UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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# DECOMMISSIONING WORKSHOP

U.S. Nuclear Regulatory Commission

Two White Flint, North, Auditorium

11545 Rockville, Pike

Rockville, MD

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The above-entitled workshop commenced, pursuant to notice, at 8:34 a.m.

P R O C E E D I N G S

[8:34 a.m.]

MR. NICHOLSON: Good morning. I'd like to begin the meeting and I'd like to begin the meeting by introducing John Greeves, the Director of the Division of Waste Management of the Office of Nuclear Materials Safety and Safeguards, of the US Nuclear Regulatory Commission.

John?

MR. GREEVES: Good morning. It's good to see so many of you here for an early start. I also know it starts to fill up a little bit as time goes on. So a couple of you might be here, a couple of the people might be grabbing coffee.

So good morning. This is a fourth workshop that the Nuclear Regulatory Commission is sponsoring, in part, to help us develop a standard review plan for the decommissioning program.

The standard review plan would support decommissioning of nuclear facilities, and this would include the reactor facilities. We've had a lot of contact with the reactors that have shut down recently, fuel fabrication facilities -- I see a number of familiar attendees in the audience -- and large nuclear materials licensees.

There's quite a stake that you have involved in this process and I'm pleased to see you participating in these workshops.

As I said, this is the fourth in a series of six public workshops, for those of you who may be here for the first time. The first one was held in December of last year and then we had follow-ups in January and March. These covered topics ranging from dose modeling, restricted use criteria, and ALARA analyses.

This workshop, as you know, is focusing on ground water modeling. A number of you were at an off-site meeting the last couple of days focused in detail on this. So I welcome you. I also want to welcome our regions. We have all four regions plugged in. I understand we

have some technical difficulties in terms of hearing what they have to say. So we'll get that fixed by lunchtime, but it's my understanding they can hear the presentations here. So I send my welcome to all four regions.

I'd like to thank the people here from industry, government and some of the academic speakers for taking time out of your busy schedule to join us. There's a number of interesting presentations. I'm going to try and stay for as much of the workshop as I can for the next two days and try and visit with you, so if there is something that comes up you need to talk to me about, I will be around to participate as much as I can.

Before I turn over the meeting to Tom King from the Office of Research, I've got a few administrative items.

We are planning topics for the future workshop on the 18th of August. The first day, we would look to have the comments on the current set of standard review plans that we have up. We have a number of modules posted. We've also, in this workshop and other venues, gone over the D&D screen code. We'd like to get some feedback on that, and the draft guide for 006, which we've put out for comment.

So those are some of the topics.

We could spend a day on issues associated with surveys and other issues identified by the states. The states have a large role in this process, because many licensees report to the agreement states. So we'd like some ideas on that front.

I'd like for you to contact Robert Nelson, if you've got other possible topics for the August workshop.

Copies of the draft standard review plan modules are up on our web site. Please take a few copies of these back for your colleagues. We are looking for comments on these till the end of the year.

Nick Orlando is the point of contact. I think most of you who have been to our meetings know Nick. So he is the point of contact for these comments. This is your chance to

provide input on the standard review plan process. We've gotten a lot of good feedback and some help in solving some of these difficult problems. So we appreciate that.

We do have a new web address and it's on that single slide that indicates which ones of the modules are up there. We're doing better. The address is shorter than it was before, but I'd like to challenge us to even make it easier to recognize.

So as I said, ten of the 16 modules are up on the web and we would appreciate those comments.

The rest of the modules we expect to be up on the web by the end of July and we have a full schedule today, so I don't want to really take much more time. So at this point, I would like to turn it over to Tom King.

Tom is the Director of the Risk Analysis and Applications Division in Research. So, Tom, please join us.

MR. KING: Thanks, John, and I want to add my welcome to all of you, also, to the workshop. Probably at the last workshop you had a different Division Director from Research up here, John Craig. We've reorganized recently and all the work on radionuclide transport and dose modeling has been relocated into a new division, which is my division, in the Office of Research.

So the people working on it are the same, but the name of the division has changed and the division director has changed.

I'd also like to express my appreciation for all of you who are participating in the workshop, particularly those of you who are going to give presentations, our contractors and other Federal agencies, people from Sandia, from Pacific Northwest National Laboratory, Argonne National Laboratory, University of Arizona, DOE and EPA, and, also, appreciate their helping to organize this workshop.

The workshop moderators are going to be Tom Nicholson, from the Research staff, who is in my division, and Jack Parrott, from the Office of Nuclear Materials Safety and

Safeguards.

The objectives of the workshop are to discuss ground water modeling using dose assessments, for demonstrating compliance with the radiological criteria, for decommissioning and license termination.

Today and tomorrow's workshop follows a two-day workshop we had Monday and Tuesday of this week out at the Department of Agriculture Center in Beltsville, Maryland, where the details of the research work in this area were discussed. Probably a number of you were there.

NRC staff and contractors are going to present their findings and discuss their ongoing studies in the area of ground water modeling. There are several places in the agenda where there is going to be opportunity for discussion of the presentations and the technical subjects, and I certainly encourage you to participate actively in those discussions.

To facilitate these discussions, we've attached, at the end of the agenda, a set of questions that might be used to stimulate some thinking and stimulate some of the discussion.

The staff is going to use the information from this workshop to help identify technical and licensing issues that need further work and help improve and continue to develop the guidance and the SRP, standard review plan, content for implementing the license termination rule.

It will also be used to inform the Commission of the status of the program. Because of that, we're making a transcript of the workshop proceedings today and tomorrow. We intend to publish these proceedings similar to previous workshop proceedings we've published on the same topic.

Like John, I'll be in and out the two days. So if any of you have any subjects you wanted to talk about, if you see me around, feel free to come and approach me and we can talk about anything that's on your mind.

With that, I'd like to turn it over to Tom Nicholson, who is going to talk about the

agenda and the objectives of the workshop.

MR. NICHOLSON: Thank you, Tom. I also want to welcome all of you to the US Nuclear Regulatory Commission. We're very pleased to have you here. I want to tell you just briefly about how we're going to run the meeting, so everyone understands the ground rules.

First of all, as Tom pointed out, we are going to have a transcript of this meeting, which will go to the public document room. This morning, Jon Hundley, to my left, your right, from Ann Riley & Associates, will be the courtroom reporter, and in order to help Jon do his job well today, whenever you ask, raise your hand and we will call on you to speak, if you could go to the mic and speak very distinctly into the mic, identify yourself and your organization, that would help Jon an awful lot trying to keep a transcript of today's meeting.

As Tom pointed out, there are going to be five group discussions. It's extremely important that all of you participate in those group discussions and to help the discussions begin, we've proposed a series of questions. We're not limited to these questions.

If you have questions that aren't listed here, you're more than welcome to bring them up and we'll entertain them. If we run out of time at the end of each one of those group sessions because of time issues, tomorrow afternoon, we're going to revisit the questions that have not been covered in the group discussions because of time limitations.

So hopefully we'll have plenty of time for group discussion throughout the meeting.

Now, I'm asking all of you, as the person makes the presentation, if you could let the person make the presentation without interruption, but at the end of every presentation, you're more than welcome to ask clarifying questions. But if the questions become more of a discussion topic, then we'd like to defer that to the group discussion.

So with that, I'd like to introduce our first speaker, Bobby Eid, from the Office of Nuclear Materials Safety and Safeguards. Bobby?

MR. EID: Good morning. My name is Bobby Eid. I came here to talk about a

very important issue, which is the ground water modeling and the dose assessment.

The major issue is how to integrate ground water modeling with dose assessment. My name is Bobby Eid, and I'm a Senior Technical Staff with the Division of Waste Management, and I lead the group who does modeling for development of the standard review plan.

My name, phone number and e-mail is on the left corner of the first slide. So please don't hesitate to contact me if you have any questions.

The title of my presentation is ground water modeling issues and dose assessment of decommissioning sites, critical group receptor, scenarios on site-specific conditions.

My presentation outline will cover the following areas; generic dose modeling issues pertaining to implementation of the radiological dose criteria under 10 CFR Part 20, Subpart E.

The next topic I will be talking about is the ground water models for screening analysis, focusing on generic assumptions and applicability of the screening models.

Then I will be talking about generic performance assessment issues for integrating ground water models in dose assessment. Specifically, the source term abstraction, compatibility of site conceptual models, critical group receptor, and exposure scenarios and pathways.

Also, I will be presenting some examples on conditions for pathways and scenario modification.

Then I will touch base on generic approaches for selection of input data, providing some thoughts on modeling of complex sites, and hopefully I will make some recommendations and some conclusions.

First, I would like to talk about the generic dose modeling issue pertaining to implementation of radiological dose criteria under 10 CFR Part 20, Subpart E.

10 CFR 20.1402, which is the restricted release criteria, first, it is required to have restricted use conditions; in other words, there would be no controls in place. Then the TEDE, which is the total effective dose equivalent for the average member of the critical group is 25 millirem, or .25 a millisievert per year.

The average member of the critical group scenario on pathways, as required under 20.1402, requires initiating or modeling using resident farmer scenario, specifically when we are talking about soil and subsurface contamination.

Then the pathways, they may be modified or eliminated based on site-specific conditions. And as you know, we have DG-4006 and NUREG-1549 to give you more guidance on this issue.

Also, under this regulation, you know that the ground water pathways are included. So you have to include starting with the dose modeling, you need to consider that, of course, if it is applicable to site, to include the ground water pathways.

In addition, you know that we do not have separate drinking water dose criteria, as possibly other agencies. So the 25 millirem will include, as well, drinking water pathways. The performance assessment timeframe, as you know, is 1,000 years. This is in accordance with NUREG-1496 and DG-4006.

Also, under the regulations, there are ALARA requirements. For 10 CFR 20.1403, which is the restricted use, the regulation requires that you need to demonstrate that further reductions and residual radioactivity to comply with 20.1402 would result in net public or environmental harm or they were not made because the residual levels associated with restricted conditions or ALARA.

In this case, under 1403, the average member of the critical group scenario is a modified resident farmer scenario based on site restrictions. The critical group member or the average member of the critical group may actually reside off-site, rather than on-site.

The pathways may be modified based on site conditions and restrictions and the

total effective dose equivalent also here is 25 millirem. However, the conditions now we consider restricted use conditions, like institutional controls, are in place.

Also, under 20.1403, you need to know that the average member of the critical group under unrestricted use conditions, so there will be two critical groups, one group under restricted conditions, other group under restrictive conditions, this means when institutional controls are no longer in effect, the TEDE dose to the average member of the critical group here in this case now is 100 millirem rather than 25 millirem under 1402, or 500 millirem provided that further reduction in residual radioactivity necessary to comply with 100 millirem are not technically achievable, would be prohibitively expensive, or would result in net public or environmental harm.

The ground water pathways are included under 1403, but may be eliminated based on site-specific physical conditions. This is an addition also to the -- for consideration of restrictions under 1403.

Again, no separate drinking water dose criteria and the performance assessment timeframe is 1,000 years.

Those are the generic outlines under our regulations and, in general summary, what is needed to be done. Now, in dose modeling, we'd like to make things easier for you. One way is by not collecting so much data or to go into much detail, by doing screening analysis. For screening analysis, we develop D&D code and models in order to demonstrate compliance with the dose criteria, without having much site-specific data.

The screening models currently we are having, they have special characteristics and they have special assumptions. The main characteristics and assumptions are, in a generic way, they are generally simple and conservative. For example, on D&D screen, we have what's called the three-box model. I guess many of you are familiar with this model, where you have the contaminated zone in the 15 centimeter, then the unsaturated zone, and then, of course, the aquifer or the saturated zone.

Also, these models assume a uniform surficial soil source term, typically, in the top 15 centimeter, but this could be expanded to be a little bit thicker.

Also, they assume the critical group receptor is on-site rather than off-site. So specifically for small sites, when you do dose modeling for ground water, you think about the receptor on a small site residing directly and performing all the following activities. Such that you think about what kind of transport under these conditions.

Also, typically, they assume that activity, leaches in the contaminated area via infiltrated water through the unsaturated zone to the aquifer, with no significant dispersion. They typically assume no retardation in the aquifer as we have in the D&D screen.

Typically, the infiltration volume is dependent on infiltration rate, the area of irrigated land, and the infiltration period.

The unsaturated zone and the aquifer are initially free of contamination. So those are the major assumptions for the screening models.

When you have your site, you need to do the dose assumptions and see your conceptual model for your site integrates well or is compatible with the conceptual models in the screening analysis.

Now, I would like to talk about the screening models and the default tables and their applicability. We are currently having D&D screen version 1.0 on the web site for use as a screening tool. We are testing and evaluating the current code and we may modify the screen numbers in the code.

We are testing the parameters, as well as developing default tables for soil. As you know, in November 1998, we developed a default table for beta and gamma emitters for surface contamination and we are now in the process of developing a default table for soil.



So the numbers in the current version 1.0 may change. So please note -- try to look at what we are doing, so in the near future, it we'll be publishing revisions. Just our notice

for modification of those numbers for screening.

So the screening analysis using D&D code or default tables, they typically apply under the following conditions. First, unrestricted release conditions. If you have site restrictions, this means you will be eliminating the pathways, this means you will be moving away from the resident farmer scenario.

Number two, the source term is compatible with the source term assumptions of the screening code. So when you use screening codes and models and default tables, you will need to ensure that your source term is compatible with the source term assumptions in that code.

The site physical conditions are compatible with the screening code assumptions. The unsaturated zone and the aquifer at the site would be free of contamination. If you have already contamination in the ground water, you need to think about using the screening codes before you try to use them to see how they are compatible with your site.

Also, in the screening analysis, all the code default scenarios -- you cannot use different kind of scenarios or default input parameters. As soon as you change input parameters, this means you are moving from the screening mode to the site-specific mode.

Only code and default input parameters are used unless approved by the NRC, who are in the process of modifying some of the parameters in the D&D code and then will inform you about these changes.

The next topic I would like to talk about is the generic source term abstraction, it's the generic ground water performance assessment issues for integration of ground water models into dose assessment. As I said, it is extremely important that the performance assessment issues for ground water and dose -- and for dose assessment, they must be integrated together. Otherwise, we may have inconsistencies in the models and the codes.

The first issue that you need to address to ensure that you have integration, proper integration between ground water modeling and dose assessment is the source term

abstraction. You need to assess, first, the source term configuration, to look at the contaminated area, the depth and vertical and horizontal extent of contamination, to look at the residual radioactivity profile, distribution, homogeneity, and if you have multiple sources or you have a single source, and then to look at the chemical form, specifically the solubility issue in this case applies for performance assessment.

The next issue to ensure that you have proper integration is to look at the compatibility of site conceptual model. The code conceptual model assumptions and mathematical computations should be compatible with the site physical and environmental conditions and the exposure pathway scenarios.

The model should also account for site restrictions and institutional controls.

The third significant issue to ensure integration between ground water modeling and dose assessment is the critical group receptor and the exposure scenarios and pathways. Under restricted release conditions, we initiate dose modeling using on-site resident farmer scenario and the exposure pathways. Thus, in ground water modeling, it's extremely important to consider where that receptor is located. It is on-site.

The pathways that are considered for that specific scenario include external exposure pathways, indoors and outdoors, the inhalation exposure pathway from the suspended soil for outdoors, indoors and surface sources, and from the ingestion pathways, this is a lengthy pathway, which includes direct soil ingestion, soil tracked indoors, drinking water, plants grown in contaminated soil, plants irrigated with contaminated ground water, and animal products grown on soil and fish products from contaminated surface water ponds.

Then you could modify the pathways and scenarios as necessary based on site-specific conditions. You may use more than one critical group or scenario, to multiple sources. In some cases, you may segregate the contaminated areas into more than one source area and you may need to remediate one area in a different way than remediating a second.

So you need to consider the possibility of having multiple sources on the site

and the impact of one source area on the other, in order to account for possibility for having multiple remediation options.

The next issue is the critical group and exposure scenarios. Under restricted conditions, initiation of dose modeling should be through the use of on-site resident farmer scenario and the exposure pathways. As we indicated and I explained, the pathways included under the scenarios.

Then modify the pathways based on site physical conditions, modify the pathway scenario based on site restrictions. We have here addition of site restrictions and institutional controls. So you could eliminate the pathways based on these restrictions.

Then perform dose analysis based on failure of these controls, because you need to meet two criteria; one criteria under restrictive conditions and another one under unrestricted conditions, under the same criteria, when the controls are removed.

You may need to perform, also, off-site dose assessment using a critical group receptor at the boundary of the site, because of the potential for off-site releases, and in this situation, you may require more advanced ground water modeling. However, we anticipate that for on-site resident farmer, specifically if the site is relatively small, ground water modeling would be simple.

Many of you may question about how can we modify the scenarios, how can NRC accept modification of the scenarios. Do we need always to use the resident farmer scenario? The answer is no, we do not need always to use the resident farmer scenario. You could modify the scenario and you could modify the pathways.

If you modify the scenarios and the pathways, you need to construct the local and regional characteristics of the soil. Maybe these characteristics, they do not support the agricultural activities or the pathways associated with that scenario. For example, the soil in the unsaturated zone, there are salty deposits and suitable for growth of plants and crops.

In this case, the agricultural pathways may be modified or eliminated under

these conditions.

Another example, the water quality or the volume of the aquifer do not support ground water exposure pathways or drinking water pathways. If you cannot have -- if the ground water is not suitable for drinking or for irrigation, this means the scenario, resident farmer scenario is inapplicable. You cannot apply the resident farmer scenario if you have quality of water that's not suitable for irrigation or for drinking.

So in this case, irrigation and drinking water pathways may be modified or eliminated. In this case, you may need not to address the issue or to do ground water modeling in this case.

A small site -- another example, a third example, when you have a site, a small one, situated in a highly populated urban area and historical and future planning records support the assumption that the site cannot be used for farming activities.

Like in the middle of a major city, and historical and future planning shows that this city is very unlikely to be developed into farming. So in this case, the scenario may be modified to a resident gardener scenario, for example, and instead of having farming, where you grow cows and crops and grains and all of these kind of activities and fish ponds, so you could eliminate those pathways.

So meat products, grain crops and fish pathways may be eliminated under this specific situation.

One last thing I would like to touch base is the generic approach for assessment and selection of input data. For input data, they are extremely important because the effect calculation of the dose. If you have highly conservative input data, as currently we have, in the screening analysis, of course, you expect to have conservative dose. But you could modify those based on site-specific conditions.

So for screening analysis, you need to use the current input data in the code or when you use default tables, of course, you do not need to have input parameters, without any

modifications.

Then you could use the mean values of metabolic and behavior parameters for your site. So you could assume a range of metabolic and behavior parameters or preferably you could use NRC's values for metabolic and behavior parameters in NUREG-5512, Volume 3, and 1549.

You could use also site-specific physical parameters based on available historical and environmental monitoring data. This data could be valuable, such that it could reduce the amount of effort of characterization that you may need to do for the site.

Also, you need to take a look at the regional data and to see applicability of the regional date to your site-specific conditions. There will be a great deal of information related to soil, data, climate, and hydrological data, which one of the speakers will address this morning.

Then conduct site-specific measurements focusing on sensitive parameters. You need to assess in advance what are the sensitive parameters in modeling, whether in dose analysis or in ground water modeling, and focus on dose parameters and see if you need to do measurements or you could -- you could have sufficient data available based on regional data.

So before going through much detail of characterization and analysis, you could focus on the sensitive parameters and if you need to do measurements, you go and do the measurements.

Then you need to establish reasonable ranges of parameter distribution and assess the uncertainties. We like to see the uncertainties and how conservative you are in your assumptions and how these assumptions they fit your site-specific conditions.

For site-specific analysis, the staff's current approach is to use the mean of dose distribution. So when you move to screening analysis to site-specific analysis, currently, we are proposing and most likely will adopt the use of the mean of the dose distribution. For screening analysis, we are not using the mean of the dose distribution, but this is not final. We are looking into that issue.

The dose modeling, you need to perform iterative dose modeling and assess the data needs.  So before going through much details of characterization and collection of data, try to do iterative dose modeling based on the available data and assess how much data that you need to optimize your dose modeling.

In some cases, certain sites could be quite complex and you need to have more advanced ground water modeling and analysis, and these will be based on site -- on case by case.  It's very difficult to explain these conditions specifically for each site and to make a list of those conditions.

However, I would like to give examples for these complex cases that you may encounter.  I would like to emphasize that those are very, very few sites.

So more advanced water modeling is needed for dose assessment for complex sites.  The first example, when you have extensive on-site/off-site ground water and/or surface water contamination.

Also, the other example, you may have on-site/off-site complex engineering barriers that are used in the performance assessment analysis.  In this case, you need to address the performance of the barrier and the transport through the barrier and the integrity of the barrier.

So these are becoming now more complex.  In other cases, you may have complex restrictions, maybe you propose very complex restrictions and conditions and you have multiple on-site barriers, but, in this case, you need to assess the source term issue and how these restrictions will apply and the critical group could be more complicated.  It is not only a single critical group; rather, there could be two or three or it could be more critical groups that represent the site in order to derive the dose.

Also, we have complex site review of -- but briefly, the way to deal with the modeling of complex sites is not exactly can be described in a plain language to you.  However, the staff will be reviewing those complex cases under case by case conditions, will review all the

details pertaining to these complex sites.

Finally, I would like to make some conclusions and recommendations for ground water modeling and dose assessment. First, there is no need for additional ground water modeling for screening analysis, because it's already taken care of.

Default tables and NRC approved screening codes could be used in this case, but the users, they need to verify the compatibility of the site conceptual model with the conceptual models and assumptions of the screening codes. So we need to verify how compatible these models and the assumptions in the screening code are with your site.

The critical group receptor exposure scenario and the environmental pathways are significant factors. The ground water modelers need to consider in their modeling analysis and they need to be addressed and integrated with the dose modeling. The ground water and dose modeling may be initiated using the default resident farmer scenario. So without having any information about the site, this is the first thing you need to assume, the resident farmer on-site, and you move from there.

The transport and dose impact pathways could be modified or eliminated based on site-specific physical conditions. As we gave an example, for the soil and the top of the aquifer. Site institutional controls or restrictions, potential off-site release conditions, source-term conditions, potential current and future land uses, as I explained, and, finally, the conclusion, the recommendation that dose modeling is an iterative process, initiated using limited data and conservative assumptions and subsequently optimized using site-specific data and actual conditions.

If you have any questions.

MR. NICHOLSON: Thank you very much, Boby. Are there any questions from the floor for Boby? If you could just go to the microphone and identify yourself and your organization.

MR. ROBERTS: Rick Roberts, Rocky Mountain Remediation Services. A

couple of clarifications. On your earlier slides, you talked about the D&D screening code only being applicable to soils, that's the top 15 centimeters of soil.

Does that mean if you have contamination below 15 centimeters, down to ground water and within ground water, you would expect there to be some site-specific modeling involved and the D&D screen model really would not be applicable?

MR. EID: I believe if the source term is different than your side, then you are, in a way, moving to site-specific analysis. The way you may have your conceptual model to fit with the top 15 centimeters, that Mark Thaggard will talk about, I will not talk about it right now, and if you convince us that you could have a conceptual model similar to the source term that we are having, which is in the top 15 centimeter, it could be more, it could be down from 15 to one meter, possibly, depending on the conditions of the site.

This means we could -- we may entertain to consider screening analysis, and Mark will talk about this.

MR. ROBERTS: And the second question is, you had said, in one of your overheads, that it would be acceptable to the NRC if you did a site-specific analysis to take the mean dose from the output distribution.

I just wanted to clarify that's from all pathways and not just from the groundwater pathway. That would be, if you had an output distribution and you took the mean off of there on a site-specific analysis, the NRC would find that acceptable.

MR. EID: For the all pathways applicable to your site, in case you eliminate certain pathways because of certain conditions at the site, still you need to calculate the dose from all pathways applicable to the site.

MR. ROBERTS: Thank you.

MR. NICHOLSON: Thank you. Yes?

MR. CHENOWETH: Good morning. Paul Chenoweth, NEI. I just had one question. On Table 7, you were talking about screening models and default table applicability,

and you indicate, at one point, only code input -- default input parameters are used and then, in parens, unless approved by the NRC.

What is the mechanism that a licensee would gain that approval in moving forward, if they decided to change a specific input parameter?

MR. EID: Currently, we have a code with input parameters and the probabilistic analysis for the input parameters has been established. We are reviewing those parameters and certain parameters will be changed.

An example of a parameter that may change is the mass loading factor for plant deposition. That's an example. We realize that it is highly conservative and we need to change it.

Now, when we change this parameter, we will let you know that we are changing that parameter, but if you have a proposal for a parameter that indeed generically that should be acceptable, you need to talk to the NRC in order to modify that parameter.

For example, before, we were talking about using the screening analysis for the current code about cesium and we realized we have soil to plant transfer factors, they are rather conservative, that they need to be modified.

So we are dealing with this and then we'll let you know about dose parameters. But, also, you propose to us that dose parameters, they need to be changed.

So this interaction, it is very fruitful and we are trying to modify now dose parameters.

MR. GREEVES: Just to amplify, Paul, I think a licensee should contact his project manager and work through them. It could be a public meeting, discuss it, and then whatever comes out of that. So work through -- the licensee would have to work right through his project manager on the record.

MR. CHENOWETH: Thank you.

MR. NICHOLSON: Are there any other questions for Boby?

[No response.]

MR. NICHOLSON: Thank you very much, Boby. And thank you for your questions.

Our next speaker is Mark Thaggard, also from the Office of Nuclear Materials Safety and Safeguards. Mark is going to talk about decommissioning decision framework discussion, focusing on ground water. This is from NUREG-1549.

MR. THAGGARD: As Tom mentioned, my name is Mark Thaggard. I'm in the Division of Waste Management, here at NRC. I'd like to say good morning to everybody.

I'd ask your apology, I do have a head cold. Can everybody see the overhead or do we need to dim the lights?

Okay. I'm going to talking about our decommissioning decision framework. I'd like to acknowledge my colleagues at Sandia National Laboratory, who actually put this framework together under contract here at the NRC.

I have included my telephone number and e-mail address in case anybody needs to get a hold of me after the workshop.

The purpose of my presentation is to go over our decommissioning decision framework and, in particular, to talk about how ground water analysis would fit into this.

This schematic here on the right is a diagram of the decision framework. I'm not going to go over it right now, because I am going to be talking about it as I go throughout my presentation.

As was mentioned earlier, it's documented in NUREG-1549. NUREG-1549 is referenced in our draft guidance document 4006. So some of you may have already -- may be familiar with this already.

In terms of framework, I would like to talk about a few important aspects of it. The decision framework is similar to the hydrogeological decision framework put together by Freeze and Massman and some others in a series of ground water articles in the early 1990s.

Some of the ground water people may be familiar with that work.

I would also like to emphasize that the framework is still under development. So because 1549 is linked to our guidance document, which is a draft, we may see the need to change this framework at some time in the future.

We've been testing the framework out on some test cases and we also currently have Sandia testing the framework out on a fairly complex decommissioning site.

The framework should facilitate decision-making for a range of sites from simple to complex and it should facilitate the decision-making by providing us a structured approach for evaluating a range of decommissioning options and these options can include the remediation, land use restrictions, site characterization or some combination of these.

Ultimately, we intend to implement the decision framework in the computer code called SEDSS, which is being developed through our Office of Research.

Over the last couple of months, as we've gone through these workshops, we've kind of given you guys a lot of information and some of it may be a little bit confusing.

So I'd like to really step back for a moment and say how this framework fits into the analysis for these various sites. Some people may take a look at the framework and say, well, gee, what if I've got a simple analysis or a site that doesn't really ought to have an analysis, do I really need to walk through this maze or this complex process.

So if we group our decommissioning sites based upon the type of analysis that we anticipate, we can see how these various analyses would fit into using the framework.

Some sites can be decommissioned obviously with doing no analysis. For example, if we've got a site that has sealed sources, where they can demonstrate that the sealed source has not leaked, then they decommission without doing any kind of analysis. These sites will fall outside of the decision framework. So a licensee for one of those type of facilities wouldn't even need to be bothered with the framework. And obviously, because there is no analysis, there would be no ground water analysis for those sites.

Some sites can probably be decommissioned using screening analysis, as Boby went through earlier. For our screening analysis, we assume that the only information that you have for doing the screening analysis is information on the source term. So in step one of the framework, it's kind of difficult to read here, you would gather information on your source term.

For step two, which is defining your scenario, we've defined two scenarios for screening analysis, the building occupancy scenario and the resident farmer scenario.

For the building occupancy scenario, we assume that there is no ground water exposure for the resident farmer scenario. As Boby mentioned, we do assume that there is ground water exposure.

In terms of our conceptual model, for the screening analysis, we've already defined the conceptual model. So it's a little bit incumbent upon the licensee to make sure that that conceptual model that we've developed is applicable for their particular site, although we've developed these conceptual models with the goal of trying to have wide application.

As we move into step four of the decision framework, where we're actually doing the dose assessment, this can be done -- for screening, this can be done using look-up tables or actually running the D&D code.

I would like to point out, also, that for the screening analysis, all the parameters have been established. So you can use default parameters.

In step five of the framework, you basically make a decision at that point. You look at your results from your analysis and compare it against the dose limit. If you pass the dose limit using the screening analysis, then you move on to steps six and seven.

Step six is where you carry out your ALARA analysis. On the other hand, if the screening analysis indicates that your site don't pass, then you'd probably want to look at some other options on ways that you might be able to demonstrate that you pass.

You obviously wouldn't stop just at the screening analysis. So you would move into step eight and start identifying some other options, and one of those options could be the

use of more site-specific analysis.

So let's talk a little bit about site-specific analysis. A site-specific analysis, we assume that you have a little bit more information about the site. The step one, we recommendation that you gather all available data that you have about your site, and the reason I underlined available there is to indicate that at step one, we're not recommending that you go out and do a full-blown characterization program. It may be possible to do some preliminary analysis based on just the information that you have available and doing those preliminary analyses may steer you in terms of what information might be most fruitful.

Then as you move down to step two, similar for the screening analysis, the ground water pathway is generally included for the resident farmer scenario. But when you get into a site-specific analysis, as Boby indicated, you might have some data that could allow you to either determine the specific type of use or maybe even to justify excluding the ground water pathway all together.

When you get into step three, where we're looking at developing our system conceptual model, generally, for a site-specific analysis, we assume that you have enough information, more information about your site so that you can develop a site-specific conceptual model.

Generally, what we're talking about here is that for most analysis, we're using computer codes where they have predefined ground water conceptual models, and the emphasis here is that we need to demonstrate that those pre-defined conceptual models are appropriate for our particular site, based upon what we know about the site features and processes.

In step four, for the dose assessment, you would use -- you can use the D&D code, the RESRAD code, or some combination of other codes. There is wide latitude.

We're going to be -- we're going to have some presentations throughout the workshop on the conceptual models in D&D and in RESRAD. Also, you may be able to use a

more complex ground water code to do some more sophisticated analysis, if you think that's necessary for your site. However, if you do that, then there are some issues that need to be addressed in terms of how you link the ground water analysis with the dose analysis, and we're going to also have some presentations on that tomorrow.

Again, at step five, you have a decision. You look at your dose assessment, the results from your dose assessment, compare it against the dose limit. If you pass, then you move on to steps six and seven. If the dose analysis indicates that you don't pass, then under step eight you would start evaluating various options that might allow you to be able to pass the limit.

And then on step nine, these various options would be evaluated, and these options could include, as I've indicated, characterization, remediation, the use of land use restrictions or some combination of these. You could have actually part of the site where you're proposing to have land use restrictions and part of the site you plan to remediate. So there could obviously be some combination and there could actually be another part of the site where you may think it's pertinent to gather some additional data so that you can refine your analysis a little bit more.

When we talk about characterization, most times people think about collecting data to change the parameters in the analysis. But there's actually other information we could also gather as part of characterization. Obviously, the most important one would be to collect data to support changing parameters.

As I've indicated, at step one, when we initially gather the data to begin the assessment, we use whatever available information we have and some of that information may not be all that relevant or tied to our particular site.

The preliminary analysis may help us focus in terms of which parameters are most important for the analysis. So for the Kd, we may realize during our preliminary analysis that the Kd is an important parameter. Well, one of the options that we would consider under

step eight here would be to go and get some more site-specific data on Kd.

One other thing I should have mentioned, in step one, when you're gathering available data, there's a lot of data that's readily available and we're going to have some discussions on this throughout the workshop.  There's data available on the internet, there's data you can get from your local soil conservation service or even your nearby university.

But some of that data may not be particularly relevant for your particular site, but it may be adequate to at least begin the analysis.  And as you get through doing the preliminary analysis, it may help you focus on which parameters you actually need to think about collecting more site-specific data.

Another option on characterization would be to gather information to support changing your conceptual model of the ground water system.  If you've started your analysis using a code like D&D, which has some severe limitations on the conceptual model, or even RESRAD, for that matter, one of the things you may want to consider as an option under step eight would be how you could change the conceptual model.  So that would be another type of characterization, would be to gather data to help support the changing of that.

Then another one would be to gather data to support changing the land use restriction, as Boby pointed out earlier.  Typically, we include the ground water exposure pathway in the resident farmer scenario and so we may do some preliminary analysis and turn out that the ground water pathway is the most important pathway, where one of the options we may consider under step eight would be to gather some information that could help maybe support eliminating that pathway, as Boby pointed out, things such as the well yield or the water quality, things of that nature.

The bottom line is that the framework provides an opportunity or provides a way to help focus the characterization effort.  If site characterization is selected as our preferred option in step ten, then we will implement it in step eleven of the framework, and then whatever changes that we need to make in terms of the parameters or the models or even the scenario,

that would be implemented in step twelve, and then we would basically reiterate back through the framework again. So it's an iterative process.

So that pretty much concludes my presentation and I'll try to answer any questions that you have.

MR. NICHOLSON: Thank you very much, Mark. Are there questions of Mark on the framework?

[No response.]

MR. NICHOLSON: If there are no questions, I'd like to call on our next speaker, Dr. Phil Meyer, from Pacific Northwest National Laboratory.

Dr. Meyer and his colleague, Dr. Gee, are contractors for the Office of Research. We've asked Phil to give you an overview on the ground water conceptual models that are inherent in the D&D, RESRAD, NEPAS and PRESTO codes, and the types of information that would be needed in order to use those ground water models, those conceptual models, excuse me, within those dose assessment codes.

Phil?

MR. MEYER: Thank you, Tom. Can everybody hear me okay in the back there?

I was asked to spend a few minutes talking about ground water conceptual models of D&D, RESRAD, NEPAS and PRESTO, all dose assessment codes that involve the ground water pathway.

I thought since most of the authors of these codes were going to be in the audience here, that I didn't want to get bogged down in details and finding out that I didn't really know what I thought I was talking about.

So I'm going to avoid talking about most of the details and emphasize the similarities between the codes and similarities in the parameters related to the ground water pathway.

So I thought that it might be useful, since we're talking about conceptual models, to start out by asking the question just what is a conceptual model, so that we can have a common understanding.

This is one definition of a conceptual model that was taken from a National Academy of Sciences book on fractured flow or flow in fractured rocks, and they described a conceptual model as a hypothesis that describes the main features of geology, the hydrology, geochemistry, and the relationships between these different components.

This idea of a conceptual model, then, is a mathematical modeling that goes on -- is a mathematical modeling, is a process of hypothesis testing, whereby you can propose different hypotheses for the way things work in your system and then use a mathematical modeling to test this hypothesis and reject or accept various hypotheses.

As an example of that sort of thing, I'd present a figure from a report at the Hanford site, prepared for the Hanford site. This is one of the tanks in which there is high level waste, and this figure encompasses various means by which the contaminants from the tank can make it down to the ground water, including things like clastic dykes and breaks in this caliche layer, leaks at the top.

So this figure describes a variety of hypotheses by which contaminants may move in the environment. The rest of the report went on to examine several of these hypotheses using mathematical models.

As an alternative, perhaps a more conventional version of what a conceptual model is, it is a pictorial or a qualitative description of the ground water system itself and it involves the same components, hydrogeologic unit, system boundaries, that is the boundary conditions, inputs and outputs, sources, sinks, and all the parameters and properties that are needed to completely specify that system.

In this version, mathematical model is a quantitative representation of this conceptual model.

Usually, these pictorial representations look something like this. This is also a tank farm at Hanford and the figure just shows various -- a conceptualization of the way the soils vary throughout the site, underneath the tank farm, with questions and variations, heterogeneities.

Here is another example, also, of the soils underlying the tank farms at Hanford, a more particular site. You can see the same sorts of structures, somewhat simplified.

As a further simplification, we might see something like this, where the heterogeneities have been evened out into a series of homogeneous layers, basically rendering a 1-D flow system.

So these ideas of conceptual models that I have presented always couple a conceptual model with a mathematical model; that is, in general, the analysis to take place involves both. You have a conceptual model, which represents your ideas of the system, and a mathematical model, which implements them in a quantitative way.

I'd just -- I put this slide together to try to illustrate some of the issues there and some of these concepts. The conceptual model is here and informing that conceptual model, we generally have a number of inputs. We have regional or -- what I call regional or analog information, which is what Mark referred to as available information, perhaps, stuff that you can gather from other sources.

Then, also, site-specific field observations about properties and boundary conditions, et cetera, for your model.

These data all go into forming a conceptual model and then in order to either do your hypothesis testing or to do any quantitative analysis, that's coupled with a mathematical model and then there's some sort of iterative process whereby field observations may modify your conceptual model, which, in turn, modifies the mathematical model and changes your ideas about how the system operates.

So some basic concepts expressed very simply.

Two things to be aware of here. You can take the same information, two people or the same person, can look at one group of information and develop multiple conceptual models from the same information; that is, there's usually some sort of ambiguities involved and there is no single conceptual model that will be consistent with the data. Usually, there's more than one.

So in this conceptual mathematical framework, as Dr. Neuman will discuss later, you can end up with a separate mathematical model for each conceptual model, that alternative conceptual model that you can propose.

Alternatively, for a single conceptual model, you may implement it in more than one way, in the mathematical model, and that situation is quite similar to the models, RESRAD and NEPAS and PRESTO. They all embody fairly similar conceptual models, but they're implemented somewhat differently. And the fact that their implementation in a mathematical model is different means that you could run the same -- the code on the same problem and arrive at two different solutions.

So given that discussion, I wanted to now move into a bit of specifics about those codes. Just describing what I see as the similarities in the ground water conceptual models for these codes.

This is a figure that represents the D&D model and that's already been discussed somewhat by Boby Eid, but what we basically have is a contaminated zone here, a vadose zone, which is a simple box, an aquifer and perhaps a surface water pond. That's D&D.

This is a figure here taken from the RESRAD 5.0 manual and we see something very similar. There is a contaminated zone, an unsaturated zone, a saturated zone, and perhaps a surface water pond. The representation here, although they're somewhat different, there's a lot of similarities; that is, the contaminated zone is assumed to be fairly uniform.

The unsaturated zone is either uniform or a series of layers, each layer which is uniform. This figure could also be used for MEPAS or PRESTO. They are very similar.

The exposures are also fairly similar.  There's usually a well maybe on-site or further off-site, and in the aquifer, the mixing that goes on there is described perhaps differently, but in similar ways.

So just to summarize these, I have a slide that I believe highlights the major assumptions of these models that are held in common by all the models.  That is, they have a simple near-surface water budget.  So the input water to the system that drives the transport is all described in -- described in every case by a very simple water budget model.

The codes all assume that flow in the system is steady-state; that is, it's constant with time.  The flow is one dimensional throughout the system and advective transport is also one dimensional, down through the unsaturated zone and one dimensional in the saturated zone.

There is a small number of layers, contaminated zone layer, maybe a few vadose zone layers, and aquifer, and each of these layers has uniform properties.  In addition, they all assume some fairly simple aquifer mixing to determine what happens in the transfer of contaminants from the unsaturated zone to the saturated zone.

So given those assumptions, we can ask ourselves, well, what are the site-specific conditions that might violate those assumptions.  I list some of them here.  I don't think this list is all inclusive, but I did identify these conditions.

Preferential flow, that is, flow in the near surface that could lead to enhanced infiltration that wouldn't be considered by the simple water budget models.  Transient flow could lead to changes in dose that would be significant and violate the assumptions of these models.  If we had significant heterogeneity, this was mentioned by Boby earlier, two or three dimensional flow, focused flow, fast paths, and fractured formations.  These all lead to conditions that concentrate flow in small areas instead of spreading it out as the codes all assume.

So I'm going to finish my talk just by going through the parameters of these models that are basically all held in common.  This will lead into later talks by other people and

also by myself that will discuss the parameters in detail, data sources, that sort of thing.

The near surface hydrologic input, this deals with the water balance, the water budget at the surface, determining how much water goes into the system.

Specify yearly net infiltration rate. So that's the purpose of this component and all the codes require this net infiltration, which I define as the amount of water that moves past the root zone; so the amount of water that's going to contact the waste and contaminants and produce the contamination that potentially will result in exposure.

Basic water budget is solved by all these codes in some way or another. Infiltration equals precipitation minus a combination of runoff and evapotranspiration, or water used by plants. Irrigation may be included, if desired.

The parameters here, net infiltration rate, for instance, D&D requires that you just simply input the net infiltration rate.

If this is calculated actually from the relationship like this, then it requires you to input precipitation, either as an average annual value or perhaps as a monthly average value. Runoff needs to be calculated somehow, either specified directly as a fraction of precipitation or else calculated using something like the SCS runoff method, which requires a curve number.

Evapotranspiration could be either specified directly as a coefficient, again, or else calculated in some manner from a variety of meteorological parameters.

In the contaminated zone, a similar situation exists. All the codes basically have -- require the very similar parameters. The purpose here is to specify the contaminant flux to the unsaturated zone, given the net infiltration rate.

The leaching models vary somewhat between the codes, but are relatively similar. The parameters required in terms of calculating this contaminant flux are thickness of the zone, the area of the contaminated zone, bulk density, the porosity and potentially the effect of porosity, which are related, and the water content.

Now, the water content may either be specified directly or else it might be

calculated using a simple assumption on the nature of the flow and the variety of soil, specific parameters.

Then the distribution coefficients for each contaminant are also required.

Again, those parameters are required by all the codes in one manner or another.

With the unsaturated zone, the purpose here is simply to continue the transport, contaminant transport to the saturated zone, determine the flux. The parameters required, again, are the number of layers, the thickness of each one of those layers, and then within each layer, bulk density, again, porosity or effect of porosity; a water content value, which, again, may be either specified or may be calculated using a simple relationship.

Distribution coefficients and then in some cases, a dispersivity value may be an option.

Very similar in the saturated zone. The purpose here is to calculate the flux to the well or the surface water, and, Charlie, you pointed out to me that the RESRAD mass balance model does, in fact, consider -- although all the contaminants end up in the well, the mass balance model does consider the time to the peak -- time to peak dose in the saturated zone itself.

The parameters required are basically the same as in the unsaturated zone, thickness, bulk density, porosity, specific discharge. Again, this is like water content. Specific discharge may be either specified directly or calculated using a simple relationship and a couple of parameters. Distribution coefficients and then dispersivities. Dispersivities may be multiple, because some of the codes allow dispersion in the longitudinal direction, as well as transverse.

There are just a few other parameters related to the ground water pathway, related to exposure terms; that is, the depth of the well, distance to the well, and the well pumping rate. These parameters aren't required by all of the codes, but in some manner, they have parameters involved that determine basically dilution in the well, whether or not it occurs and the effect of dispersion.

So in conclusion, I would like to just point out that the way these models may be used, and you might be tempted to use them, is to do the opposite of this, where you actually use the -- accept the model before you set the conceptual model for your site, and it should be the other way around; you want to fit your mathematical model to your conceptual model, not vice versa.

So if you determine that your site does not fit the conceptual model as one of these codes, then consider very carefully before you decide to use one of these codes and consider what the implications of doing that are.

As I've discussed and mentioned many times here in my short talk, these codes are all very similar. They embody similar conceptual models and the parameters required are very similar.

Now, that doesn't mean, as I mentioned before, because the implementations are different, it doesn't mean that they're going to give very similar identical results.

A number of comparison studies do exist between these codes and I list a couple of them here. This is a draft report that I believe is available on the NRC decommissioning web site. Charlie, you also mentioned to me a paper and a report with additional RESRAD comparisons and I can give you that reference or Charlie can give that to you, if you're interested.

Also, this NUREG here compares D&D to a variety to a variety of numerical and hybrid codes.

So are there any questions about what I've talked about?

MR. NICHOLSON: Thank you very much, Phil. Are there any questions for Phil on the conceptual models within RESRAD, MEPAS, D&D and PRESTO? A question from John Greeves.

MR. GREEVES: Yes, to loosen this group up a little bit. Phil, either you or other speakers, as you go through the day, both Mark and Boby talked about a transition from the

fairly simple -- actually, going from a screening case for the lucky licensees who don't have complicated sites, but then you step into the D&D and RESRAD type models and you showed us a quite interesting picture of the Hanford site.

My question to you and others, as you go through the meeting, can you give us some insights as to what the experience base is in going from RESRAD to a more complicated model and particularly out at Hanford, if you have that knowledge, what type of modeling is used out there and under what circumstances could you select these various models?

I can imagine, even on the Hanford site, at some locations, you could use screening technique. Others, you might be able to use RESRAD, but for the tank you just put up there earlier, I have my doubts about using some of these simple models.

So do you have any experience base on that, you and other speakers? As you present, I think it would be useful if you share. And it's really the 1549 methodology. You walk through that and there are places that it says you can't use this model, it's too simple, it doesn't match the conceptual model, you need to go to a more site-specific model.

So, again, if there is some background you have on that, or other speakers, I think the audience would appreciate hearing how that process takes place.

MR. MEYER: Sure. I can just offer a couple of comments related to the Hanford site and also discussions that we had in the research review meeting on Monday and Tuesday.

In general, and this is the case at the Hanford site, in fact, at the tank farms, MEPAS has been applied fairly extensively. In general, you assume the simplicity, unless your -- at least this is the way things work in practice.

You assume the simple case, unless you are given evidence to suggest that things are not quite so simple. And in the case of the Hanford site, it was evidence of contamination in the ground water that violated people's assumptions about the way the unsaturated zone behaved, as the contaminants showed up when they weren't expected to.

And this caused people, some people -- of course, there were some people who were already thinking this, but it caused many people to start asking questions about the representation of the unsaturated zone and so then, at that point, because there were observations, field observations that didn't match the conceptual model, then you had -- it had to be that the conceptual model was wrong and it needed to be modified in order to explain the field observations.

The difficulty, as we discussed yesterday at length, is that in a site characterization, if you don't go out looking for things that violate your conceptual model, then you will never find them until perhaps sometime far in the future when the contamination is some place potentially where it's totally not expected to be.

That is the difficult issue of trying to do an efficient site characterization and still look for things that violate your conceptual model.

I'm sure other people here in the audience can offer other ideas.

MR. GREEVES: Just as a follow-up, I thought I had heard that Hanford was developing a site-specific model. Now, was that a version of MEPAS or -- I'm a little beyond my depth here, but I thought I'd try --

MR. MEYER: Hanford is a huge site and it involves a lot of smaller sites which are having analyses and models developed for specific sites. As far as the unsaturated zone modeling, most of that or all of it that I'm aware of has been on a site-specific basis, small-scale. Some of the ground water modeling has been for the entire site.

MR. NICHOLSON: Again, a question from the floor. Would you identify yourself, please, sir?

MR. TAYLOR: My name is Stew Taylor. I'm with Bechtel Power Corporation. A follow-on question. The suite of models you presented, could you clarify what assumptions regarding the initial state of the saturated zone, whether it's contaminated or uncontaminated, what's the underlying assumption?

MR. MEYER: I believe, and some of the authors of the code could correct me on this, but I believe that with MEPAS, I'm pretty sure you can specify, if you have some information to specify the distribution of contaminants in the saturated zone, you can perform a simulation with the contaminated zone that's actually within the saturated zone.

With RESRAD, I think that it's been -- it's capable of doing that, they've done that in a comparison, I'm pretty sure, but I'm not sure how straightforward that is. And with PRESTO, I'm not aware of that.

The D&D, it definitely violates the assumptions.

MR. TAYLOR: So if there was an aquifer -- or a site with an aquifer that was already contaminated, we'd be either driven to use one of the codes that allows the initial condition of contamination or, alternatively, go to a more complex numerical model, perhaps.

MR. MEYER: Definitely, if you have contamination in the aquifer, then you should be using a code that allows that. D&D does not, as Boby pointed out in his talk, so you would not be able to use D&D in that situation.

MR. TAYLOR: Thank you.

MR. WOLBARS: Tony Wolbars, from EPA. Does that mean that a reasonable way to check your code would be to start the clock running at a much earlier time and see if you end up with a contaminated aquifer?

MR. MEYER: Some people have done that sort of thing. I'm not sure if -- this may be a discussion that we want to carry some other time. We're getting a little bit sidetracked.

If you haven't satisfied the conceptual model of -- if your site does not satisfy the conceptual model requirements of the code, then doing the sort of thing that you're talking about could lead you to an erroneous conclusion nonetheless.

I'm not sure if I'm answering your question, but we could maybe discuss this a bit later.

MR. NICHOLSON: I think during the group discussion. We're going to take a

break in about a minute here. There's a couple of things I wanted to point out. First of all, as Phil points out, the authors of the codes are here and they'll be making presentations, talking about their conceptualization. Dr. Cheng Hung from EPA will be the next speaker after the break.

Also, I want to point out that some of the viewgraphs were missing this morning. We're having copies made. They're out on the table out in the foyer. So by all means, pick those up.

Are there any other questions before we break?

[No response.]

MR. NICHOLSON: Okay. Let's take a 15-minute break. Be back here at about 10:20. Thank you.

[Recess.]

MR. NICHOLSON: As people are sitting down, I want to let you know that some of you haven't been able to sign in. We'd really appreciate it, because we're keeping a record of this public workshop and it will be going to the public document in about a week, and it's important that we know everyone who attended.

So those of you who haven't signed in, on the table in the foyer of the auditorium, in the back there, there is a signup sheet. So if you could please put your name down, it will be part of the transcript record, because we want to make sure of everyone who is here. If you'd accommodate us, I'd appreciate that.

I'd like to now continue the discussions. This morning, we were lucky to hear from NMSS staff on what their view is on decommissioning and on the framework, and then Phil was kind enough to walk through the conceptual models for the conventional dose assessment codes, and now we're going to talk in particular about one of those codes, the PRESTO code.

Our next speaker is Dr. Cheng Hung. He's from the US Environmental Protection Agency, the Office of Radiation Protection and Indoor Air, and, Dr. Hung, you have

the floor.

MR. HUNG: Thank you. Good morning. First of all, I would like to say thank you to NRC staff members for letting me speak on these topics. As you all know, the ground water pathway is one of the most important pathways in the risk assessment model, and more so, the calculation of the well water concentration, pumping out from the pool is also an important process.

So my presentation will start with a theoretical background of this calculation and going to the practical modeling. In that section, I would like to present the upper bound model and semi-dynamic model.

Following that, I would like to say the difference between the results of the analysis between these two models and make the conclusion of that.

First of all, the system we are considering is a steady, uniform flow condition in the aquifer.

And in the system, we assume that the boundary condition will be the dominant injection, at the optimum, and then at the boundary, well have a well scheme sink. With this kind of schematic, we could write the equation that's shown here. Because of the steady uniform flow, all we need is a mass balance equation.

In this equation, we would include that they are diffusion term, convective term, and decay term. For this particular case, we used a line source injection and at the sink, we assume that they will screen as a sink.

So as you know, trying to solve this equation, we would need that three-dimensional model. One of the examples that we use in there, flow surface model that the -- we all know that trying to integrate this type of complex three-dimensional model into this screening type of risk assessment model is impossible.

So we at the practical point, we do need a practical model. In the practical model, all I see are all these models would divide into two important steps.

The first one is the transport through the aquifer. In this calculation, we're trying to calculate the transport through the section of interest or to analyze for the plume. At the second step, we're trying to use the result that we calculate from there, from the first step, and to calculate the concentration of the water in the well.

Trying to calculate the transport through the aquifer, the basic equation will be the same that we originally had, but we don't really need the sink as a boundary condition.

So in the practical model, we're trying to simplify our calculation and all the models, like in the previous presentation, different models have different types of simplification.

So MEPAS has their own simplification and RESRAD has its own simplification, and the PRESTO model also has a different simplification. We will talk about that a little bit later.

The detail, just that the simplification is not the scope of this talk, so I'm going to -- I'm not going to talk about this. We'll concentrate on the transport through the pumping well.

As you know, trying to define the equation to calculate the well concentration is quite complex. I couldn't find any governing equation. So the purpose of this talk, I would use the dimensional technique just to show the functions, it's shown here.

This equation simply says that the concentration in the well is a function of Cw, the radionuclide, the concentration in the well water, the transport through the well section, and blah, blah, blah, blah.

So this is just to show the function, and I couldn't find the governing equation for that.

So we have to based on this to see how all the model transport, I simplified that. So as I look into the model, there's two types of models that are currently being used.

The first one is the upper bound model and the second one I call the semi-dynamic model. So I would like to go into the detail of these two types of models.

First of all, let's see what the upper bound model do. The upper bound model,

trying to simplify it just that the calculation and say just calculate the upper bound. It means the maximum concentration that a person drilling a well at that location, what the maximum concentration you could get.

The way to calculate it, theoretically, using the screen, the well screen, and calculate the moving average concentration when we move in this and get the maximum for that. This is the way to calculate the maximum equation concentration.

So you know that this is a rather simple way to do it, but you calculate the maximum probable equation or concentration. The scenario of this occurrence will be minimal.

Let's move into the semi-dynamic model, which is what the PRESTO model used. Before that, I would like to talk about the transport through the aquifer, how our PRESTO model calculates that. The PRESTO model uses a one-dimensional model to calculate the transport through the section at the well. The PRESTO model uses a dynamical solution that will be a simple equation. This is the boundary conditions.

Using the boundary condition, this is the radioactive decay term. We suggest that you could have some sort of -- would have some sort of error. So we needed one correctional factor. So this correctional factor was derived at, and it's in our paper and I'm not going to describe that here.

But this includes a function -- this correctional factor is site specific data. You can calculate from the site-specific data, that P is the number, probably people are not too familiar with that number. That's involved at the diffusion term.

So we suggest we can reasonably use the simple calculation to get the rate of radionuclide transport.

Of course, being a one-dimensional model, we don't calculate that the -- we cannot calculate that the plume. So now I -- let's go into how the PRESTO model calculates the transports through the pumping well.

The first step is trying -- we have to design the configuration of the well. In

designing this, we have a concern. It's that the well will be drilled by a licensed well driller. That's the best under typical state regulations.

That means we suggest that if the driller is putting in the drilling machine to the site, it means additional costs due to incremental well depths is minimal. The increase in the depth is just the drilling machine, if they take a few minutes, and they had a steel pipe, it's at the minimum.

So all this -- that the well driller and well owner would like to go into as deep as possible to secure the water quality and the water quantity.

So you know -- everybody know that in our case, the risk assessment considers that contamination is in the vadose zone. So in order to get a better quality, we have to go the well as deep as possible.

The third assumption is that we try to do a -- simply by that calculation, we assume just a well. The screen depth -- actually, the screen depth would be just at the bottom parts, but we assume that the whole depths will be screened.

The reason for that is a conservative assumption. With this kind of calculation, if you compare it with a three-dimensional model, it's screen depth at the bottom, that would get a higher concentration.

The reason I say conservative is that it's higher, but if you use that three-dimensional model to calculate the screen depth at the bottom, then you get much, much less concentration, but it's not the maximum concentration that the critical population may expose.

When you move downstream, then this concentration would increase. So we use, in the PRESTO model, this is the upper limit of the concentration when you move that downstream.

So I would say this is a conservative assumption.

With this kind of assumption, then the previous function can be simplified into a

very, very simple form, and with this form, we can find that they are -- the equation for calculating the concentration in the well is transport divided by available dilution of water. So it's a very, very simple calculation.

So let's compare the two models. We can see the upper bound model is very easy to calculate the concentration, there is no question about that, and -- but it would give an overly conservative, compared with the PRESTO model, overly conservative dose values. And the important thing is that the third one, it may unnecessarily boost the cost of disposal or decommissioning or cleaning up.

On the other hand, we look at the PRESTO model, the semi-dynamical model, as we discussed it before, it doesn't really add too much process in the calculation. So it's reasonably easy to calculate the concentration.

Secondly, it gives reasonably conservative, this still conservative dose to barriers. That's a very important thing. It's still conservative.

The third one could result in the reasonable cost of disposal or decommissioning or clean-up.

With this kind of difference, we would like to see how much is the difference. We use just two models. What's the difference? So what I took one example that's just from the NRC report, that's the analysis showing -- analyzed just at the plume. I used that as an example. And then assuming that the well is located at the X=80, that location, and for calculating the moving average, I used the screen depth of one meter and for the PRESTO model, we assumed a depth all the way down to near bottom, about two feet above the bottom of the aquifer.

So the screen will be 18 meters for the PRESTO model and the result, we can see that the upper bound model would be 0.31 units per cubic meter and for the PRESTO model we got .056 units per cubic meter. That's a big difference. The difference is about a factor of 5.5. That's a big difference.

So from this discussion, we'd like to make a conclusion. The first is that the 3-D model used in the calculation for well water concentration is extremely complex, that everybody should agree with this, and the second is that the simplified upper bound and the semi-dynamical model are commonly used, a practical model. And the third is that the upper bound model is easy to use, but you get overly conservative results and boost up the disposal cost.

The last one would be the use of semi-dynamic model may be slightly more complex, but it gives a reasonable conservative dose, and could result in reasonable disposal costs.

So that concludes my presentation.

MR. NICHOLSON: Thank you very much, Dr. Hung. We are going to have copies of his viewgraphs. They aren't in the back, but we're going to get a copy of these and provide them to you after lunch.

Are there questions of Dr. Hung on his conceptualization and calculation of well water contaminants for a given plume? Yes, Dr. Neuman, from the University of Arizona.

DR. NEUMAN: Dr. Hung, I have two technical questions. With respect to your statement that the calculation is conservative if you assume DW to be the maximum. I don't understand that.

It seems to me that if you had a screen which just touches the plume and does not draw clear water to it, you should get a higher concentration; therefore, a more conservative result.

In fact, I'm looking at your equation, CW equal to QP divided by V times DW, C is inversely proportional to DW.

Let me also ask the second question and then you can maybe answer both of them, and I'll sit down.

My second question is when a well pumps, it develops a radial flow regime. In a

radial flow regime, the velocity is not constant. So V is not a constant.

Your calculation seems to be a two-dimensional one. How do the two relate?

MR. HUNG: That's a good question. See, the first question, as I mentioned, you use the bottom screen, near the bottom, because you know the plume is on the top. If you use the three-dimensional model to calculate, they draw most of the water from the bottom.

That would go down a bit, but mostly it comes from the bottom. We use the model and calculate it and it's small.

The second question is that --

DR. NEUMAN: Radial flow.

MR. HUNG: Also, if you look at the plume and the potential line and flow line using the 3-D model, you will see that it narrows down into that area. So actually, although you get it -- most of the flow is coming from nearby the well.

MR. NICHOLSON: Are there any other questions for Dr. Hung?

[No response.]

MR. NICHOLSON: Thank you very much. And as Dr. Hung indicated, he is going to be submitting a paper for the proceedings and his references in his discussion of the 3-D code you were talking about.

He'll have a reference to that. That was developed by Hydrogeologic Inc. for us many years ago in the Office of Research.

I'd like to now introduce our next speaker. Our next speaker is from Argonne National Laboratory, Charlie Yu. Charlie is going to be talking about ground water and radionuclide transport model used in RESRAD off-site. So this is the second conceptual model that Phil had talked about. First is PRESTO. Now we're going to hear about PRESTO on-site -- excuse me -- RESRAD off-site.

MR. YU: My name is Charlie Yu. I'm the RESRAD Program Manager at Argonne National Laboratory. I will give the introduction of the ground water transport model

using RESRAD off-site and then my colleague, Dr. Emmanuel Gnanapragasam is going to talk about the details of the models that we implemented in RESRAD off-site.

As you probably already know, we have three computer models. We call it the RESRAD family of codes. RESRAD itself is an off-site model. You can see that the well is located at the site boundary. Although we have two options in RESRAD. One is a mass balance model, which assumes the well is located at the center of the contaminated zone, but the default model is that the well is located at the site boundary. We call it non-dispersive. It's considered advection, but dispersion is not considered in the on-site model.

If receptors are located at off-site locations away from the contaminated zone, as shown here in this picture, the well is located off-site. There is a distance from the well to the contaminated zone.

In this situation, if you don't consider dispersion, you are too conservative, it will give you a much higher dose or much higher water concentrations.

So several years ago, we conducted a benchmarking comparing RESRAD, the on-site model, with MEPAS, the PRESTO code, and MMSOILS code, which is another EPA model which deals with hazardous chemicals.

At that time, we compared the results and we showed that there is some difference, significant difference if you don't consider dispersion. I'm going to show you some of the results, the benchmarking results that we did a couple, two or three years ago.

Before I do that, I want to mention that the RESRAD, this is an on-site model picture, if we move the well off-site for the transport, we developed a new model including three-dimensional dispersion for the model. But for air dispersion, when people are living off-site, the air dispersion pathway is simply used, CAP-80, which is the EPA model, to handle the air dispersion part of the transport of contaminants.

This are the results that we did several years ago, two or three years ago, comparing RESRAD, MEPAS and MMSOILS, PRESTO code, that was three years ago. So by

now, probably all three codes -- the other codes are probably already modified, but I'm not quite sure yet.

Here it shows that MEPAS and MMSOILS concentration profile here, they pretty much overlap, and this is the concentration of strontium-90, a parent nuclide that does not have daughters. The advection dispersion equation using MEPAS and MMSOILS is pretty much the same. So they've got pretty much the same results.

RESRAD, we took the opportunity when we did this benchmarking, we added dispersion to the model and we can get this curve here, which the peak dose is lower and the reason is that the definition of the retardation factor in RESRAD is different from the definition of the retardation factor you see in MEPAS and MMSOILS. We used the total porosity and other codes use the effective porosity and so on.

So if we modify the retardation factor, we can get this curve. This simply shows that the dispersion model incorporated into the RESRAD off-site, we can get comparable results compared with other models.

That's for parent radionuclides. Let me show you some daughter nuclides results. This one in a source, we have uranium-234 and uranium-234 decays to thorium-230, and this is the concentration profile for thorium-230. Initially, in the source, there is no thorium-230. And uranium has a KD-7, in this case, seven milliliter per gram and thorium has 30 milliliter per gram.

So uranium has lower KD, is less absorbed in soil during transport and so when uranium transports from source to well, it decays and thorium-230 was generated, and thorium-230 has higher KD, so it's highly absorbed, transported slowly towards the well.

And this is the results that we got over here, and the MEPAS results are here, and the MMSOILS is here.

I mentioned that MMSOILS and MEPAS, they use pretty much the same dispersion advection equation. So MMSOILS should get a curve like this, but MMSOILS

modelers, they adjust their concentration by the retardation factor of daughter and parents to get this height, which is comparable to what RESRAD got.

And this curve is another result done by MMSOILS modelers. They used another numerical model, I'll call it DPM. This numerical model can handle three-dimensional dispersion and decay or ingrowth of daughters, but they got this shape. So they got this daughter thorium-230 tail, which has a similar shape as what RESRAD models that way.

So we expected, because thorium-230 has lower KD, so you expect that they move slowly towards the well, so you expect, with the tail, something like this.

And this is the model that we developed at that time for benchmarking studies and then they have incorporated this model into the RESRAD off-site model. So RESRAD off-site has this model in the code, but this model is not in RESRAD on-site model.

If you would like to get a copy of the RESRAD off-site model, we can send it to you. You can send it e-mail to us. Actually, eventually, we're going to put the whole RESRAD family of codes on the web, so you can download it.

The RESRAD model, a new model is coming out, version 5.9, and will be on the web sometime next month, probably July 1st.

That's my brief introduction and now Dr. Gnanapragasam is going to talk about the details of the three-dimensional dispersion model, implementing RESRAD off-site.

MR. GNANAPRAGASAM: I will talk about the ground water transport model, both the movement of water and also the contaminants. The first two slides show how we modeled the movement of water in the RESRAD. First, in the unsaturated zone, we take the infiltration rate and use the soil moisture, saturated soil moisture, hydraulic conductivity relationship to calculate the saturation ratio that is needed to support the infiltration rate that we have at the site.

We checked to make sure that this satisfies the field capacity constraints that may be imposed. Then we applied the saturation ratio that we calculated to the effective

porosity that the user might specify to find out the amount of moisture that will actually participate in the movement of water, and we divide the infiltration rate by that moisture content to find out the actual rate at which water moves in the unsaturated zone.

For the saturated zone, we get the inputs, the hydraulic conductivity and the hydraulic gradient and we compute the velocity of movement of water, divided by the effective porosity in the saturated zone, to get the actual rate at which water moves in the saturated zone.

Moving on to how we compute transport of radionuclides, we have two different models, one for the parent -- that is, the nuclide that enters and exits the zone in the same form -- and a different model for progeny, where nuclides parent enters the zone and then we're interested in the progeny coming out.

For the parent, we have this transport equation, which considers the dispersion in the longitudinal direction and also retardation of the nuclide. Our definition of the retardation factor is shown here and we have an equation for output flux.

For the progeny nuclide, the situation is a little different. We have the input flux of the parent. We need to consider its transport up to some length, at which point it will transform into the progeny, and then the progeny will be transported, this equation, and this distance could be anything from right at the top here to the very end or bottom down here.

Finding a solution for this equation is a little difficult and so we make one of two approximations. We either can consider the transport velocity of the parent and longitudinal dispersion and assume that the progeny will also move the same rate as the parent or we could say that dispersion is not important and, therefore, we will use the parent velocity and progeny velocity and account for their different transport rates.

You could also do a third case value and say longitudinal dispersion is important, but this time we will transport at the rate of the progeny and not of the parent. That could be useful if the parent is short-lived and decays at the top, so it's mostly traveling as a progeny.

In RESRAD, if you input different KDs for the parent and the progeny, it will default to the case of considering their different transport velocities and it will ignore dispersion.

If you input the same KDs, it will then do this. If you do input different KDs and you still want to do dispersion, you can set that option, there is a button for that.

If you have a case where you think that both dispersion and progeny and parent KDs are important, we could model that, to some extent, by subdividing the unsaturated zone. Right now, we allow up to five subdivisions for the unsaturated zone, and we will look at that case, considering a two-member chain. If you're having a parent entering here, I've turned the saturated zone sideways -- the unsaturated zone sideways so that you can put it on the screen here, if your parent is entering here and your progeny is exiting here, then we have five different sub-zones, then we have five components to the progeny flux coming out here. One would be the parent entering, transforming in the sub-zone, and then traveling as the progeny to the next four zones. This would traveling as the parent in the first zone, transforming here, and then the next three zones and so on.

Looking at the case of the component where transformation is in the fourth zone, if you divide it into five different zones, RESRAD would account for parent transport and dispersion in this zone, same for the three zones. Here it's traveling as the progeny, so it would account for its retardation and dispersion. In here the user has to make a choice, because we cannot do all three. The user may choose to model the parent retardation and dispersion, or parent retardation and progeny retardation. This one we do not provide at the moment, dispersion and progeny retardation.

And in this manner, we can, therefore, account for -- say, if you choose this option, where you think travel is important, we can account for dispersion in four of the five zones or 80 percent of the region and we would account for retardation over all of the region. If you go the upper route, you do dispersion over the full zone and in four of the five zones, you would account for the correct transport rate.

In that way, you could consider both factors. Obviously, it would take a little more time because you have five zones instead of one, the computation time, that is.

In the saturated zone, we have a different situation. We have lots of nuclides coming in here and we are interested in a concentration somewhere out here.

Again, for the parent, we can follow the equation, considering longitudinal dispersion and also dispersion in the lateral direction. For the transfer dispersion, both vertical and horizontal, we use an approximation and the purpose of that is we also want to be able to model transfer of dispersion of the progeny and this approximation allows us to use the same equation of both parents and progeny.

We also output well water considerations in relation to what is in the aquifer and by using the approximation, it allows us to do a semi-analytical computation of the concentrations in the well instead of having to get too many points and do a numerical thing. It also cuts down on the computation time.

To take the considerations of the well, we look at the well and try to figure out what part of the upstream end of the aquifer contributes to this well. So although things are really at the end of the well, far upstream, it would be still straightforward and we want to find out what cross-section upstream contributes to the well.

And we assume that the depth of the aquifer up to the specified stream will contribute to the well and we get the width based on the pumping rate and flow velocity in the aquifer, and then we get the average consideration in the aquifer or that cross-section, because we assume that all that water will enter the well.

For the progeny transport in the unsaturated zone, we can again go to the same thing. We have to consider two of the three factors, and you can do that, and, if you want, you can, again, subdivide the saturated zone into different zones so that you can model both factors.

The consideration is a little different here because if you want to subdivide, you have to be able to get the expression of input flux this way and output flux there. We have that

expression. Then we use the unsaturated zone expressions for flux in, flux out, and then we have another expression for flux in, concentration out. And we combine all of them and when you subdivide, we can go up to a 100 subdivisions, although if you too high, you run into situations where, because of the subdivisions, there is a loss of accuracy. Up to about 25 to 50 subdivisions, the loss of accuracy, so far, for the cases I tested, within five percent.

And when you go up to 25 subdivisions, you essentially are modeling both dispersion and retardation in 24 or 20 of those subdivisions and then ignoring one of the factors in only one -- say, as many subdivisions as you have progeny, and that helps us model both factors when there is a need for that.

That's about all I have on this. Are there any questions?

MR. NICHOLSON: Thank you very much, Emmanuel. Are there any questions for Charlie or Emmanuel on the RESRAD code, their presentation?

MR. THAGGARD: I'd just like to ask, what is the status on the documentation for that, the off-site ground water code?

MR. YU: We have used this guide for the RESRAD off-site. We have draft documentation describing all the equations available. If you'd like to get a copy for review purposes, we can send you a copy.

MR. EID: I have a question to Charlie. What is the possibility for using probabilistic analysis for the off-site RESRAD code? Is it available?

MR. YU: It's available.

MR. EID: Within the code itself?

MR. YU: Within the code. I believe it's also uncertainty adding --

MR. GNANAPRAGASAM: Same as RESRAD.

MR. YU: Same as RESRAD, I'm sorry. But it is available.

MR. EID: Thank you.

MR. NICHOLSON: Thank you very much for your presentation. I'd like to invite

Walt Beyeler to join us at the table. Walt? What we'd like to have now is we'd like to have a group discussion now and Mark Thaggard is going to lead us through the group discussion. We've heard these presentations this morning on conceptual models and you've gotten some background from the NRC staff on the framework.

We would now like to have a group discussion on conceptual models and scenarios. These are a series of questions. If you turn to page four of your agenda, on page four, the same thing is on your agenda, and we'd like you to interact with the people here at the table. We'll go around the table and just quickly introduce. Most of you, you've already heard from. But Walt Beyeler, if you could raise your hand, please.

Walt is from Sandia National Laboratory and he's been working on D&D. Gene, do you feel comfortable talking about MEPAS? Do you want to join us also at the table? Okay. Gene Whelan from Pacific Northwest National Laboratory is also here and he's worked on MEPAS quite a bit. MEPAS was developed by PNL.

We'd like for you to ask questions, as we go through these questions themselves, for clarification, and we're asking the people at the table to contribute, also. So, Mark, lead us on a discussion.

MR. THAGGARD: I would just like to say that there isn't necessarily a right answer or wrong answer. We want to kind of have an open dialogue here. I think the way we're going to do this is we're going to give people the opportunity to speak and then if nobody speaks, then as the moderator, I get the free will to start calling on people, and that certainly includes the audience.

Why don't we take these questions one at a time? The first question is under what circumstances can the ground water pathway be eliminated. We've had a lot of feedback from some of the previous workshops, people asking what kind of justification is needed to eliminate the ground water pathway. So I think we'd like to get a little bit of dialogue going on that.

I mean, we've got some ideas certainly in terms of what we think might be some justification, but we would like to hear and get some feedback from other people.

Would anybody like to take a stab at that? I know there are some people here that have got ground water problems. Dave?

MR. FAVER: Dave Faver, ISI. I guess a general topic for a conversation is how would the path life of the radionuclide come into play on this decision.

If you have an area that is essentially exclusively supplied by a local water company and wells are just not typically used in that area, for example, if you have a short half-life radionuclide, should that factor into the decision-making in terms of the probability of the well being dug in that area over the effective time that the water would be contaminated?

MR. THAGGARD: I think that's kind of a new concept, the use of a half-life. Anybody else have any other comments? Walt?

MR. BEYELER: It seems that to a large extent, this question may be a matter of regulatory policy. There are certainly physical aspects of the system that will enter into that consideration, hydrodynamic properties of the aquifer, can it yield quantities of water that are consistent with the assumption scenario.

I think it's largely a matter of policy, I would think, as to how those considerations weigh in, whether it's relevant for the analysis or whether the scenario is meant to capture the physical characteristics of the system, whether it is meant to be a sort of stereotypical surrogate.

MR. THAGGARD: I think what we have heard so far is we have heard that the use of the radionuclide half-life, if we've got short-lived radionuclides, that might be justification -- of course, there are physical limitations, which I think Boby talked about some of those physical limitations during his presentation. Obviously, if you've got a site where you've got minimum ground water yield, that might be -- that's a physical limitation, so that might be justification, or if you've got ground water that's contaminated.

I'd like to hear maybe from some of the industry people. I know this gentleman,

I've forgotten your name, from NFS, you're currently working on a problem with the ground water. Is that correct?

MR. KIRK: Scott Kirk, Nuclear Fuel Services. The issue that we are up against is at what depth do you model the ground water. For example, if you have shallow ground water, contaminants that may be in unconsolidated sediments, but site-specific information leaves us to believe that the most typical well installation practices using state regulations would indicate that the wells would be installed in bedrock.

And the transport models indicate that the ground water would not be affected at this depth. Would that be justification to exclude the ground water pathway?

MR. THAGGARD: If I understand that correctly, you're saying the use of state regulations.

MR. KIRK: Not only state regulations, but also site-specific information. For example, if you did a study, like a five-mile radius from your site, and you have indications that all wells are installed deep in the bedrock and that you indicate that behavioral traits or the average member of the critical group would comply with state regulations, both of those allow you to exclude the ground water pathway.

MR. THAGGARD: I think the current use, if you summarize it that way, you're saying one justification would be current use. If you can demonstrate that people in the area are not using the ground water, then that might be justification that should be considered.

Did I paraphrase that correctly?

MR. KIRK: That's correct.

MR. THAGGARD: Does anybody else have any other comments on this question? Like I said, there's no particular right or wrong answer here. We're just trying to get some free thought going here. Yes? And I should know your name, from Sequoyah Fuels.

MR. ELLIS: John Ellis, from Sequoyah Fuels. EPA has a ground water classification scheme that actually has a quantitative number for yield. I believe it's -- say, it's

typically ground water would fall into what they call Class 3 if it's less than 150 gallons a day.

I was wondering if the NRC has considered trying to develop some sort of a quantitative standard. At our site, particularly, when you get down into bedrock, we hand-bale most of our monitor wells dry. It's kind of hard to conceive somebody putting a well in there that would yield enough water to support a household, and that's been the premise of our argument to eliminate the ground water.

But we don't find anything in the NRC guidance or regs that would allow us to adopt that EPA concept or some version of it.

MR. THAGGARD: I think that's one of the areas that needs to be looked at, and this gets back to the physical limitations issue again in terms of -- obviously, if you can't get the yield to support the use that you model, then that might be justification.

Now, what that number should be, whether it's 150 gallons per day, I guess, still needs to be debated a little bit.

MR. ELLIS: I might add just one other thing, too. Specific to our area, virtually all of the rural households in a relatively sparsely inhabited area are provided by rural water systems and we believe that that ought to be a strong factor in the consideration. There are highly developed systems for treatment of surface water and distribution all over eastern Oklahoma, where we're located, and except for households that are located along the stream bottoms, where there's some alluvial ground water, you don't find any domestic wells.

Just the vast majority are served by these water systems and we also think that that ought to be a criteria by which the pathway can be justified to be eliminated.

MR. THAGGARD: So that kind of gets back to the surrounding land use argument again. Paul Chenoweth.

MR. CHENOWETH: Yes, I'm Paul Chenoweth, NEI. This discussion, I think, is very fruitful and this is a great opportunity in these workshops to highlight these.

I guess the question would be, how can you feed back the answers after you've

thought about it? Is there a way for you to, for instance, in a guidance document, document some of the sources that a person might use that the NRC would find acceptable for determining, for instance, that ground water was not potable or not acceptable for use?

Is that merely just the state regulations or the local county regulations in the area or are EPA values already available and so forth? It seems like for salinity, for quality, quantity, et cetera, it would be a very big help, I think, for the industry to know where to go to get that data to document these assumptions.

MR. THAGGARD: Yes. Tom reminded me, we're going to be talking a little bit about that during the next session, some of the data sources, some of the information that's readily available, and ultimately, as we resolve this question, NRC resolves this question, then we would certainly look to try to provide information on where people can get that type of information to justify. John?

MR. GREEVES: John Greeves. Mark and others, I think a way to do that is to put it in the standard review plan. If we've got some clear cases demonstrating where we, as an agency, don't think the water pathway applies, we can write that right in the standard review plan as basically guidance for our reviewers.

One example is salt water. We could write that right in the review plan. If the water body is too salty to drink, we're not going to use that in our review procedures.

So I think these kinds of workshops, to the extent we can come up with those examples, they could be written right into the standard review plan and then I think licensees would have some comfort that, well, it's in the review plan, I think that's the place we'd like to locate these things and that's why we have the review plans on the web and we're looking for feedback.

If you, whoever you are, have recommendations on cases where it should be included or cases where it shouldn't be included, we want to hear about that.

Actually, the agreement states also have these questions and these issues. So

this whole series of workshops, the modules on the web are opportunities to document that and the way to record it is to get it into the standard review plan.

So I'd just offer that to all of us as a goal.

MR. EID: Yes. I would like to add to what John said, it's true. We will be placing, in the standard review plan, the areas that you are very clear where you could eliminate ground water pathways and I gave examples in my presentation for three cases, that they are very clear you could eliminate the ground water pathways and the associated agricultural pathways with the ground water and drinking water, of course.

There are also other areas where you cannot eliminate the ground water pathways and those are very clear and it will be explained in the standard review plan. However, there will be gray areas where it is very difficult to decide whether you could eliminate or you cannot eliminate the ground water pathways and it depends on the site-specific conditions and you need to provide other information in order to justify for elimination on the ground water pathways.

Those will be explained as gray areas and the need for additional information, of course, would be based on site-specific case conditions.

MR. THAGGARD: Okay. Why don't we move on to the next question here? I think we got a lot of good feedback on that first question. We've kind of touched on this second question a little bit during this morning's session. It has to do with what site features and processes would make the selection of the simple models inappropriate for a given site.

I think we would kind of like to lay out some of the -- I mean, Phil, in his presentation, talked about some of the simplification that -- how some of these models are very simple and they may not be completely appropriate in all cases, and we would kind of like to lay out some of those and maybe get some more discussion on that.

And why don't we start with Dr. Yu? Can you think of some specific places where you would think that RESRAD may not be appropriate?

MR. YU: Before I answer this question, I want to make a comment on the previous one. There are circumstances that you can eliminate a ground water pathway for certain purposes, maybe in the review plan, you'd want to list them out. If the water quality is not good enough for drinking purposes, you can eliminate the drinking water pathway, but not the feeding livestock and irrigation purposes. You still can use this water for irrigation purposes.

MR. EID: This will depend on the quality of the ground water. If a certain quantity of the ground water can't be useful to support the livestock drinking and to support also the irrigation, the salinity could be so high, I mean, certain brackish water, of course, you cannot use it even for irrigation. So it depends on the conditions, the salinity, and depends on other factors.

The type of soil also could impact what kind of crops you could grow. So those could be taken into consideration.

MR. YU: But I'm just saying that you should not have just one criteria to eliminate all the ground water related pathways.

MR. NICHOLSON: So which one do you think for RESRAD?

MR. YU: What site-specific features, process, events, would make the selection simple dose codes not conservative. While RESRAD -- the RESRAD model is -- we're trying to make it more realistic. The on-site model is conservative because there is now considered dispersion. What feature is not conservative?

Do you have any comments on that? I cannot think of features -- it's pretty --

FROM THE AUDIENCE: Or appropriate.

MR. YU: Or not appropriate.

MR. THAGGARD: What we've mainly had in mind, not conservative, but if you can answer it for not appropriate, that's good, too.

MR. YU: Well, if the model doesn't fit. Of course, you can see that -- Phil Meyer presented a conceptual model. If your hydrological conditions are so complex, it doesn't fit the

conceptual model, then it's not appropriate.

MR. THAGGARD: We've had this gentleman standing for a while. Can you state your name?

MR. MAIERS: My name is Bob Maiers. I'm with the Pennsylvania Bureau of Radiation Protection. Pennsylvania did a considerable amount of characterization work for our state in an attempt to site a commercial low level waste facility and we have several automatic disqualifiers which I think apply to this question.

Some of the automatic disqualifiers we had were the existence of Karst geology, the existence of flood plains, the existence of underground mining activities in the area, the existence of oil and gas wells.

The reason why these are automatic disqualifiers for a commercial facility are basically because it makes it very difficult to model what's going on. So I think that this should actually be addressed and pointed out to licensees that when they have features like this on-site, these models are not appropriate.

MR. THAGGARD: Thank you. Before I get to you, Tom, this gentleman.

MR. BELLINI: Frank Bellini, Duke Engineering at Yankee Atomic. I have one input parameter and I know how it works in RESRAD, I'm not sure how it works with the other codes, that kind of dogs me, and it is the depth of the well intake, the pump, or I guess it's the depth of intake water level for the well.

I find it gives me a great deal of variation in my ground water dose by varying that, for example, from a depth of one meter to three meters to ten meters to 30 meters.

I'm not sure how to deal with it. I don't know how the other codes deal with it. It's not exactly addressed to the question here, but I'd sure be interested in your comments.

MR. THAGGARD: Do you have any comments on that?

MR. GNANAPRAGASAM: If you put the well too deep, you are drawing in clean water and that's why it varies too much. So if you want to be conservative, you should put the

well right at the depth of the plume.

MR. BELLINI: Sure. I can put it at one meter, but I'm not sure -- that's awfully non-realistic, I'll call it. I'm not sure what the right depth is and whenever I run the code for ground water, I'm really not sure.

MR. GNANAPRAGASAM: With the off-site, when there is dispersion, it will be a little less dependent on the depth. With the on-site code, it's not dispersed in the vertical direction. It is sensitive.

MR. BELLINI: So it sounds like I'm doing the right thing and struggling with it anyway.

MR. YU: In running the code, if you have extra data where the screen is, you should input that into the code, but if you don't have that, you probably need to be more conservative. You can run a sensitivity analysis, make sure the screen is catching the plume so that you will get the conservative dose concentration.

MR. GNANAPRAGASAM: Also, it depends on the pumping rate. So if you put too small a depth and you put a large pumping rate, it's going to put it on the sites, so you not only need to look at the depth, but also the pumping rate.

MR. BELLINI: Okay. The other parameters, I have this huge river that the site is on, but it's backed off the river enough so that the drainage area, using the drainage area for this whole big river, which has, I don't know, a 1,000 square mile drainage basin up above the plant, versus using a smaller drainage basin in the area of the plant, creates an issue of which should be used.

I suppose you could answer that and say, well, use both and try and bracket it again, but I'm not quite sure how your model works in terms of providing dilution either from a very large upstream drainage area versus a small local drainage area.

MR. YU: You're talking about the surface water pathway? That drainage area is used to -- it's a dilution factor in the code for the surface water considerations.

MR. BELLINI: Right. Well, I can use a dilution factor for a 1,000 square mile drainage area or I can take my local drainage area of five square miles and the result will vary accordingly.

Any wisdom on how that might be applied, other than bracketing -- using both, trying both ways and bracketing it?

MR. YU: You don't the actual --

MR. THAGGARD: Why don't we move on? That's probably a little bit site-specific. I think it's a generic issue in terms of --

MR. CARTER: I think my comment and question kind of goes to this, really, because I think the commenter from Commonwealth of Pennsylvania and this commenter, too, have some problems that I think are rooted in the form of the question.

It isn't so much what site-specific features rule out use of certain models. I think what really matters is -- and, in fact, I think you can use almost any model on any site if you're willing to be conservative enough and careful enough.

What really matters is whatever model you settle on, make sure it's representative of the site, and if you're talking about a 10,000 square mile drainage area and you're worried about concentration in this little particular area close to your source, that may not be appropriate, it's just not realistic.

You have to make the model match the site. That's the key thing. With respect to the Pennsylvania discussion about ruling out certain features, that makes perfect sense if you're going in and proposing to site a facility that is not sited yet.

In our applications, we're trying to terminate a license -- licenses on sites that are already there. I mean, we don't have a option to site the site, it's there. So the question is how do we represent the site for purposes of dose assessment.

I think you have to look at the site, look at the model, look at the parameters and make the best fit.

MR. THAGGARD: That was Tom Carter. Yes?

MR. BURKLIN: My name is Rich Burklin. I work for Siemens. Regarding the depth of the well and so on, would a reasonable approach be to find out what the depth of the wells are in the area that you're in and then say -- and then do some type of distribution study in order to be able to get, for instance, the mean value of the depth of the wells, rather than guessing?

We don't want to take the most conservative necessarily. We want it to be realistic. So maybe you can get an idea what realistic is by looking at the wells that already exist in that area and doing something along those lines. So you think the NRC would find something like this acceptable.

MR. EID: I would like to add to this that the NRC is contracting INEL to develop a probabilistic code with a different kind of site-specific parameters and the future code hopefully will enable trying to look at the probabilistic analysis using different ranges of parameters.

So an example of the sensitive parameter is the depth of the water well and this could be used in order to look at the mean dose distribution, based on RESRAD.

MR. MEYER: I have a comment here regarding this subject. I don't know if the NRC has considered this. You guys probably have. But your scenario requires a certain yield. You're assuming that you're going to get so much water out of this well to satisfy the scenario demands. From the perspective of a well developer, a hydrogeologist going out and developing a well for this particular purpose, what is reasonable. What would their requirements be in terms of installing this well?

They certainly wouldn't put in a screen that's a meter long right at the surface of the aquifer. So if you want to incorporate concerns about reasonableness, that seems like the approach to take.

MR. THAGGARD: Dr. Hung, I think you've been holding your hand up for a while.

MR. HUNG: I was trying to respond to the question that the gentleman asked on the depths of the well and also the upstream drainage area.

The PRESTO model is trying to use the most -- I realize that the depth of the well is very sensitive to the concentration in the well, as I presented earlier. So our PRESTO model is trying to use most of the probable scenarios. This is assuming that the well owner brings in the well driller and tries to use that.

If you are the owner of the well, how deep do you want to go? So my presentation was saying that most probable scenarios to use that for this.

On the second question, on the drainage area, the PRESTO model considered that. So for instance, you have a ten square mile upstream. That means a lot of recharge area. So at the site near the well, you'd have a -- you have to allow for the flow to go through, compared with only one square mile.

So that's at the -- in the PRESTO model, we allow the user to input this difference. So that will take care of the difference in the drainage area.

MR. THAGGARD: Dr. Neuman.

DR. NEUMAN: I cannot resist, having at the table the developers of some of these codes, to ask them the following question, which is kind of rephrasing the question that you have asked.

Could you kindly -- I'm a hydrogeologist, I'm not a regulator. Could you explain why these codes or in what way these codes are conservative?

MR. THAGGARD: Okay. That's an interesting question. I'll give you a few minutes to think about that while I call on the gentleman.

MR. KUHLTHAM: My name is Rick Kuhltham, I'm with Morton Associates. I wanted to speak quickly a little bit about this dilution factor with the well intake.

I have always been troubled by the idea that nobody seems to consider that when you pump from a well, that the pumpage from the well in itself distorts the flow field within

an aquifer, and that, in fact, those of us who do aquifer testing and whatnot are familiar with concepts of partial penetration and where you see the effects of partial penetration.

When you get a certain distance from the well, you don't see it anymore. This basically shows us that as you move away from the well, that well, when it pumps, will draw water through the whole depth of the aquifer and some of these effects can be influenced by vertical, horizontal and isotropy. But in many cases, as you move away from the well itself, you draw water from the entire aquifer, not just a narrow zone which is contaminated.

And I don't really see that these models and these discussions really address that or adequately acknowledge that, and I think that is the reality of it.

Of course, it does depend somewhat on the anisotropy that's present.

MR. THAGGARD: I think that's kind of the heart of the issue. The assumption you make for the screen length, that affects how much of the aquifer you're assuming you're pulling water.

MR. KUHLTHAM: But that's not true, that's my point. My point is that if you have a 100-foot thick aquifer and you have a ten-foot well up here and you pump it, that as you move away from that well, you gradually draw water up.

The point is eventually all the water will come up into the screen, it has to, but you bring this water up through and actually you distort the flow pattern of the plume itself. So that the plume, if this happens, will likely narrow and move to the top of the screen over time if this is a continual pumping.

So that you would be bringing water from a lot different areas vertical depths and increase the dilution by that mechanism.

MR. HUNG: May I answer this question? In the PRESTO model, we realize that -- what you mentioned is significantly true, but when we do the three-dimensional model analysis, we found that -- see, in this particular risk assessment we are talking about here is for one family.

MR. KUHLTHAM: Is for what?

MR. HUNG: One family. That means that the pumping rate is not that fast. It's very small. So for the risk assessment, when you pump it with a very small amount of water, then the range is really fairly small. So in the PRESTO model, right now we assume that that would be the same depth of the screen, but we are in the process of trying to expand that to include the depth that they would draw in.

But our preliminary analysis showed that this depth is almost negligible in most of the case. But in the future, we would like to include that in the model.

MR. KUHLTHAM: Just to address this a little bit further, a good study, if you want to really evaluate this, it seems, if somebody wants a good paper or something, is to get a good 3-D or even 2-D model, preferably 3-D, and you want to get your flow lines and develop these patterns, and develop these patterns even for very small withdrawals over wells and see where your water goes and where your contaminant, where your plume goes and how your plume will move around and, in essence, perhaps even thin as you get towards the well due to other water coming from deeper portions of the aquifer.

If you want to evaluate that effect, you have to fully model it so as to show those effects.

MR. HUNG: Yes. We plan to do that.

MR. THAGGARD: Either way, you're still left with the question of -- you could do that if you know the well depth you have to work with and you were actually modeling a real well. But I think the problem we're wrestling with here is we're dealing with a hypothetical well, and so you --

MR. KUHLTHAM: I guess my point is, I really wonder if the well depth is that important, if it's not really the thickness of the aquifer that's really the primary driver here.

MR. THAGGARD: Okay.

MR. MEYER: Exactly. I'm not positive about this point, but I think you're right on

that and if you included a more realistic model, that the well depth would not be as important.

Also, I just wanted to point out that the NRC, this has already been pointed out, but the NRC doesn't require use by licensees of the models that we are discussing here and there is nothing stopping someone from using a more realistic model that incorporates the effects that you're talking about.

MR. THAGGARD: Before I call on Henry, I'd like to go around the table and see if we can get any of the gentlemen to respond to Dr. Neuman's rephrase of the question. Walt, you want to talk about D&D?

MR. BEYELER: I'd like to be able to just make a short attempt at starting to answer that question.

I think it's -- we had this discussion a bit at the program review yesterday and I think it's -- first, I would suggest that the conservatism of the model is very difficult to argue for without talking about how the parameters of the model were established in general. It's very difficult to make a sort of structural argument that the model is conservative and that it's also important to bear in mind conservative with respect to a particular performance measure, the dose in this case.

Specifically with respect to D&D, I think a case could be made that the treatment of the aquifer is conservative, provided there is a conservative estimate of the amount of material that enters the aquifer, and that that entire amount of material has been available for ingestion, is brought up from the aquifer.

It seems to me that at least that element of the model is conservative, again, provided the estimate of the penetration is conservative.

I guess just a second observation regarding site-specific conditions that might bear on the suitability of the model. I think Dr. Meyer discussed the presence of strong heterogeneities being something that is inconsistent with some of the assumptions that are made in the model, and I would, again, suggest that certainly real sites are heterogeneous to

some degree or another and that the important consideration is how is the parameter assigned in view of that heterogeneity.

It seems that it is possible, in principal, in a very heterogeneous setting, to assign a single number for, for instance, infiltration rate, provided that that infiltration rate characterizes the rare or infrequent features that may occur at the site.

So it seems at least possible, in principal, that that sort of a calculation can be done in the presence of strong heterogeneity, but it's important, again, to consider the procedure by which the site-specific parameters get established.

MR. THAGGARD: Let me call on Dr. Whelan, who has been sitting there kind of quiet. How would you respond to Dr. Neuman's rephrase of the question? How do you think the MEPAS code is conservative or do you even consider it to be? I mean, the ground water components in the MEPAS code, do you even consider them to be conservative?

MR. WHELAN: The first thing I'd like to say on that issue is that, number one, it depends upon the questions that are being asked and the questions that you're trying to answer.

From my experience, and it isn't just with the MEPAS, the codes or this classification of codes, and that is that I do applications, hazardous waste site assessments for a living and I use these codes to help me do these assessments.

My experience is that the contaminants generally move faster than we think they move and the concentrations generally show up at the wells higher than we anticipate through our assessments that they will be.

And even though we have measured soil properties, et cetera, for some reason, mother nature tends to throw a wrench, a monkey wrench in the system and the contaminants, they'll go through preferential flow paths and things of this nature and before you know it, the concentrations are at the well sooner than what you think and higher than you think.

I firmly believe that when you go to apply these models, that if you have some site-specific information which you can calibrate these models to, that becomes very, very

important in terms of trying to at least capture the essence of the contaminant movement from the source to a potential receptor.

With respect to MEPAS, I'm not totally convinced that MEPAS is designed to produce conservative results. As I noted, that if the contaminant moves faster than the parameters that you have defined for that mobility of that contaminant, you're going to find that the concentrations are higher than what MEPAS predicts, and I believe the same thing is true of RESRAD, et cetera, because our conceptual site model, how we conceptualize what's happening at the site is actually inappropriate and as such, we're not producing conservative numbers.

Now, obviously, you can structure systems such that you do produce conservative numbers. For example, a receptor ingests a source. That is pretty much of a worst case type scenario and things such as dilution, decay, et cetera, generally don't get factored into this.

I'm not convinced that these models, when you blindly run them, are conservative and I would be -- I would strongly urge people, if they have monitored data, that they at least try to calibrate their models and this goes to question number three, four and five, and the reason is that that calibration provides you insight into whether your conceptual site model is correct or not or at least if it's close.

Secondly, it provides you insight as to whether the values that you're putting in for those input parameters, whether they are within an acceptable range.

MR. THAGGARD: Thank you, Gene. Let's get this gentleman, then Jim, and then we're going to have to move on.

Why don't you go ahead?

MR. NARDI: Joseph Nardi, from Westinghouse. I'd like to hear what people would say -- in our specific situation, we have a site where we're starting with ground water contamination and I understand some of the models would not handle that. I particularly

understand D&D would not be able to handle the situation where you start with ground water contamination.

I'd like to hear from the other models how their code would handle that situation.

MR. THAGGARD: Charlie, do you want to say something on that, RESRAD?

MR. YU: Right. In RESRAD, we allow users to input ground water concentrations into the code, but you also need to input other parameters, like waste placement time, how -- when the contaminant was placed there, and RESRAD will use those information to back-calculate effective KD values and use the effective KD values to further predict future use concentrations in multiple pathways.

So that's how RESRAD handles the existing contamination in the ground water.

I also wanted to comment on the conservatism in the RESRAD code. I believe that when we say conservative, we don't want to be too conservative. We are reasonably conservative. We think the assumptions made in the ground water models and other multiple pathways models using RESRAD, I think it's reasonably conservative and we are conservative in the sense that we try to be reasonably conservative on the peak dose, peak concentrations in ground water, for example.

If you are conservative in the peak concentration, you may not be conservative at other times, because the other times may not be conservative. The measured concentration could be higher than what we predict at different times. But we're trying to catch the peak concentrations, trying to make sure that the peak concentration is conservative.

And on the other hand, if you are too conservative in one pathway, in the ground water pathway, most of the contaminant is leached down to the ground water, you may not be conservative in other pathways. For example, waste contaminants stay in the contaminated zone, then that will give you a higher external dose, uptake, other pathways may have a higher dose.

So you need to be reasonably conservative. Otherwise, you'll focus on certain

pathway and you're too conservative, you may miss some other pathways and especially important for certain radionuclides. For cobalt-60, for example, it will give you a much higher external dose and if you are too conservative in the leaching of cobalt-60 to ground water, you may miss the primary pathway, which is the external dose.

MR. THAGGARD: Before I call on Jim, Gene, do you want to make a comment on how MEPAS handles existing ground water contamination?

MR. WHELAN: The way MEPAS handles existing ground water contamination is you put in a volume, a parallel, the length, width and thickness, and you place that length, width and thickness volume within the saturated zone and it can be at any location within the saturated zone, so it doesn't have to be at the water table surface, and then you define an initial concentration associated with that volume.

So, in effect, it's uniformly distributed, that concentration in the volume, and from that, it then -- the code will then calculate emission rates based on the hydrogeologic properties in that saturated zone.

MR. THAGGARD: Jim Shepherd.

MR. SHEPHERD: Jim Shepherd, NRC. Since you uncovered it, Mark, I'd like to jump to question four, which I think is closely related.

In our past practice, where we've required licensees to essentially clean up their sites for unrestricted release, we didn't have a great deal of original contamination and consequently we didn't need a lot of sophistication in our models.

I think under the provisions of 20.1403, where we're now allowing considerable contamination to reside on-site -- in particular, contamination in the ground water -- I've had one proposal that I've seen where the preferred remediation and alternative for contaminated ground water is monitored natural attenuation.

This comes from the EPA, which is directed primarily at chemical spills, where they can demonstrate some kind of biodegradation.

In the case of heavy metals, there is not going to be biodegradation, by and large, and the mass reduction requirement essentially will be met by some kind of migration. So I think we are going to need more sophisticated analyses to identify the actual concentrations, where the plume is today, and, more importantly, where it's going to be in the very long term, and I'm not certain that our existing models can do that.

Because we now need -- if we're going to do monitored natural attenuation, how do we know exactly where to model in order to track the plume.

MR. THAGGARD: Okay. Well, we're running out of time on this first section here. So what I'd like to do is go ahead and call on Henry, because he's been up and down, up and down, and then we'll get the other gentleman.

We're going to continue these questions tomorrow, as Tom indicated, we've got some time in the program. So whatever we didn't get to today, we're going to go ahead and continue tomorrow. So we're going to come back and have some more discussion tomorrow.

Go ahead, Henry.

MR. MORTON: I'm Henry Morton. There were two items, I think, that were raised on which I'd like to comment. One relates to, in effect, where within the aquifer you take the water or screen the well. The other relates to the first question under what circumstances can the ground water pathways be eliminated.

I think what I'd like to do is speak to these from what -- at least from my experience and relative to trying to think of these as residential wells in the more narrowly subsistence or low usage or ordinary usage circumstances.

I spent two summers in the 1960s as a well driller's helper and there are some fairly sensible things that I think come out of this experience of drilling. First, with respect to where to screen the well and what aquifer, you basically try to put the well where the person wants it and then you take what you get below, in the ground below that.

In the areas that we were working, basically had clay, chert, with gravel beds as

the aquifers, were underlain by limestone, bedrock, and then with the fractures or the caving within the limestone, you could get water from within the bedrock.  So you had two circumstances of getting water there.

The other circumstances were largely sand, sandstone, shale, bedrock.

With respect to, first, where to screen the well, in these cases, basically we would try to -- generally try to screen the well over the entire depth of the aquifer.  Simply, you want all the water you can get and in many of these cases, the wells don't produce as much as you want.  So that was the general rule, screen over the whole depth of the gravel bed or if it's in bedrock, you've set your casing and you're not casing into bedrock, so you get everything within the aquifer at that depth, in the bedrock depth.

The other is, with respect to well depth and how to deal with the shale aquifer, I think it's fairly uncommon, quite rare, as far as I'm concerned, that you would get a well generally shallower than maybe 20 or 30 feet, all because, first, there is the old issue of the trust on the part of the user that he's not going to get contamination from agricultural waste on the surface. So he doesn't want a shallow well, really shallow, even if he can get it.

Secondly, there is the concern for the well going dry good parts of the year.  If that well is going to go dry part of the year, it's really not a usable well.  So it has to be in the saturated zone, with enough production to get useable quantities of water all year long. Otherwise, it's not a well.

Then, finally, another factor is the water quality and the threshold is fairly low.  If he's not going to be happy with the water quality because of salinity, because of mineralization, because of turbidity, if you don't have a happy customer, you don't have a well, better get another one.

So in many of these regards, there are sensible things that define what's a well, and, of course, the last one is you've got to get the quantity that will serve a family and serve them all year long.

So there are some fairly sensible things, regardless of what the regulations might be, with respect to well construction that govern what's a useable well.

MR. THAGGARD: Thank you. We'll take this comment.

MR. ZHENHUA: My name is Zhenhua, and I'm from Argonne National Lab. I have a few comments, after I heard this morning's presentations.

My comments here address Dr. Neuman's questions on conservative estimates. Really, a 1-D model is really not conservative or liberal; rather, it's a simplified model, first, that's my comment.

Second is I think one issue -- my background is contaminant transport. So I'm sort of a little bit different from everybody here, mostly concentrated on the screening model here -- is that there are two issues involved here. One is a ground water model. You're modeling ground water flow, and I think that has been concentrated on this morning.

Another issue is contaminant transport, which is separate from the ground water flow, for example, and we're talking about KD, and that's one issue here, and that usually is a first order model.

A different model, for example, a diffusion model depends on the chemical behavior and that has been very explicit in lots of VOC kind of contaminants. One gentleman just mentioned this natural attenuation, that a particular situation now has been heavily emphasized by DOD or EPA. The one particular issue is the modeling as a 3-D behavior rather than -- in other words, you have to observe or take -- continually modeling and monitoring -- modeling and monitoring what's going on in the plume, and I think that is probably beyond the model we're talking about here. Mainly, it's a screening model.

That's my comments.

MR. THAGGARD: Thank you. With that, I'm going to turn the meeting back over to Tom. As I indicated, we're going to get to the rest of these questions tomorrow.

MR. NICHOLSON: Great. I want to thank all of the speakers this morning and

everyone sitting around the table and all the questions from the audience.

Just a little bit of logistics. This auditorium does have public access, so the room will not be locked. So it will be open. So, please, take anything with you that you consider valuable.

We'll leave now and have lunch. We will start promptly at 1:00, and Walt Beyeler from Sandia will make the presentation.

Thank you.

[Whereupon, at 12:07 p.m., the workshop was recessed, to reconvene at 1:00 p.m., this same day.]

AFTERNOON SESSION

[1:11 p.m.]

MR. NICHOLSON: I'm glad everyone is back from lunch. We're going to continue our program now. What we're going to talk about is we're going to talk about publicly available data sources and databases for estimating ground water flow and transport parameters.

We have asked two of our contractors who are doing -- Walt Beyeler and Glendon Gee, who are doing related work, we asked them and they are in the process of finding publicly available databases, we asked them if they could share some of their experience and what they have been learning.

So the first speaker will be Walt Beyeler, who is at Sandia National Laboratory, and Walt is going to talk about the D&D code and the types of information they put into those parameters.

Walt?

MR. BEYELER: Again, as Tom mentioned, I wanted to review some of the data sources that were used in the parameter analysis for the D&D code, specifically those that are hydrologic parameters.

I wanted to also briefly mention some of the other parameters that are used in the ground water pathway; that is, the behavioral parameters that describe the use of ground water. These aren't strictly hydrological parameters, but they, in a sense, determine the importance of the hydrological parameters by specifying the amount of water that gets used and the different ways that it gets used by the resident.

Then I would also like to go through the physical parameters that characterize the ground water system in the Volume 1 model, thickness of the unsaturated layer, the porosities of the surface soil layer, the unsaturated layer, the saturations of those layers, the infiltration rate from the unsaturated layers into the aquifer, and the partition coefficients that characterize the unsaturated layer.

Just to quickly go over, again, the behavioral parameters. Use of W is drinking water rate for the

resident farmer. The data for drinking water came from the US Department of Agriculture's annual nationwide food consumption survey. VDR is the volume of water that is removed for domestic use. Values for that parameter were obtained from the USGS inventory of per capita water use data from a self-supplied water system. So these were annual usage estimates from people who get their primary water from wells, as opposed to general consumptive use.

The irrigation rate estimates were obtained from the US Department of Commerce, their farm and ranch irrigation survey.

I should mention, also, the specific references for these parameters are provided in a final slide at the back of the package.

The parameters that characterize the physical part of the ground water system include the depth to ground water, the porosities, relative saturations and infiltration rate. The depth to ground water was -- distribution for that was estimated from a compilation of USGS and state observation well reports.

The porosity, saturation and infiltration rates were developed from a model that related to soil texture classification to basically impose what seemed to be a reasonable correlation among these parameters, and, intuitively, the porosity, the relative saturation, the infiltration rate would be a function of the type of soil that would occur at the site. So to -- rather than to impose that relationship in some statistical way, we relied on a simple model that connected the estimates of those parameters with the soil classification. I'll discuss that a little bit in a moment.

But in overview, Carsel & Parrish and in a report by PNL, which I think Dr. Gee may discuss in a little bit more detail, provide distributions for porosity, for saturated hydraulic conductivity, as well as for other soil physics parameters as a function of soil texture classification.

The US Bureau of Reclamation provides an estimated percolation fraction; that is, amount of applied water that ultimately escapes the root zone and becomes deep infiltration as a function of the saturated soil permeability.

Those two pieces of information, along with the application rate at the surface, were used to

estimate these parameters. The application rate at the surface includes both an estimate of precipitation at the site and also an applied irrigation rate consistent with the definition of the scenario.

This illustrates the sort of simple model that connects the soil texture classification to the estimates of the parameters that are directly used by the model. The soil texture classification is associated with the distribution for porosity, saturated hydraulic conductivity, and, among other soil physics parameters, the exponent B of the Campbell relationship for unsaturated permeability.

So the soil texture via the saturated hydraulic conductivity and the relationship that the US Bureau of Reclamation provides gives an estimate of the percolation fraction for a particular soil texture, the percolation fraction and an estimate of precipitation, plus irrigation rate, then determines the amount of infiltration, limited by the saturated hydraulic conductivity. That information, along with the unsaturated hydraulic conductivity relationship determines the saturation that is consistent with that rate of infiltration.

Lastly, the partition coefficient data that were used in the parameter analysis included the compilation of Thibault and others. These were referenced in Volume 1. They provide values of KDs for a number of soils, other estimates of KDs based on concentration ratio measurements. In addition, we looked at a database maintained by the Nuclear Energy Agency, which contained extensive information on soil batch -- on batch tests for KDs, some information on the dynamic column test for KDs.

Again, there are some more specific references for those data sources, which I won't go through, but should be in the handout material that you have and a more complete list of references can be found also in the Volume 3 of 512, as well as a more extensive discussion of those particular data sources and how they work, how they were used.

MR. NICHOLSON: Thank you. Leave that up there, please, while we have a discussion.

MR. BEYELER: Sure.

MR. NICHOLSON: Are there any questions for Dr. Beyeler? If anybody has a question about the information or how -- I shouldn't say how D&D came up with its information, because it's all values. No questions? Boby?

MR. EID: Yes. I have just a comment and a question. The current version of D&D contains default parameters and the default parameters, they respond to all radionuclides, such that you will ensure that the 90th, above all radionuclides, we have parameters above the 90th percentile. Do you have any plans for modification of those parameters or the approach for selection of the solution in order to account for all radionuclides, or do you have some kind of other approach?

MR. BEYELER: I think the approach that would be used in Version 2 of D&D, rather than using default parameters or all sources, would basically directly look at the distribution of doses for each particular source; so in a sense, bypass the definition of specific default parameters.

MR. EID: In other words, that currently you have the dose for certain radionuclides as higher than the peak dose for the individual radionuclide.

MR. BEYELER: Well, the dose for each radionuclide is within the distribution of doses for that radionuclide. The dose for each radionuclide may be higher than, for example, the 90th percentile of the dose distribution for that radionuclide.

Does that answer your question?

MR. EID: Yes.

MR. NICHOLSON: Mr. Meyer, PNNL.

MR. MEYER: Thanks, Tom. I wonder if you could just clarify for us what the distributions that you just presented are intended for. For instance, the precipitation represents nationwide distribution of precipitation, correct? Same thing for irrigation?

MR. BEYELER: Yes.

MR. MEYER: So in terms of an application at a particular site, how would these distributions be used? What were they intended for use as? I understand that they were used in the derivation of the default parameters, but you haven't gone into any of that. Was there some other use,

also, that they're intended for?

MR. BEYELER: I think the follow-on use of the -- well, let me start with what the distributions were meant to describe.

In a slide that Mark presented earlier, the screening calculation is a calculation that is meant to be done with source term information. So the distributions that are used for the parameters are uncertainty distributions for those parameter values, given, in effect, no information about that parameter value. Therefore, the distributions are meant to characterize possible parameter values, possible site-specific parameter values might be used there, in a sense, the broadest distribution that -- a distribution describing the uncertain about that parameter value given no site-specific information about that parameter.

So the process of going from that broad distribution to a more site-specific distribution is I think something that is under discussion in the development of guidance.

Clearly, there would be updating of that distribution in consideration of site-specific information.

MR. NICHOLSON: A question?

MR. POTTER: Yes. With respect to --

MR. NICHOLSON: Identify yourself, please.

MR. POTTER: I'm sorry. Tom Potter, Radiation Protection Consultant. With respect to KD, which is one of the most important parameters in dose assessment related to the ground water pathway, you mentioned sources of information, the NEA database, and also Shepherd and Thibault. You had mentioned in some of your earlier work that I recall reading that unlike the Shepherd and Thibault work, which was to identify frequency distributions for KD that varied with soil type, when you looked at a broader base of data, you were unable to find such clean separation.

Would you care to elaborate on that a little bit for us and bring us up-to-date with your current work in that regard?

MR. BEYELER: There is no current work going on in that regard. Again, we did look at

correlations amongst percent silt, percent sand, percent clay contents, with the KD data, both in the Shepherd and Thibault, and in the NEA database, and did not find a significant correlation. I find that a bit surprising, but that's -- again, there are some more details of that provided in Volume 3, but there has been no additional work on that.

I'm not -- I guess as far as a potential source for site-specific data, I'm not sure that that assumption is necessarily relevant in the -- if it can clearly be demonstrated that there is a specific soil classification at a site, then it seems reasonable that clearly KD data that are collected for that soil type would be especially relevant, and whether or not there is a discernable correlation with other types of soil that do not exist at that site seems, in a sense, irrelevant.

MR. NICHOLSON: Dr. Neuman, University of Arizona.

DR. NEUMAN: It is my understanding that a determination on whether or not D&D can be used at a site and accepted is based, in part, on information regarding whether or not there already is contamination in the vadose zone and the ground water.

In order to obtain that information, some site-specific investigation should already have been performed. So I cannot conceive of a situation where no site-specific data are available and yet D&D is accepted for screening purposes.

MR. BEYELER: Yes. I guess I'd just remark that the practical condition may never occur. It was, nonetheless, I think, difficult to anticipate the specific amount and type of information that would be required to be available or expected to be available at sites. So the condition was, in a sense, to structure the analysis under the requirement that there was -- there was no presumption about the amount and type of additional information that would be available.

I think there is a practical matter and perhaps folks from licensing would care to comment, that they do, in fact, frequently have a good deal of information about a specific site.

MR. EID: Yes. I would like to say that the first block that Mark Thaggard shows in the decision framework starts with the information available on the site. So you will have some information and typically if you have contamination in the aquifer, you will have information because of

monitoring activities. So you will have some information to know whether there is contamination and to proceed forward with using D&D.

MR. NICHOLSON: Thank you very much, Walt. What I would like to do now is move on to the next -- we have a logical progression here, and Glendon Gee, Pacific Northwest National Laboratory, will speak about available databases for VZ and ground water transport analysis.

MR. GEE: The disclaimer that I would make on this talk is that even though it says we're going to talk about all of the databases, Walt has talked about whatever geochemistry is going to be discussed and I'll talk about the hydrology.

I've been accused by my colleagues at PNL, my geochemist friends, I needle them that they never talk about hydrology and always ignore it when they make their proposals, and here I am talking about transport without talking about geochemistry, but Walt did that for me.

So you'll have to at least bear with me on talking about data sets that are available and I'll be talking specifically about things related to measurement of the hydrologic properties related to some of these conceptual models.

Here is an example from one of our reports, quite specific, you have a waste site with a cover on it, a soil that's been some kind of designator that someone has supplied a -- either measured or there's been some kind of generic identification of the soil type, a little bit about the subsurface, sandy loam, saturated zone, and then some information about the depth of water. That's usually the kind of information that's available to begin with.

And the summary slide that I would put up here that you'll probably see later on, since this is courtesy of Phil, you have certain types of information. Some of it is available on the web, some of it not. The generic information come from both regional and national sources.

There are hydraulic property information in the database from the ARS, the salinity lab. There are other sources that are identified in our NUREG report, but using this information, one can attain parameter uncertainty distributions, and I'll give you an example of that.

What that does with those larger databases is give you some bounding values. You assume

that the particular soil or subsoil at the waste site somehow has a representation similar to these large regional or national databases.

Stepping down in terms of increasing site-specific information, there are indeed state, local state information that has been now compiled. Those of you who have a soils background know that every state and every county have soil surveys and these have been put into STATSGO and SSURGO. STATSGO is a map-based database that is on the web, that is more a generic database. SSURGO has more site-specific state information in it.

Then, of course, to do the forcing function information, the National Climatic Data Center has the precipitation from literally thousands of sites and the USGS has the national water information system and a ground water information system.

But using this kind of information, one can, from the more local data sets, you can modify the uncertainty distributions and bounding values and improve those estimates, but this is all in the absence of site-specific data.

Then, of course, locally, extension service, state agencies, university experts can provide site-specific information. Cities have information on percolation tests and other things from building permits and so on. Using that kind of information allows you to modify the uncertainty distributions.

Then, of course, there is the site-specific direct measurements. Putting these together, and there are processes that we've identified in some of our reports that allow you to use that information, coupling them with the other larger databases to make uncertainty predictions.

I'm going to be talking about hydrologic evaluation and so the input is precipitation. You have water storage changes through the vadose zone, through the waste and to the water table, whether you have a cover of some kind and whether it's 1-D or 2-D or 3-D, it all involves these processes that are controlled right near the surface, and that kind of information is basically available in the data sets that I've talked about.

The climatic data is the forcing function. The soils data provides storage and transmission

function information, along with the geologic and hydrologic data. The thing that I haven't mentioned much and is not necessarily as readily available is the vegetation, because that is a very dynamic thing, but also very important in terms of the hydrologic processes, particularly the evapotranspiration.

So we want to get information related to precipitation, have that in a data set that's useful. Similarly, as Phil talked about this morning, the net infiltration, also the redistribution, if that's available, which is governed by the soil properties, and then subsequently, what kind of throughput in terms of drainage into the waste and into the aquifer.

The other information that can be obtained from soil conservation, which is also tabular information, is the runoff soil type curves. Then less information certainly a real, at this point, nebulous piece of information that is not necessarily directly obtained is the vegetation, and I will talk about it a little bit.

In terms of the climatic data set, of course, the generic information is obtained from National Weather Service stations and one would typically, in an analysis, take the local NWS obtained from the National Climatic Data Center, simply a look-up, and then the help model, as some of you know, you can simply type in, as a default, the nearest weather station and that provides you all the information, at least in principal, that you need to know about ET, except the plant parameters.

So you would want hopefully the longest climatic record, because that gives you more statistics on which to base your estimates and uncertainties. Then if available, and often it's true, you do have some site-specific climate information, but typically that information is very sketchy and the climate record is relatively short, generally less than ten to 15 years. So the statistics are not nearly as good.

The kind of information, as Phil mentioned this morning, includes the water input, the precip, the maximum temperature, solar radiation, wind speed and humidity. These latter four are typically used for potential ET estimates.

In our NUREG report, Phil identified the process in obtaining the information from the National Climatic Data Center. There is a three-step process. Typically, if you don't have any real need for daily information or at least can't justify it, you obtain these monthly meteorological parameters, but typically all of those parameters are on a daily basis and in some cases, you can use some kind of function to estimate hourly information.

But you identify the appropriate station, you can download the data using an anonymous FTP directly on your computer, and then run a computer code that puts that data into a data file. That's pretty standard things.

Again, available in standard water balance calculations, with the HELP code, with I think MEPAS and the other codes that you've heard today, particularly MEPAS certainly does that.

Here is an example of the kind of information from one anonymous site. The kind of information you need, you have precipitation for every month of the year, with standard error, similarly, temperature, wind speed, cloud cover, and oftentimes you don't have solar radiation, but you have the cloud cover and you can make some estimates on the solar radiation, humidity and rainy day periods.

With that kind of information, you can generate an uncertainty in the weather record. So you have -- at this particular site, you have variations of over -- coefficients of variation well over 100 percent for almost every month of the year and that kind of uncertainty then should go into your model and leads to uncertainty in the ultimate analysis.

Similarly, with runoff, ET and drainage, this kind of information is available, and this particular analysis was for Ohio, where there was a long-term record of drainage.

Now, I talked about the availability. I want to talk a little bit about some of the limitations and part of the limitations is in how you use the data. You noticed I talked about monthly records and I'd like to just illustrate on where this might lead us in terms of conservative estimates or not.

I don't have a map of the Hanford site to show you, but the USGS performed a regional ground water study, where they took climatic data available from the local weather station, long-term

record, so they knew the precipitation variations.

They took soil data, where they had to estimate some of that, because there was only one soil map and it was very old. So they had to update it and correlate it with the county maps, because the county data was not available. In addition, they had soil type from aerial surveys.

So they took that information and they basically tried to estimate the recharge from the plateau where the processing, waste processing occurs, to the river, to the Columbia River. Of course, there is variation in topography, there is variation in soil type and vegetation.

The precipitation records were assumed to be, because of the relative uniformity of the area, to be similar. So the precipitation was similar over the landscape, but the soil type varied, as well as the vegetation. That was all put into a model and an analysis done.

In that analysis, they tried to estimate recharge. They did it for the entire region outside of Hanford, as well, and they were calculating these numbers, the amount of entering, the ground water, as recharge.

They took a 25-year record and they basically did it several ways. They took the information from -- assuming a long-term average, basically the kind of numbers that I put up on the board before for Hanford, for the months of January through December, as opposed to the actual records, the actual historical record, and I'll just show you the differences in the calculations.

Basically, in their analysis, from the USGS, they showed that the recharge calculation for a 21-year climatic record had a maximum of 58 millimeters, a minimum of .5, with an average of 12, if you took the actual daily record for that 21 years.

In the other hand, if you took the long-term averages, which is the kind of data you get from the NCDC, the kind of information you get on the web, the average climatic record was -- the maximum was 31, the minimum was zero, and the average was two. So a factor of six difference in recharge.

The point is that in some cases, this may not make a lot of difference, but at Hanford, where we're trying to calculate transport rates, this 12 millimeters a year represents basically a six-fold

increase in transport to the ground water, and in our case, it was important. Another case that was reported by Phil in the earlier NUREG was a case in South Carolina. In this particular case, Phil took a water balance model and he calculated the water balance parameters based on daily average precipitation. These are the sums that were computed for on an average for the year. Infiltration of about 1,121. This is the net water moving through the surface soil, runoff of 84, storage of minus two, ET of 769, with a net infiltration, basically a drainage number of 355.

When he then took the hourly data, you can see a striking difference in infiltration, almost a reduction of 50 percent, and the net infiltration dropped from 355 down to 48. One could do this analysis and say, well, it's a conservative estimate, but we basically were at the same site and the only difference is that we were looking at hourly averages versus daily.

The only point I'm trying to make here is that one has to be cautious when you use this kind of information from data sets and this was from a National Weather station data set, right? Correct me, Phil. Okay.

But a significant difference in the amount of net infiltration. So if one is going to design a -- if you're going to use this in the codes, and you're using 355 versus 48, it could make a difference in the transport analysis.

I just want to say a few things about the database information that's available. I've already mentioned that the -- that these two databases are on the web, readily available, and from these databases, a lot of information is typically extracted to make estimates of hydrologic properties, porosity and other information.

The USDA has been working on a more detailed database, but it's basically under construction. It will not be available for at least another year, but it has what I think is a better estimator of hydraulic properties. From these databases, you get soil texture, you get water holding capacity, field capacity, wilting point information, and in some cases, in some cases, you get seasonal water table depth.

Now, I would caution that all of these databases which are typically used are designed primarily for agronomic purposes. They're basically soil PEDON information that's taken from the top meter and if you're going to predict transport to ground water and ground water is six meters or 20 meters down and you're using this kind of information to estimate the subsoil and you're extending that information beyond what I think is a proper limit.

However, for water balance purposes, I think these data sets are good. I would just show you that the Carsel-Parrish information gives you some details where you can get joint probability distributions, so you can get uncertainties in the soil types. In this particular case, there are some 1,500 different soil types, ranging from sands to clays.

But, again, a word of caution, and that is that these 1,500 soil, individual soils were taken from all over the United States. They have different mineralologies. Even though one may be a sand, it has a different mineralogy, and, therefore, it may not necessarily be applicable to your site, even though the texture is the same as what you identify on-site.

It's, again, from the NUREG, courtesy of Phil's fine work, and, again, from NUREG-6565, these are some of the data sets. This is the K-SD statistics, but generally distribution functions for residual water, wilting point, field capacity, the B value that Walt mentioned.

This kind of information is available from these large data sets. How applicable it is to an individual site, again, is -- may be questionable. It may be better if you have some detailed information from a county soils map, but at least this information is a place to start.

I would just say in terms of the geologic and hydrologic databases, that indeed, as Walt pointed out, this kind of information is available and contractors and others can get at this. There is a national water information system, but when I went to retrieve it on the web, I contacted one of my colleagues from Nevada, who is with the USGS, and he had these words to say; the USGS NWIS database includes ground water level information, but my understanding is that on-line availability is primarily handled at the USGS district or project level, and then he went on to say how to obtain that.

And then he referred me to the chief of the office of ground water, who said that's correct, and that presently, the availability of ground water data on the web is quite limited and variable among the states; we are presently modifying our national weather information system to serve ground water data on the web and plan to have improved national capability to serve ground water data in the future.

But then he goes on to say something that I think is significant and perhaps worthy to note; we have some parameters from aquifer tests stored in NWIS, but many of these data tend to be only in USGS reports. Of course, the quality of hydraulic parameter data is highly variable, dependent on many factors, including the type of test, whether it be multiple or slug tests. One thing I suggest is to encourage contractors to look carefully at such data, whatever their source. That's from what I think is a very reputable source that indeed we should be cautious about the availability and the type of data that we're obtaining.

I'd make one further statement about the vegetation database. If you are going to use this kind of information, a typical thing, those of you who have run the HELP code or similar codes, MEPAS has similar kind of default parameters, that one can, if you use a vegetation, that you assume that the waste site is going to be in grass or some other kind of cover, you simply click a button and that information is available to that extent.

I sometimes question whether that's efficient information. There are limited data, regional ecosystem assessments in some states and some regions. Pacific Northwest has a regional ecosystem assessment that provides detailed information about vegetation types and persistence. Of course, in the county soil surveys, there are vegetation types. A series of associations generally provide the type of cropping, the type of vegetation that is typical, but there is no national database available for this vegetation and you would have to rely primarily on the default values from HELP or MEPAS or these other codes.

I'm kind of beating a dead horse here, but I'll just repeat these kind of things. The national weather data are typically daily values. If you want to get the -- see the dramatic effects of

hourly information, then you have to embed that kind of information into your analysis, because there are -- in some cases, there are dramatic differences in how that precipitation is distributed, whether it runs off or runs into a site.

Again, the national soil database is limited typically to the top meter and a half.  So if you're going to use subsoil, try to extrapolate that to subsoil, textures and other kinds of information, that's probably extending it beyond its limits.

The NWIS is currently under construction and the national plant data is not available.

And just finally, we do have large weather and soil data sets that are on the web.  As far as I know, there's no immediate plans to provide this vegetation information in more detail than perhaps is available in HELP or MEPAS.

I would just caution that weather and soil data should be used with caution on large data -- and large data sets may be inappropriately applied.

The site-specific data are largely absent, but may be required, in some cases, to verify the use of generic data.

I'll entertain questions.

MR. NICHOLSON:  Are there any questions for Dr. Gee?

[No response.]

MR. NICHOLSON:  Glendon, your comments -- I assume that the comments you're referring to came from the USGS' Office of Ground Water.  Did he talk much about the ground water atlas that's under development?

MR. GEE:  I know it's under development.  We searched it on the web, but he basically said that their NWIS is still under construction.

MR. NICHOLSON:  There is quite a bit of information, though, I think, if you go to the district or the sub-district level to survey.  Unfortunately, I don't think there is anybody here from the USGS.  We invited them here, but unfortunately they didn't attend.  But there are a lot of information.

There's also a lot of people here from the state. Is there anyone here from a state government that wants to comment about availability of information at the state level?

[No response.]

MR. NICHOLSON: No one from the state wants to comment. Okay. Are there any questions for Dr. Gee? Yes?

FROM THE AUDIENCE: At least in one case, one of the codes has an input for soil erosion rates. Have you seen anything on that?

MR. GEE: There are certainly estimates. In most of the soil survey data sets, there are engineering -- I can't remember the exact title, but there are engineering applications and erosion rates are often cited.

There are a ratability indexes that can be obtained from the county soil surveys. So that is a parameter that can be obtained, at least for some soil types.

MR. NICHOLSON: Any other questions or comments?

[No response.]

MR. NICHOLSON: What we'd like to do now is just have a very brief group discussion on this topic. There are three questions, if you turn to page, I think it's five in your agenda, you will see these three questions. The people at the table and people in the audience, I'd like people to comment on this. Ralph, could you turn the lights up? Thanks.

The first question is what are the most convenient sources of publicly available information on soil and ground water properties for a specified site. I think Glendon went into this to some extent, but he didn't really get into the possibility of finding other information from studies done locally. For instance, going to universities, like land grants universities, or going to the USGS' state agencies.

Who would like to venture an answer for this first question? Glendon? What are the most convenient sources of publicly-available for specific -- you answered this to some extent. But for instance, at the Hanford site, there's been quite a bit of work done at that site and other

places where DOE has large facilities. What can you say about how you'd go about getting that information?

MR. GEE: I think certainly for the Hanford site, the information that is available is typically available from research reports. There are data sets on both the geologic property characterization, thousands of wells have been drilled. The granular metric data, lithology and other things have been tabulated in what's called a rock-sand database. This kind of information is available.

So we would at least for Hanford, we would go to the local source. We're probably somewhat unique in that sense, that a lot of characterization work has been done on the site, more so than many others.

MR. NICHOLSON: The next question basically talks about how to take this national or regional information and apply it to a specific site. Are there any insights on how to determine whether it's efficient to model a site-specific ground water site? Walt, do you have a comment on this one?

MR. BEYELER: Not specifically. I think Glendon made some good points about there will also be some residual uncertainty about what an estimate of the site-specific parameter is. I think data from, say, the nearest weather station doesn't uniquely determine the appropriate value that modeling would be considering.

There are time variations that occur naturally and variations.

MR. NICHOLSON: I think one thing that probably is missing from that question is obviously you have to have some conceptualization of your site and the question is part of your conceptualization comes from the national or regional information sources knowledge, not just data, but obviously we talked about this ground water atlas that the Survey has developed surveys, and then you start asking the question on what level of detail do I need to do my modeling, how appropriate is that information.

Would other people like to comment on this question? Dr. Neuman?

DR. NEUMAN: My comment is simply that I will be addressing some of these questions in my talk by examples.

MR. NICHOLSON: All right. Finally, for which parameters is it appropriate to use generic data and for which ones is it not. Glendon, you alluded to this already. Could you comment further on this question?

MR. GEE: Well, I think with caution, you can -- there are now mounting efforts by states and regions to obtain more detailed and up-to-date weather records, in addition to the NCDC.

So I think weather information probably is the most -- likely the most appropriate.

Secondly, I think if it's a near surface contamination and you have some site-specific information on near surface soils, then I think it's probably a good estimate to use particularly the county soil surveys in the local area where your waste site is located.

Beyond that, I think you're making some -- you're bringing a fair amount of uncertainty with you.

I can't speak of water table depths and other things, but I think we'll hear a discussion about if you use regional maps on water table depths, you may miss your mark, unless you have some on-site data.

MR. NICHOLSON: Is there anyone in the audience who wants to comment? Boby?

MR. EID: I would like to comment on the use of generic data for a parameter, which is very important, which is the distribution coefficient or the KD value.

It was indicated by one of the speakers that the KD value could be selected based on some generic literature value or all type of soils and there is no correlation for that. I believe it may be, in a generic sense, it's okay, but I guess one needs to be careful that the KD is more site-specific and depends on many factors.

I do believe there should be some correlation between the soil type and the KD value, experimental work shows that KD for sandy soil is different than for clay soil. RESRAD lists the tables for different kinds of soils and ranges of KD parameters for different kinds of soils, as an example.

So I believe this parameter is very important, it's a sensitive parameter, and I think I'd caution to use this as a generic parameter.

MR. NICHOLSON: Dr. Wilrenga, from the University of Arizona.

MR. WILRENGA: Tom, in my opinion, one should basically, at most sites, either small or large, take some site-specific data and some of the data is collected relatively simple. All one needs to know, I guess, certainly one who is interested in the surface soil, one needs to go out with a drill rig, take some samples, have them analyzed for at least particle site distribution. So you know you're dealing with a sandy soil and a clay soil and then one can use the national databases and make some inferences about the water holding capacities or the hydraulic properties of those particular soils.

But one has to know a little bit about it and this at least the minimum that you could do and perhaps also determine, get a feel for the KD value for that particular soil.

So I would think that is the minimum one has to do, my opinion.

MR. NICHOLSON: Thank you. A question?

MR. BURKLIN: Yes. Rich Burklin, Siemens. I really know very little about this subject, but if you are trying to get a KD value and let's say you have 30 feet to the ground water and maybe have some literature that says, hey, these are the KDs that you might anticipate, do you only take soil samples at the top or are you supposed to take them 15 below the ground? What do you do?

MR. EID: I believe that is a good question. You need to consider variation at the site and you may take samples, because KD value, depending on the code that you use, you could assume KD value for the soil, KD value for the unsaturated zone, even some retardation also for the saturated zone in certain codes. The D&D code, for example, does not assume that there is retardation in the saturated zone. So you do not need to worry about that.

So whereas if you have different KD values between the soil and the unsaturated zone, this means you have two values for the KD or retardation.

Now, the site variability, of course, the site, if you have a small site, would be not a problem, but if you have a very large site, it would be a problem. That's the purpose of the probabilistic analysis, where you try to analyze the distributions of the KDs and as we've said, if you move to site specific analysis, you need to be somehow conservative, but not excessively conservative. And we do accept the doses based on these distributions, where it is the mean dose rather than the dose at the 90th percentile or the site-specific analysis.

MR. NICHOLSON: Bill Dam, from the NRC's Office of Nuclear Materials Safety and Safeguards. He's a geochemist, so set us straight, Bill.

MR. DAM: I was just going to make a comment about USGS data, from my previous work at the USGS. They have this NWIS database, which covers water wells and also stream gauged water data, and then GWSI is the ground water site inventory, as Glendon said. But any data that would be in the database would be published, as he mentioned.

There's reports that are published annually with all that data in it. But the thing I would go to would be the actual interpretive report, where they've collected that data and interpreted it, the value of the information, rather than trying to get it off the web site. When it's completed, I would go to the actual site.

A couple of the programs that they've had, one is the regional aquifer systems analysis, called the RASA program, several ground water basins in the country have done this regional study and then there is the NWQAP program for national water quality assessment program, and that's very useful if you're interested in water quality data.

But I would go to the actual report rather than trying to get data off the web site, when it's available.

MR. NICHOLSON: Most of these reports that Bill is mentioning are open file reports. Some of them are water supply papers. There's a variety of them. Obviously, here in the Washington, DC area, you go over to Reston, USGS headquarters, and you can purchase them there, some of them, the circulars are free.

As I said earlier, a lot of the Survey has cooperative programs with the states. So like in Harrisburg, Pennsylvania, the USGS has an office there and they work with the Pennsylvania Geological Survey.

So in most areas, that would be probably one of the best places to go first to get your information.

Are there any other comments?

[No response.]

MR. NICHOLSON: What I'd like to do then is move in a different direction now. We'd like to -- now we've talked about the conceptual models. We've talked about the available databases from the national, regional and perhaps related site-specific.

Now we'd like to see what it is like to actually go to a site and try to bring some of this information together. A contractor for us at the University of Arizona, Dr. Shlomo Neuman, is developing, for the Office of Research, a methodology.

We are just in the beginnings of developing a methodology. We're not sure exactly how far we can go with this, but we think it might have some value to people. It is not, obviously, at this time, fully developed, but perhaps some of the insights that Dr. Neuman has found in trying to apply his methodology to a real site might give some information out. But this is just a research project at the present time.

Dr. Neuman?

DR. NEUMAN: Can you hear me when I speak into this microphone? The NRC staff has identified the issue of conceptual modeling and conceptual model development as one that may result in more uncertainty in ground water predictions of flow and, in particular, transport than uncertainty in parameters.

So they asked me if it would be possible to develop a more or less formal methodology or strategy that would help one to identify, based on available data, at the particular site, conceptual models that the site data would support.

For those of us who have experience in hydrogeologic interpretation of data, it is very common to be in a situation where you bring five colleagues to a roomm and show them exactly the same data and each one would interpret them in a slightly or sometimes rather drastically different way.

So the question is, can this process of scientific thought and interpretation of data be somehow formalized. I don't think it can be formalized to the extent that one could develop a step by step methodology, saying step number one do this, step number two do that, and so on. But I think that what one can do is try to pull together important steps, put them in a certain order, but then leave enough flexibility for people to understand that these are essentially guidelines and not a step by step procedure.

What I am going to propose to you is essentially a rudimentary concept. It is at a very elementary stage. I don't know if the NRC will at all buy into it eventually or not. Certainly, at this point, it is nothing but a concept in my own head and I would be very much interested in knowing what you think about some of these steps that I am proposing.

And what I will do is paint for you this methodology at a very high level. I will not go into great detail. To the extent that there will be details, they will be illustrated by a particular example. That example, I think, harks back to the discussion that we just had a few minutes ago, about the publicly available data, what one can and cannot do with this publicly available data, and then what might be achievable with site-specific data.

So here is the proposed methodology, in a nutshell. This is kind of the highest level of the hierarchy that we are proposing, and you will immediately notice that I started my discussion by focusing on conceptual models, but what you see here goes way beyond conceptual models and, in fact, proposes a strategy for ground water model development all the way from the beginning, where one defines the problem, and all the way to the end, when one uses the model or the models to come up with performance measures and some information about the uncertainty of those performance measures.

So I refer to this as a skeletal framework because it is really just a skeleton of ideas at this point, and rather than, as a conceptual model, I will refer to this as the conceptual mathematical model, very much along the lines of what Phil Meyer told you earlier, and that is these two concepts really have to go together. They don't always, but certainly in the ground water arena, they can and I believe they should go into enough about the physics and mathematics of ground water flow that we can cast those in mathematical form.

Without that mathematical form, of course, we cannot speak of mathematical models and of quantity predictions.

So the first step then, and what I will do is, after I show you this kind of general highest level hierarchy, I will go to each one of these boxes and show you some of the sub-steps that I envision beyond, and those will be shown by models and I will not go beyond that into any level of detail.

One has to know why one wants to develop a model, what is the context for the analysis, what are the questions one wants to address, what is the problem or the problems that one wants to solve, perhaps something about how one wants to solve those problems, how important is it to solve the problem accurately, with little uncertainty.

That will determine, to some extent, how much time, money and effort one puts into the analysis.

The next step -- and for those of you who are familiar with the development of ground water models, I will assume that what I am proposing here is really nothing but a summary of your experience, to some extent at least.

The second step is to define what you know that is relevant to the solution of your problem. Now, that involves knowledge about the site, and I will only be speaking about hydrogeology. There are many other aspects, of course, to the problem, but I'm focusing on hydrogeology.

So the question is going to be what do we know about relevant hydrogeology on a regional local scale, what do we know about flow and transport processes that may be relevant to the problem; of course, what do we know about the source term, what do we know about how the source term

is mobilized, transported, in the vadose and ground water zones only.

And here the availability of data, of course, enters. Then once you have collected this information, I refer to it as knowledge-based rather than data-based, because it involves some knowledge of ground water pathology, some knowledge of ground water physics, soil physics. If you don't have that, you may have a difficulty following some of the steps which I am proposing here. We're talking about site-specific rather than generic type of modeling.

The whole idea here, contrary to picking up a code off the shelf, is that the developer will conceptualize the system rather than accept a pre-concept or pre-developed concept and will select the correct, maybe develop in some cases, correct mathematical model. Hopefully, one would be able to find one off the shelf and apply it in a way which is consistent with his concept and the data.

So the next step then is the one that we are, in fact, focusing at the present time more than on some of the other aspects, is the qualitative conceptualization of hydrogeology and flow and transport within that hydrogeological setting. And as Phil has indicated to us earlier this morning, and I have just mentioned, this is the stage where hydrogeologists very often start arguing and sometimes coming to blows over just exactly what do the data imply.

So if there are multiple hypotheses that one can derive from a given set of data, multiple conceptual frameworks, this would be the place to articulate them and this would be the place to maybe select those among them that make sense, and those that make less sense, in light hopefully of available data, and perhaps rank them.

Hopefully, if this is accepted, if these ideas are accepted by the NRC, one day we will have a NUREG report which describes this and we have already collected a large number of examples that illustrate various aspects of this, and we are going to be developing examples, one of which I will very briefly discuss with you.

Now, once you have conceptualized things in terms of pictures and descriptions and charts, the next step would be to put things into mathematical language. The first step is not to develop a

computer code, but rather to decide what are the physical processes and their mathematical expressions in the form of differential equations, partial differential equations, perhaps representations, we have seen examples of those today, that one could use to describe these models, these qualitative concepts, to put them into a mathematical quantitative framework. The next step would be to actually develop these, implement these in a computational -- as a computational tool.

Now, one of the things that I believe quite strongly is that at least up to about the middle of this box, things can and should be done in three dimensions. The reason for that is that when we are conceptualizing geology, it is virtually impossible to conceptualize geology in one dimension. You can conceptualize information from a single bore hole in one dimension, but if I was to drill a well in a horizontal direction, I would see something quite different than what I would see in a well that is vertical, immediately telling me that there is a three-dimensional element to this geology, three dimensional.

I think that before we decide that we want to do the calculations eventually in one or perhaps two dimensions, it is good for us to step back and say, now, wait a second, what gives us justification for doing that and what is the proper way of simplifying what really is a complex three-dimensional flow system, what is the best way to simplify it for purposes of embedding it in a dose assessment code where computational limitations are such that a fully three-dimensional model cannot easily be accommodated.

I say easily because I think that many of our notions about what can and cannot be embedded in those assessment codes are somewhat outdated. They are based on computational capabilities that existed ten, 20 years ago perhaps.

Computers are developing to such an extent that I can today run easily two-dimensional codes of great complexity on my PC and so can almost anybody, for $5,000 or less. For $10,000, you can buy yourself a workstation and do calculations in three dimensions.

So I am not as convinced as some are that the limitations to embedding more complex models

in dose assessment curves are real. I think that to some extent, they are a relic of the past and perhaps a result of the fact that our existing codes, which were developed years ago, are not geared up for this.

Okay. Once a model has been put into a mathematical computational framework and this can now be in one dimension or in two dimensions or maybe three dimensions, as a hydrogeologist, I would very much like it to be compatible with data in two ways. I would like this code to be able to accept real data which are compatible with the complexity or simplicity of the model.

Most measurements in the field are relatively small scale. They model things on a relatively large scale compared to the scale of a single pumping test, not the speed of the scale of single core samples. So we face this very serious question of how do you take data collected on a small scale and meaningfully build them into a model which is much cruder, has a much lesser resolution.

This is a fundamental question that has not been resolved. So as part of our work for the NRC, I have some students doing fundamental work, asking themselves how to resolve this issue. It may very well be that when our project is completed in a few years, we will still not have a complete answer to that question, but at least we will have some.

Sorry, you cannot hear me too well. Let me know if you cannot hear me. Raise your hand, then I will know you cannot hear me.

So one question is how to make sure that the data that you're feeding to the model are meaningful and compatible with the model and then comes the question of how do you know how good your model predictions are.

Well, there is no way for us to confirm predictions made over a period of 1,000 years. But it should be possible to confirm some elementary aspects of a model, things that perhaps could be verified either by observation or by deliberate experimentation.

I feel very uncomfortable about models which make predictions of things that cannot be observed or measured. If I predict concentrations, I would like to be able to predict them on a

scale, spatial scale, and maybe temporal scale, that I can actually compare with real measurements.

Water levels, I would like to be able to compare with real measurements. Models that do not do that leave me queasy. I do not feel confident.

No matter what we do and how much data we have and how much understanding of a site we have, we will always end up with residual uncertainty.

I mentioned in the beginning that there are at least two important aspects of this uncertainty, one which many of us know in many cases how to quantify and there is uncertainty in parameters. If you have a large set of measured parameter values, you can draw yourself a histogram, fit a DDF to it, and you can say that you know something about the probability distribution or the statistics, and, therefore, the uncertainty associated with that parameter.

You can then perhaps propagate it through a model and know something about the uncertainty in the model predictions.

How do you do it with conceptual models? When five different hydrogeologists look at the same data and come up with different interpretations, how does one quantify it? This is one of the questions that the NRC would like us to answer and we are thinking about it very hard and I even got some very interesting ideas during a project review over the last two days, but, frankly, I don't think that we know very well how to do that.

So that's a challenge and hopefully we will, in two years, be a little bit smarter than we are today.

And why do we need to quantify the uncertainty? Because the NRC would like to know to what extent can it rely on performance measures that the model predicts. It would be very nice if those performance measures could be given not just as numbers, but as numbers plus an associated margin of error or confidence limit.

So that is the ultimate goal.

What I will do is very briefly now go through my ovals for each one of these boxes and then, as I said, illustrate some aspects of that by an example.

So the first rectangle is the definition of the contextual framework, and I don't think that there is much mystery as to what is meant by that. One has to know the precise reason for the development of the model, what is the nature of the problem, what is the range of potential solutions that one would contemplate, what is the distance over which a plume may travel from the source, making some reasonable estimates of site conditions, the timeframe, of course, very often that will be 1,000 years or for decommissioning, at least under the current rule.

So there are certain limits on the scope of the problem and on aspects of the problem that one wants to look into and certainly performance measures, the specific performance measures that you want to evaluate would enter right here.

Once you know that, you have essentially defined the scale of the hydrogeologic system that you want to study and at this point, you may want to decide how deep you go. Do you go to that bedrock and embed it in your model? Do you only look at the uppermost unconfined aquifer? Do you only look at the vadose zone? How far sideways do you go in each direction, just to your boundary, go two miles beyond your boundary? These are the questions that would have to be answered somewhere at this stage of the approach.

But, of course, as we have seen earlier, it would depend on what the NRC wants you to do. So perhaps this would be a place to interact with your project managers, as we have heard earlier, and help you define the scope of the problem.

The circumstances and the scenarios, are you going to accept an on-site farmer, off-site framer, drinking water scenario, where exactly will you want to calculate your results.

Relevant hydrogeologic aspects, what is important; is the nature of the layers in the system important? Do you want to embed faults? Is it a fracture rock? To what extent do you want to map out major fractures? Is that something that's relevant?

Those are the kind of questions that would be addressed here.

And I think the NRC should really tell you something about the accuracy and the uncertainty that it is willing to accept in your calculation. So here the onus is going to be, I think, on the agency

to tell the modeler just exactly how important is this model going to be.

If it's not so important, there is really no need to spend a lot of money, time and resources developing it than otherwise there would be.

Now, the particular example that I'm going to briefly discuss with you concerns an agricultural center, called the Maricopa Center, about 20 miles, is it, southwest of the City of Phoenix, in Arizona, a very heavily agricultural area, which we think has some analogies to a decommissioning site.

There is, of course, no radioactive material on-site, but in terms of the hydrology, there are many similarities to many decommissioning sites.

We have some general questions that we would like to address with respect to this site. I'm not going to go through all of them. But one that is relevant to a previous discussion is how well can the site be characterized based entirely on publicly available information. I will show you in a moment what kind of information we've been able to obtain.

The next question would be what alternative models can one validly postulate for flow and transport based on such public information. What ambiguities and uncertainties are associated with these alternatives, and I will point out to one or two that kind of jump at you right at the beginning. They are at the very beginning of this exercise.

How can such uncertainties be quantified? I'll indicate one way of doing that. What tools can be employed to do so? What tools can one employ to explore alternative models and their uncertainties? What are the plausible modes and rates of flow and transport in the vadose zone? What happens to a plume when it reaches the water table? How to verify with limited resources, how to reduce uncertainty, and how to simplify the flow and transport representation in realistic and hopefully conservative manner.

I'm not going to answer all these questions, but these are the questions that we are hoping to address.

Of course, in order to address them, the first thing is to define what is it that we know, what is it

that we don't know. So define available knowledge base. The first thing is to assemble data and the first thing we'll be looking at are the publicly available data.

Then assemble and acquire the knowledge base, meaning what do you know about what could happen with flow and transport given those data. Then we'll ask ourselves the question could we improve the available knowledge base and its interpretation if we were given site-specific data.

Now, site-specific data exists. Professor Peter Wilrenga, who is sitting right here, has conducted very detailed studies at the site that I'm going to discuss.

We're playing a game. We are saying we know nothing about his results. I have a student working on this and he has not read any of the NUREG material, has not heard anything about what Peter has found at the site.

In addition to that, we are planning this NRC support, some field experiments at the site. So the next step is going to be to bring this site-specific information into the game and see by how much does it change our concept and our model and the level of uncertainty with which we can work.

The particular sources of information that we were able to very easily identify, I'll list it for you here, even with the web sites, if somebody wants to repeat the exercise with us. There are various reference maps, some of which I will be showing you, which are easily obtained from the University of Arizona, a land grant university, Tom mentioned land grant universities would be a good source for such information.

And some of it is on-line, some of it is not. You need to go to the archives and look for it.

Meteorological data, there is a local network called the AZMET that provides a wealth of meteorological information, you've heard quite a bit about that, I will not go into the details.

It's a heavily irrigated area. This is an arid region. There is information about irrigation, both from the MAC, Maricopa Agricultural Center Administration, and from the Arizona Department of Water Resources, on a monthly and annual basis, some of that on-line.

Irrigated land distribution and soil type distribution, well inventory and ground water resources. Much of the well inventory is on maps and on-line, much of the well information is not. It has to be collected, one has to go well log by well log and collect the information. This is one of the laborious things that my student had to do.

Sources, Department of Water Resources and the US Geological Survey. And pumping rates from wells, because this is an irrigated area using ground water, so there are active wells in the area, some of that is available on CD-ROM and some of it in terms of records; not published, but archived records that one can get access to.

So an example. This little red rectangle here is the area of interest to us and you can see that because of the heavily irrigated site, there is a large number of wells in this area. Now, not everywhere will you find so many wells, but I believe that almost everywhere you will find some wells. So almost everywhere will you be able to do some and plot some of the types of maps that we are plotting here.

The green are irrigated areas, the yellow are unirrigated areas.

Soil distribution, we have no site-specific information at this stage about soil properties that we need for flow modeling and transport modeling. So the idea is to take soil textural information off such maps and then supplement it with distributions of parameters associated with these textures out of the NUREG, which I will hopefully have time to show you again, but you already saw some figures out of it that PNNL, Phil Meyer and Glendon Gee here have developed.

Well log information gives us the third dimension. There is, of course, other maps that one could draw. All of this information, by the way, is on a GIS system. We have put it on a GIS system. You don't have to. It's very helpful if you have a GIS system to help you organize your material.

Now we go into the third dimension. So here is -- I'm just going to show you one or two of these well logs. It is important to understand, and those of you who have sat on wells or are geologists or are familiar with the work of geologists will immediately recognize that what you see here is

already the result of an interpretation by the geologist or the well sitter or the well logger. He decided that everything here can be lumped into a green area called clay, sand and sandy clay. If you actually looked at the cuttings, you would find quite a range of soil types, even within each one of these categories here.

This uncertainty we have no information about, because we do not have the original data and probably we wouldn't want to spend the time looking through them and pouring through them in the first place.

So we accept this at face value and when you go just a short distance away, to another well, you'll see this, at a short distance away to yet another well, you see this, and that immediately implies that things are changing in both the vertical and horizontal direction. Therefore, it is virtually impossible, based on this information, for us to conceptualize this system, certainly not in one dimension, but not even in two dimensions properly. It's a three-dimensional system. And all we can do, of course, is subdivide it into layers or try to subdivide it into layers based on this kind of information.

So then the next step is conceptualization. We have collected -- I will show you part of the information we have collected.

Now, what about conceptualization? And hopefully I have convinced those among you who might not have thought that this is necessary, hopefully I've convinced you that this conceptualization of the hydrogeology, the geology and hydro aspect of it should be done and can be done three dimensions, even if there are many fewer wells than what we have here. I have not yet seen a place where there isn't enough information to do some of this in three dimensions, certainly on a regional scale.

So you really face the task of conceptualizing this, deciding what is an aquifer, what is an accliclude, how many of those will you have and how are you going to model their boundaries between them, and once you have that, to decide which way are you modeling -- going to model the flow. Is it occurring primarily in the vertical direction, horizontal direction, what?

Well, in this three-dimensional system, it is sometimes very difficult to make that decision. Once you have conceptualized the flow, we'll conceptualize the transport. Then there are many other aspects one can take into account, such as isotopes, geochemistry, if you have temperature data, that can be very helpful. In most cases, that will not be available and people will simply ignore this information, which is fine as long as everything else helps you develop the model that you need.

Then comes this question of ambiguities and I will be pointing to one or two of those as we go along with the example. I have, what, 15 minutes, I think that should do it.

Identify some uncertainties associated with this and hopefully postulate some alternative concepts and hypotheses and then compare and eliminate -- I will not go through this entire process, but I'll just kind of allude to it.

So the first thing you do is to try to develop, based on this information, first, a two-dimensional picture along various directions. So you draw a cross-section. And here we use a piece of software, commercially-available software, which costs about $1,000 or so, called Rockware, some of you perhaps may be familiar with. It does the work for you. You don't have to be a geologist. It's better if you understand what you're doing, but this program could do this for you. You give it the well logs and their locations the way you read them off the public record and then you can draw your north-south cross-section. We have drawn these cross-sections through wells which are in the vicinity of the area of interest, for the sake of time, and I will not go back and show you just exactly where they are.

Where the program doesn't know how to connect these, it will leave it blank. So you will know that there is an open question.

And if you look at a west-east cross-section, it will look quite different. The water table is somewhere within this green unit. That's the regional water table.

And the program can also draw for you a fence diagram which provides -- it's a little difficult to read here, but it provides a three-dimensional picture, and you can rotate it and look at it from

various directions, so that you have some idea of what the subsurface looks like. Now, there is very little detail internally within these layers and very often the most important part is in the upper soil layers. Public information of this kind only provides you with the soil map, which I haven't used in drawing this. This is the deeper geology. So you still need to supplement this with the soil information.

Based on this, you can draw maps, iso-thickness maps for units that seem to be acting as potential aquifers or potential confining units between the aquifers. And it's possible to draw contour maps of the regional water table.

Now, the depths of these -- these are actually not depths but actual elevations. This can also draw maps of depths. I didn't bring those maps. This is a 1988 water level contour map. I'm sure that all of you know that ground water in an isotropic system flows perpendicular to lines of equal head. So if you draw arrows perpendicular to these contours, you will see that this is not a simple one-dimensional horizontal flow regime, but it's a rather complex, in this two-dimensional sense, flow regime, and if I was to draw it at various elevations, and I don't have that publicly available, it would look different in different units.

That would mean that I have a three-dimensional system. In some places the water is flowing down, in other places it's flowing up. It's a complex three-dimensional system.

So if you want to model it in 2-D, as we are about to do, you will have to decide how you draw your two-dimensional vertical section and the only right way to do that is to draw it perpendicular to this contours.

So I will show you in a moment such a section perpendicular to the contours in the vicinity of the triangle, which is the area of interest.

The problem, of course, is that this is a 1980 map, '88 map, and if you compare it with the 1993 map, things will start looking a little bit different, so you'll have to decide which of these maps. There was quite a change in water levels in those few years.

When are we going to draw this contour? Well, it turns out it doesn't matter too much for our

site, but if you wanted something on a slightly bigger scale, it would matter. So transients in this case probably would be of interest.

All right. We are ready to start doing something that goes beyond just a concept of the hydrogeology. Of course, one could say much more about it than I did. But the next thing is to try to do something mathematically.

The easiest thing to do here is to find a piece of software that's available commercially or publicly to do this and we have used a piece of software called Hydros, that allows one to study in a vertical two-dimensional section flow in the saturated and unsaturated zone.

We have to decide how we are dividing the system into layers. So we focus, just for the sake of this exercise, on the uppermost two layers in those cross-sections you have seen, in the close vicinity of the site, and we are going to approximate the boundaries between them by horizontal lines, starting to approximate things, of course.

In order to input soil parameters, we have used the PNNL NUREG, from which we have drawn PDFs of distributions of permeability, porosity, and unsaturated flow properties. There was no information available about how those vary in space, no information about spatial variabilities.

So we are going to make some assumptions about that, just for the sake of illustration.

Here is a grid, which I will refer to as a course grid, for the analysis in a vertical two-dimensional section, two layers, water table somewhere here, it's not shown here, and this is a five-by-three meter square grid, meaning these are nodes of a computational grid and each one of these little squares, really a rectangle, is a five-by-three meter one.

Then I will show you results with a finer grid, if I have time, and see what happens.

So spatial variability. We assumed some distribution -- some correlation, spatial correlation between the data and used a standard geostatistical method, which is actually, in this case, available in the Hydros code. You don't have to go to a geostatistical code to do this. The Hydros code does it for you.

You provide it with a PDF, you provide it with a vertical and horizontal correlation scale, and in

this case, this code can only do it for one layer. So in order to do this, we had to lump those two layers together. That's a code limitation. The codes can do it layer by layer.

So this provides us with a so-called scaling factor for hydraulic conductivity. The actual hydraulic conductivity, saturated hydraulic conductivity would be this factor, I don't have a scale here, but it's quite a variability, multiplying the average value.

So this is a heterogeneous system, there is a certain pattern of heterogeneity, and we can vary that and see what a difference it would make with respect to our predictions. A very simple game to play.

And since each one of these patterns is random, we can generate randomly as many as we want. If we generate many, many, that would amount to a Monte Carlo simulation or many realizations of this.

So I'll be talking about realization one, realization two. On the coarse grid, it turns out that it does matter whether you use a fine grid or a coarse grid. When you use a two-by-one meter grid, such a this, which is easily done, the patterns are going to be somewhat different. You get a much finer resolution of your heterogeneities.

And depending on how you build them into this, your plume may eventually indicate a response or be sensitive to your choice of grid and your assumptions about heterogeneity.

Now, I'm going to show you simulated with this code, this code does some strange things, such as drawing this contours, simulated movement of a plume of a contaminant which is maintained at constant concentration right up here.

I will be showing you two stages of contamination or plume evolution, the 200 days and at 7,000 days. Now, let me first mention that when we took the publicly available record of precipitation, irrigation, there is no runoff at the site whatsoever recorded anywhere, and the code has an ability to calculate evapotranspiration for you. It has a plant uptake model built into it. So we used it and we got no where. There was no plume movement at all.

In fact, the publicly available data with this feature of the code predicted flow out of the system,

no infiltration at all.

So we said, well, let's just suppress the evapotranspiration, and what you see here is the result of suppressing evapotranspiration. So this is the result of irrigation, which is quite a high rate, and precipitation.

In the meantime, I talked to Peter, who, of course, knows the site and he is telling me that he knows that, in fact, there is infiltration at the site. He's talking about an irrigation efficiency of between 50 to 80 percent, which means that I should perhaps not completely suppress the transpiration, but suppress it down to 50 percent or less, but nevertheless, it immediately shows you that the publicly available information is very misleading, at least if you use it in the way we have, which is not uncommon.

We heard about this water balance approach today quite a bit. That's exactly what we did, with some modification based on the features of the model.

So what you will see are some slight nuances as you go from one type of assumption to another.

That was realization one, with a coarse grid, realization two, with a coarse grid.

Just one realization is a fine grid and the case of homogeneous two layer. The plume is still moving in the vadose zone. Not very important differences so far.

Interestingly, this code suggests that the plume splits when you use a fine grid. That's clearly a numerical artifact of sorts. That's in the case of no heterogeneity in the system.

Now, here is what the two-dimensional model suggests happens when the plume reaches the water table, it refracts, because there is a dispersion built into the model. It refracts in a rather smooth way. So, again, you start getting these differences.

And here the differences will be a little bit bigger between one realization and the other, not as degreed, has reached below the water table and has moved in 7,000 days. So the distance -- this, by the way, should be 7,000, not 9,000 here. Some differences between two realizations.

These could be much bigger if we took the local internal heterogeneity to have larger correlations, in which case we would literally build lances into the system, something we haven't

done yet.

Here is the fine grid result. The green is up here. In the coarse grid case, at least in two realization, it flows down here already. So we are starting to see some meaningful differences between these various results, and, of course, the proper thing to do would be to run this many times, all plausible realizations, all plausible assumptions about the infiltration rates and so on, and then come up with a range, potential values that you could interpret in terms of uncertainty.

I will not bore you with these pictures and this is my last overhead. It's going to be a little bit difficult to see, but it kind of summarizes where or how we envision formally now the last part of our methodology, building uncertainty analysis into the modeling process.

So the first thing that we would like to account for are scales and the first box here is a question; are the scales of the model -- are the scales of model resolution and the scales of parametricization, how you divide your parameters, consistent with the support or measurement scales of the data.

If they are, well, then, you can continue and go directly to this box. But if they are not, as is usually the case, you have to grapple with the question of how do you make them compatible. I said this question of how to do this is not fully resolved in hydrogeology. So you can skirt it or you can try to do certain things and there is more and more coming out in the literature about how to do it, I think, as I said, we will know more about it in two years.

You can either rescale the model to fit your data, you can rescale the data to fit your model. That's the easiest thing to do. There's a little bit more methodology available out there.

Then you ask yourself can you treat parameter variability and uncertainty as random fields, and we just had, in the example, where the permeability has varied in a random matter, as a random field within this vertical section. If so, then you can conduct Monte Carlo simulations, essentially the same thing I've shown you.

I've shown you two realizations per grid, you can do it 100 times, and then statistics based on that, calculate a range of possible outcomes, and, based on that, a range of possible

performance measures and perhaps even try to summarize that in the form of suitable statistics. That kind of summarizes it, in a nutshell.

MR. NICHOLSON: Are there any questions for Dr. Neuman? Boby?

MR. EID: Dr. Neuman, I think this is a very good presentation, with lots of illustration to convince about using complex modeling.

But there is a question remaining to be answered about how much characterization that -- characterization data needed to support complex modeling and, of course, people may be concerned about the cost associated with collection of such characterization data, because the cost is not just the models itself, because they are available for free, the cost is the characterization data that is needed.

DR. NEUMAN: I'm very happy that you asked this question, because there was another point that I forgot to mention.

All the modeling that you have seen here used publicly available data. There was no site characterization whatsoever. I did mention one piece of information that I received by interviewing a person who knows the site and has characterized it, Professor Wilrenga, and out of that, I learned two things; I mentioned one of them.

One of them was that my mass balance was completely off the mark, based on the publicly available information data. Clearly, the mass balance approach, the way we have used it anyway, which is not uncommon, simply has not worked. He is telling me that there definitely is deep percolation at the site, at the rate of anywhere from 50 to 20 percent -- or 20 to 50 percent, say, of the irrigation rate, which is quite high.

By the way, I think it's much higher than 18 centimeters at that particular location that's irrigated. The reason I'm mentioning 18 centimeters a year, because that is what the D&D code has generically built into it.

The other piece of information that I received from him, which my generic data did not tell me anything about, is that at the site, the water table is not as deep by far as what my regional data

told me, but that there is a perched water table only about 20 or 30 feet below the site, and that's where all the water accumulates.

Now, we have no idea of what happens to the water below that perched zone, but locally, there is the infiltration rate and the location of the first water table that one encounters is quite different from what the publicly available data told me.

My conclusions from that is that publicly available data, even from such a dense network of wealth as we have here, is only good for very crude approximation of the site on a large scale and one should be very careful of applying that on a much smaller scale, such as the Maricopa site, which is, say, several hundred meters in terms of kilometer scale.

So I personally, from this exercise and based on my other experience, would definitely support Professor Wilrenga's suggestion that you always collect some site-specific data. I would go a little bit further, I alluded to before, during the discussion, I just don't believe that it's possible to know anything about whether or not there is subsurface contamination in the vadose zone and of the ground water, without actually having done some site characterization.

So when you approach the NRC with a statement, yes, we do or no we don't have ground water contamination at the site, you will already know something about the site. Therefore, in all cases, I'd certainly be interested in hearing otherwise, in all cases, you will have site-specific data and I think you need to use it.

MR. NICHOLSON: Paul Chenoweth, NEI.

MR. CHENOWETH: Yes, hi. Actually, the comment or the question comes from your presentation, but probably is directed to the staff.

Early on, in showing the publicly available data, showing where the wells were and the irrigated land, it made it very clear that the entire area surrounding your site was irrigated and there were very few areas around there that weren't.

Is that sufficient justification to eliminate the irrigation pathways for the subsistence farmer? I mean, I'm trying to get to real practical areas here and I guess I'd like a response.

MR. THAGGARD: Yes. Let me make sure I understand. You're saying is that justification to eliminate the irrigation pathway?

MR. CHENOWETH: Yes.

MR. THAGGARD: I think in this case, it would definitely be justification not to eliminate the pathway. I mean, most of the water use in that area is irrigation. So I don't think you will have any justification for eliminating it. I mean, simply because it's not at your particular site, it's clearly being used in the area there.

MR. CHENOWETH: I'm sorry. I lived in Phoenix for a while. The irrigation water came from remote locations. It didn't come from your ground. It was brought in from the Arizona River or the Salt River Project. So the water wouldn't be coming up from your contaminated area.

MR. THAGGARD: That's right. But there are pumping wells at the site.

MR. EID: Additional comments. I guess for this case, it is very clear that you could bring water and use it and for irrigation and the land could be used for irrigation. So for that specific case, we have just closed that, adjacent to that not irrigated area, an area which is irrigated and is used for farming activities.

So this is support that, yes, there is some use of the farming activities. If that specific area was remote, it is very difficult to acquire water and to develop the soil and make it suitable for agriculture and farming, yes, it could be an argument to eliminate the ground water pathway.

MR. THAGGARD: Let me just see if I can answer your question in a generic sense. I think what you're getting back to is the issue that was raised earlier about the use of surrounding land use information as justification for eliminating a particular pathway, and that certainly is something that we're looking at.

I don't -- I mean, I can't give you an answer on that today, but that is the kind of thing that we're looking and that is the kind of thing that we're going to ultimately put into the standard review plan.

I don't know if that answers your question.

MR. CHENOWETH: Yes, it does. I guess to be clear, what I was saying is perhaps this wasn't the best example, but for instance, there are areas where all the irrigation water comes from a remote source. So is that sufficient justification or am I following the right approach to follow the logic to say, all right, since the water won't be pulled from the subsurface to irrigate this particular land, that pathway isn't important, other pathways are, I'll calculate those. I'm just trying -- you know, obviously, I'm not looking for a generic answer today, but I'm trying to say these are the thoughts that licensees are going to be going through to try to justify what their specific situation really looks like.

MR. EID: I believe that the source in this case is brought from non-contaminated source, so there is no reason to include it. This I am telling you based on a generic example. Now, if the aquifer is good under the source and the technology allows pumping the water, although you have a deep aquifer, this is something to think about, of course.

MR. PARROTT: I'm Jack Parrott, I'm with the NMSS licensing staff. I think one thing we've got to keep in mind is if we're doing these analysis for 1,000 years, you can't look at just what the source of water is today, but you have to ask yourself is the -- is there a source of potable water at your site and look at that as a potential source; maybe not now, but sometime in the future.

MR. NICHOLSON: Shlomo?

DR. NEUMAN: In the framework of a 1,000 years, it may be interesting to note that this external source did not exist before the 1920s. In other words, the dams at the site were built in the early 20th Century, toward, say, the first part of the 20th Century. So the picture has changed completely. Imagine somebody went through this discussion even a hundred years ago.

MR. NICHOLSON: Paul, did you have a follow-up question or is it a different question?

MR. CHENOWETH: Very brief. Just the -- I guess the point is are we supposed to anticipate -- I thought we were supposed to use current land use activities for our planning purposes. So if currently everyone uses irrigation or whatever from a remote source, are we supposed to still

look that they might drill down an extra 1,000 feet to find that potable source or do we go with what people are doing today?

MR. THAGGARD: I think the answer to that question, Paul, is that there are a lot of issues associated with the use of current land use conditions and not only in terms of the timeframe that you should apply to information, but as somebody pointed out earlier, the area that you should look at, how far out should you go, so there are a number of issues like that that need to be resolved and we haven't resolved those yet.

But we're certainly thinking about it, we're working on it, but we don't have an answer for you today.

MR. NICHOLSON: One more comment.

MR. EID: Just to say that there are two extremes. One extreme, we could eliminate completely the ground water pathway and the agricultural pathway completely, and then you say there is no ground water irrigation, there is no agricultural activity.

The other way, in between, you could say the ground water pathway -- the ground water is brought from somewhere else, is not contaminated, however, you will have some agricultural activity, so it will be just only leaching from the soil to the plant. So there is the ground water in this case could be eliminated, too.

Then the other, of course, possibility, where the aquifer is good, you could use it and then you have -- you pump water from there and then you irrigate, this means you have these two conditions together.

So there are different analyses the staff could make to convince the assumption whether the ground water pathway should be included or not. Fortunately, these they do allow, specifically more advanced codes or models, they do allow elimination of these pathways.

MR. NICHOLSON: Sam Nalluswami, from NRC's licensing office. Sam?

MR. NALLUSWAMI: My name is Sam Nalluswami. I am from the NRC, the decommissioning group.

I really appreciate Dr. Neuman's presentation, especially the logs that you presented side by side. That shows how the geology can vary from point to point to illustrate the geological characteristics of the site.

In addition to the water resources departments, where you can obtain the well log data, I have used, for example, from highway departments, the state and county highway departments, their logs. They are very useful in getting the geological characteristics of the site.

For example, when the geotechnical investigation is going on, when they do the logs, they always know that when they encounter the water table, they are supposed to note down the water table level. So that is another additional information that would be very useful in getting the water table information.

So really that's a very useful tool. But I have a question to Dr. Neuman. From the illustration that we saw, your three-dimensional model of ground water flow model is a very good way to go in evaluating ground water flow.

Also, we have to evaluate the contamination transport characteristics and what will be your recommendation with regard to the flow modeling, for example? Would you recommend a deterministic model or a statistical model, both for flow and contaminant transport?

DR. NEUMAN: As a hydrogeologist, I have never in my life encountered a situation where the geology is not heterogeneous or virtually every scale of interest. Wherever you look, whether you look at a scale of millimeters or centimeters or kilometers, you always find variability.

On the larger scale, such as the one that I was showing in those cross-sections, you can draw boundaries between units that appear to be homogeneous and can be called aquifers, but internally they will still be heterogeneous and that is something that I showed could at least to some extent be accounted for through spatial variability models, geostatistical techniques that are well established.

And one has to know, of course, some expertise is required to know that, but there are well established techniques. So it can be done. They are not cheap to apply. You need the

expertise, you need the time, you need the tools, but it can be done.

Because the only information that's available to us about the subsurface is from wells and I appreciate your suggestion about the building boring logs, which I think is going to be very useful for shallow information, and from soil data, there is a lot of information missing about this vast volume of three-dimensional material down there.

There is no way that I can see that you can assume deterministically that you know what it is. So, therefore, virtually everything that we do is statistical and stochastic and a simple way to do that is just by repetitions of the kind that I was showing before, the Monte Carlo approach.

There are more sophisticated ways to do that, which, in fact, were on my last diagram, but I didn't talk about them, and those are in development. But right now, the Monte Carlo approach. And you don't necessarily need to run thousands of these. Very illuminating to run two or three, just to see the range of possibilities.

MR. NALLUSWAMI: Last question. The last question is, for example, the RESRAD model in the RESRAD code, it is very simplified, very simplistic approach. How would you approach combining a three-dimensional flow model and a transport model to get the results for the ground water flow? Combined in the RESRAD code, how do you approach that?

DR. NEUMAN: There are two possibilities. Either you have the computational capability to embed it within a dose assessment code, which cannot be RESRAD, it would have to be a newly developed code, unless RESRAD is modular, in which case it would be -- a modular code should really be your object-oriented code, such as SEDSS, that Dr. Ralph Cady and his contractors are developing at Sandia. That's one way to do it.

The other way to do it is rather than using an over-simplified ground water code in which you vary an average permeability a thousand times and give the impression that you have taken uncertainty into account, I would much prefer to run a more complex ground water code, externally, not a thousand times, ten times, and look at that variability, make some simple calculations as to what the variability could be, go beyond that.

If you can run it a thousand times, that's good, but I realize that's time-consuming. In other words, I think that a more detailed description of the ground water system, especially for transport, run a few times, so you don't cover all possible ranges, and the results embedded in a dose assessment code, to me, that is much more meaningful, as a hydrogeologist, than an over-simplified code that you run ten thousand times.

MR. NALLUSWAMI: I completely agree with you on that.

MR. NICHOLSON: Thanks, Sam. Last question before the break. Would you take the microphone?

MS. PARR: Elizabeth Parr, Colorado. I think they covered it quite well. I just wanted to make sure those points were made.

MR. NICHOLSON: Okay. Thank you. I really appreciate the audience's patience. We've gone a little beyond the break point, but I appreciate the discussion. We're going to take a break now for 15 minutes. So if we could be back in here at about 3:32, we'll start up again. Thank you.

[Recess.]

MR. NICHOLSON: Before we get started, I want to just make a couple of brief comments. This afternoon, we're going to obviously get into some ore discussion with regard to experiences. There was some discussion before the break about how you go from simple models, like RESRAD, D&D and MEPAS and those, to more complex or how can you use a more sophisticated hydrogeology model in conjunction with what we've called conventional or state-of-the-art dose assessment models, and we'll get into that.

But in order to kind of get an understanding of what we're trying to provide to you today, this workshop, we're hoping, will produce a proceedings and the proceedings hopefully will provide you with not only the information provided, but references and other material in something that is a citeable source.

WE also are going to have a proceedings, the proceedings, as I said, meaning the transcripts,

the transcripts should be out in about a week, but there was some confusion. It's going to be at the public document room here in Washington. It's not going to be the local ones. It will be just the one here in Washington and it will be there if you want to look at the official transcript of this meeting.

Now, hopefully, everybody has picked up a copy, if you're interested, a copy of the last proceedings we did. The last proceedings was a meeting similar to this workshop, held November the 13th and 14th of 1997, in which the codes, MEPAS, RESRAD, D&D and PRESTO were presented and there was actually a demonstration, and the proceedings actually have papers in here about those codes.

So this workshop kind of builds on that and now we're getting into the ground water aspect, and we hope to produce a proceedings similar to this one. So you might want to contact us in about six months.

I'd like to now introduce our first speaker. Walt is going to be talking about integrating site-specific ground water modeling into dose assessment. So imagine, if you would, that somebody like Professor Neuman or someone has done a site-specific analysis using some type of a detailed or more complex model, how can it be integrated into a dose assessment. So Walt will try to go through that for us.

MR. BEYELER: As Tom mentioned, I wanted to talk a little bit about integrating site-specific ground water modeling into dose assessments.

I wasn't going to talk about a particular case study, but rather cover in general some of the issues that would be faced in using a more detailed simulation of a ground water model in a dose assessment calculation.

So I'd first like to give a quick overview of the elements of the default model. I think it was discussed in Professor Meyer's talk. The other models, RESRAD, MEPAS and so on, have also a fairly simple conceptualization of the ground water system. So some of the issues associated with interfacing a detailed model of ground water with a dose assessment calculation would also

occur for those simulations, but I was going to discuss this in terms of the D&D model.

One of the important issues that comes up is, as has been discussed, the parameters of the default dose assessment model do not vary in time. Generally, it's a steady-state model and there is also one number that's used to characterize important quantities, such as infiltration and so on.

So a site-specific model is likely, among other things, to include some additional spatial detail and perhaps transient behavior. So there is a general question of how to interface between more and less detailed elements of the system. So I'd just like to discuss some possible approaches for dealing with that.

As far as the mechanics of doing that interface, I wanted to just briefly mention the SEDSS program that's being managed by Ralph Cady under Research. The goal of SEDSS is to provide for a method of tracking the logic and the mechanics of interfacing more complicated or developing a comprehensive system simulation in a decision support context.

So I won't go into great detail on this. This has been discussed, I think, quite a bit in the earlier presentations. But for the residential scenario, this system conceptualization includes an initially contaminated surface soil layer, an unsaturated zone and an aquifer layer. Water is withdrawn from the aquifer layer, both for irrigation purposes, for drinking directly, and for other consumptive uses on-site.

So a central feature of this conception of the ground water system is a recirculation of contamination from the contaminated soil layer through the aquifer and back. We have very simple water balance considerations. The irrigation rate is specified independently of the infiltration rate and so there is an implied amount of either net precipitation or evapotranspiration and then, in effect, provides a water balance for that layer. That's not an explicit simulation in the D&D code, but rather an implicit difference between these two rates.

Similarly, there is a total amount of recharge to the aquifer, through the contaminated layer, and a total amount of withdrawal that's determined by this independently specified irrigation and total

consumption.

If there is a discrepancy between those two quantities, any excess withdrawal is assumed to come from an uncontaminated source. Any excess infiltration is assumed to escape the capture zone of the well. But to the extent -- to the total amount of contaminated recharge to the aquifer, those show up in the well, subject to the consumptive specifications at the surface.

So really any of these elements, there are three sort of large elements of the ground water system it would seem reasonable to consider modeling in more detail, developing a site-specific model for it; that is, the surface soil layer, the unsaturated layer, the aquifer itself.

So any one of these or any combination of these might consider -- might conceivably be modeled in more detail using the site specific model.

The information that is exchanged among these elements, in the case of the surface soil layer, there is a flux of water and radionuclides obviously into the unsaturated layer. Similarly, from unsaturated layer, the aquifer, flux of water and radionuclides, water and concentration in-ground water are the key quantities that are withdrawn from the aquifer to be used for consumptive use and for irrigation.

So the -- again, any of these elements could conceivably be refined, replaced with a site-specific model. The things that might be included in that -- in a site-specific model would include, again, more detail on the spatial variability of the parameters, a consideration of transient effects that might be occurring in those elements; also, additional processes that are not considered in the simple screening models.

And some of the additional process, this is by no means an extensive list, that might be included would include consideration of solubility. Currently, there is no dissolution or precipitation modeling default D&D code.

The default code includes a linear reversible absorption. There are other absorption models that potentially could be defended. Again, variability or transient behavior in these elements, the default D&D code does not include a consideration of the aquifer hydrodynamics; that is, the

potential for the hydraulic characteristics of the aquifer to limit the ability of the well to produce water. It's assumed that however much water is in the aquifer is capable of withdrawing that amount.

There is currently no absorption considered in the aquifer and that's potentially something that might be supported and included in a model.

But if one or more of those extensions are made to one or more of those elements, incorporating the or integrating that sort of a refined calculation in a dose model involves specifying these summary quantities. In other words, if a more sophisticated, a more detailed model of the unsaturated layer would still be required to accept -- if these elements were not replaced -- a single number for infiltration, mass flux in the top, and to provide a summary integrated measure of some kind of flux into the aquifer.

And so one of the general issues associated with a site-specific modeling is, again, accomplishing this change of scales, either going from very crude specification, for example, in the surface soil layer, to a detailed spatially variable transient specification of the unsaturated layer, going back from that more detailed specification to a crude specification of the aquifer, for example.

So in general, these are some procedures that might be used to do that sort of thing, in going from a coarse to a fine scale, for example, from an integrated or a summary measure of infiltration in the unsaturated zone to a detailed model of the aquifer.

One possible procedure is to assume that the single infiltration rate is a uniform rate or that more detailed simulation in the aquifer, that's a possible approach, but it seems that there are other assumptions about the spatial variability that are also compatible with a single number for infiltration.

I think it is not automatically the case that a single number in a simple element is best represented as a uniform number than a more complicated element, and I think this perhaps goes to the point that Dr. Neuman raised earlier with respect to using a single number to

characterize a very complex system. It seems that it's possible to do that, but there needs to be very careful consideration of the possible spatial variabilities that are being assumed, that are being assumed in that process.

Going from fine to a coarse resolution, this is maybe less of a conceptual problem. A clear example there would be coming up with a summary concentration from a very detailed model of an aquifer.

If the number of interest is concentration in the drinking water, then clearly an integrated value or an average value over the scale of the well is an appropriate number to use in the calculation.

But those are, I think, just some general observations about the interfaces that need to be considered in incorporating more detailed ground water modeling.

Again, we're working on a system that deals with some of the mechanical issues associated with making those kind of matches. This is a SEDSS program that Ralph Cady is managing. Just some features of that system are that the models that are used are specified in terms of assumptions that are made about the system rather than selecting from a particular code. The system is designed to allow the user to describe the assumptions that they believe are appropriate and can support as being appropriate for different parts of the system and the calculation to reflect those assumptions.

It also includes a data worth calculation to help the user in assessing the value of including -- of collecting additional data, both for supporting parameter values for an existing model or for supporting a more detailed model.

The intention is to allow a wide range of computational tools to be accessible and for this year, we're looking at incorporating the D&D default models with the existing 1-D network transport model.

That's all I had to say.

MR. NICHOLSON: Thank you very much. Are there any questions about integrating site-specific modeling into dose assessments?

MR. ROBERTS: Rick Roberts, Rocky Mountain Remediation Services. In refining the D&D model, I believe there may be another pathway that would be really good to look at, as well. We talked about earlier where there are sites where the ground water ingestion pathway or irrigation just is not applicable to a site because it doesn't yield enough or it isn't of good quality. And what has to be looked at really is the transport of contaminants from the ground water at the site to a surface water body, where people could contact the contaminants, and I guess I would ask if adding a surface water component to your ground water pathway has been thought about and if that's something that would be added in the future.

MR. BEYELER: Right now, there is an aquatic pathway, as you're probably aware, but the exposure that would occur there is simply through the ingestion of fish. There is, I believe, no calculation of dose due to immersion in contaminate water and I don't know if that's something that is under consideration for inclusion in the scenario. I believe that's an element of the definition of the exposure scenario that immersion does are not considered.

MR. EID: You're right, it is not included in the scenario and it won't be included in the scenario for immersion water, because the model is already conservative and assumes the concentration in the pond is exactly the same concentration in the aquifer, where you're pumping contaminated water, where, in fact, actually you may have this pond is coming from rain water rather than from the contaminated water. That's one of the reasons. So the immersion in surface water is not included as a pathway. However, ingestion of fish and seafood grown in the pond is accounted for.

MR. ROBERTS: Okay. So you're saying that if you have contaminated ground water in the D&D code, then there is an assumption that an adjacent surface water body has the exact same concentration in that -- and someone ingests the fish from that surface water body.

MR. EID: That's the assumption of the model, that you are pumping the water from the aquifer to put in the pond. That's the current assumption in the model. It's different than RESRAD, RESRAD is different.

MR. ROBERTS: That may be -- you're looking at refinements to the model. Then I guess I'm saying that may be a refinement you would want to put in the future to look at that transport and using the surface water body for things other than just fish ingestion.

MR. EID: That's a good suggestion. We have another model, which RESRAD takes into account for this. Now, developing the D&D model further, I'm not sure if there is a plan right now to make the model more sophisticated, but it could be in using SEDSS, you could link SEDSS dose impact analysis to another kind of model, which is more appropriate, getting more ground water in a more sophisticated manner and dealing also with surface water.

MR. BEYELER: I would just mention it seems there are perhaps two issues. There is incorporating immersion dose in the D&D model, that is one question, and whether that is considered as part of the residential scenario or not is perhaps a larger question.

So in other words, if there is no consideration of that pathway in the scenario definition itself, then really it would not be included in the model, although it would be an easy thing to include if the scenario definition were changed to include that pathway.

I don't know if that answers your question.

MR. ROBERTS: Thank you.

MR. NICHOLSON: Thanks for the recommendation. All comments made will be considered.

MR. MORTON: Henry Morton. Historically, we have looked at those pathways and dismissed them as being minor and insignificant.

Basically, what I'm talking about in particular are immersion, swimming, boating, and then the shoreline, shoreline recreation or standing on the shoreline fishing and being exposed to the sediments.

The particular history, I think, if you go back through Appendix I, reactor effluent water, and, for instance, look at the output from a code like LADTAP or other comparable codes that we developed and used, they were all pretty consistent, those are minor pathways.

Only the fish is really worth considering.

MR. EID: I have a question, if you'll allow me. I believe when we talk about integration of ground water models with dose assessment, it's quite important to talk about location of the receptor, because it will make a difference if you assume the receptor is located directly on the pile of the contaminated zone. I mean, the center of the contaminated zone has some assumptions for these models, or the receptor is located off-site, and this makes a difference. This means you need a more sophisticated transport, specifically if the site area is large. The other question which I just mentioned, the site area, it is quite important to take it into consideration. For small sites, and you assume the location of the receptor is directly on-site, could be more detailed and sophisticated transport, could be overdone, whereas if you have a very large site and you assume that the person is located even at the site boundary, and the site is more complex, you may need to construct some kind of more advanced transport analysis. So I would like to have your comments about these two aspects, the area of the site and the receptor location related to integrating dose assessment with ground water modeling.

MR. BEYELER: I guess my observation would be that that question is much more general than the ground water question, in that I -- if I understand, the assumption that the receptor is directly on top of the contaminated area has a strong bearing on the calculation of the dose due to direct exposure and inhalation and many other pathways that are not necessarily just the ground water pathway.

So it seems that consideration of the size of the site is likely to have a much stronger influence on the estimated dose due to those pathways, rather than to ground water pathways specifically. I think that it is -- the calculation of the effect of displacement on the receptor can certainly be included in a more elaborate ground water pathway, but it just seems intuitively stronger effect would be through those other pathways. I don't know if there are other thoughts.

MR. EID: I don't know -- I perceive that, if the area if the site is very large, you need to have more advanced analysis because of the infiltration rates will be higher and the mechanism for leaching could be a little bit different and, also, if the site is more complicated, you have thick

layers, for example, you may need to account more for more sophisticated models, specifically when you talk about retardation and dispersion at the same time.

So whereas if you have a small site, these issues could be minimal, rather than important for larger area of the site.

MR. NICHOLSON: I think we'll end the discussion there and we might follow-up during the group discussion.

Gene? Our next speaker is also going to talk about integration site-specific ground water modeling into dose assessment. Gene Whelan will be presenting a paper. Gene is from Pacific Northwest National Laboratory. The work is supported by DOE and EPA and his co-authors are Gariann Gelston and Karl Castleton.

MR. WHELAN: Can everybody hear me? I'm going to sit down here a little bit and kind of work with my little computer. I'd like to note a couple of things and then I have been asked to talk about linking different models together, ground water models, dose assessment models. But in general, this concept of linkage, how do we -- what are the procedures we go through to link two, three, four different models together.

I'm going to be talking about that. Walt talked about the types of information that one might transfer from one model to another, the source term to the vadose to the saturated zone, et cetera. So I'm not going to get into that.

I'm going to talk a little bit about when the rubber meets the road, actually how do you do this, and we've been involved in developing actually three different techniques which - and some of them everybody uses. These are real world linkage techniques. It's not vaporware, these techniques are out there in platforms or frameworks that people are actually using and doing assessments with.

So this is not a hypothetical concept. Terminology, I'm going to use some very generic terminology, descriptive terminology as opposed to scientific terminology. So if you see things like plug-and-play, it's more descriptive than scientific.

All right. The real world is a very complex place and we all know that and any modeling that we do, at least in my opinion, is a gross simplification of that real world. And one of the things we do is we take the real world and we tend to break it up into little components, little boxes, if you will, and then we try to simulate or model or monitor aspects associated with each of these boxes.

Our world that I have described here, we've broken it up into four areas. One is source, one is transport, one is exposure, one is impact.

Source being the release mechanisms from a source term into the environment; transport being transporting those constituents from a source to a receptor; exposure talks about the ways in which a sensitive receptor can be exposed; and, obviously, the fourth one is what are the impacts, dose, risk, et cetera, to that exposure.

And as we can see, the ground water, which I put in this nice big box, is sitting right here in the middle of everything. So it can interact with the source term, it can interact with other transport media, it can interact with the food chain and exposure routes.

So we can't just look at the ground water modeling by itself, but we have to look at the bigger picture and understand where it sits within the bigger picture.

Many questions have been asked and many questions will be asked over these two days and the answer that you're generally going to get is it depends.

It depends on the questions you ask, it depends on the assumptions you have, it depends on the data, it depends on the level of analysis you want, et cetera. It depends. Can you do this with a more simplified model or a more complex model? There is no really blanket answer yes or no. It depends.

And likewise, when we're dealing with approaches of linking two different models together, it's a function of many aspects. I've listed just a few of them here. The first one is the type of question that you're trying to answer. All right. For example, I want to do a nationwide analysis of 10,000 waste sites and I want to have a system where I link models that address that issue.

Well, that may be a different type of linkage than if I have a single waste site and I'm just simulating it through a vadose zone, a saturated zone to a well.  The second piece of information that might be important to determine what type of linkage you might want to put these codes together, these models together, is am I importing data or am I exporting data.  For example, I run a source term model and then I export that information out of a system to a very detailed numerical ground water model.  I run that detailed numerical ground water model.  I import that information in and I link it up to a dose model and have my doses calculated.  So it's important to know whether the data is being imported and exported or whether it's self-contained.  That data is self-contained within the system itself.

The third and fourth items I've listed here, which tend to crop up as being very important, scale and resolution and time and space and my definition of resolution may be different from others, but it's just a placeholder.

Scale, what do I mean by scale?  Medium specific, basically a waste site, if you will.  Watershed, regional, global.  Each one of these scales may require different types of models, may require different types of boundary conditions.  Resolution, you can have low, medium, high.  That's what I use. Somebody else could use something else.  High being the three-dimensional finite element numerical model with bells and whistles and spaghetti hanging off.  It does everything.  And then you have medium type models, analytical, semi-analytical, then you have your low resolution models, your hazard ranking system, for example.

So each one of these may require different spatial and temporal constraints associated with them.  For example, in the medium range, for analytical models, you may be dealing with a plane where the mass fluxes across the plane is uniform, whereas in a numerical model, you may have nodes and that mass flux rate associated with each node varies spatially and temporally.

So these things are very important when you're trying to decide how you're going to link these models together.

There are three approaches that I'm going to outline here. They are approaches that we've dealt with, there may be others. I've placed them in two main categories.

The first one I call the traditional linkage approach. That's really tricky. And there we link models a priori by hardwiring all of the connections. We take the models, we glue them together, fuse them together, and they're stuck. What you see is what you get.

The second main heading is what I call object-oriented specifications approach. There are two categories under this. There is the master file approach and from the master file approach, this is where we -- where the linkage specifications are developed to meet the needs of the specific models in the system.

Then the plug-and-play approach is where the models themselves are adjusted to meet the linkage specifications of the system. So for the master file approach, I've got the models and the system is being manipulated to meet the requirements of the model and then the plug-and-play, I have the system and the models are being adjusted to meet the requirements of the system.

We've developed approaches and frameworks for both of these and I will talk a little bit about those in a minute.

This slide, and I'm sure everybody has seen one version of this or another, this is what I call your traditional multi-media modeling approach, where your ground water system sits here and you have your dose assessment sitting in these boxes over here, and you've got your source and you've got your transport pathways, exposure routes, outputs, and notice the lines, everything is hardwired together and like I said, what you see is what you get.

More mechanistically, in terms of what does a traditional model linkage mean, I've put this slide together, and think of these boxes as separate or different models.

And each one of these models communicate with each other through these little elliptical circles called processors, data processors. You may have one model with sub-routines and these processors could be common blocks, they could be include statements, they could be objects of call statements, they could be literally processors that transfer the information from one model to

another model.

But as you can see, as I add more and more models to the system, the linkages become very complex. The reason is because this system that I have put together is hardwired together. So some of the attributes of this traditional approach are that the models are hardwired together, the data enters the system through the traditional routes, either as a user, I punch the information in, or the information is included in the database which is associated with the system itself.

Generally, you have minimal access to outside databases. I just can't say let's go read this database over here, STORET or something else, and access that information and put it in my system. You generally also tend to have minimal GIS connectivity. So you don't really -- you can't really incorporate very well the spatial variability associated with the GIS system, and GIS is going to be very, very important in the future, I believe. In general, what you have is you tend to have a closed form system. I can hit a big go button and this whole system can work because everything is self-contained to a certain degree. I've just heard today that some modifications to SEDSS have occurred, so SEDSS may or may not fit in this category, but here are some typical examples that I feel fit in this category.

The second major category in terms of linking models together I call the -- this is your object-oriented specifications approach. What we say is that before we link models together, we actually specify what the linkages, what the formats and what the form of these linkages will look like. And then we adjust the models to make sure that they meet the requirements of these linkages.

So I have a model sitting here and this is a processor which takes the output from this model, reformats it into the format of the system that links these models together, and then stores it such that any other model that wants to have access to that information can access it, consume it, reformat it so it fits into that other model.

As you can see, with this specifications approach, this spider diagram gets cleaned up

significantly, which means that each one of these boxes can represent objects and I can take one box out and very easily stick another box in, and the only requirement is that it meets the specification of the system for transferring information from one model to another model. Cleans things up. This is very good for QA/QC, for making modifications, for future modifications, say, for example, computers now run so quickly, I want to get rid of an old model and I want to plug in a new model. We're not changing the system. All we're doing is changing the model.

So what is the non-traditional master file approach? This is under the specifications approach. This is the first category. These linkage specifications are established to meet the model's needs. So I have specific models, I say these models have certain needs, and what do I do? The system is designed to meet the needs of the model.

So how do we do that? We establish a master file which contains all of the parameters that are required by all of the models in this multi-media system and of those parameters that are contained in this master file, we group them according to real world objects, like ground water, like surface water, like air, like wetland, et cetera.

So we take this master file of parameters and we group them, these parameters according to a particular category that is representative of these objects, those boxes, if you will. Those boxes could represent, as I said, vadose zone models, saturated zone models, source term models, river models, et cetera, dose models.

Also important on this is the parameter names in this master file are fixed. So if you want porosity to be N, that parameter name, then it's N and everybody, all the models recognize in this master list that porosity, that is designated by the letter N.

And also included in this are the attributes associated with each of the parameters. Is it a constant, is it an integer, is it a reel, is it stochastic? If it is, what are the characteristics associated with that parameter?

Finally, the models are fixed into these object-oriented slots, all the ground water models are

over in one area, the surface water models are over in another area, et cetera. There are constraints to this master file approach. It would seem nice to be able to have access to all the information by all the models for all the parameters, because now you don't have data redundancy.

The problem is that the models tend to be hardwired and you have no plug-and-play attributes. I can't pull one model out and put another one in, and the reason is because that new model may not recognize the parameter names I have in the system.

Second, data and databases tend to be hardwired. Again, the reason is because all the names in the system are fixed. It doesn't allow for different parameter names. We have to fix those. Therefore, it limits the use of legacy codes, which I just covered.

It doesn't allow very easily for different model user interfaces. Each one of these models might have its own user interface. Now I need a user interface that is system-wide consistent. And finally, any new applications using different models require retrofitting.

Now I'd like to talk about the third approach, which is the second under the specifications, and that's the plug-and-play approach. Basically, how this works is you end up with a tool bar and there is an icon for each of the main categories associated with the real world. Here I have chemical database, I have source term models, vadose zone models, watershed models, saturated zone models, surface water models, air models, food chain models, dose or intake models, and risk and hazard models.

I mean, we can have other icons, but that just gives you an idea. And under each one of these, you could have a suite of models to choose from. Let's look at the source term. Here is an example page, if you will, where I have three source term models and the one that was chosen is the MMSOILS source term model.

People use models not necessarily because they're the most appropriate, but because they're familiar with them. They like to use what they're familiar with. They understand the limitations, the constraints. They can make that model dance and do all the nuances to make sure that

assessment is done correctly. Therefore, they will want to use their own legacy codes and that's one of the attributes associated with this plug-and-play system.

In effect, what you can do is you can pull down these icons at the top, source term, I know it's difficult to read, here is vadose zone, here is aquifer, and I can link them in any way that's applicable to the assessment at my site.

Then under each one of these icons, I can then pick the model that's most appropriate for the assessment at my site.

So this is how the plug-and-play system works.

These models in particular are adjusted to meet the linkage specifications of the system. The system says if you want to communicate, I'm going to give you the telephone book. It has all the numbers in it. You're not allowed to change those numbers.

So therefore, model A must produce a certain amount of information in order to communicate in the system. Model B automatically knows that a minimum set of information exists, so it can go in and consume it if it wants to.

You can create additional information if you want, that's not a problem, but there is a minimum set of information that needs to be provided by your model if your model wants to play within this system.

This system views all of these modules as common objects. It's all ground water models clumped together as ground water models. And all of these like models, say vadose zone models, have common data specifications.

So they all know what they need to produce and what they can consume in the system. The reason why we do this is because we want to minimize the modifications to existing codes. We want to leave the legacy codes alone, so people aren't spending resources trying to change the model so it fits in some system someplace. So you can leave the legacy code alone and use the resources in doing the analysis and the assessment.

The other thing is that with a system like this, and I'll demonstrate it in a second, you can link to

other framework environments. In other words, multiple frameworks can now communicate with each other and the reason is because you know what information exists within that framework. And I demonstrated earlier the easy problem definition protocol. You can visually see your conceptual site model.

Now, how do we go about linking these, say, two models, three models, or other models together within this system, such that the system understands what your model is and how it can communicate with other models.

Well, we require a description file, a DES file, and it's a very short file. It's not very long at all, which is nice because you don't have to do a lot of work.

In fact, we've developed a program in which it can help you fill out and create this description file. In it, you have to identify the class of model that you have, is it an aquifer, is it a vadose zone model, is it a river model. You also have to identify the acceptable connections. All those lines that you saw connecting the different boxes, they may not be applicable to your model or the model that you put in here.

Therefore, you must tell the system which connections are applicable.

There is also support information, support information being if the model breaks down, who do they contact? They're not going to contact the system developer, they're going to contact the developer of the model.

And then finally, in this description file are all of your input parameters. The names of those parameters and the attributes associated with those parameters, is it a reel, is it an integer, what's the range, is it constant, what are the -- is it stochastic, what are its characteristics. The reason is because you want to be able to do a Monte Carlo assessment with -- have your model included in Monte Carlo assessment.

If this white outline represents a model that's being put into the system, it can be broken down into three basic components; the general information includes your description file, and then all of the inputs that comes into your system, including input through your model-user interfaces or

databases that you're calling in, all of that information gets stored in what's known as a global input data file, a GID file, which is outside of your module, if you will.

Now, that information is then sent -- that's in the format. That data is in the format of the system. Your preprocessor reads that information and reformats it for your input file, maybe it's a flat ASCII file. That's so you can run your model. You send the output out of your model. Then you have a post-processor that reformats that information and puts it into a format that the system understands.

And any other model that wants to communicate will understand what that format is of the system information. So in effect, this is what your model does and there is very little modification that is required by any models that are put into the system.

Now, in addition to having models communicate, we are also moving forward to using this type of an approach, the systems specifications approach to linking in databases and they can be different types of databases. For example, let's look at scale. I could have a database that provides site-specific information and I go to run my model and my model -- that site-specific information lacks a few of the parameters. I can't populate it.

So I can then go into a regional database, pull that information out that's missing, and populate my database for my model and if I need to go to a national level, I can complete filling out the database that's going to run my model. So I can pull in information from multiple types of databases. As long as I meet the data specification needs of the system, all of these models will be able to communicate with any and all of these databases, and this is an area that we're moving into and we've already begun this with EPA Office of Research and Development and the Office of Solid Waste.

Where does this all lead us to hopefully some place in the future, we're looking at setting up a -- not we, but DOE and I know NRC is having discussions with respect to this, EPA, and DOD in terms of setting up or having a platform set up on a web-based system. And what you can do with a web-based system is you would -- you can have located there the operating software and

you can have the databases that are required to operate that software, the software required to consume that data.

And for each one of these, you can either have the software or the data at some central location. So you go up on the web, you go to Argonne National Labs, they have all the data, all the models, and you run everything there, and then you download the results to your system.

A second option would be to download the software and/or the data to your computer, which is what I like to do, and then I run it on my own computer and I have the results sitting there. I can send the information back up to the web if I want.

And then the third option would be to have the computer models located in multiple locations, at Sandia, at Argonne, at PNL, at EPA-Athens, and I could have data -- databases located at remote locations, different locations, and I could actually use the web to call up the right computer models and pull in the right databases and operate this system from your PC, and it -- or from a UNIX system, because it wouldn't make any difference whether you're dealing on the web with a UNIX or with a PC.

The primary motivating factor for these systems or these approaches for linking models together is to allow for independent models to be developed, linked and applied within a single modeling structure.

It also allows for efficient development of future software, because I can pull out one model and plug in another. And it also facilitates this multi-tiered assessment approach, one that's -- NRC, that's why we're all here talking about it, and that is that we try to use a simple a system as possible that is scientifically defensible and get more complex as the situation requires.

Finally, I'd like to note that all the work that's being done is to support the decision-making process. It's so we can perform scientifically defensible assessments that are more useful, faster, cheaper, and more understandable to stakeholders and regulators and, more importantly, the scientists and the engineers that seem to think they know everything there is to know about these assessments, because a lot of times, they do not capture the essence of what the

stakeholders are looking for.

And I want to emphasize this is not academic. That's why NRC is here and that's why these workshops are being held. These are not academic exercises.

Thank you.

MR. NICHOLSON: Thank you very much, Gene. We have time for just one or two very quick questions. Then most of your questions or comments we will save for the group discussion at the end of the day.

Are there any quick one or two clarifications for Gene?

[No response.]

MR. NICHOLSON: If not, we'll move on quickly to the next phase of the program, which is basically we invited industry to make a presentation on their experiences in moving from a site-specific -- to a site-specific dose assessment modeling. Dr. Yim has prepared the presentation for today, but he can't be here, so Carol Hornibrook from the Electric Power Research Institute in Mountain View, California is here to fill in for him.

MS. HORNIBROOK: Thanks. I just want to thank Tom for inviting us to do this presentation. I thought I turned the thing on, but maybe not. Does it matter which this was set on? Good. Okay. Obviously, in our presentation, we're not going to address conceptual modeling, because that was done earlier, and done quite well, obviously. What we're going to look at is nuclear utility perspectives on site-specific ground water modeling, per se. So what we see that applies to us and affects us.

And the approach that we're taking to this is a couple of steps. One is to determine how important is ground water modeling for a nuclear power plant's decommissioning and their dose modeling, and there are two things we want to look at that. One is the actual multiple nuclide mix that we actually have at the sites. Then, two, we also want to look at individual nuclide cases, because in some instances, people are not finding all of the nuclides. There are just a few that are really standing out.

The next thing, once we look at that, then we wanted to figure out, okay, what's the impact of site characteristics and here we took three reference sites, and I will explain those in more detail, but ostensibly what they had to do was with the ability of the nuclides to get to the ground water being high, medium or low.

Then once we had these two questions answered from the first two bullets and if the answer was yes, ground water did have an effect, then what we wanted to do was look at what are the major parameters of importance in the ground water modeling, with the use of the D&D and the RESRAD codes. So we're only looking at these two codes in terms of ground water impact.

And then do the default input values of these parameters properly represent the industry?

Okay. So for the first question, how important is ground water modeling for a nuclear power plant in decommissioning, we did a test case problem and we picked ten radionuclides and we selected these, they actually came from two actual sites, neither site had all of these nuclides in their data, but we thought it is representative of what we find typically at plants.

But we also added Europium business Europium-152 has been found by Battelle in concrete. So we thought just to be comprehensive and get a good understanding what would really be the impacts, we would add that in.

Unfortunately, RESRAD doesn't have Europium-152, so we used Europium-154, which I think is fine. There is no real problem there.

We took cobalt-60 and used it at one picocurie and then we scaled the rest of these nuclides to that to come up with our representative inventory, and we have a good handle on scaling factors for the industry. So I feel confident that our mix is very representative.

The results of this -- I need to find my pen here. In the ten nuclide mixture, it kinds of shows something that made me feel good. Both in the D&D code and the RESRAD code, the majority of the dose was from external. So that's a good thing. I means that for our mix of radionuclides, we really think on the average, from what we know so far, that it's not going to be that difficult for us to have a good outcome with both of these codes.

So that's for the ten nuclide mix. And so what we did was we took this information and we ran a sensitivity analysis on the multiple nuclides and we did it for each code and came up with the following parameters as being the key in this particular analysis.

And don't let it fool you, that it looks like there's only four here, we did it this way so it would be enough space. It's indoor time, indoor shielding. So there's really six parameters here that are really key in the D&D code and four in the RESRAD code. And as you can see, none of them really have to do with ground water. So ground water is not dominating our nuclide mix.

Now, when we started doing comparisons of the RESRAD and the D&D code, the NRC, the industry, EPRI, we found that there were some nuclides that you did get kind of a real difference in your results. I know NRC is working actively on that right now. The changes to the code are on their way and not too far in the future.

But I wanted to show some examples, so you could get an idea of what kind of comparison we did, and how this kind of an analysis shows the impacts.

So we looked at strontium-90 and here what we found was that the -- again, you don't see a ground water component. It's agricultural food, non-aqueous, also in RESRAD, agricultural food, non-aqueous.

So the good news is there isn't a ground water component that is showing up in these codes, not with any kind of strong measure.

One thing I would point out, though, it doesn't mean that the doses that come out of these two codes are the same at this point. I'm sure when the correction is made, there will be a difference. But right now, it's almost a factor of ten difference.

Again, we did a sensitivity analysis to try to see which parameters in the code were of importance, just to confirm that the ground water was not an issue, and pretty much that's what you see when you look here. You don't see ground water, the parameters that are important for ground water popping out at you.

We also looked at cesium-137 and here we do see something is happening. There is a

significant difference in where the two codes say that there is an impact. In D&D, it's from aquatic food and irrigated food. In RESRAD, it's from external gamma. And I think most of us would kind of more expect that it would be from external gamma. So this does say that there is some difference going on here.

And the implications, to us, is that perhaps the D&D code is, in its simplicity, may be a little too simple and this is an artifact as to why you would see the cesium-137 so high in the aquatic food.

We also did this same analysis on plutonium-239 and came out with similar results. So it's not just cesium where that happens.

Similar results for both codes in terms of the percentages. Again, with the sensitivity analysis, now you start to see ground water showing up, especially in the D&D code. KD saturation ratio of the unsaturated zone, thickness of the unsaturated zone, density of the unsaturated zone, infiltration rate, all of these are ground water associated parameters. You don't see that really in the RESRAD code. You see more of what would give you that external gamma.

So to our way of thinking, cesium is something we should be looking at. Here we're being impacted by a ground water, the ground water models within the D&D code. So the next thing, as I pointed out earlier, the second bullet was, okay, how important, if that's the case, how important are the site characteristics when you look at D&D versus RESRAD in your comparison.

As I said earlier, there were three types of reference sites, site A, low potential for ground water contamination; site B, medium potential; and, site C, high potential. This is based on an actual EPA report where they wanted to look at ground water issues and I really don't want to discuss the numbers up here because it's from the EPA. I didn't select them. We used them because it was actual sites that they had this data on. So we thought it was kind of a good representation to try to get a handle on what these differences might mean.

But I included it so you'd know what we did in our analysis. And here, now I realize it's a little --

not complicated -- confusing to look at this, but check it out. If you look at site A, B and C, realizing this is low, medium and high, if you look at the D&D code and look at strontium-90, here you get 59 millirem per year, 59, 59. That's pretty much what you would expect, because it's not that water soluble. You don't expect it to be going in the ground water.

Same thing for the RESRAD analysis. As I said before, the numbers are quite different, but same thing. You would not expect to see a difference in the ground water.

Let's pick two nuclides where you would expect to see a difference. Carbon-14, Iodine-129, again, remember, now we've just used one picocurie per gram. We're not using the ratio that I used earlier with the ten nuclides from our site and trying to put those in some kind of proportion. So this is much higher concentrations than we would ever find at our site, especially for these two nuclides. And if I could take a step back for a second, you may have noticed that I didn't include Iodine-129 of we didn't include it in our analysis of the ten nuclides and the reason is that our concentrations are so low that when we've done the analysis, the actual dose resulting from Iodine-129 is in line ten-to-the-minus-three. So we weren't concerned that it was an actual contributor to dose, not of any significance at all.

But you will see, with nuclides that are water soluble, migrate kind of easily through the environment. The expected changes in terms of lower numbers, increasing numbers, increasing numbers, same thing in the RESRAD. There is a little difference here where it goes up a little higher in the median, I'm not sure why that is, but you can still see that there is an increase, because these are more likely to be in ground water. But as I say, realize that these numbers are very high. We'd never get these numbers at our site. It would be much lower, way lower. So what do we see from this? With cesium-137, we see that there is a factor of four difference if you look at the predicted peak dose and a low potential for ground water contamination, with D&D. But then when you get over here, also with median, then when you get to high, it's a factor of four difference, and that's not what we would really expect. And in the RESRAD code, you

don't actually see that and as I said before, it's kind of a similar thing with the plutonium-239 that you see an increase which you really wouldn't expect to see and that RESRAD doesn't show.

So now we want to look at the default parameters and these are the same ones that I showed you before, only we've just reordered them and the only difference in the ordering is not any magic. It's just the fact that when it came to these parameters, we wanted to order them in terms of what information we actually had available to us and how much there was.

And actually thanks to Sandia and Walt in particular, we were able to get quite a significant amount of data on thickness of the unsaturated zone. There isn't a lot of data for us in these two areas right now and we're actively trying to collect KD information.

So my next slide will be on our analysis of the thickness of the saturated zone. In a sense, this is kind of my last slide. Walt was able to provide us with 211 independent measurements. Since that time, we've gotten about five or six from the industry and what we did was a data fit with a maximum likelihood estimation and this is kind of a typical statistical analysis that's done with hydrogeologic data. What we did was a lognormal distribution and we came up with a geometric mean of 2.296, and a geometric standard deviation of 1.265, and I realize that's a pretty significant size standard deviation, but we feel fairly comfortable.

We also did a goodness of fit with these numbers and though I'm not a statistician, what I'm told is this is not a bad goodness of fit. The difference between those numbers falls in a pretty good area.

Now, what does this mean? For the 95 percentile, what we would come up with when we look at the goodness of fit from that data is a 1.24 meter would be the -- excuse me -- the parameter that we would get. At the 90 percentile, we would get almost two meters. However, in the D&D default right now, it's a 1.22 and I believe, am I right, that this is at the 90th percentile or is at the 95th?

MR. BEYELER: That is the default for doses at the 90th percentile.

MS. HORNIBROOK: At the 90th percentile. So our analysis is not a one-for-one with theirs, it's

not too bad, but it's not a one-for-one. But I say it's not too bad in the sense that, remember, when I gave the original slides on this, I also said that I really thought because of the simplicity of the D&D code, that perhaps that was also contributing to make it an artifact to see some of this difference.

So we haven't quite ironed that out yet. In fact, we're still talking to Walt a little bit about it to see what he thinks.

But so far, what you can see is for the nuclides that we have on-site and the concentrations that we're likely to have, for the most part, ground water is not -- we don't see it as a big issue at this time.

When it comes to specific nuclides, I'm assuming that once some of these corrections get made to the code, that NRC is working on, they'll probably fall a lot more in line with what we're expecting from these kinds of analyses.

Thank you.

MR. NICHOLSON: Thank you very much, Carol. We would like to have a few quick questions or comments.

MS. HORNIBROOK: Easy questions.

MR. NICHOLSON: Easy questions, be nice to her. Boby?

MR. EID: Yes, first of all, I would like to commend you on this presentation and the comparison, it is really good work, and I would like just to explain one thing. That the data that you showed, I believe you did use D&D code version 1.0, which is on the web site.

MS. HORNIBROOK: Yes, right.

MR. EID: Now, we have looked into that and we gave presentations before about the cesium and the strontium and we said that the default parameters in those were used because of the current methodology of selecting the solution vector, because you assume that you have a solution vector for all radionuclides, that they are there.

And I'll guarantee that all the radionuclides they have, the dose distribution above 90th

percentile. We have looked at the single radionuclides and to have the parameters that they are consistent with the single radionuclides and looked at the peak dose, and those numbers are significantly different.

So do not be discouraged from these values in the D&D code. However, we have numbers using single default values, using default values for single radionuclides, and those they are somehow comparable with RESRAD results.

And we will soon, as I said this morning, be publishing in the Federal Register Notice, default table for soil, for alpha, beta and gamma for common radionuclides.

Those default tables, many of these radionuclides, cesium and strontium, uranium, plutonium, they changed. So I'd like just to bring your attention, so just look for this comparison and there will be a more valid comparison.

MS. HORNIBROOK: Okay. I was trying to give you credit, but I didn't know how much to actually say. Thank you. Are there any other questions? Yes?

MR. YU: Charlie Yu.

MS. HORNIBROOK: Hi Charlie.

MR. YU: Argonne National Laboratory. Carol, I may have missed your explanation on the last slides you showed.

MS. HORNIBROOK: You probably didn't.

MR. YU: Geometric mean is 2.296 meter.

MS. HORNIBROOK: Hold on. Sorry, I don't have it right in front of me. Has anybody got a copy of the presentation? Okay. Yes, 2.296.

MR. YU: And your 95 percentile is 1.24 and 90 percentile is even higher. Can you explain that a little bit? Is that what you get from --

MS. HORNIBROOK: That's a Man-Sung Yim answer. I can't honestly give you that answer. I'm sorry, Charlie. But I can have him call you. He's in Korea right now, but when he gets back, I'll have him give you a buzz. I'm sorry about that. Any other questions? Oh, dear, another one.

MR. NICHOLSON: Gene has a comment.

MR. WHELAN: This is Gene Whelan, PNNL. I just have a quick question, it's an easy one. In general, we see that the D&D results tend to be, at least from what I saw, tend to be more conservative.

Excluding the magnitude of the results and from your experience of doing the comparison between these two models, would you see significant differences in the decisions as opposed to the numbers?

MS. HORNIBROOK: Right now, we look at the numbers because of the regulations.

MR. WHELAN: But you make a decision based on those numbers. Would you have different decisions?

MS. HORNIBROOK: I would think so, sure. Yes. I mean, at this point, fortunately, one of the decisions could be to use another code and once you've explained why that code is appropriate. But after Boby does the improvement, then I'm anticipating that it will work out. Not work out, I don't know what the right term to use is. It would be good representation of what's there. Reconsidered.

MR. ROBERTS: A question. Rick Roberts, Rocky Mountain Remediation Services. On your basic parameter list, you talk about you have a lot of different parameters on saturated zone thickness, KSAT, B parameter, you go through for reach of -- of each of the sites. And it seems you've got your unsaturated zone thickness for site A is 45 meters.

MS. HORNIBROOK: This is EPA data. It's straight out of an EPA report. I just picked it because it was based on real sites and I just wanted you to know what I used. I really don't want to try to defend it because it's their stuff.

MR. ROBERTS: Okay. That's fine. What I'm wondering is, on your last slide, you say that the thickness of unsaturated zone should be about 1.2 meters or 1.9 or less than two meters.

MS. HORNIBROOK: All I'm saying is that when you take the -- two meters.

MR. EID: I believe she wanted to say that the unsaturated zone is thicker than D&D code

assumes and the assumptions in D&D code is conservative because the thicker the unsaturated zone, the more you have retardation and the less that you will have concentration in the aquifer. So she is proposing to you thicker unsaturated zone, two meters, based on her analysis, which is the 90th percentile.

MS. HORNIBROOK: If you look at the cesium dose, it goes from 28 to 18, when you use these numbers between 1.2 and 1.9, which is two meters.

MR. ROBERTS: I guess my question was if you did an analysis, and I'm not sure who did -- I guess EPA did it, but it seems like if you reduce the unsaturated zone to less than two meters, that your dose assessment from your three sites would be much different and your pathway analysis would show much different results.

Is that -- you're shaking your head. Have I missed that point?

MR. EID: I agree with you. You are absolutely right. Depending on the pathways, if you have the direct exposure pathway, it's more significant. This means if you have more leaching of the material, this means you are going to be more conservative if you have thinner unsaturated zone.

MR. ROBERTS: Okay.

MR. EID: So you are right. Depending on the pathways. Whereas if the ground water pathway is significant, it will be the other way around.

MR. ROBERTS: So up front, what pathways are most important, those could really change drastically given a much smaller unsaturated zone.

MS. HORNIBROOK: Right, yes.

MR. ROBERTS: Thank you.

MS. HORNIBROOK: Thank you.

MR. NICHOLSON: Thank you very much, Carol. I would like to now introduce Dr. Ralph Cady, who works in the branch. He is both a hydrogeologist and a performance assessment specialist. He will be leading a group discussion on experiences in integrating site-specific ground water

modeling into dose assessment and the ground water pathway.

MR. CADY: You must have stayed around either to see what I look like or to hear Carol's talk. So I won't presume what the answer is.

And remember that I have to answer all these questions or I don't go home tomorrow. We can worry about some of these tomorrow, but it would be nice to be able to at least step through a fair number of them.

Primarily what we're talking about here is mechanics. It's writing code to essentially link the sophisticated or more sophisticated ground water models into a more traditional dose assessment code.

The first question really gets at the mechanics, whether it's a ground water model or the radionuclide concentrations from monitoring.

We went around the table of the models that are being discussed and there are some that can't handle any of these monitoring data whatsoever, and Gene proposed an engineering approach to incorporating a plume into MEPAS, I would assume within the FRAMES approach, there's a perhaps even more elegant way.

MR. WHELAN: There is a model there.

MR. CADY: There is a model there, good. All right. In that case, you're talking. What's your answer?

MR. WHELAN: We've actually done a lot of linkage of models and I would say that if people want to link a different model in either with D&D or with RESRAD, et cetera, I would say take one of two approaches and, again, SEDSS may fit into one of these approaches, because the information I heard today is slightly different from what I have been hearing in the past. So pardon me if I got SEDSS wrong.

MR. CADY: I've got a thick skin, don't worry.

MR. WHELAN: And that is that I would either do it the way that we have done it with the plug-and-play approach, and that is that we have run more sophisticated models,

quote-unquote, outside the system and then actually when you go to run your dose assessment model, you just pull that file in and it's just like that file was created by a model inside the system. That's one way of doing it.

The second way of doing it is literally taking that model and I'll say hardwiring it into the system. I don't think it would fit very well in the master file approach. So I would say one of those two approaches would probably be the best way to go.

And if you're going to change models a lot, maybe the first one, that is this plug-and-play approach.

MR. CADY: You've got to take your output from your source term and get that into your transport model or in the case of infiltration, get it into your flow code. So you've got stuff to do at the front end as well as the back end of this external model if it's outside the framework construct.

MR. WHELAN: That's correct. And that can be done within the framework construct. Again, like I said, if you're going -- if you're not going to change that model, it may be just as easy to hardwire that model into your system. If you're going to change it, you may want to reconsider doing that, but it's either way would be acceptable, depending upon, again, down the road, how many changes and modifications you expect.

MR. CADY: How about number two, for the external. You've got existing data.

MR. WHELAN: If you've got existing data, then, again, you can do it one of -- with either way. Right now, with the plug-and-play, for example, you would actually be reading in a file that contains that information. So it's just like somebody ran a ground water model and produced that file.

The flipside to that is you would have to build, for this hardwired system, you would actually have to build a model or a processor that allows you take in this monitoring information and use that directly, skipping, if you will, the transport components.

MR. CADY: Another little issue -- you might as well just keep that down. Shlomo acknowledged

a sort of nauseous feeling with a lot of these codes because he couldn't look in and see what the concentration is at a point.

I noticed, I believe -- I believe it was in one of the viewgraphs. Well, you also said the same thing. You didn't quite get the nauseous part in, but that you would like to be able to look in and see how your monitored data relate to a simulated data point.

MR. WHELAN: I'm not helping you on this one.

MR. CADY: Oh, I'll get the question. It may take me a while, but I'll get the question. In what I saw you present for the FRAMES approach, I didn't see that ability to, okay, tell me what the concentration is at this point. I mean, I would assume that that would be something that may be in there or you certainly would like to have that ability to look at internal variables that typically, in a lot of these codes, you don't get to see.

MR. WHELAN: I do have an answer for that.

MR. CADY: I know.

MR. WHELAN: If we think back to what I had mentioned, I noted that at least in this plug-and-play, that's the FRAMES concept that Dr. Cady is referring to, in this plug-and-play environment, how that plug-and-play environment is structured is that the models are adjusted to meet the specifications of the system.

In other words, this telephone book exists as to if you run a ground water model, there is a certain minimum amount of information you must produce in order to communicate within the system. You can produce more, you can produce intermediate files, you can produce any extra stuff you want. But as a minimum, you must produce -- meet the specifications of the system. Therefore, if you want to look at these internal numbers, if you will, of this model, this plug and play environment allows you to do that. It's just that when you have other models that come in which were not developed by the same person, they don't know those temporary or intermediate files exist.



Now, if you wrote both models, you can also read those temporary files yourself if you would

like. So the system does not preclude you from generating more information for you to inspect and view and visualize. It just tells you the minimum amount you have to produce.

MR. CADY: Okay. Trust me, if I wrote both those models, I'd probably shoot myself. Walt didn't have a great opportunity to go through a lot of the mechanisms, but I know that there are elements of the design in the new version that we're putting together for SEDSS that address these issues.

Is there anything that you can add to the discussion?

MR. BEYELER: No. I think it is more of an object-oriented design and I appreciate that acknowledgement. I think the old version of the code did, in fact, every combination had to be explicitly constructed. We're endeavoring to get around that.

I guess the only point I'd make is that it seems that this is maybe the easier end of the question; that is, if we're interested in going from a complex representation of the ground water system to a dose assessment it's simply a matter of integrating the concentration over the volume, sucking it up in the well and coming up with some average number.

I think maybe the more complicated question is the other end, going from a simplified representation, how is that specified in a more complicated ground water system and, more specifically, how do you specify the many alternatives, because you're going from a case where you have one number for infiltration, say, into the aquifer system, what are the possible ways that that might be distributed spatially given that you're representing a higher degree of spatial in the aquifer.

I think that's -- it's a methodological question.

MR. CADY: Maybe it's time to move on, because I don't see too many other volunteers here.

MR. POTTER: I would --

MR. NICHOLSON: Would you identify yourself?

MR. POTTER: I'm sorry, I keep doing that. Tom Potter. Until we have RAD Windows, which apparently will be available pretty soon, there's -- I have had great success with RESRAD,

which, in its simplicity, allows a lot of flexibility.

There are two files, the detailed report file and the concentration output file, concentration includes concentration in water as a function of time, and it is quite simple to manipulate data to produce whatever ground water concentrations you want in a way that is conservative; that is to say, you don't deplete your source too quickly, things like that.

So if you have a sophisticated ground water program that's fun off-line, produce concentrations as a function of time, I can assure you it's a pretty simple matter to make RESRAD produce those concentrations artificially and integrate the results of the complex ground water model.

MR. CADY: I think Gene also mentioned that the ability of a knowledgeable user to tweak the system considerably, you've got a vision of what the conceptualization is, but by an appropriate choice of parameters, it's amazing the amount of trouble you can get in or the problems that you can attempt to solve.

All right. Let me look at these two, three and four. I guess we did try to put them in some sort of order. So let's try to address number two. Gene, how did you go about selecting the particular code that's within the existing MEPAS as well as the current and how about potential futures for FRAMES?

MR. WHELAN: I'm going to start backwards, I'm going to start with FRAMES, and that is that the models that were in FRAMES are EPA models, MMSOILS, DOE models, basically MEPAS and GENII, which is an EPA model now, I guess. And those really are the first proof of principal models to show that FRAMES is a very viable platform for integrating different models.

And DOD, at WES, has just incorporated in the HELP model and the RECOVERY model. In the RECOVERY model, they have asked us for no help whatsoever, they just put it in. So it's not a real -- I mean, they have real smart people, but it's not as difficult as it might seem putting a model in to communicate with these other models.

In terms of why we chose the models we chose for MEPAS, and RESRAD may be a similar thing, back in '84 and beyond, and even today this happens, if you look at the type of models

and assessments and the data that are available at Superfund sites, DOE sites, RCRA sites, et cetera, many times what you end up with is assuming homogeneous iso -- in other words, the data back then were not necessarily there to warrant a more complex model, number one. Number two, the computing power was not really there to run on your PC, if you will, running a three-dimensional finite element model, plus the data generally weren't there either. So it specifically met the needs that the regulatory industry has and the regulatory industry is still using that class of model for comparative assessment. So it isn't like we've graduated to just using numerical models now in all of our assessments. That's not the case.

In addition, what's nice about these semi-analytical models is that they actually do fit a nice niche. Being able to go in and do a very quick preliminary assessment to get a feeling for what type of problems I might encounter, so I can now focus my resources on the more detailed assessments, I know what questions to start asking for those detailed assessments, and, in fact, the preliminary analysis may provide me with the same decision that I would end up with a more detailed analysis.

Which isn't to say that the numbers are right or the numbers are better, but the results are such that, say, I get de minimus results and I know that the concentration is going to drop if I run a more detailed code. Therefore, I can show that to regulators and they will say, fine, all you have to do is monitoring or whatever.

So that is one of the main reasons why we chose the models that we did for MEPAS. It's because they were very consistent in the regulatory environment.

MR. CADY: I don't know whether Walt, whether you want to address D&D as well as SEDSS, but you have the opportunity.

MR. BEYELER: As far as why those particular models were included, I would say to meet customer requirements.

MR. CADY: Well, in that case, I'll fill in. In the D&D ground water model, it's really almost a misnomer to call it a ground water model. It's a bucket and you fill that bucket with enough

water to meet the needs of whatever the scenario is, how many liters per day drinking water, as well as the irrigation and livestock requirements, that sort of thing, and whatever comes out of this unsaturated zone delay function plops into this bucket and you drink it.

So there is not -- Walt alluded to the lack of data in the D&D model as far as the hydraulic conductivities and a lot of these other things that appear in many different models. There is no -- within the aquifer, that sort of thing.

So that model was chosen explicitly to be about as conservative as people can think and for use purely as screening.

In the SEDSS construct, we've chosen NEFTRAN as the first candidate to go into the flow and transport portion of SEDSS for ground water and NEFTRAN was developed by Sandia, so that helps pinpoint one reason why it was a candidate.

The other reason was its ability to handle decay chains, very long decay chains, and NEFTRAN handles them quite well. So that's really my basis or at least my understanding for why it was incorporated.

MR. BEYELER: Yes. I think that's true. I'd just add that, again, in the case of SEDSS, the specification of the model for ground water, it's more done in terms of the assumptions that are made about the ground water system. And one of the key assumptions is clearly the dimensionality of the aquifer.

So from that standpoint the D&D model to NEFTRAN or more sophisticated models are sort of a natural progression to, in effect, a zero dimensional model at the aquifer that D&D represents to the one-dimensional model that's represented in NEFTRAN and later models that are three-dimensional.

MR. CADY: Okay. I'd like to take a couple seconds just to address a balloon that Shlomo lofted before he left, and that was that we currently have all this computational power, why are we stuck with these simplistic codes, like can we do better, shouldn't we do better.

How about can we or do we have plans to? I think historically, there has been an interest, at

least from the folks at EPA that we deal with on SEDSS, to consider strongly pulling in at least 2-D ground water to SEDSS.

MR. BEYELER: Yes. I think -- this is Walt Beyeler from SAndia. I think clearly the capability needs to be there. I think there is a still a question of estimation of parameters for the more complicated model. There are aspects of the uncertainty that you can get around by simulation, for example, but it sort of raises the higher order questions of what is my barrier and how do I deal with uncertainty barriers. So there are, I think, it's important to have the analytical capability to do those sorts of simulations and it's important to make that capability easily available from a variety of dose assessment standpoints, to solve the mechanics of the integration problem. I think it's also very important to think through systematically how each of those complications is best parameterized, where the parameter values are best established for each of those various degrees of complexity in a way that's consistent with specific assessment and dose concentration.

MR. CADY: Has there been any sort of interest at DOE or EPA?

MR. WHELAN: The reason why we have FRAMES was just for that fact that we get away from is my model better than your model, is this model better than that model, and we let the users themselves make the decision as to what's most appropriate for their analyses.

I will say this, that -- and I've developed numerical models, as well as analytical and semi-analytical, and that is people tend to use the models they're most familiar with to start off with.

Second, when you do preliminary assessments, you really are not looking at detailed mechanistic aspects associated with why contaminants move. All you want to be able to do is to be able to try to capture the essence of a contaminant plume as it passes, for example, a monitoring well, et cetera. That's why I say if you have calibrated information, many times the semi-analytical models, which are analytical and numerical solution, they contain both, you can calibrate those models to that monitored information and then to a certain degree, and it's not

very far, you can extrapolate to get some idea as to the ramifications associated with the analysis.

And what's nice about that is the analytical and semi-analytical models, you can get up and running and calibrate this thing and in a week you have numbers.

Numerical models, although with the computing power we have, it makes a great access, they are a little more difficult, as we all know, to operate. You've got convergence problems, stability issues you've got to deal with, you've got to put more data in it, et cetera.

The more simplified model does not take the place of the more complex models. They actually should compliment the two. And I firmly believe, after doing the site assessments for years and years and years, that a tiered approach is going to be the most cost-effective approach.

Now, we have to be very, very careful, though, and that is that if your answer that you're looking for is yes or no, maybe you don't need the right numbers to come out in order for you to come up with the right decision.

But if you are interested in the right numbers, for example, if your value is above this by so many, I pay you a million dollars in restitution, if it's four times higher than that, I pay you twice as much in restitution, then it's very important to make sure you get the right numbers, if you know what I mean.

So sometimes you don't need the right numbers to make the right decision. That's why I asked the question earlier, but sometimes you do. So it's based on the question that you're asking as to the type of assessment.

The other thing is that the simplified models try to capture, in general, the essence of what's going on in the system. It's an average. Like when you do estuary modeling, you use the average velocity of the tide coming in and the tide going out. You don't necessarily have to model all the tidal effects in order to come up with an idea that the contaminants are leaving the river and going into the estuary.

MR. CADY: We have a question.

MR. LEE: Sam Lee, from USDOE. Just for the comment. From this afternoon, based on Dr. Neuman's presentation, I totally agree, we have to have a three-dimensional model to try to catch all the complicated features of underground flow and transport. No question about it. It's a complex situation. It's happening underground. The question is now, refer to your rough equations, how, within this kind of computer power, can we still we have to use this complex model or not. I think so, because the question now is how can we select a complex model to be used. Now the question is, it's important, if we do not have enough measurement data to select a complex model to be used.

So that's why I suggest we have to select at the site where you can have a very good measurement data, a variable, to be used to be selected where is -- which complex model can be used, then convert or compare, use all those measurement data are variable, then compare it with the different complex model. Then we can choose which complex model to be used. So that's why my suggestion is we have to select a site where it can have a very sufficient data can be used, that then we apply, try to use complex model. Tomorrow I have a presentation to talk about another complex model and I'd like to present it to the audience and see how the comment.

MR. CADY: Well, we invite you all back tomorrow, then.

MR. NICHOLSON: Are there any other comments? We'll save a lot of this discussion for tomorrow, also. Mark, did you have a comment?

MR. THAGGARD: Yes. I just wanted to make a point of clarification. I think what Dr. Neuman said was not that you had to do a three-dimensional ground water analysis, but that you need to develop a three-dimensional ground water conceptual model and that's not quite the same. So I just want to make sure we didn't walk out of here with the wrong information.

MR. NICHOLSON: I think also the issue is that we don't need to do complex models simply for the reason of complexity, that there has to be a very legitimate and relevant need to do it, and I think we can talk about that tomorrow and that's a good topic.

We have two very good presentations tomorrow, real world dose assessments at real sites, and I think that will be a very interesting point to bring up.

I want to thank all of you for staying here late. I'm sorry we went over past five, but obviously there was an interest. We'll start promptly at 8:30 tomorrow morning. Those of you who want to say something in the afternoon, talk to Paul Genoa and other people, please contact Dr. Ralph Cady, the last group discussion leader, if you want to be put on the agenda to make a few comments tomorrow afternoon.

Thank you.

[Whereupon, at 5:25 p.m., the workshop was recessed, to reconvene at 8:30 a.m., Thursday, June 24, 1999.]