign a leach test where you don't allow the secondary stages to form, you get pretty conservative results. That's truly stripping away the surface. And if you look at the early phase of the glass leaching where you're diluting the surface of the glass, that's exactly what you have, but if you wait long enough, the secondary minerals form in the glass and you can get the Volkswagen started.

They're also conservative if the monolith matrix is relatively stable and the geochemistry of the disposal horizon. It doesn't hurt to try to match your waste form with its element disposal horizon. Now you minimize physical degradation of it. And ultimately, what you want to achieve is a waste form in a geochemical environment where all the reactions are pretty much controlled by diffusion, solid diffusion, and now we're trying to interpret the geological eras in terms of things like that, which is what we need in the case of transuranics.

To summarize, there's a tremendous body of knowledge. Cementitious waste form is probably the most widely used treatment across the DOE complex, so here's an enormous body of engineering knowledge on how to make waste forms and process the cementitious waste. All this disagreement about how to characterize risk in a near field transport, and the element of leaching the interaction, and there's really no coordinated effort at this time across anthropologists, and geologists, or repository designers on how to reconcile and coordinate the collation and taking of data, and trying to use natural and anthropomorphic analogs to make the fix. And that's it.

VICE CHAIRMAN CROFF: I'm going to -- first, I think we should do the questions and answers for Les right now while we've got it fresh in our mind, and then we'll adjourn.

DR. DOLE: I'll be back.

VICE CHAIRMAN CROFF: Well, I'm counting on that, and tomorrow we'll hear from the rest of this particular panel, and then we'll open it for -- Les will be here for rebuttal and this kind of thing. I'm going to assert the chairman's prerogative and ask a couple of things to start, and that is, my sense is what I'm hearing from you is that grout cements do pretty darned good in most cases when they, let's say, maintain their integrity, if you will. And I'd like your views on the susceptibility to degradation by a couple of mechanisms.

I think one is - let me just say cracking - in other words, over time through physical or whatever stresses, it cracks and it becomes a lot more permeable to water, which can get to it. And secondly, thinking about the example of something like a salt stone, something that has an awful lot of sodium in it, as the fellow from the Corps of Engineers brought up this morning, what does that do - I mean, if you get 15 or 20 percent sodium nitrate in this thing, does it sort of turn into - I don't want to call it swiss cheese, but something that a whole heck of a lot of water can get through and get to the radionuclides?

DR. DOLE: Let's take on the cracking. In so much as the ultimate transport surface from inside the monolith outside is the surface-to-volume ratio, we have cracking from tectonic produce some fissures through a monolith, but probably wouldn't change that ratio very much. You may be talking about crepitation like from heat shrinkage, we have fine micro cracks. The trick that is that, for example, when you cast these enormous monoliths for dams, you actually have to pout cooling coils in them to take the heat out. The heating reaction is intense for the cement reactions. That's another reason, so you can slow that down so that with a monolith the idea is to have a reaction rate low enough that you never really make the temperature rise enough where you get shrinkage crack. That's one trick, is to control the reaction rate so that it develops properties at a regular steady rate and doesn't overheat. That is one way to reduce the cracking.

The other way to reduce cracking is basically we design them so they're slightly expansive. We like it when the final formula swells a little bit, we're talking about .005 percent dimensional changes. If they are slightly swelling, then they create these internal stresses that actually close cracks. And finally, if you put excess silicates in here, there's a possibility that the unreacted components when they're exposed during cracks, they heal themselves, so all those things get popped. But the bottom line is that cracking is not a problem unless you reduce the surface-to-volume ratio to the point where the transport is unacceptable, and that's pretty rare.

Now the other question was?

DR. HAMDAN: Sodium.

VICE CHAIRMAN CROFF: High chemical

content effects on degradation.

DR. DOLE: Well, it varies. Certainly, the sodium and the nitrate will leach. I mean, obviously, if you have -- the hydro fracture grouts were also made with sodium nitrate solutions about 12 mol or 15 mol, and yes, sodium and nitrate leach out at a rate. The good news is that at the same time the sodium and nitrates are being diluted, the Strontium, Cesium, Cobalt-60 are not. That's one important thing. Yes, there is definitely a dynamic in which the diffusion coefficients for sodium and nitrate will probably be on the range of 10 to the minus 8, to 10 to the minus 9 centimeters squared per second at a time when the Cesium and Strontium, and Cobalt-60 would be 10 to the minus 10, 10 to the minus 13. So yes, it doesn't move in saturated water. And the goods news is, is that the nuclides don't follow it. And second, given the leach rate and the flux of water, like the shell and barrier, especially at Oak Ridge with 45 to 55 inches of veneer, and most of the hydrolysis in the first meter, how much exchange do you get with the biosphere? Is that an unacceptable loading, does that cause problems? Is the grass greener down range from your burial pit? Did I answer the question? It will leach. It'll leach at a different rate.

VICE CHAIRMAN CROFF: The message I'm getting is that chemicals will leach out, but they don't -- well, most of them don't tend to affect the grout properties and its retention of radionuclides very much.

DR. DOLE: At least in the first 20-30 years that we noticed. Now you can make some case that the illusion of the -- if you have solid bodies of sodium nitrate in there and then opened up the structure, would it change? We haven't seen it yet.

VICE CHAIRMAN CROFF: Okay. But the experience base is decades on this kind of thing.

DR. DOLE: Yes. And that's all you -- well, you would like to have 300 years.

VICE CHAIRMAN CROFF: Technetium maybe a couple of more years. Okay. I'm going to pass. Ruth.

MEMBER WEINER: I just have one questions. I notice that your chart of principal compounds, Uranium-containing compounds, you cite Uranium-6, and we found on the WTP Project that Uranium-6 solubility is very strongly dependent on pH.

DR. DOLE: Yes.

MEMBER WEINER: Do you find a problem when you get off of a pH, if your pH changes?

DR. DOLE: On pH if you don't silicates.

MEMBER WEINER: But the silicates will mitigate that.

DR. DOLE: And that's exactly what happened in the Yucca Mountain model. They put in the -- Rob Ewing put in the carbonate and the combination of carbonate and high pH gives you a very mobile uranialcarbonate complex. But even disregarding the presence of cement, if you have the silicates coming in from the top, it's not very mobile.

MEMBER WEINER: Thanks.

VICE CHAIRMAN CROFF: Jim.

DR. CLARKE: I just wanted to follow-up a little with you, Les, on your second point on your last slide. There's disagreement on how to measure, and there are different ways to measure leaching to put site specific factors into the test and all of that. And there's disagreement on which model they use, and I just wondered how far off are we on that? What is our ability to compare measured leaching rates to model predictions?

DR. DOLE: Basically, we do the ANS-16.1 for the dynamic leaching test, and if you take the early data from static leach tests, those are very conservative. And if you take those data and put them in your near field transport model, and things are okay, you're probably all right.

DR. CLARKE: What does "probably all right" mean? I just wonder about the uncertainty.

DR. DOLE: It depends on the setting. Once it's released to the waste form it goes into the near and far field transport models, depending on where your nearest receptor is, what the geology is.

DR. CLARKE: A more basic question, the agreement between the measured leaching rates and the predicted, how well can we do that?

DR. DOLE: Okay. That's where we really disagree. Some people think that you really predict something with a leach test, and I question that. You've predicted what you've done in the lab. You've done a post mortem on your laboratory test, how that relates to the real case. You can do the best you can to model it, and you try to do it in such a way that's conservative. That's the only thing you can try to do, is to design the laboratory test so it's conservative. And how do you do that? Well, you use real ground water, that helps because a lot of times ground water comes with alumina silicates, but to use deionized water, then that may be too much. That's very aggressive leaching, and so the tendency is not -- because you can reproduce deionized water, it's really hard to reproduce ground reliably and consistently, so the tendency is to use deionized water. Those are very conservative results, and if you can live with that answer, that's fine.

MEMBER HINZE: Les, speaking about grout and steel containers, what is the impact of iron on the grout, and grout on the iron containers?

DR. DOLE: I hate to sound like I say high silica all the time, but it's been my experience that certainly with high silica, the silicates.. I would see cases where I used to fish off -- in World War II they made barges out of cement because they were low on steel, and they used reinforced concrete barges, and I used to fish off a barge at the north entrance to Largo Sound, and one day they weren't biting, so I went over and I found a piece of iron and I hit a piece of concrete that was on a rebar. When it broke away, you could still see the machine marks on the rebar because the lightweight formula was use silica, and so you could see that it was right in the splash zone for 25 years and still was able to protect that surface.

MEMBER HINZE: And the grouting of the

waste in the stainless steel containers, do they use high silica?

DR. DOLE: Don't know. Who, which?

MEMBER HINZE: Yes. Okay. Thank you.

CHAIRMAN RYAN: Thanks for a great presentation. I really enjoyed it. You covered 30 years of cement chemistry and history in a short period, and gave us a good run through it. You mentioned a number of kind of what-if cases, if you do this, or if you add silica you'll get this kind of result. Has anybody taken a numerical view of trying to look at that as a system, like we've talked about in terms of estimating propagated uncertainties, and things of that sort?

DR. DOLE: Not in particular. I guess the closest they come is -- what were they called? Neurex was developing an expert system by using rules of thumb to design grouts for some of the --

CHAIRMAN RYAN: Yes, have an expert elicitation sort of approach.

DR. DOLE: Yes, but it doesn't address the kind of issues you were talking about.

CHAIRMAN RYAN: Well, it's an interesting thing to think about, I would suggest, and tell me if I'm wrong, that if we took a system, tried to define some system and said well, if we added silicate we'd get this kind of benefit. If we didn't add silicate, we'd get this kind of detriment, and then look at the ins and the outs, and try and get some assessment of what works and what doesn't. Not only that, but how much, what might it be. I mean, do you get an order of magnitude change, or a factor of 1.3, or six orders of magnitude change? It would be interesting to try and systematically find out where the bang for the buck is here, where do you get a big return?

DR. DOLE: Where we are right now, I don't want to get too Aristotelian, but we're looking at the shadows on the page, you're looking at the porosity changes, you're looking at the strength changes, things like that, permeability, physical things you can measure, but not down to the fabric and the chemistry of the fabric. That's why we bring up the idea of doing some of these -- trying to develop a thermodynamic diffusion control model, because in the end these things go rapidly and they're very amorphous, and then things start to evolve very slowly. How you do that, and you can imagine being trapped in intermediates, metastable intermediates because of the diffusion and so forth and so on.

There's a big gap between what we see at the bench and what these guys see in autoclaves with gold capillaries. There's a big gap in there.

VICE CHAIRMAN CROFF: Okay.

DR. HAMDAN: Yes.

VICE CHAIRMAN CROFF: How did I know this?

DR. HAMDAN: Yes, excellent presentation. Are there alternatives to grout for radionuclide?

DR. DOLE: Silicate? Calcium silicate, alumina systems? Well, certainly people have used Gypsum and phosphate cements, and they have some advantage. For instance, Argonne has used phosphate cements, and it doesn't require that you -- when you use a regular Portland cement you have to neutralize the waste. You use a phosphate cement it can fix acids directly with out neutralization.

I guess where I came from, again you talk about institutional -- Oak Ridge drifted into high silica cements in the late 50s, and so we've been stuck in the 50s for a long time. And we've been able to use it very successfully. And one of the things we do is we look out our window and we see mountains that were 240 million years old once, and they were alumina silicates, and so phosphate, there are phosphate formations, there are Gypsum formations, but they're pretty rare, so the majority of the systems in the crust of the earth that have lasted for a very long time have been alumina silica systems, so we stayed pretty with that. But there are other approaches.

VICE CHAIRMAN CROFF: Any other questions from anybody? I think we've worn them down today. Okay. I think that's it for the working group per se today. We'll reconvene at 8:30 tomorrow on that. Mike, do you have any non-working group administrative --

CHAIRMAN RYAN: Again, I think everybody that's got a V in the red badge, if you'll hook up with a staff person to take you back downstairs, we'll be happy to help you. And then also, we're scheduled to start at 8:30 in the morning so if you would get here maybe a little bit ahead of that, we'll be down to help get you back upstairs and there won't be such a crunch to get everybody in the door. That would be helpful, as well, so we're happy to help do that. Any other questions or needs from the audience? Okay. Then I guess we'll adjourn for the day and reconvene at 8:30 tomorrow morning. Thank you very much.

(Whereupon, the proceedings in the above-entitled matter went off the record at 4:30 p.m.)