Official Transcript of Proceedings

NUCLEAR REGULATORY COMMISSION

Title: 2nd Annual Subsurface Investigations Public Workshop

Docket Number: (n/a)

Location: teleconference

Date: Wednesday, May 11, 2022

Work Order No.: NRC-1923 Pages 1-234

NEAL R. GROSS AND CO., INC.
Court Reporters and Transcribers
1716 14th Street, N.W.
Washington, D.C. 20009
(202) 234-4433

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

+ + + + +

SECOND ANNUAL SUBSURFACE INVESTIGATIONS PUBLIC WORKSHOP

+ + + + +

WEDNESDAY,

MAY 11, 2022

+ + + + +

The Workshop convened via Videoconference, at 12:00 p.m. EDT, Brett Klukan, Facilitator, presiding.

PRESENT:

BRETT KLUKAN, NRC, Facilitator

JANE MARSHALL, NRC

THOMAS AIRD, NRC

CYNTHIA BARR, NRC

BRUCE MONTGOMERY, NEI

CARL GOGOLAK, SC&A

DEBORAH FAGAN, PNNL

JENNIFER HUCKETT, PNNL

MATTHEW DAROIS, RSCS

ERIC DAROIS, RSCS

AMANDA ANDERSON, DOE

BRIAN HARCEK, DOE

TIM JOHNSON, PNNL

FRED DAY-LEWIS, PNNL

DAVID KING, ORAU/ORISE

CONTENTS

CONTENTS (CONTINUED)

P R O C E E D I N G S

12:01 p.m.

MR. AIRD: Okay, I think we can kick this off now.

So, good afternoon, everyone.

My name is Tom Aird. I am with the NRC's Office of Nuclear Regulatory Research. If you attended our workshop last July, my voice will sound very familiar to you.

And I think we can go ahead and get started.

So, welcome. Welcome to all the new participants as well as to those who joined us in last year's workshop in July.

If you've noticed, we have a very full agenda today. And so, we are going to go quickly through some brief remarks.

And the facilitator of today's meeting is Brett Klukan. Brett will now share his screen and briefly go over some procedural reminders and some workshop logistics.

MR. KLUKAN: Thanks, Tom.

Hopefully, everyone can see my screen or see the slides. If you can't, please let me know.

So, again, my name is Brett Klukan. I'm the Regional Counsel up in Region I, but today I'll be serving as the facilitator of the conference.

So, again, welcome, everyone.

Just some quick logistics before we get into it.

We are using Microsoft Teams for this meeting. And so, there are three ways you can participate in this meeting.

First, you can use the Microsoft application. Download it onto your laptop or your computer or your mobile device. This is the recommended way because it gives you the most options to participate in the meeting.

Alternatively, you can access Microsoft Teams -- can everyone hear me okay? I saw a message that one of you needed to be able to hear.

MS. BARR: Yes, we can hear you.

MR. KLUKAN: Okay.

MS. BARR: We're going to give Fred access. He came in later. So, he hadn't gotten access yet.

MR. KLUKAN: Okay. All right. Fair enough.

MS. BARR: But you're fine.

MR. KLUKAN: All right, good. I just wanted to make sure.

So, the other option is to use Microsoft Teams through a web browser. The interface is slightly different. So, the "Raise Hand" function -- we'll get to that in a second -- you have to kind of move your mouse around the screen, and a little bar will pop up and you'll see the "Raise Hand" function on that. Whereas, in the application itself, it's up in the corner of the screen under "Reactions" and the little hand.

And then, finally, I see that there are many of you, or several of you who are participating via phone. And I'll talk more about, on the next slide, how to participate via phone in terms of raising your hand and unmuting yourself.

So, the next slide.

Participants will be admitted as attendees without the ability to speak, though you will have throughout the conference the ability to talk or to write in the chat box.

NRC staff will share the topical presentations with the presenters invited to speak, to answer any questions, as appropriate.

After the presentations or after each bundle of presentations, as set out in the agenda, audience members who would like to make comments can use the Microsoft chat function to write their comments in the chat or, alternatively, you can use the "Raise Hand" function. Again, it's under "Reactions." It's the little symbol that looks just like a hand. Raise that; it lets us know that you would like to speak, and then, we will unmute you.

For those of you participating via the phone, to raise your hand, it's *5. Again, that is *5 to raise your hand, if you would like to offer a comment during one of the discussion sections.

Then, once you are called upon, you will need to press *6. Again, that is *6. You will hear me say this multiple times throughout the meeting. So, don't worry if you didn't catch that quickly. But, again, it's *5 to raise your hand, and then, *6 to unmute yourself, for those of you participating solely via the phone.

One additional thing. This meeting is being recorded, and we will be publishing a meeting transcript, along with a captioned video of the conference.

Finally, here is some contact information. If you're having any trouble during the conference with Teams itself, you can't hear, or anything like that, please email one of these two individuals here, Tom or Cynthia, and they will help you out.

And with that, I will now turn it over to Jane Marshall, the Director of the Division of Decommissioning, Uranium Recovery, and Waste Programs.

Thank you again.

MS. MARSHALL: Thanks, Brett.

Hi. I have the pleasure today to welcome all of you to the Second Annual Subsurface Investigations Workshop.

As Brett mentioned, my name is Jane Marshall. I'm the Director of the Division of Decommissioning, Uranium Recovery, and Waste Programs in the Office of Nuclear Material Safety and Safeguards here at the U.S. Nuclear Regulatory Commission.

I really enjoy subsurface. That's a good bit of my academic background, was looking at contaminant transport in groundwater. So, subsurface issues are a natural fit with me.

I'd like to start out by thanking our Office of Research for cosponsoring this workshop; most notably, Tom Aird from the Division of Risk Analysis and Kerstun Norman from the Division of System Analysis. Also, I'd like to thank Cynthia Barr and Boby Abu-Eid from my Division for organizing this event. And last, but not least, I'd like to thank Brett Klukan from Region I for facilitating for us today.

This is a part of a continuing series of workshops on the subsurface. Last year, we had nearly 200 people who took part, and last time I looked at the attendee count, we were at 97 on this meeting so far today and the count was still going up. So, that shows the level of interest in this topic.

As long as there continues to be interest and productive discussions on this topic, we'll continue to host these workshops. I appreciate each of you taking your time to work with us in addressing the need for guidance on subsurface issues.

So, for today's workshop, it's part of

our outreach. Those of you who have worked with NRC before are familiar with our focus on outreach and working with our stakeholders to continue to improve all of our processes at NRC.

This workshop is part of a multiyear effort to update decommissioning guidance. I'm happy to say that we have finalized NUREG-1757, Volume 2, Revision 2, and we expect to issue that this summer.

We were able to incorporate the July 2021 First Annual Workshop findings in the final guidance document. There are still some issues, though, that need to be addressed.

The purpose of this second workshop is to help NRC develop Interim Guidance on Subsurface Investigations, which would include optimization of subsurface survey designs. The Interim Guidance will be issued for public comment later this year or in early 2023. We plan to, ultimately, incorporate the Interim Guidance in the next revision of NUREG-1757, Volume 2.

We thank you for your interest in this topic and look forward to your participation in today's workshop, as we continue to tackle this very complex technical topic.

We will continue to work with all of our stakeholders after this workshop to address other technical challenges, including a public meeting planned on survey and dosimetry considerations for discrete radioactive particles. And that will be held later this fall.

Please check with our "What's New In Decommissioning" website, and that should keep you apprised of future opportunities for public participation. That's where we like to post those.

And if somebody can put a link in the chat, just to make it easier for all the participants to locate that website, I'd appreciate that.

With that, I'll turn it back over to Tom Aird for our opening presentation.

Thank you.

MR. AIRD: Thanks, Jane and Brett.

With the logistics and welcome over, we now move into the opening remarks section of the workshop.

And I'm going to go ahead and share my screen. If you see my screen here, it's the PDF of today's agenda. So, we've just finished the logistics and welcome, and now, we are moving into the opening remarks session. And with that, I will begin my presentation on this workshop.

Again, welcome, everyone, to this year's Workshop on Subsurface Investigations.

My name is Tom Aird, and I work in the Office of Nuclear Regulatory Research here at the NRC. I'm going to start today with a brief presentation that will, hopefully, provide some background and define the scope of today's workshop. I will also cover the latest research pertaining to subsurface soil characterization and soil design in the next few PowerPoint slides. And subsequent presentations today will expand in detail on some of the subjects I hope to introduce.

And I just want to briefly note that this work is being done jointly with the NRC's Office of Nuclear Regulatory Research and the NRC's Office of Nuclear Material Safety and Safeguards. So, it has been kind of a joint effort the past two years between our two offices.

So, the overall goal of this research project is to develop the technical basis for guidance on designing and evaluating data collected from surveys of residual radioactive in subsurface soils. And as well as covering soils, this work also includes things like groundwater and deep subsurface building structures.

For the new attendees, in July 2021, last year, we held a public workshop on this project and shared some preliminary results. That workshop was supported by the contractor for this project, SC&A. Other external presenters, including NEI, the Electric Power Research Institute, Pacific Northwest National Lab, and Argonne National Lab, were also invited to share perspectives at last year's workshop. And the EPA gave a presentation on the brief history of subsurface investigations as they relate to MARSSIM. And the results and proceedings of that workshop were published in a Research Information Letter and can be read on the NRC's public website.

Research since last year's workshop has focused on demonstrating proposed survey design and data analysis techniques through examples and case studies. Our recommendations are also being formulated for software development to provide tools that could help implement the proposed methodologies.

So, there are many motivating factors

behind this research.

First, more licensee sites are undergoing rapid decommissioning. Instead of remaining in a SAFSTOR for several decades, and then, being actively decommissioned many years from now, current plans suggest that these licensee sites are, instead, going to be decommissioned now and over the next decade or so.

And it is possible that many of these soon-to-be-decommissioned sites will have issues pertaining to residual radioactivity in their subsurface soils and building structures. Currently, such subsurface issues are addressed on a case-by-case basis. And this current process does provide adequate assurance, but it is not ideal.

And so, hopefully, new NRC guidance documents that describe acceptable tools and approaches that would help alleviate these inefficiencies could be developed. And so, that's kind of what the purpose of this project is. It is to, essentially, generate a technical basis to support future NRC guidance in this area.

So, here we have today's agenda. As you can probably tell, we have a full schedule today with presentations from many different parties. The green arrow here kind of represents or indicates where we are right now.

So, after I finish speaking in a few minutes, Cynthia Barr will take over, and she will have a more in-depth presentation that will cover some of the workshop topics I briefly introduce now.

Then, after the two of us finish, then we'll have opening remarks from the Nuclear Energy Institute, Bruce Montgomery.

And following all these opening remarks, we'll, then, move into the main part of the workshop. We'll have seven overview and technical presentations from a host of speakers. I won't read them all off here.

Again, please note we have three distinct discussion periods this afternoon. So, we have that designated here in the agenda. Each discussion period is about 30 or 40 minutes. And so, we hope to have very active and productive discussions during these sessions. Our facilitator Brett will help lead these discussion sessions and have some targeted discussion topics and questions ready to go.

And so, at two o'clock and at four

o'clock, we also have our designated breaks for today.

And finally, this workshop will conclude around five o'clock or so this afternoon.

And just as one final reminder, this detailed agenda can be found on the public meeting page, if you would like to refer to it often during this afternoon or perhaps afterwards.

And here, we have a brief summary of the July 2021 workshop on this project. We had active participation from a host of industry and government entities last year, including both federal and state regulatory agencies. And we had, I would say, approximately 160 virtual workshop participants over the course of that two-day workshop. The workshop's agenda and presentation materials are also publicly available and can be found in the NRC's ADAMS documentation system using the ML links provided on this slide.

Three existing NRC guidance documents partially address the issue being covered by this new research project.

The first document, NUREG/CR-7021, was written by Rob Stewart at the University of

Tennessee, and provides a geospatial modeling and decision framework for conducting subsurface compliance surveys and analysis for sites that have been remediated for radioactive contamination.

A second document is NUREG-1757, Volume 2, Revision 2. In that document, Appendix G and J were revised to include additional information on subsurface investigations and associated dose modeling. Cynthia Barr will cover these revisions in greater detail in just a few minutes.

And the third document listed here is NUREG-1575, which is the "Multi-Agency Radiation Survey and Site Investigation Manual," commonly known as MARSSIM. Please note that this NUREG, Revision 2 was recently issued for public comment through The Federal Register system, and the comment period ended, I believe, in February 2022.

NUREG/CR-7021, titled "A Subsurface Decision Model for Supporting Environmental Compliance," is, basically, the starting point for this research effort. The methodology laid out in NUREG/CR-7021 is supported by the Spatial Analysis and Decision Assistance, or SADA, Code.

This slide depicts some of SADA's data

visualization and data analysis totals taken directly from that NUREG/CR. Other tools available in the SADA Code related to subsurface design optimization and demonstrative compliance are also being considered by this current research project.

And this current research project will expand upon this earlier work and cover new topical areas listed in the next slide.

Here are some focus areas for this research. This is not an exhaustive list, but it provides a decent example of areas that are being explored. Please note that the Scenario B being referenced here is referring to MARSSIM Scenario B, in which the null hypothesis is that the site is clean.

If any of these topic areas are of particular interest to you, I also recommend that you check out the published proceedings from that July 2021 workshop. The video recording of that workshop is also available on the "What's New in Decommissioning" public website, and many of these topics were just by specific presentations at that workshop.

This slide covers some proposed

methodologies for subsurface survey design and data analysis. Past sampling techniques, such as Bayesian Ellipgrid, as well as Markov Cokriging, both available in the SADA computer code, were reviewed as part of this research project. Other approaches, such as Check and Cover, discussed in NUREG/CR-7021, are also being considered as part of this proposed methodology.

Visual Sample Plan, VSP, developed by Pacific Northwest National Laboratory, also incorporates MARSSIM survey methods and contains other geostatistical and other data analysis tools that would be helpful for subsurface investigations.

The current research effort is evaluating the efficacy of these computer codes to assist with subsurface investigations. Recommendations for computer codes to implement proposed methodologies is part of the overall tasking. These sampling and survey methodologies will be explained in detail in the final report for this project.

The draft report was made publicly available and attached to the workshop meeting notice. Note the red text at the top here.

And that was a quick overview of the

project -- basically, where we are now and what we have covered in the past.

Listed here is Cynthia's and my contact information, if you wish to contact us with any questions.

And I'd like to thank you again for attending, and we look forward to your active participation this afternoon.

And so, that concludes part one of our opening remarks. And so, with that, we'll move directly into, more or less, the second part, where Cynthia Barr has a companion presentation that expands upon some of the topics I just introduced and go into slightly greater detail.

MS. BARR: Welcome, and thanks for everyone's participation in today's workshop.

My presentation today is on NRC's Subsurface Guidance and Code Development Initiatives.

I wanted to provide just a little background information on NRC efforts to develop subsurface guidance to provide context for this workshop.

So, what is the problem we have been trying to solve? Well, we have been looking for innovative methods to survey the large volumes of soil needing to be surveyed in the subsurface to support decisionmaking.

Another difficulty is that these subsurface soils are not readily available for scan survey, which is a key component of MARSSIM used to release sites. You will be hearing about innovative methods to optimize subsurface survey design and characterization to try and tackle this issue.

So, some of the concepts discussed in NUREG/CR-7021 that Tom mentioned were folded into two of NRC's primary decommissioning guidance documents listed on this slide.

For example, we included information about use of geospatial tools, including geographic information systems, and geostatistical tools to assist with data visualization and analysis and conceptual site and model development.

While NUREG-1575 only addresses surface soils and building surfaces, we also updated NUREG-1757, Volume 2, Rev. 2, with regard to subsurface exposure scenarios and surveys, as I will discuss in more detail on the next couple of slides.

NUREG-1757, Volume 2, Rev. 2, Dose

Modeling Updates include: additional guidance on exposure scenarios for buried residual radioactivity. Scenarios include basement excavation, which could bring residual radioactivity to the surface where a member of the public could be exposed, and other scenarios, including the well driller scenario for deeper residual radioactivity, among other site-specific exposure scenarios.

And based on last year's workshop, we also included additional guidance on development of DCGLs or cleanup levels for subsurface residual radioactivity and the importance of various pathways as a function of source geometry, as depicted on the figure on the bottom left.

And while the cumulative dose from all sources should be considered, we acknowledge that the accounting for residual radioactivity in various environmental media can get quite complicated. Therefore, guidance on cumulative dose and integration of dose modeling in radiological surveys is also included in our updated guidance.

In the area of radiological surveys, we do have new guidance on surveys of open excavations, substructures, and materials planned for reuse. The figure on this slide shows how different DCGLs or cleanup levels can be calculated for various strata, and how MARSSIM approaches can be used to classify and survey the bottom and sidewalls of an excavation. We also have new guidance on survey materials planned for reuse.

Finally, a new appendix on composite sampling methods may help alleviate costs associated with analyzing a large number of samples, which is typical for subsurface investigations.

So, as I mentioned, we included additional guidance in a number of areas in Rev. 2 of NUREG-1757, Volume 2. We received over 200 comments on Draft Rev. 2, including the need for additional guidance on subsurface surveys. NRC staff addressed the comments, including adding several pages of new guidance documenting findings for the First Annual Subsurface Workshop. The final Rev. 2 document is expected to be issued this summer.

While the NRC made significant improvements to its guidance in the area of subsurface investigations, we recognize that there is still more work to be done. Given the breadth and risk significance of new guidance in this area, NRC staff plans to issue Interim Guidance for public comment in late 2022/early 2023.

So, guidance gaps that are currently being addressed that we hope to include in Interim Guidance are listed on this slide.

Additional guidance on development of cleanup levels or derived concentration guideline levels for subsurface residual radioactivity for specific cases. For example, we'll hear from RSCS a little later about the approach used to develop DCGLs and perform surveys for reactor substructures.

We also need additional guidance on the need for derivation of DCGLs for smaller areas of activity. For example, should subsurface DCGLs be based on the most limiting exposure scenarios from in situ leaching, intrusion, and other relevant scenarios? Or should DCGLs for smaller elevated areas also be developed? And if so, what should they be based on? How should the likelihood of intrusion into a small elevated area in the subsurface be considered, if at all?

I stated previously another area where we plan to develop Interim Guidance is on how geospatial tools and models can be used to help optimize subsurface survey design.

And finally, we are evaluating the need to update our guidance for open excavations and substructures, and additional guidance regarding classification, degree of scanning, depth, and number of samples needed.

So, we currently have a number of subsurface contracts in place. We will hear from two of our contractors today, as Tom went over.

The Interim Guidance will consider SC&A's technical white paper and proposed methodologies for survey design; PNNL's scoping of software tools to facilitate data visualization, analysis, and decisionmaking, and other technical information, including information from future work related to surveys of open excavations and substructures.

Other related initiatives include: improvements to visual sample plan used to design and analyze data from radiological surveys, including scoping of tools for importation and analysis of data acquired using modern data-logging systems with GPS.

So, just a few final thoughts:

Guidance is available in NUREG-1757, Volume 2, Rev. 2, in the area of subsurface investigations.

We will be issuing Interim Guidance for public comment soon.

Contracts to address remaining data gaps are being put in place.

And you can check our "What's New in Decommissioning" website for future opportunities for public participation and to be kept informed of issuance of guidance documents.

And with that, I'll turn it back over to Tom to introduce our next speaker.

MR. AIRD: So, thanks, Cynthia.

And that concludes the NRC's opening remarks. Again, if you have any questions, feel free to place them in the chat.

But, in the interest of time, we'll move directly on to NEI's presentation. Bruce Montgomery from the Nuclear Energy Institute has a few remarks he would like to share with us.

So, go ahead, Bruce.

MR. MONTGOMERY: Yes, thank you, Tom and Cynthia. I certainly appreciate the opportunity to participate in today's workshop as a followup from the work we did with you last year.

I'd like to make a few opening comments to kind of set the tone for today's workshop. But, before I do, Cynthia, you mentioned a couple of times the issuance of Interim Staff Guidance to address some of the issues we're going to talk about today. Is this going to be separate and distinct from NUREG-1757, Volume 2, Rev. 2? And what forum would that take, if that's true?

MS. BARR: Oh, yes. We're going to be issuing NUREG-1757, Volume 2, Rev. 2, this summer. It is complete and does address a number of topics well beyond subsurface. And we feel like we're in a position to go ahead and release that and let people start using it.

However, due to the large number of comments, or significant comments, I should say, on subsurface and our plans to consider new guidance in the area of subsurface, we felt it was important to issue that guidance for comment before we add it to NUREG-1757.

So, hopefully, in the next several months, we'll be able to issue that as a Technical Report for public comment, and then, have a followup meeting to get people's feedback on the document, and then, eventually, fold it into the next revision of NUREG-1757, which would be Rev. 3.

MR. MONTGOMERY: Okay. Well, thanks, Cynthia. That's actually very encouraging. I'm looking forward to that exercise because that holds a promise of getting us some guidance that's usable for the commercial industry prior to the final issuance of what I would guess would be Revision 3 to NUREG-1757, Volume 2. So, thank you for that.

So, I'd just like to emphasize something that Tom and Jane said, as we started the workshop. It is the importance of this topic to the commercial nuclear industry.

NEI represents the commercial nuclear industry, and we have a significant interest in making sure that these questions around performance of subsurface surveys and, as Jane mentioned also, hot particles down the road are addressed. Because these are some of the issues that are confronting us now as we go through the process.

And the reason it's so important now is, Tom, you mentioned the whole strategy and business model in the commercial industry is shifting from a preference towards putting plants into SAFSTOR after cessation of operation to now pursuing accelerated decommissioning.

And accelerated decommissioning is also evolving very rapidly. Where in the past we might have seen projects that lasted 10, 12, 14 years after cessation of operation, we're now seeing a significant acceleration of the entire process, where we can expect, on average, these projects to take only eight years or so from cessation of operations, making these sites available for unrestricted release by the NRC and made available to the communities for whatever uses they see fit. So, that, we think, is a very good thing.

But I think there are a couple of issues that we need to work through, so that we can actually productively work towards those goals consistently. And I would hope that both the industry and the staff feel a sense of urgency here, because the number of plants coming through the pipeline right now, I think we talk in terms of 10-12 plants that are either in the process of writing or implementing a License Termination Plan, including final status surveys, seeking to move towards unrestricted release, are coming to the NRC forthwith. And there's a significant workload, not the least of which is going to be to review data coming in from these sites on these final status surveys, requiring NRC to be efficient in reviews of that data.

Now, certainly, that's a two-way street. And we see our role in the industry is to make sure that what we send to the NRC is properly formatted with the right level of content, technically and otherwise.

And so, what we've undertaken, as you're well aware, is developing an NEI standard. It's going to be called "License Termination Process Improvement." It's NEI 22-01. It's currently in draft form and under a significant level of development.

It's going to include a formatted content; many discussions of approaches to be used in the development and execution of a License Termination Plan; final status surveys; how to report data to the NRC. It's also going to include a timeline that extends from prior to cessation of operations all the way through to unrestricted release, with many different milestones and touchpoints, including recommendations for appropriate communications touchpoints and protocols with the NRC and state and local agencies, and other folks that might be involved in the process.

So, we're looking forward to getting that to you. But, as it stands right now, there's a couple of notable gaps in our report, and one of which is the topic of today's workshop. So, we're hoping to come to a conclusion with the work that's going on right now, that we'll hear a lot more today, to be able to close the gap in our guidance document.

A very large body of regulatory work around license termination. It's highly technical. And it's important that we are able to take this body of work that spans many different federal agencies, state and local concerns, and many different technical reports, and distill those down into a guideline that the commercial industry can use to satisfy all of the expectations of it in this area. So, it's a big challenge, but we think it's worth doing and is achievable. So, we're looking forward to getting that report to you for review and concurrence.

So, very interested in working through these few topics, today's topic and the one Jane mentioned down the road, which is dealing with discrete radioactive particles.

I'm pleased that today we'll be able to contribute to this workshop with two Technical Reports, both by RSCS. And we have Matt Darois, who is going to be talking about utilizing the Nuclear Energy Institute 07-07 guideline regarding Industry Groundwater Protection Initiative, as a foundation for assessing subsurface site assessments. And then, Eric Darois will be talking about subsurface basement modeling and survey methods. So, very pleased to be a part of the workshop today with those two presentations.

So, I see that today's detailed agenda includes many different questions that are going to be posed to the audience. And I think that's very good, and I appreciate the thought that went into the agenda. And I'm looking for robustness in the technical discussion that will lead us to answers to those questions, so that we can help you get to where you need to be to develop this Interim Guidance.

The bottom line is, you know, we need to be able to move smartly from science and the statistical concepts to real solutions and methodologies that the NRC and the industry can align on to execute at these decommissioning sites. They need to be practical, affordable, and field-ready, and as soon as possible.

Our goal is to achieve unrestricted release meeting or exceeding all NRC or EPA and state and local expectations of our projects. That's our objective, and I think today is going to move us towards that. So, thank you very much.

I'd also like to put a plug for everybody who's on the line who's in the decommissioning business, or interested in it, to take a look at the Decommissioning Strategy Forum that's going to be held June 6th and 7th in Las Vegas. Look it up on the internet. Google it. You should be able to find it. And I encourage you all to sign up and attend.

So, thank you very much, and I'll go back to you, Tom. Thanks so much.

MR. AIRD: Thank you, Bruce, for those comments and insights.

I think we're a little bit ahead of the schedule by about five minutes or so. So, if there any questions for Cynthia, myself, or Bruce, I think we can go ahead and answer some of them.

So, I don't know, Brett, if you want to coordinate and help facilitate this, but I think we might have a little bit of time for questions right now before we move into the technical presentations.

MR. KLUKAN: Sure. Absolutely.

So, if anyone has a question they'd like to ask, please raise your hand via Teams or put it into the chat. Or, if you're on the phone, press *5 right now. Again, that is *5, if you're on the phone, to raise your hand.

And we'll give people here a minute or two to see if they have any questions about what we've talked about thus far.

(Pause.)

Again, if you're on the phone -- and you're going to hear me say this so many times by the end of today -- it is *5 to raise your hand. Again, that is *5 to raise your hand if you're on the phone.

Otherwise, feel free to just put your question in the chat, or hit the "Raise Hand" button within teams.

And if you can't find that button, you know, feel free to add that to chat as well, and we'll go through and explain it.

(Pause.)

All right. It looks like we don't have any questions at this time. Going once, twice.

All right, Tom, I'll turn it back over to you. Thanks.

Thank you, everyone.

MR. AIRD: Okay. Thanks. And thanks again.

MR. KLUKAN: We actually do have one question, actually, that just came in from Randall Fedors.

For Bruce, "When will NEI 22-01 be available?"

MR. MONTGOMERY: Yes, thanks for that question.

We're targeting November of 2022. And since the question was asked -- and I think I've mentioned this to you before, Cynthia -- as we approach the date where we would submit this report, I would think it might be helpful to have a public meeting with you to sort of walk through the content. So that, when you receive it, you pretty much know what's going to be in it. We might have some open questions that we think might be worthwhile discussing with you before it's submitted. So, I'm kind of noodling that as a concept.

But to answer the question, we'll be submitting this report well before the end of the year. I'm targeting right now to book-end this in November of this year.

MR. KLUKAN: Okay. Thank you, Randall, for asking the question, and thank you, Bruce, for answering it.

We do have one more question, and then, we'll move on, from Timothy Eckert.

The question is, "When and why did decommissioning morph into license termination?" I don't know if, either Cynthia or Tom, if you'd like to spend a minute addressing that.

MS. BARR: Well, I guess sometimes we just use license termination more formally because that's the name of the rule that was published with our modern way of using a dose-based metric for release of sites. But decommissioning is just more of a term that's easier to use and encompasses a lot of the aspects of moving from operations to that final license termination. So, we use them both, but I think that this one is used more formally to talk about it.

I don't know if anybody has anything to add to that.

MS. MARSHALL: Hi, Cynthia. This is Jane Marshall. I can add to that.

License termination is the end of the decommissioning process. So, while we tangibly --

MS. BARR: I'm sorry, I'm having trouble hearing.

MR. KLUKAN: Jane, can you move a little closer to your microphone maybe?

MS. MARSHALL: Yes, we'll try that.

MR. KLUKAN: There we go. That's better.

MS. MARSHALL: Okay. So, license termination is the end of the process. Decommissioning is sort of how we get there. So, decommissioning is the process. License termination is the licensing action that takes place once decommissioning is complete.

But Cynthia is right, we do use them interchangeable, but that's, from my view, that's sort of the difference between the two, if you slice them that way.

MR. KLUKAN: Thanks, Jane, and thanks, Cynthia.

We have one more quick question. And I'm going to take it on now because it's a process question.

So, Barbara Warren asks, "Could you explain how to bring up the chat?"

So, Barbara, you're actually posting in the chat. So, you may be wondering, like, why can't I see anything before this? And so, generally speaking, the way Teams works is you may not be able to see what happened in the chat prior to you joining the meeting. But what you're posting in is the chat.

So, for those of you who are unaware, up at the top of your Teams application, there's a little button that looks kind of like a comic book callout, a little text bubble that has "chat" written beneath it. Click on that, and it will bring up the chat box, and then, you can scroll through it. Add your message to it. And so, that's how the chat works.

And again, feel free to post your comments or questions in the chat as well, alternatively, to raising your hand, whatever feels most comfortable to you.

So, hopefully, that answered your question, Barbara. If not, let me know.

But, with that said, we will now move on to our next section, and I'll turn it back over to Tom.

So, thanks, all of you, for your questions thus far.

MR. AIRD: Thanks, Brett.

And thanks again, Bruce, for those remarks.

So now, we move into the technical presentations, which is, essentially, the heart of this workshop.

And the first presentation we have today is from Carl Gogolak from SC&A. SC&A itself is a commercial contractor that has provided assistance for the NRC on this project.

And with that, I will start Carl's presentation. Carl is actually here today and can answer questions afterwards during the discussion period.

MR. GOGOLAK: Good afternoon.

In this talk, I will try to go over some of the survey design approaches that SC&A is taking for the subsurface radiological contaminations.

There are quite a few slides in this presentation, but I don't intend to spend a lot of time on every one of them, because many of them are there simply so that, when you download this presentation, you will have the references in front of you and need not take copious notes as the talk is going on.

We will look at surveying some certain soils in contrast to MARSSIM-type survey approaches. We will also look at the fact that the decision criteria may be somewhat more complicated than just comparing an action level to a mean from a survey unit of measurements.

There are a number of key references for this kind of work, the first of which is the consolidated guidance in NUREG-1757, Volume 2. Another one is the white paper that SC&A is developing for subsurface surveys.

There is also the NUREG Contractor Report 7021, which I've mentioned before was done by the University of Tennessee to look at the issue of criteria for release after decommissioning the subsurface.

Another report is the EPRI Report on Guidance for Using Geostatistics to Develop Site Final Status Survey Programs. This is a very good reference which looks at all of the software tools that could be used for this work.

The next slide shows how the various surveys are linked together to at each stage improve our picture of the Conceptual Site Model and how the Contaminant of Concern Map will be updated following each step in the process.

Here, we see how each step in the process will improve our knowledge of the site and whether or not it can meet subsurface decision criteria. This diagram is taken from NUREG-7021 and I think shows very clearly how this should be done.

The major point to be emphasized is that the Historical Site Assessment should be used to create an initial Conceptual Site Model which contains as much information as we can use for planning the initial surveys. The output of each phase includes the latest Conceptual Site Model update. The end result is success of the compliance phase or return to an interim phase under compliance failure.

As said before, the areas of concern, contamination of concern, and DCGLS, and how they fit into the iterative data quality objective process is what is shown in that chart.

To determine release criteria is fundamental for any process that is going to involve action levels and decisions to be made. The key question, as usual, is: how many samples should be taken? How many samples are good enough in order to make a valid decision on whether a surveyed unit should be released or not?

What function of the sample data will be used in a decision rule is also an important part. It may not be just simply the mean of a sample being compared to an action level. There could be other criteria that are possible, and some of these are examined in the NUREG-7021.

It is important to note that subsurface survey units may not align exactly with MARSSIM-type survey units that are on the surface. The pathways for exposure will be different. The values will be different for the action levels. Even the decision criteria itself may or may not involve a mean of a particular set of data, but might require other statistics instead.

Because subsurface sampling is costly, the survey design would ideally have some measure of value added for each additional location sampled that would aid in the decisionmaking process. For example, in MARSSIM, that trick is the statistical power, which you can then see how much more certain your decisionmaking can be if the statistical power introduced increased by a lot in each sample.

Two promising techniques for designing efficient subsurface surveys are:

First, Bayesian Ellipgrid, which is a purely geometrical calculation of the probability of hitting a contaminated area of a certain size with a certain number of samples.

Markov-Bayes is a geostatistical technique which makes use of data in prior surveys to help improve decisionmaking for the current set of surveys being designed.

Both VSP and SADA have a set of features that may be useful in designing and interpreting final status surveys for the subsurface. Unfortunately, currently, VSP is the only one that is being actively supported. Whatever tools or software is chosen to be used, the statistical techniques being used are considerably more complicated than those that are outlined in MARSSIM for surface surveys.

Thus, it will be important to have detailed written instructions and examples to demonstrate how it would be used in subsurface applications. And this is a current activity for SC&A. Both SADA and VSP have very detailed users' guides and help files which can be used to help learn and apply these techniques.

Both VSP and SADA assume that there are some initial data that are available to design a secondary sampling survey to improve the accuracy of the Conceptual Site Model. One starting point that is very useful that's contained in SADA allows one to paint what one's prior belief is in terms of discovering a contaminated area across the site. This data is, then, used as input to the Bayesian Ellipgrid to design how many samples should initially be taken in a statistical matter; whereas, most HSA data is based on judgmental data.

Both VSP and SADA contain calculations for Ellipgrid wherein one puts in the size and shape of a suspected elevated area and what the probability of detecting that spot would be with the number of samples taken.

VSP allows the addition of prior belief in the probability of an elevated area in order to design a more efficient survey.

SADA contains a module called Bayesian Ellipgrid, which actually applies Bayes' theorem to a map of prior belief in the probability of hitting an elevated area in order to design a posterior distribution on updating the user probability map to contain the data that is designed in the initial Ellipgrid.

Bayesian Ellipgrid allows one to, essentially, pain a prior probability map which indicates the survey designer's belief that an elevated area is likely to exist in a certain portion of the site. So that a lot of time is not wasted on samples that have a very low probability of containing an elevated area.

Samples are allocated to the different regions with different probabilities, depending on the likelihood that there is actually is an elevated area likely to exist in that area. Bayesian

Ellipgrid allocates 37 samples to the search for a possible elevated area. Without using this prior information, 87 samples would be required for just a straightforward application of Ellipgrid without using prior information.

After taking these preliminary samples, a secondary sampling plan can be constructed, depending on the goal of the survey. Both VSP and SADA have several ways to do this, depending on the statistic that will be used in the release criteria. For example, it may be desired that the release criterion would identify a certain percentage of the area to have a certain low probability of encountering an elevated area there.

Markov-Bayes uses the assumption that additional so-called soft information can be taken into account for the assessment of prior distribution at selected locations. This soft information can be used to construct a user probability map, as was shown a couple of slides earlier. Entering the hard quantitative data allows one to use a Markov process to update the probability map.

Soft information can be almost anything that bears a relationship to the probability of a contaminated area being in a certain spot. This is rather similar to the idea of using ranked set sampling.

There can be an awful lot of variation in the variogram. Here, the semi-variogram is plotted against distance for each pair of data points. One can see the difficulty one would have in coming up with a single variogram that should represent all of this data.

It is sometimes more useful to think of a variogram as depending on three specific parameters. One is the uncertainty in values measured at the same spot multiple times; in other words, the measurement uncertainty.

The second parameter is called sill and expresses the value at which the variogram levels out. A function of this is and, essentially, can be considered the overall variance of the data when only far apart measurements are considered.

Comparing these models to the variogram cloud that we looked at earlier, one could appreciate that it might be very difficult to tell apart the two models when one is dealing with experimental data. It is fortunate that the part of the variogram that is most important is that at small distances. As pointed out in the VSP training programs, it is this part of the variogram that needs the most attention.

Both VSP and SADA provide methods to estimate variograms from recommended default settings. However, it is difficult to evaluate the recommended values since the assumptions and methods for these values are not fully transparent.

Here, we have some example data. One can tell from the posturing that these samples are densest around the suspected part of the site that has contained contamination. The fact that it is arsenic, rather than a particular radionuclide, is not really relevant for this example. One might just as well say these are some values for a very long-lived radionuclide.

From the clustering in the data, one could imagine that these samples were taken because there's a close proximity to a source of some contamination. One can see that it could take very detailed data to define what experimental variogram should be fit to the data.

Notice that in both blocks there is a recommended button which will allow you to take default values and calculate it from there. SADA will warn you that using the recommended values should be further refined by the user in searching for any correlation structure that may exist. However, we will just continue.

This is the variogram that results from using the default values in SADA. The fit is pretty good, actually, especially at the lower distances, where the weighting factor is most sensitive.

Here, we have plotted in the same area of the site iodine-129 samples. Again, we will take the recommended values. Here, we get quite a different picture. Curiously, it turns out that chemical contaminations have variograms that look very similar to arsenic; whereas, the radionuclide measurements tend to look like the iodine-121 model.

This slide shows some of the discussion questions that will follow the next talk. And hopefully, this talk alone that has been very, very brief and a quick overview will be enough to stimulate discussion on these topics.

Thank you.

MR. AIRD: And thank you, Carl.

Again, like Carl said, questions and

comments can be answered in the discussion period following the subsequent presentation. Both Carl's and the following presentation were kind of related. So, we felt it was best to kind of wait until the discussion period to have all the Q&As answered.

And with that, we will move directly into the next technical presentation from Deborah Fagan and Jennifer Huckett from the Pacific Northwest National Laboratory. And they will be giving the presentation live and will join Carl Gogolak in the discussion period following their presentation.

MS. HUCKETT: Hi. This is Jen Huckett.

Are you able to see my slides?

MR. AIRD: I can see your slides and hear you well.

MS. HUCKETT: Thank you.

So, my name is Jen. I'm a statistician with PNNL. And I'm going to get us started today with an overview of the scope and assumptions for this talk, and then, a discussion of subsurface data considerations. I am going to hand it over to Deb Fagan to discuss survey planning and analysis methods.

So, I just talked through that outline of what we're going to talk through, and I just wanted to note that we have discussion questions sprinkled throughout the presentation. As just explained, we're not going to expand on these during the talk, but they are intended to spark discussion during the period following this talk. So, please feel free to bring those up during the discussion or bring your own topics. Either will be welcome.

So, to start with, the kind of scope and assumptions that we're talking about today. I'm outlining here the MARSSIM roadmap for the surface. Hopefully, this figure on the right of the data life cycle is familiar to many. And we've highlighted the major components on the left in blue: planning, implementation, and assessment.

So, this provides, or MARSSIM -- excuse me -- provides detailed guidance for planning, implementing, and evaluating environmental and facility radiological surveys conducted to demonstrate compliance. And so, we wanted to note really here this is focused on the compliance phase of the decommissioning process, and as shown in this upper right corner, this data life cycle or this part of the process assumes that input data will be available from Historical Site Assessment, scoping, characterization, et cetera; and that this is really walking us through planning, implementing, and assessing the final status survey. And so, we are focusing on the need for a similar roadmap for the subsurface, and specifically, with respect to the compliance phase, in this talk.

So, Carl's presentation showed this flow diagram of the subsurface process. And this is from start to finish, including HSA, preparation, et cetera. And again, what we're focusing on here is: what is the guidance needed in this compliance phase, given that we have information from these other phases, including things like the Conceptual Site Model; what COPCs are; how they're commingled? If there's spatiotemporal dynamics, that actually adds another fourth dimension.

We'll assume that groundwater/surface water interactions, vadose zone/groundwater interactions, and end-state objectives have been defined or estimated or modeled as part of these previous stages, and then, will be used in the compliance phase to provide the information that's required to show that the end state is achieved.

So, what is required to show that end state is achieved are subsurface and surface matrix samples showing perhaps fate and transport of the COPCs on and off the site are understood and well-captured, and that concentrations meet these criteria.

And so, again, the assumptions are that data from these previous phases will be available, but perhaps not all of them, right? Some of these phases will be necessary, or perhaps mandatory, depending on the guidance. But data from the other phases may not have been collected. And no matter what, there will be variation in how much and what type of data from each stage is available.

So, another thing that PNNL is focused on is: what are the tools that are needed in this compliance phase? So, data visualization for sure, data collection, planning, data analysis, and then, uncertainty quantification or providing confidence bounds for hypothesis testing for the purpose of end-state decisions.

Some of the things that we are focusing on at PNNL, again, are incorporating these tools into Visual Sample Plan, or VSP, software, and we kind of discuss that here.

So, Carl's presentation included some details on VSP, but I would also encourage you to visit last year's workshop presentation or transcription. We discussed a lot of the geostatistical tools available in VSP. This particular presentation right now is at a higher level, where we're discussing the general approaches for incorporating statistical methods into planning and assessment. But last year's workshop gives a little more detail about what is currently available in VSP for the surface.

So, in brief, VSP is a software tool that supports defensible sampling plan development based on statistical sampling theory. It supports statistical analysis of collected data to support confident decisionmaking, and it also provides visualization of surfaces, sample plans, and results from statistical analyses of sampled data. It couples site building and sample location visualization capabilities with optimal sample design and statistical analysis strategy, and it implements MARSSIM guidance through many surface sampling and analysis functions. And so, we're focused on a future which includes incorporating similar functionality into VSP, but for the subsurface.

All right. So, some of the things that were discussed a lot in the previous workshop are the variety and potential complexity in the data available for subsurface analyses. So here, we just laid these out in a table to demonstrate the wide variety and volume of potential data sources from previous efforts that could be available for the compliance phase of the process.

Because the quantity and quality of these data will vary, we believe that data quality assurance will be a big part of the compliance phase. And so, we think that a major component of the data wrangling and the data process for the compliance phase will include data quality assurance of datasets that have potentially already been combined. And so, while combining these 3D spatial or 4D spatiotemporal datasets from disparate sources that have varying formats, quality resolutions is expected to be a major undertaking and quite a challenge.

We think it's arguable that at the compliance phase a lot of that will have been performed. And so, that data quality assurance of that combined data will be most pertinent to compliance phase guidance.

So, some discussion topics, as promised. Some things to consider are: what kind of DQA activities should be performed on each dataset? Some of those things will include determining the representativeness of the timeframe over which data were collected. So, although historical data may exist, if there were remediation efforts, a DQA process will need to assess the extent to which those should be used in that final survey status effort. Considering seasonal or annual effects, validating fate and transport models are other topics that may need to be addressed in DQA guidance for subsurface.

We expect that subsurface surveys will use convenience sampling to a large extent. So, for example, collecting data from existing boreholes. And so, then, any guidance will need to address what methods will be required to determine or verify that those existing locations or depths, or data from them, are representative of data for the larger subsurface volume. And then, finally, what will the resulting compliance survey datasets look like at the outset of the compliance survey process?

So now, I'll turn it over to Deb to discuss subsurface survey planning and analysis.

MS. FAGAN: Thanks, Jen.

Next slide? Can you hear me?

MR. KLUKAN: We can hear you.

MS. FAGAN: Okay. Thank you.

Okay. So thank you, Jen.

And thanks to everybody for attending today.

As Jen mentioned, historical -- we believe historical locations, particularly bore hole locations, should be leveraged into compliance survey design. And so these might be termed convenience sampling, judgmental sampling where those bore holes have been placed based on geophysical models or subject matter expertise for the optimum location to either verify remedial efforts have been successful or to validate geophysical modeling efforts.

And so then additional locations could be based on classical or geostatistical models. And here I'm using classical as meaning everything except geostatistical. So current MARSSIM guidance covers all of those methods I'm considering to be classical. And so those approach could be either parametric or non-parametric. Carl Gogolak wrote this great guidance document on the non-parametric approach in MARSSIM and so for this talk this is still considered a classical approach.

So the main statistical assessment and planning technique here then would be a combination of random and systematic sampling or random and judgmental sampling where those judgmental locations are the ones that have been previously identified. And then similar to what Carl alluded to related to probabilities of contaminated -- contamination for different areas, we think stratified approaches are going to be the most useful here.

And so some important considerations for stratified sampling and planning for that is what is your representativeness criterion? And so how -- when you take a bore hole or when you take a sample core of the subsurface, what volume of soil or subsurface does that represent? And inputs to that need to be based either on your risk model or your geophysical model.

And then additionally to your risk model strata you can have additional strata based on your geophysics. So if you think about horizontal layers and what is going to be accessible in either a risk model or to groundwater, then you could have strata based on vertical geophysical layers and/or just even depth. And then horizontal strata could be based on -- or vertical could be based on your risk model.

So for instance, if you have a risk model with someone drilling a well down to groundwater, those layers beneath your -- the depth to which your model is assuming a well is drilled may be a different stratum than a geophysical model that says groundwater is actually below that level.

And then we have something that's referred to in 7021 as check and cover, and that's really a combination of convenience and random sampling which we've established that we're -- we believe is a valid approach. So there the basic approach for check and cover is that -- the way it's implemented in VSP is you specify your number and location of your convenience samples or judgment samples and then VSP provides additional random locations to allow you to make statistical statements about the data you've collected.

Next slide? So those are sort of the classical approaches. And then in a geostatistical framework this is more about locating your samples based on your geostatistical model. And if you use kriging or a few other methods to get this geostatistical model, you also get an estimate of your uncertainty at locations where you have not collected data.

And so determining where to put additional samples would not be random; it would be based on where you have the highest uncertainty in your kriged estimates. And then you would locate samples in those areas to bring down the uncertainty in those areas. And you could get geophysics input to those models through either Bayesian methods for kriging or geospatial methods that combine different fields of view or uncertainties as well as the hard and soft data that Carl referred to in his presentation.

And soft data might be as easy or as -- well, straightforward as subject matter expertise or it might be as -- I can't think of the word -- data driven by techniques such as those that will be discussed by Fred and Tom in a later presentation, almost like screening methods. And the geophysics input to those would help you identify your strata and then you could allocate your samples across those strata.

Next slide? So Carl mentioned Ellipgrid and Bayesian and Bayesian Ellipgrid and as well as Markov-Bayes. And I think that these are probably most used for characterization surveys and you might use check and cover or geospatial techniques to supplement these samples that were taken in characterization, or at least the locations taken in characterization with additional data points.

And so there's just a brief overview here. Ellipgrid and Bayesian Ellipgrid result in systematic locations of samples, not -- there's no randomness. There may be a random start, but once your random start is implemented, everything is systematic after that. And they require some inputs that may or may not be easy to achieve and those inputs would be based on your previous activities to compliance surveys. So you need the size and the shape of the potentially elevated area of residual activity that you're interested in and then you need some kind of probability or relative probability that that area exists.

And so if you can make those assessments, make those estimations and defend them, then you get -- the result is a reduced number of samples to achieve a similar decision rate. And then the real question is what arguments do you bring to bear and what verification of these probabilities and size of hotspot or elevated areas can you make?

And then Markov-Bayes and Bayesian Ellipgrid again. This is the combination of hard and soft data. And soft data, as I mentioned before, might be soft in that you have painted areas on a plot related to your conceptual site model of usage in a specific area or volume, or it might be harder data such as screening data that can be -- that's used to verify geophysical models and also verify levels -- potential levels of contamination based on things like soil conductivity or other screening methods.

Next slide? Carl also mentioned ranked set sampling which again we think you're going to be -- if you're going to implement them, you would maybe first implement them in a characterization survey, and those are really to help you identify your strata. And then you would -- those would become locations that you could subsequently sample in a compliance survey and potentially augment those locations with additional samples that are located based on some statistical or geostatistical framework for your compliance survey.

So again by using stratification you -- if you're correct in identifying your strata, you end up with a higher statistical power and an increased probability of detecting elevated areas if they exist, but then the caveat is that you need to be able to identify those strata correctly. And the way VSP implements this you're assuming that you have multiples of three, four, or five restricted to your sample size. And then those number samples would have to also extend into the subsurface.

Next slide? So that's sort of the planning phase for how maybe you're going to achieve additional locations for compliance surveys, and now I'm just going to very briefly talk about some analysis approaches.

So here we're moving from 2D to 3D, and so we still could do hypothesis testing, comparing estimates to a threshold, say a DCGL, in 3D or we could do it layer by layer. And the way that I envision a layer-by-layer approach would be to identify a subsurface layer, which is also going to have some thickness, but we're going to assume for the purposes of geostatistics that it is all at a single level.

And then do your kriging or geostatistical analysis just for a single layer or are you going to apply to a 3D volume? And I think the way that you're going to decide how to do that is going to be based on your risk model, what layers of your geophysical model are appropriate to sample given your risk model, and also if you believe, which at the compliance phase you're certainly hoping not to believe, that you have residual contamination, how you're going to draw the boundaries around that residual contamination. And you might do that for a 3D volume.

Next slide? So again this follows sort of classical and geostatistical approaches. And one thing to keep in mind here I think is the way MARSSIM is written right now is you don't -- even on the surface you don't take into account your X, Y, and Z locations of your data. And so if you do have data that are spatially correlated, you increase your probability of incorrectly assuming that your acceptable site is actually unacceptable.

So even in the classical sense it might behoove you to spend some time thinking about a variogram and incorporating that into an estimate of a mean concentration to compare to a DCGL. And so really the emphasis here would be on how are you going to model that spatial correlation. It's going to be a parametric or a non-parametric method. And there are both and we'll touch on those in our report that's upcoming.

Next slide? So now this is how are you going to determine the boundaries? Assuming you find some elevated residual activity in your 3D volume how are you going to determine the boundaries of those? And so there are a couple different options you can do here. Moran's I is sometimes called a local indicator of spatial associations statistic, and so that's an option where you use clustering to identify the boundaries of your potentially contaminated area. And then the other one is geostatistics through kriging. And there you have several different kriging options that you can implement there.

FRK is fixed-rank kriging, and it's sort of a different approach than not-Markov-Bayes in that the hard and soft data for fixed-rank kriging are more about different fields of view. So if you have a survey technique that applies to a larger area and then you have fixed sample locations that apply to a smaller area, if that area of representativeness is different for different instrumentation or different areas of your site, then you can used fixed-rank kriging to combine them. And again fixed-rank -- both Moran -- well, the kriging and the inverse distance weighting rely on you to model your spatial correlation. And again you can do that parametrically or non-parametrically.

Next slide? So I'm a little bit over. I apologize for that. Here are our potential discussion topics that we could talk about here. What are the 3D kriging methods that could be most useful? What new statistical methodologies are needed to improve current practice? And then how do we use censored data, non-detect data, and kriging?

So thank you for your time and we can move onto discussion.

MR. AIRD: Thank you, Deborah and Jennifer.

Yes, so like they said, we can now move

into the dedicated discussion period. I'll go ahead and share my screen again. And so for this discussion period, Brett again will help facilitate and coordinate any questions you may have pertaining to these prior-to technical presentations.

MR. KLUKAN: Welcome, everyone, to the discussion portion. And thank you to the presenters as well.

So again to enter the chat or to let us know that you'd like to make a comment, you can first of all just put it directly in the chat, as I think someone has already done, or you can raise your hand within Teams by using the raise hand function. If you're on the phone, again to raise your hand if you hit *5. Again that is *5.

And as you can see, both -- all the presentations included discussion points. We have also provided some discussion questions that were published as part of -- or on this -- in the meeting notice page on the NRC website. And they're up on the screen right now.

Thanks, Tom, for doing that.

So I will go through those in a minute, but first I think we have -- Boby would like to say something. I think Boby has his hand up. And so then we'll go to him. And then again if you have any questions, feel free to raise your hand.

DR. ABU-EID: Yes, thank you very much. Excellent presentations. I am Boby Abu-Eid, SLS Advisor in DUWP, NMSS. The presentation excellent.

Just two things I want to say: The first thing is I understand the subsurface contamination and establishing DCGLs is complicated, more complicated than the surface. That's number one. That's a reason we are dealing with that in a statistical approaches.

The other thing we need to keep in mind, we would like to have a resolution and solving the issue for the survey as simple as we can so our licensee could comply with. We don't want them to go into very complicated aspect. So we need to think from both direction in order to assist actually how the contamination can be reduced such that the impact to the public will be of use to the dose criteria. That's -- these are the two things first just comment on to say.

The other thing I want to say that the presentation considered many statistical approaches, however we need to keep in mind we have a performance period of 1,000 years to comply with. This means any dose calculated for that period that is considering the -- of course the averaging for the dose in the end which is the best estimate of the dose that could impact actually the DCGL. Therefore, we need to keep this mind. We have a performance period of 1,000 years. In other words, this means that we need to consider possibility of the dynamic contaminant transport vertically and horizontally in order to assess.

So the first step I believe we need to bound the areas vertically and horizontally the impacted areas and the un-impacted areas. To not be drilling holes everywhere we need to minimize drilling sampling holes inside the site as much as we can. So that's number two.

Number three, we need to some kind of assessment for different layering approach. Layering approach, we mentioned that. And say that -- and I worked with both previous, Robert Stewart, and the late-George Powers for that and we came with the conclusion this is good approach, layering, but we need to assess the risk for each layer. And the risk for each layer could be different, therefore maybe it will be an idea to assume unit concentration at each layer and within the performance period and to see how it can vary. And then we do dynamic modeling how the source term could move and could change that within the performance period.

Thank you. Is just only a comment I would like to make and I just want to throw for discussion. Thank you.

MR. KLUKAN: Thank you, Boby.

So we have several people who have lined up to speak. So we're first going to start with Randall.

So I'm going to allow you to -- I think you're already un-muted or allowed to un-mute yourself, so feel free to un-mute and begin.

MR. FEDORS: Yes, thank you. Good presentations, but what I had running through my mind as you were talking about layered systems and strata and whatnot was how far along are we in dealing with something a little more complex like a fractured bedrock or even lensing and fluvial environments and applying these tools which we've seen that have occurred at some of our decommissioning sites?

MR. KLUKAN: Thank you for the question. Does anyone from the NRC staff or the presenters want to take that on or provide --

MR. FEDORS: That was mostly for the presenters to (audio interference) --

(Simultaneous speaking.)

MR. KLUKAN: For the presenters?

MR. FEDORS: -- the last presenter, yes.

MR. KLUKAN: So, Jennifer or Deborah, do you have any comments on that?

MR. GOGOLAK: Yes, I think it might be appropriate to keep in mind the aphorism that was -- that George Box, former president of the American Statistical Association, was fond of saying all models are wrong, but some models are useful. And he also went on to say then that the more complex the model the less useful it's likely to be. So simpler in some ways is better.

We have to bear in mind that there will be non-geostaticians -- geostatisticians who will be attempting to use these tools as they're being developed. And so I think that we have to bear in mind that the tool has to be useful for the audience that's going to be using them. And once goes into very complicated models, it involves lots of different changes to the analysis. Will be lots of different anisotropies for variograms both in the horizontal and the vertical direction and a lot of other things that will require input data that may not easily become by or even designed for.

So I'd just like to keep in mind that whatever tools are chosen or used have to really be useable ones. That's all I wanted to say.

MR. KLUKAN: Yes.

MR. FEDORS: Yes, thank you. It was almost more a question of have you taken a stab at that and saying anything about it in this reports that you coming up with. The limitations maybe is what (audio interference). Thank you.

MS. FAGAN: So I'll just throw in my two cents there; this is Debbie Fagan, and then I'm going to kick it over to Fred, who's a geophysicist at PNNL and is primed to answer this question as well.

So I think that that fundamentally goes back to your conceptual site model and what you can defend as an approach. And so if you have very complex sites with a high potential for contamination, then I think you're going to have to use some of the more perhaps geostatistical and geophysical tie-ins to do an assessment there.

And that is about the limit of my expertise on that, so I'm going to ask Fred Day-Lewis if he could maybe chime in.

MR. DAY-LEWIS: Sure, Deb. Thank you.

Yes, I can certainly think of a number of applications of geostatistical simulation and fractured rock, including some work that I did over 20 years ago with indicator geostatistical simulation conditioned on different types of data, but there's -- it's a stretch using these continuum kind of models in fractured rock. And there are instead applications in the petroleum industry using discrete fracture networks rather than these continuum approaches, not relying on variograms or indicator variograms, but rather the statistics of fracture -- the fracture network itself. And that becomes a much more complicated problem especially when looking at things like sampling because sampling is preferentially drawing from fractures in these kinds of environments.

So that's, yes, a more difficult application of these techniques for certain.

MR. KLUKAN: Right. Well, thank you for those responses.

And thank you again, Randall, for the question.

We're now going to turn to Barbara.

I am now un-muting you, so please feel free.

(No audible response.)

MR. KLUKAN: And this is Barbara Warren. Feel free to go ahead and make your comment or ask your question.

(No audible response.)

MR. KLUKAN: You just need to hit the un-mute button for yourself.

(No audible response.)

MR. KLUKAN: All right. Barbara, we're going to come back to you hopefully, but right now we're going to go to Eric next up.

So, Eric, whenever you're ready. Eric --

MR. E. DAROIS: Yes.

MR. KLUKAN: -- I think you're already un-muted. All right. Good.

MR. E. DAROIS: Yes, thank you, Brett.

I just want to say a few things, and one is I think Carl is absolutely dead on about keeping this simple.

Secondarily, I know the NRC's got lots of experience with subsurface at many sites, but very few are for nuclear plants and nuclear plant decommissionings. Probably the most significant that I was involved with was the Connecticut Yankee site that did involve some fractured bedrock. We did come up with a scheme 20-odd years ago, and I use the term scheme lightly here, but we came up with a methodology to classify the site similar to MARSSIM classifications. We used A, B, and C rather 1, 2, and 3 as to just designate them differently. And there were different subsurface sample densities. We came up with the methodology that ended up satisfying all the stakeholders and we terminated the license, obviously.

But I think it's important to recognize that it's fine to go down all these pathways and have all these tools and models, but more importantly perhaps would be to define when you have to step into that space and when you don't. Because most of the nuclear plants, at least that are in some phase of decommissioning today, I'm going to get out on the limb and say they shouldn't be having to go down this complex pathway.

I know we're going to hear from Matt Darois a little bit about the application of NE 07-07 and I think that's very relevant to that -- to this comment, but I just -- that's my passing comment, that we need to define when to get into it and when not to. So thank you.

MR. KLUKAN: Thank you very much. Appreciate the comment.

So, Robert, we're now going to turn to you. I think you're already able to un-mute yourself, so please feel free.

MR. STEWART: Oh, hey. Can you hear me okay?

MR. KLUKAN: Yes, we can. Thank you.

MR. STEWART: Oh, hey. Thank you very much. And really -- so this is the Robert Stewart who led the team at UT that developed 7021 and I am just thrilled to be here and to see that we're pulling all this back together again and moving forward.

I guess my comment is; and I think Carl and Boby know this, after completing 7021 I took one step further; heard this in the comments, and I sort of entered my dissertation work. Sort of sewed together a way forward sort of connect geostatistical simulation approaches with things like check and cover as a way to sort of simultaneously consider -- I know it's your first potential discussion question -- simultaneously consider multiple exposure unit sizes, DCGLs that vary with depth, DCGLs that vary with size, and put together a work flow that sort of sews all that together and kind of comes up with optimal sampling strategies and optimal remedial designs.

And I just want to make the community aware of that in case you were not aware of it. I'm not sure how it fits in nowadays, but it seems like it would be interesting to explore that. And I think all the tool -- or a lot of the questions I see in the potential discussion questions at least some of those are -- that work can contribute to some of those questions.

I don't claim that this is the holistic answer to anything, but I just want to bring up the dissertation work. I want to say I'm glad to be present again and hearing this stuff going on and I look forward to continuing the conversation, hearing the other presentation. Thank you.

MR. KLUKAN: Well, thank you, Robert. We appreciate it. And thank for the comment as well. I was going to read it during a down time, but I think you summarized your point here. So again thank you.

I think, Randall, you have your hand up again, so please feel free.

MR. FEDORS: Okay. Thank you. A much more direct question, and this I think was for Jennifer. When she was talking about ranked set sampling she mentioned a course system of measurements maybe. I should call it that. And then that would help focus something in our sampling for compliance later on. So that was where the ranked set sampling came in.

So what type of course sampling was she talking about? Was that geophysical or something like that?

MR. KLUKAN: Jennifer, do you want to take that on?

MS. HUCKETT: Actually I'm ask Deb to field that question, if she's still on.

MS. FAGAN: Hey, I'm sorry.

MS. HUCKETT: Thank you.

MS. FAGAN: So I'm also going to have to punt a little bit, I think. I'm looking at the VSP help page for ranked set sampling and you choose -- sorry, it's going to take me a minute. I'm going to punt and I'm going to say I'm going to get back to you on that question after I've had a chance to look at it for a minute, if that's okay.

MR. FEDORS: Well, an example of ranked set sampling for -- like for surface soils would be to do walk-over scanning of the area and then bin up the different results. And then only take soil samplings to sample each bin of your distribution for an area. But trying to apply that to a subsurface I was wondering where the analogous walk-over scan might be, what (audio interference) --

(Simultaneous speaking.)

MS. FAGAN: I think --

MR. FEDORS: -- that is.

MS. FAGAN: I think that would have to be some kind of geophysics technique like is going to be presented later. Tim Johnson and Fred, who just answered a previous question, are going to talk about some tools that are in development that could potentially fill that part of it.

MR. FEDORS: Yes, makes sense. Thank you.

MR. KLUKAN: Sorry, having trouble with my mute button there.

Thank you, Randall, again for that question.

And thank, Jennifer and Debbie, for answering.

So just a reminder for those on the phone, if you'd like to ask a question or pose a comment, please press *5. Again that is *5 to raise your hand. Otherwise, if you're participating via the Teams app, you can raise your hand or place your comment into the chat box.

So would like to focus our attention maybe on some of the discussions. So we'll start off with the one for 3. And I think we've touched upon this a little already, but in your -- what are your thoughts regarding what methods are available to determine an elevated area size of concern and should multiple sizes and geometries at elevated areas be considered? So any thoughts on that that you have regarding -- in the context of the presentation?

Please feel free again to raise your hand, put your thoughts in the chat. We're here to hear from you, so please feel free to engage. We want to hear your opinions.

And so I'm going to try while we're waiting for others to raise their hand -- Barbara, if I -- as far as I can tell, you should be able to un-mute yourself. This is again Barbara Warren. Feel free to un-mute yourself.

(No audible response.)

MR. KLUKAN: Okay. And, Barbara, if you're having troubles, feel free to reach out to Tom or to Cynthia to help you out logistically.

MS. BARR: Yes. Well, they can also put their questions in the chat.

MR. KLUKAN: Yes. Or, Barbara, put your --

MS. BARR: We can read them and we can answer them in the chat or we can discuss it out loud. We can just repeat them if they're having trouble.

MR. KLUKAN: So I'm going to go next to Kalene Walker who has her hand up. So I'm going to allow your microphone, so whenever you're ready.

(No audible response.)

MR. KLUKAN: And again you have to un-mute yourself. There you go.

MS. WALKER: Okay. Hi. So as a member of the public I'm interested in what kind of -- or transparency for one thing to the public -- what kind of requirements -- for the decommissioning entities what is required of them before they start dismantling these facilities and is there any oversight from an outside independent assessor? Because it seems like it's very much in the hands of the industry and there's a lot of wiggle room in here for doing your assessment and your projections and your estimations and modeling and whatnot. So I'm wondering where's is the check and balance on this?

MR. KLUKAN: So I appreciate your question, Kalene, and thank you for participating in the conference. That's a little outside of the area -- or it's outside the area of the scope of this presentation, which is really focused more on the methodologies we're going to use to analyze subsurface contamination potentially.

And so what I'm going to say is if we have time in the end, we can potentially come back to that, but for right now I'm going to table that because that's a separate question regarding oversight of these facilities where the -- really the focus of the conversation today is on again the methodologies, the techniques we're going to use to conduct these types of analyses. But I do appreciate your participation, so thank you.

MS. WALKER: And what part of the NRC regulations will that be discussed or when will we -- when will that be an official part of the NRC's process? Because there's facilities being decommissioned now by entities that have never decommissioned plants before. They have no history of the facility other than whatever documentation there may be from the licensee. So I'm just -- seems like it's a lot of unknowns once they've decommissioned a facility to just throw the dart and see if there's some kind of indicator, but that's just my perspective. Thank you.

MR. KLUKAN: Well, thank you, Kalene. And again if we have time at the end, we don't really have -- the people who do that kind of oversight here with us today. Really the focus of this is on the analysis. And again, you're -- always feel free email us your questions, given that we may not have time to get to them today. So feel free to email either Cynthia or Tom. Both their email addresses are included in this presentation. They'll be happy to answer their questions or forward your questions to -- if they can't answer them themselves, to whoever can.

So again feel free to enter your questions in the chat as well. You don't have to wait to raise your hand.

So but with that said, take a -- what we have in chat here. So we have question or a comment from Rob, Robert. In terms of question 1 he took this on in his dissertation with the Mr. DM model, or MRDM model. And then Rob also writes this -- and I'm reading this out for those of you participating on the phone. And this again from Robert Stewart.

It is estimated that the area of concern or remedial design is based on different exposure scenarios and DCGL levels. If one can produce a variogram as in kriging, they can use MRDM. And hopefully I'm saying that acronym correctly.

For question 4 the cheekily named MRSDM; I guess I am saying that right, is a secondary sample design aimed to reduce uncertainty in the MRDM area of concern. By reducing uncertainty the MRDM area of concern can be reduced or further refined.

Again thank you, Robert, from -- or for those comments. We really appreciate your participation again today. And apparently I was saying it correctly, I think.

So other comments on the draft, or excuse me, the discussion questions that we have up there? And again feel free to put them in the chat or to -- if you prefer to raise your hand, please feel free to do that within the app. Or if you're participating via phone, hit *5.

How about with respect to the question for 4, or the -- what we're calling the 4th -- presentation No. 4?

MS. BARR: Brett, before you go on I did want to add to (audio interference).

(Simultaneous speaking.)

MR. KLUKAN: Oh, of course.

MS. BARR: Sorry. I put my hand up late.

MR. KLUKAN: No, no, no.

MS. BARR: No, I just wanted to back up Rob Stewart's comment. And this is an area where I discussed in my presentation that we need additional guidance. We don't currently have guidance on how to determine elevated areas for the subsurface. And MARSSIM is based on scan surveys and the ability to detect these elevated areas between sampling points so that you don't miss them because people can get exposed to these elevated areas at the surface.

But when you're talking about a subsurface, surface, or buried residual radioactivity, people can't access that material as easily. And so the way you would treat an elevated area on the surface may be different than how you would treat it in a subsurface because really you're very limited on how you could get exposed.

And so we do have some guidance in NUREG-1757, Volume 2, Rev 2 in Appendix J on some of the exposures scenarios that you might need to consider that could bring that radioactivity to the surface through some kind of intrusion scenario like basement excavation or well drilling or a large construction project if that is something that could occur in the area of your decommissioning site.

So all these different scenarios could bring that radioactivity to the surface and maybe those would be a basis, particularly like a well driller when you're bringing up a small volume to the surface, on how to calculate what we call clean-up levels for elevated areas or smaller areas.

So I'm really looking for feedback on that, but I agree with the need to look and see what are the types of exposure scenarios that people could be exposed to that could lead to unacceptable doses? And then how would you go about considering the likelihood of some of those exposure scenarios? So like if you're talking about a well drilling scenario and you're talking about a few-inch radius/diameter well, what is your likelihood of actually putting that well exactly where the hotspot is? So that's based on the number of hotspots you have and the size of those hotspots and things of that nature.

So it could get kind of complicated, but it's an interesting problem and it's a real problem that we have. And we do need additional guidance in this area, so I think it's important in any -- for any site to evaluate the risk associated with large and small areas for all the radionuclides. And because subsurface has three dimensions, then you start having to worry about how deep is the contamination, how thick it is, because all those things matter on whether it's risk-significant or not. And identifying the risk-significant source geometry parameters is important to making sure that you adequately survey and demonstrate compliance with the release criteria.

So looking for discussion and people's thoughts on that particular topic. Thank you.

MR. KLUKAN: Cynthia, thank you for that.

And I just want to -- before we go to Boby, who has his hand up, I just wanted to clarify, Robert Stewart, that the MRDM model means multi-scale remedial design model.

So that's what -- for those of you on the phone that's what that acronym stands for. Again that's a multi-scale remedial design model.

And with that I'm going to --

MS. BARR: Brett, I couldn't hear what you just said. I'm not sure -- did you mute yourself?

MR. KLUKAN: And of course I had it on mute. I'm so sorry, everyone. So well that's a -- can mark that off on my check -- bingo card for today.

So all I was saying is that Robert in the chat -- for those of you who may not be familiar with

MRDM, it stands for multi-scale remedial design model. So again for those of you on the phone who can't see the chat, I just wanted to clarify that, that when we're saying MRDM, that means a multi-scale remedial design model.

And now I'll turn it over Boby who has his hand up. So sorry about that.

DR. ABU-EID: Yes, thank you. Just like to -- Cynthia, what she said, I agree with her 100 percent. Just to add that we use land use scenario. Depends on what kind of scenario that to be used for the land. It is it for industrial, recreational, or for farming? So when we consider the land use scenario and the LTRs, and this is to be of course addressed by the licensee to consider what kind of exposure scenario. We'll consider that. We'll consider the potential exposure from digging the site or construction or other kind of uses. Just to clarify what Cynthia she said. Definitely we look at the land use scenario. Thank you.

MR. KLUKAN: So does anyone -- and thank you, Boby.

And thank you, Cynthia.

Does anyone have any comments on what

either Boby or Cynthia laid out there? Again we want to hear from you any thoughts on what they raised. And again feel free to enter your thoughts in the chat.

(No audible response.)

MR. KLUKAN: Okay. It looks like, Cynthia, you have your hand up again, so feel free.

MS. BARR: Sorry. No, I didn't un-raise it. But just to follow up on what Robert Stewart was saying earlier -- and we have this question No. 4 under topic -- or Presentation 3, question 4. We do have this topic of remediation versus compliance.

So geostatistics can be used for two purposes, and that is to determine how much remediation you might have to do if you're above the release standard. And so it's really trying to give you -- optimize that problem of you don't want to dig up more soil than you need to dig up essentially. And so adequately analyzing the risk of these multiple sizes, geometries of elevated areas and coming up with the optimal amount of soil to remove is a complicated process, but he's kind of worked that out in his dissertation.

And then the other use -- possible use of geostatistics is in a case where you don't have anything dug up, if you don't have open excavations that you can survey. You still have this very complicated problem where you have potentially large volumes of soil and how do you go about optimally sampling that soil to demonstrate that you meet the release criteria without having to do remediation? And so that's an area where we're trying to develop guidance as well.

And so when he's talking about these different protocols or methods, it's really to solve these two different types of problems. And so it's another good question, No. 5 on Presentation No. 3 potential discussion questions.

And I only offered that because my hand was still raised, but I didn't really actually have anything. So sorry about that.

MR. KLUKAN: No, no.

MS. BARR: I will un-raise it now.

MR. KLUKAN: All right. So Robert added to the chat, and I'm reading this out loud for those of you again on the phone. Using simulations instead of kriging could support specific scenarios. For example, if I dig a well right here, what is the probability of striking/pulling up something bad?

And then Marvin Resnikoff, the question raised by Barbara Warren is appropriate under 3 where it asks about statistical methods. And I would add that Cynthia did respond to that in the chat as well.

But if people have further comments with respect to that, please feel free to put them in the chat or to raise your hand.

Okay. So any other thoughts, particular those who haven't had opportunity to speak on either of these two topics? We have a couple minutes left here. I just wanted to see if others have any thoughts on any of the proposed questions that we have up here.

Again at 2:00 we're going to go to a 10-minute break based on the agenda. And then again it's posted on the public meeting web page.

So any other thoughts on what we've heard or regarding any of the questions or other questions you think should be asked with respect to these topics? Because we've had a series of questions so far, for example those proposed by Randall.

And again thank you for that.

Any other thoughts on these?

MS. BARR: Yes, I just wanted to acknowledge Barbara's question. She asked: Erosion is a significant problem for some sites and the potential to uncover buried residual radioactivity is a concern and would be a value -- and would be -- I'm sorry, that's my answer. Not reading the right thing. She was asking if -- to what extent would you characterize a site that had severe erosion? And my response back to her is that that would be something that you would characterize.

Now it's not an intrusion scenario where there's a human activity leading to bringing that radioactivity to the surface, but if natural processes could lead to erosion down to where the residual radioactivity was buried and that material could migrate off site in rivers and streams, that's an actual problem at sites that are being decommissioned and it's something that we do look at. And that would be part of the evaluation. So I just wanted to stress that.

And that was an excellent question, so thanks for asking that. And if you have any follow-up questions, just put them in the chat if you can't speak. But thank you, Barbara.

MR. KLUKAN: And, Kalene, I see that you have your hand up. Did you have other -- we have about two minutes here. I just wanted to see if you had anything else to add to this. And feel free to un-mute yourself. And then we're going to go to Carl after you, so -- and then we're going to go to break. So, Kalene, did you have anything or do you -- oh, it looks like you just lowered your and.

Okay. So, Carl, please go ahead.

MR. GOGOLAK: Yes, the thing that I was hoping would get into a little bit particularly from the more statistically-inclined members of this workshop, is -- are the questions about the assumptions necessary for analysis, both from the Bayesian Ellipgrid and Markov-Bayes.

The reason I asked that is for example in MARSSIM we have a model where we pretend every location is independent of every other location. So there is no co-variance. But we know that's wrong, but it still seems to work in practice.

In the case where we have the Bayesian and geostatistical part we now acknowledge that yes, there is correlation. We may not know exactly what it is or exactly what the model is, but we are now going to take that into account. So this is the kind of thing -- information that I personally find very useful in terms of evaluating different approaches for the work that SC&A is doing for the NRC.

MS. FAGAN: So I can inject something there, Carl. So when spatial correlation is present, if you don't account for it, then you get a higher -- you run the risk of a higher type 2 error rate, which works in the regulator's favor because a type 2 error is one where you can conclude incorrectly that a clean site is dirty.

So your comment about it seems to work rather well, I think that that's generally true because of the conservatism that -- in the way that MARSSIM is set up and the way that the rules are applied. However, in my opinion in the surface whenever you're taking sort of georeferenced data, you should think about the possibility of spatial correlation and -- because if it is there and you model it, then you can get away with the same decision criteria with fewer samples.

And in the subsurface I think one of the reasons that we think about it more is because we don't have those survey techniques that we have for the surface where you can cover large volumes of data -- or sorry, large areas with relatively inexpensive data collection techniques. In the subsurface that's really hard to do.

And so -- and I think that that technology is being developed; and I've mentioned a couple times that Fred and Tom are going to talk about that later, but I think until -- I think you need to go through the exercise of modeling your geophysical parameters to concentration to be able to use those methods or there needs to be technology that's developed that can achieve classical survey results.

So that's why I think that it's more important in the subsurface to think about spatial correlation.

MR. GOGOLAK: We get the opposite effect from scenario B, is that correct?

MS. FAGAN: Right. So with scenario B you assume your -- you flip your hypotheses and you assume that your site is clean. And typically if you're going to invoke scenario B, you end up taking a lot more samples than under scenario A. There's that possibility there. So scenario B in the subsurface, I can't quite think how that would be implemented, but -- I have to think about it a little more.

MR. KLUKAN: So, thank you, Debbie. And again that was Debbie Fagan with PNNL responding to Carl. Both of them were earlier presenters.

So right now we're at the 2:00 mark and just part of my job is to facilitate here as a time keeper. So there have been some great comments in the chat as well by Robert Stewart, Jess Joyce, as well as -- and then Timothy Eckert.

And then, Timothy, I think maybe your question with regard to is there a public domain report that summarizes decommissioning thus far is that -- that's something that maybe the staff will try to address during the break or get back to you after the meeting with the -- but thank you for raising it.

And again we'll come back to these if we have time later on. Right now I'd like to take a short break because as I think Boby noted in the chat the NRC infrastructure -- IT infrastructure decided this would be a great time for all of us to restart our computers. So I need to do that myself.

So we will reconvene promptly at 2:10. So again at 2:10 all of us will come back and we'll begin with Presentation No. 5 and No. 6. So thanks, everyone, thus far. So again we'll be back at 2:10. Thanks.

(Whereupon, the above-entitled matter went off the record at 2:04 p.m. and resumed at 2:11 p.m.)

MR. AIRD: So, welcome back everyone.

This afternoon we have two more technical presentations. These two presentations are from Matt and Eric Darois, from Radiation Safety and Control Services.

These two presentations will be given live, so they're going to take control and share their screens and walk through them.

After these two presentations, we're going to have a similar discussion period starting at 2:50 p.m., and Brett will lead that.

So, save your questions and comments till then.

With that, I think we can hand it over to Matt and Eric.

MR. M. DAROIS: Okay, thank you. Can everybody hear me?

MR. AIRD: I can hear you, and I can see

your slide.

MR. M. DAROIS: Excellent, thank you.

Well, good afternoon everyone. My name is Matt Darois. I'm the Corporate Environmental and Engineering Manager from NRSCS, and I'm a certified groundwater professional.

I'd like to thank Bruce Montgomery at NEI, and the NRC staff, for inviting me to speak today. I had a great time speaking at this last time.

And, to some degree, what I'm going to talk about today, will follow up on some of those concepts.

My academic background is in environmental science and hydrogeology. This month marks my 20th year working in commercial nuclear decommissioning, and commercial nuclear environmental monitoring, specifically groundwater. And, also asset management and repair.

So, I kind of work in both worlds, and I've certainly worked in this transition between operating plants, and decommissioning plants.

And, we've heard a lot of discussion about that this morning, and I've taken some good notes.

So, based on that, I just want to start with some opening remarks.

First of all, I want to talk about today, an existing Nuclear Energy Institute initiative called 07-07. It's the commercial nuclear power's Groundwater Protection Initiative.

And, I'm going to talk about it in terms of how this kind of becomes the foundation for the follow on work, to design subsurface investigations.

And, how the foundation for this work provides a large step off pad, for, or launching pad, for investigations that would happen, and remediation that would happen, during decommissioning.

So first of all, with that said, I just want to make it clear that subsurface investigations at nuclear power plants, don't start at decommissioning.

And, that's there's been a strong push for that since the mid- to into the late 2000s. And, some of this pre-dates that by some degree, and of varying levels.

But there's been a large body of information that's been pulled together to support ongoing subsurface investigations, both during operations and during decommissioning.

And, work to help do mitigation and remediation of those sites.

So, these sites as I mentioned, have commercial operating sites have mature, hydrogeologic conceptual site models.

Those are built based on the limitations that occur at operating plants, and I'll get into that a little bit.

But they provide this informed, ongoing investigation and survey design information that can be leveraged, both hard and soft data we've heard people talk about.

And, this initiative lives on during D&D. So, I'll get into some of those details after that.

So, there isn't this, I want to make it clear that there isn't this loss of information as people leave a site.

Whether it goes into SAFSTOR decommissioning, they lock the doors and walk away, and then a new group of people come in.

That's really not the case. There's a body of information. A lot of studies that have been done that are available and can be leveraged, to the folks that are going to come in and perform active D&D and license termination.

So -- I have a problem with the slides here. Okay, so just to, I'm going to start by again, recapping what I talked about last year in July, which was a graded approach to subsurface characterization.

This focused on the triad process, which is really embedded in a lot of the investigation methodologies, that have been used in the last 20-30 years. Including some of the ones that are being considered in the NUREGs moving forward.

The use of the conceptual site model in that, within that framework. And, then how NEI 07-07 Groundwork Protection Initiative dovetails into that, and how it builds upon that, and improves upon it.

And, we'll talk about that in terms of operating plants. And then again, how it can be used in decommission.

And, I'll finish that by talking about some applied examples.

So, the triad approach. The NEI 07-07

Initiative includes all three of these aspects of the triad approach.

Systematic planning. So again, starting with a historical site assessment. What was, how the site was use, what happened at the site. Where are the areas of concern. What materials are present. What operations happened. What practices happened.

Develop an initial changing dynamic conceptual site model. And, this conceptual site model drives the characterization. Develop dynamic work strategies.

The characterization plan is the technical basis for the CSM. So, the CSM has to be defendable. And, because of that, characterization has to be data driven.

So, in terms of the complexity of the site, I think of it not, not like a prescriptive methodology, but the complexity of the site is driven, or the data being collected and utilized, is driven by the complexity of the site. Not the complexity of the model that you're building.

So, the amount of information, real information that you bring in, refines the CSM, not the other way around.

And, then real-time measurements. Real-time measurements is sometimes problematic with subsurface work.

Certainly in groundwater monitoring, real-time measurements is difficult for radionuclides. There are other methodologies that can be done.

Soil sampling as part of groundwater investigations, is important. And, there are some real-time measurement methodologies for that, but that's not going to be a major part of what I talk about today.

So, in terms of conceptual site model. We've heard about this a lot today, and certainly last year.

So, what is, I just want to take a step back and talk about what a hydrogeologic conceptual site model is, in a general term.

And, I really like this quote up above. It says a hydraulic, a hydrogeologic CSM is a description of various natural anthropogenic factors, that govern and contribute to the movement of groundwater in the subsurface.

So, when we talk about a hydrogeologic

conceptual site model under that umbrella, at a site that has potential for subsurface soil contamination, and groundwater contamination, we need to bring in that aspect to this as well.

So, I more or less defined a CSM for nuclear power plants, and decommissionings, as the following. It's a collection of tested hypotheses that are iteratively attempted to be answered.

And, the questions that need to be answered are listed below. What are, where is groundwater coming from? What types of porous media is it flowing through? Is it soil, is it fractured bedrock, is it backfill?

How much groundwater is there, and how fast is it flowing there? Where is groundwater going, where is it discharging to?

How did, and these are important, especially for decommissioning in the next one. How did groundwater behave in the past, and how will it change in the future? Both due to natural and anthropogenic processes.

What are the past, present, and future contamination risks for groundwater? And, how do contaminants move in groundwater? What is their fate and transport?

So, in terms of the NEI 07-07 Groundwater Protection Initiative, it encompasses all of these ideas of the hydrogeologic conceptual site model.

07-07 was initially developed in 2007, to describe the industry's initiative. It applies to both operating and decommissioning power plants, and new plants under construction after 2006.

So, even a plant for example, that was in SAFSTOR, that went into decommissioning after the initiative went into place, would have to develop one of these.

It's a voluntary initiative of all the U.S. commercial, all of the U.S. commercial fleet signed on to it.

And, subsequently, there are some means for the U.S. NRC to review and provide oversight of the program, through the plant's radiological effluent monitoring program, as a mod to their inspection procedures.

So, the initiative provides improved management and monitoring of groundwater again, and events that have happened.

The initiative uses three major parts.

The Groundwater Protection Program part, a communications part, and program oversight.

So in terms of subsurface investigations, I'm going to talk about in detail, the Groundwater Protection Program part, and the program oversight part. Not the notification and communication section.

So, under NEI 07-07, under the Groundwater Protection part of the initiative, there are several objectives.

The hydrogeologic conceptual site model that covers both the hydrogeology and the contaminants of concern and risks, fall under Objectives 1 and 2.

The site risk assessment is going to be an important part of this, because it defines these areas of concern that are problematic for survey design. And, both non-biased and biased sampling.

So, part of this initiative from day one when it's executed at a plant, involves risk ranking all the systems structures components and work practices, that provide a risk to the subsurface soil contamination, or groundwater contamination.

Part 3 is an ongoing programmatic

groundwater monitoring program. Objective 4 is a remediation protocol, which we'll talk about in more detail.

And, Objective 5 is record keeping, which is making sure that any events that occurred, reports, any new findings, all of that is tracked formally under 10 CFR 50.75(g).

So, I'm going to briefly talk about each one of these objectives in the initiative. Objective 1, the site hydrology and geology, is really the first step in the initiative.

Each one of these objectives to some degree, is iterative and they, and they grow and change along with the CSM. This is certainly part of the CSM.

So, development of understanding of the aquifers that are on a site, understanding the recharge and discharge areas.

Understanding the gradients and hydraulic heads, and the trends in those hydraulic heads across the site relative to the site structures, and risks that I'll get into.

The hydraulic head boundaries. Where, for example, where is the water discharging to?

Where are there upgraded head boundaries? For example, ponds, lakes.

Anthropogenic effects. Are there pumping wells on site? Are there French drains? Are there barriers to flow as I mentioned here, or preferential flow paths such as backfill?

And, are there areas where there's non-preferential flows, like in native fill, or aquitards, or areas that there are low permeability?

So, just while I have this up, I tried to embed some figures in here. This is a good example of that.

An initial phase of a, of this project when you're developing CSM, is to determine whether you have an appropriate well array. So, your groundwater monitor array.

So, both characterizing all the aquifers vertically, and spatially, to allow you to understand the gradients and seepage velocities and vectors, or flow directions, is important.

So, not all wells in this initiative are meant to monitor and release, or a system structure components and work practice. You need to understand the hydrogeology that feeds your CSM, which is the basis of the program.

And in this case, the figure here that I'm showing, shows that there are a whole bunch of anthropogenic effects. In this case, backfill and structures, that drive the shape of the aquifer, which again, then drives the defensibility of where groundwater monitoring wells are, relative to your risks.

So tested hypotheses. So, in development of the hydrogeology, there's a lot of data collection analysis that goes on, as part of this initiative. And, it's an iterative process.

Knowing the make up of the geology, the surficial geology and the bedrock geology, is important. They can help answer questions on why your aquifers look the way they do. Why they flow in different directions.

And, it helps test these hypotheses, test these questions. Why is groundwater flowing the way it is? But why are the, why is it flowing under buildings a certain way? Why do they make these somewhat strange shapes.

So, you need to be able to defend those answers. And, a lot of that can be found in the geology, or hydrogeology of the site.

So, a good example is this bottom example of where we've got the structural bedrock, and these bedding planes that are angled, along with pumping wells in the lower right-hand corner in the center of the screen, that creates a draw down along a preferential flow path, in the bedding planes in the bedrock.

And, we can explain the shape of this aquifer by studying the underlying bedrock. So, all this information together in one place, helps us defend well placement, and monitoring strategy.

So, risk assessment, which is the second big part of a conceptual site model for NEI 07-07.

If you evaluate system structures components and work practices that could contain licensed material, with a credible pathway to reach groundwater.

So, what is a credible pathway to groundwater? A credible pathway is where there is a single barrier between an SSC, or work practice in the environment.

So, in the case of a work practice, if you're storing waste containers outside on gravel, or on soil, there is a single barrier. It's the container.

If you're, if you have an outside tank, it's the tank wall is the single barrier. If it's a system, a high risk system inside a building but there is a seismic gap, and there is potential for water on the floor, the floor is the single barrier.

Those are some examples of that.

Other examples of systems structures components would be again as I noted, outdoor tanks, buried pipes, foundation joints, as I mentioned.

Those areas are areas where you would prioritize monitoring, and make sure that you're groundwater monitoring wells, are placed in an appropriate area based on the hydrogeology to monitor for those leaks.

Other parts of this objective include evaluating potential enhancements to leak detection systems, or programs.

One of the NEI Initiatives that came out of the Groundwater Program, is NEI 09-14, which is the Underground Buried Pipe and Tank Initiative.

That initiative actually looks at the integrity of safety-related piping in tanks.

Underground safety related pipe, buried piping of tanks.

So, they actually have a quantitative means to risk rank systems structures components, and it's consequence times susceptibility.

So, at most of the time using that initiative to help feed this initiative, you can see systems structures and components, or work practices, that contain licensed material having a high consequence if they were to leak.

So, they usually rank high on that level, but even using NEI 09-14, if there is a non-system that, for example, that has, that doesn't contain rad material in it, but it does leak, that can change the hydrogeology of the site.

And, there are several instances of that, that I've seen in the past.

So, understanding that and making sure those initiatives talk to each other, is an important part during plant operations and decommissioning.

And, we've seen quite a bit of that integration between the two programs.

Okay, Objective 3. Ongoing Groundwater Monitoring. So, this is developing a formalized groundwater monitoring program.

These programs trend and track groundwater information over a long period of time. So there's a long history of trending information, analytical data, groundwater elevations.

There are updated groundwater flow maps, flow nets that are created. And all of this is documented and tracked, through a formal tracking and documentation process. It's available to feed a historical site assessment later on.

This groundwater monitoring program also contains triggers for program reviews. If something changed at the site, if there is a new release, it triggers a review of the groundwater monitoring program and the CSM, for updates.

So, all that information again, is contained in this and can be used for, for a survey design later on.

Remediation. So, really I'm going to talk about remediation, record keeping, and Objective 6, which is D&D and SAFSTOR impacts, together.

So, I want to read what it says in the initiative for remediation. It says to establish a remediation protocol to prevent migration of licensed material offsite, and to minimize decommissioning impact.

So, this is where we need to be really careful about how we use the word remediation. There is not a huge amount of final remediation that happens at operating nuclear facilities.

It's really mitigation. This is this big difference between the two words. Now, mitigation is the, is to reduce a threat, and remediation is to remove the threat beyond some action level.

So, when you're operating a nuclear plant, you can't dig up underneath the spent fuel pool, and remove the contamination threat.

You can mitigate that threat for offsite migration, or you can mitigate exposure so that threat during operations.

So, this process of remediation, the term remediation in 07-07, really is a means to mitigate the threat down below a point where you're not having offsite migration. And, you're, you have a good understanding of the contamination and where it is, and where it's extent is.

Which can help during further investigation and clean up.

Remediation is something that happens at decommissioning in most cases. This information picture at the bottom is a good example of that. And, record keeping.

This is part of a contamination verification survey that I did at a decommissioning site, to document the as-left remediation of the site that would not be able to have been done during operations.

There was a slab where this excavation was. And, the concrete you see in the slide, is a spent fuel pool foundation.

There was a lot of contamination underneath the slab. There were mitigating factors in place to keep that contamination from migrating down-gradient. Which we understood where down-gradient was here.

And, actually, the, as we dismantle the site, the risk of this contamination after the slab was removed, was elevated to a higher level.

So, the CSM had to be changed. We needed to understand how removal of the slab, exposure of the soil, and these contaminated medias, would affect, the conceptual site model, would affect the aquifers, and affect our monitoring of the site, and record keeping going forward.

So, these are all kind of, remediation in my mind, record keeping, and impacts for D&D, all kind of come together.

And because of this, there's this whole program as it transitions from an operating plant to a decommissioning, has to be reevaluated.

The risks that the systems structures components, and certainly the work practices that happen during decommissioning, are much different than they are in an operating plant.

And, so this whole program needs to be realigned to meet those needs.

I apologize for this. My mouse is sticky.

Okay, and then I wanted to briefly talk about Part 3 of the program, which is Program Oversight.

So, this is this program, the NEI Initiative 07-07, has independent program oversight, and it's a self-assessment that's done by independent people not related to the program.

Generally, they're from a different

facility. And, it was done initially when the program was stood up, and then this type of assessment is done, a program assessment is done on a routine every 5 year basis.

This includes a review, and update to the CSM is necessary on that 5 year interval. And, more frequent reviews and updates to the CSM in the Groundwater Monitoring Program, can be done if there are significant changes that happen at the site.

So, this 5 year assessment on its own, provides a pathway to routine CSM updates and record keeping, that can help establish areas of concern, investigation areas, and survey design during the decommissioning.

(Pause.)

Okay, all right. So, I wanted to end this discussion, and leave a little bit of time for where we can discuss this openly, with some applied examples.

I want to kind of talk about scale, and how this all kind of comes together with some figures here. I mean, pictures speak 1,000 words.

So, I already showed this picture in the upper left-hand corner. It shows the bedrock aquifer at this site. You can see a bullseye in the middle, which is the high groundwater elevation. It's an elevation contour map of the aquifer.

That's the recharge, where recharge is coming from. And, then you see water kind of move off radiantly in each direction. But it doesn't radiantly move out in every direction equally. It's some heterogeneity to that.

And, we discussed that that's, we've answered that hypothesis in the CSM, with an understanding of where there is pumping wells, and the lithology, and the structural bedrock, below the plant.

We can look at that in terms of these structures, which also are anthropogenic barrier to flow for the aquifer, and how that interacts with the aquifer in the backfill on a large cross-section, which is the image below that. Which is all described in the CSM.

And, then we can look at, you can even look at it on an aquifer size scale, and we can look at it on a structure, system structure and component scale in the lower picture, which shows how groundwater really interacts with those structures, and the with backfill.

In this case, we can look at how groundwater flow is not just laterally, but vertically.

And, this arrangement of the aquifer, with pumping wells, and an understanding of lithology of the bedrock, lets us infer that groundwater is moving from the surficial backfill aquifers, the bedrock, and then back into the surficial on either side.

So, this drives where we monitor systems structures and components. And it becomes, and it's very defensible in this way.

We're allowed to, the placement of wells may not be exactly where the SSC or work practice of concern is, but we can justify placing, and especially in a challenging environment where the plant is operating, to meet our objectives.

Furthermore, we can look at systems structures and components inside the facility, that might be a problem using a common data environment. Either a BIM or a GIS, which was mentioned before. Both of which are shown on the right.

We can look at the arrangement of systems inside. And, then we can look at the arrangement of systems inside, along with buried pipe and monitoring wells on the outside of the plant, and determine the best location to put these wells, relative to the hydrogeologic aspects of the plant.

So, there are other concerns that we can glean from long-term groundwater monitoring programs, that are part of 07-07, that could impact future decommissioning of these facilities.

Or facilities that go into SAFSTOR, and then on to decommissioning later.

These programs, these long-term environmental monitoring programs essentially, are trending not only contaminant location and concentrations if they exist, but also groundwater elevations as part of CSM updates.

And, we can see trends that occur over these long periods of time, that can help us predict, as I mentioned in my earlier slides, what groundwater is going to look like in the future.

And, there are a lot of trends related to climate change. In some regions of the U.S., we're seeing groundwater recession due to irrigation, or a drying climate.

And, especially in the East in the U.S., we're seeing generally groundwater elevations rising. So, this can drive dose modeling in NUREG-1757, in terms of how much vadose zone soil there is versus saturated soil.

It can drive level of effort to remediate structures, or soils that are below the water, the water table, static water, in the future.

And, it can drive future risks to mobilizing radionuclides that are higher up in the vadose zone, or underneath slabs, as I mentioned earlier. So, understanding these trends long-term is important.

And, we can look at this information, and then what's shown on screen here is the regional information on the left trend, and site information on the right. And they correlate with each other, and we can defend that trend long-term.

Other things to consider. We talked briefly earlier about erosion. Coastal erosion, sea level rise, those things can impact groundwater.

Salt water intrusion can change groundwater elevations. Again, change the level of effort to do characterization, and clean up later on.

They can also, change in salinity can change the partitioning coefficients, radionuclides, and mobilize things.

So, those kinds of considerations need to be addressed. And, some of this information's retained within these long-term groundwater monitoring and trending programs. And, the CSMs that go with them at operating plants, and decommissioning plants.

Okay, last slide.

Just another example of a trigger for a CSM update in accordance with 07-07. A lot of sites are dealing with groundwater intrusion leakage. A lot of sites are implementing active engineered pumping systems to remove water.

These types of changes can have significant effects on the site, and it's a big justification for these 5 year reviews.

Or triggers if major events happen like a de-watering system being installed in a plant, that changes the aquifer significantly.

These are important things to note, and I applaud the industry for doing this. What we're seeing here is an example of how you can reverse groundwater flow, upgrading or downgrading of your SSCs.

So, this can completely change on a site-wide level, your defendable monitoring locations, and the distribution of contaminants in the aquifer, which will be important during decommissioning.

So, survey design later on, will have to take into account that there was a period of time before de-watering where contaminant transport was different than it is, was later in life when the plant was having active de-watering going on to keep systems structures and components, important to plant operations, dry.

So, with that, I'll open it up for questions.

Thank you.

MR. AIRD: Thank you, Matt.

Like our earlier technical presentations, I think we're going to just move directly to the next technical presentation, and then hold off questions and answers until the discussion period following Eric.

So, with that, Eric, if you want to go ahead and present your presentation, and then we'll take Q&A afterwards for both you guys.

Thanks, Matt, again.

MR. E. DAROIS: Great, great presentation, Matt, and you're probably getting back at me for something I've done in the last 40 years taking up all my time.

(Laughter.)

Anyhow, I'm just kidding.

I'd like to, I don't have a very long presentation. I've got about 10 or so slides to share with you.

But let me give you a little context. I've been in the industry for well, I'll give you an example. Forty-five years ago I had my first internship job in health physics and Yankee Rowe.

And, I remember walking the site in 1977 looking around and saying, I wonder how this place is going to be torn down some day.

Little did I know that I would find out first hand. So, kind of a fun story.

Anyhow, I'd like to discuss some subsurface basement modeling and survey methods. Little bit different than the soils.

And, I am not having luck, there we go,

there we go.

A little bit different than the soils because subsurface basements are different, at least initially they are different attributes of the site.

So, I want to first start off talking about some of the historical treatment, and what we did 20 or so years ago, in managing and getting license termination for subsurface basements both in regards to modeling and surveys.

And, then I'd like to look at what's been done more recently, for some of the more recent decommissionings, and do a compare and contrast between subsurface structures, and subsurface soils.

And, then throw an idea out there as we can get our arms around this for the future.

So, the two case studies I want to look at are, take us back to the early to mid-2000s. And, the case is Maine Yankee and Connecticut Yankee.

They were, basically they were three sites actually. Maine Yankee, Connecticut Yankee, and Yankee Rowe, that I mentioned I was interning at in '77.

So, these three plants decommissioned shortly after MARSSIM was initially issued. So, that made them the first three plants under this, under the new license termination rule, and under MARSSIM.

And, they had to address modeling, dose modeling, and survey methods. They both did them a little bit differently, and I was involved in one of them.

So, I just want to briefly go over what happened in the past, because it may have some reference, or some, something to do with what we do in the future.

At Maine Yankee, the modeling was done, they developed what was referred to as a basement fill model. The concept was everything three feet below grade and deeper, would be backfilled with a flowable fill.

And, with regards to the surfaces of the basement, there was an assumed one millimeter depth of residual radioactivity on the, basically the basement walls and floors.

The radioactivity distribution was characterized in, well not the fill, but the distribution was understood in concrete, and water.

But the model, the model contemplated what will happen with radioactivity moving into the fill, moving from the concrete, and then into the potential drinking water source.

So, the dose pathways include drinking water, irrigation dose, soil and farming, and direct dose.

What was absent from this, because it wasn't raised as an issue, is some sort of an intruder scenario, where someone's going to drill into this matrix, bring it to the surface, and be exposed to a small source of this.

The other subsurface sources that were considered in the modeling include buried and embedded pipe, deep soil, and groundwater.

Well the surveys, they had Maine Yankee identified a difference between irradiated concrete, and surface contaminated concrete.

And, the irradiated concrete, which would be activated by neutrons, was really limited to the in-core instrument sump, that region below the reactor vessel.

And, it was only subjected to a characterization survey. And, the goal was to estimate the total activity. It was present in this subsurface structure.

Once the total amount of radioactivity was quantified through this characterization effort, it was then compared against the model results, to come up with a dose profile for those three, for those dose pathways we just talked about.

For the other surfaces, though the license termination plan allowed for in-situ gamma spectroscopy, or some alternative method to be used to demonstrate compliance with a 30-day advance notice to the NRC, for the review of the technical basis documents. And, that was codified in the Maine Yankee LTP.

In the case of Connecticut Yankee, it was LTP Revision 4, I got this from, being involved in it as well.

But the subsurface modeling was used to derive what was referred to as, a future groundwater dose.

So, the concept was these structures were going to be backfilled, and there could be a time in the future where if somebody did put a well into these features, they would be drawing groundwater out of these features. And, there would be some residual radioactivity in it.

The basement fill model, which it was called in this case, included all basements and embedded pipe, the containment mat, structure, walls, the in-core sump, spent fuel pool, cable vault switch gear, and all these other structures.

So, a little bit different than Maine that in this case, all of the subsurface features that were to be left, were kind of lumped in together.

There was a commitment and decision made, to put flowable fill and grout in certain structures, including the in-core sump, that was grouted in place.

And, the model actually included the appropriate KD value for the different backfill sources.

In fact, there was a borrow pit that was used to get backfilled sand, to put in some of these structures.

And, prior to doing that, there was a KD, chemical KD study done on those soils, so that that could be fed back into the model appropriately.

So, a little context there.

Again, for the surveys it was from, got this from LTP Rev 4, the whole design was to, the whole concept of the survey was to determine volumetric residual radioactivity.

So, for Connecticut Yankee, there was 84 cores collected across the site from all of the structures.

Twenty percent of the cores were analyzed for a full suite of hard to detect radionuclides, so there were 20 in total, including easy to detect nuclides, if I can use that term.

So, that's all that was done for a survey. It was a characterization survey, designed to estimate the total radioactivity to be left in the subsurface environment.

It was no, it was not subject to final status surveys per MARSSIM. As we all know, MARSSIM was silent on subsurface surveys, and for the most part, still is today.

More recently, Zion and La Crosse had some, had backfilled basements as well. These were modeled in, again, a variant of the basement fill model. But in these cases, we converted the results of the model basically to DCGLs.

And, we also added the excavation scenarios to demonstrate that anybody in the future, bringing material to the surface, would fall under or fall below, the dose considerations for the license termination rule.

So, the DCGLs considered groundwater pathways, excavation soils, direct/indirect, all of that was considered.

For survey methods, there was a big shift here in the more recent cases. We did in-situ gamma spectroscopy, as well as, you know, some characterization sampling, to define the radionuclide profiles, including hard to detect.

But most of the basements that were radiological in nature, were considered MARSSIM Class 1. And, we went ahead and did 100 percent coverage using in-situ gamma spectroscopy.

That included hundreds of measurements. Maybe thousands. I haven't gone back to the case and see, actually count them up. But it was a huge effort, and took a lot of time and expense.

So, let's look for a moment at the difference, and I'm almost done, the difference between structures and soils.

Now remember, the structures that are available to us at some point in the decommissioning, but once they're backfilled, they're virtually impossible to get back to.

But once they're backfilled, there's no direct exposure to the surveys, I mean I'm sorry, to the surfaces.

And, really, it involves future groundwater pathways, and some pretty unlikely excavation, or drilling scenarios.

In soils, there's no direct exposure to any of this, the hotspots directly. There's future groundwater pathways, and it's really most likely unlikely that we'll see large scale excavation exposures.

As far as the surveys are concerned for the structures, I believe we could do targeted characterization focusing on elevated areas.

I believe doing 100 percent scan coverage is a bit overkill. I don't think it provides any substantial increase in the dose estimates.

If we focus on elevated areas and come up with an inventory with some conservatism in it, I, as we did in 20 years ago, I believe that would be appropriate and certainly risk informed, and protective.

But such is the case with soils. We have already heard, you know, we can't go in and do all these detailed surveys for subsurface soils.

So, we end up with source terms that are very similar. Structures, buried structures, and backfilled structures versus in-situ soils that are in the subsurface.

So, I'm simply going to end here saying that, you know, I believe the subsurface should be treated as a basement fill-type calculation, to establish the dose modeling pathways, and what the doses would look like.

Whether we convert those to DCGLs or not might be immaterial, and I think the surveys should be limited to the characterization surveys that are conservative and effective, to determine the radioactivity inventory, rather than a statistical MARSSIM approach to the surveys.

So, oop, I went the wrong way. I think that's all I have for today.

MR. AIRD: Okay.

MR. E. DAROIS: Okay.

MR. AIRD: Thank you, Eric.

MR. E. DAROIS: Thanks.

MR. AIRD: Thank you, Matt and Eric, for those very interesting and detailed presentations.

Brett will now help facilitate our second discussion period this afternoon, that focuses on these two technical presentations, and this will, this discussion period will last for the next 20-25 minutes or so.

MR. KLUKAN: So, welcome back everyone. So, thanks, Tom, for putting up the potential discussion questions.

And, I know that each of the presentations again -- of course the train goes by as soon as I talk, start talking.

But so here is some, they asked some potential questions or discussion points and at the end of each of their presentations, and there is some potential discussion points here, as well.

So, I'm just going to key it off generally about any thoughts, or questions you have, regarding the presentations that you want to pose to the presenters.

And, then we'll dive into some of the potential discussion questions you see here.

So, any questions or comments, or

feedback for, on the presentations themselves? Or questions you have for the presenters to start off with?

Again, if you'd like to ask it out loud, you know, raise your hand, or otherwise just feel free to enter it in the chat and we'll either, you know, read it out loud and they can respond verbally, or respond back through chat. Whichever way is more comfortable for you.

If you're on the phone, press *5 to unmute, or to raise your hand. Again, that is *5.

So, with that, we'll open it up for discussion.

(Pause.)

MR. KLUKAN: So, looks like Randall, you have your hand raised, so let's start with you.

MR. FEDORS: Yes, I hit the button the quickest, Tom.

MR. KLUKAN: Yes.

MR. FEDORS: Question for Matt.

As he was going through his presentation, I really liked how he's emphasizing that there's some iterative, iterative nature to the conceptual site model, and the data that you collect at the site.

And, how the site will be, the site data is changing as you go, and the conditions, and so on.

This question I had also that's kind of related to that, is a lot of these monitoring networks were set up during the operating period of the plant.

Or they were set up, you know, following the NEI guidance in 2007 and so on.

And, once you go to decommissioning mode, you might see a change in the objectives, to the monitoring network.

And, I wonder if you had any thoughts on that?

MR. M. DAROIS: Sure.

MR. FEDORS: He wants me to say something about the different objectives, I think he understands that.

MR. M. DAROIS: Yes, sure, Randall.

Yes, and that's actually a big part of the initiative during the transition from operating, to decommissioning.

So, when the plant goes from an operating plant, can you hear me, Randall?

MR. FEDORS: Yes, I can hear you.

MR. M. DAROIS: Okay, all right.

When it goes from operating to decommissioning, it triggers one of these changes. Certainly the work practices change for the plant, and certainly systems structures and the components associated with the decommissioning process, and how those components are used, change.

So, the risk ranking for those systems structures and components and work practices, change. That drives where the priority is for monitoring.

So, I've seen in many cases, wells get abandoned that are a risk themselves, to the decommissioning process, which could become a pathway to contaminating the aquifers. And, a drilling of new wells to monitor demolition and dismantlement.

So, that is a very important part. It's a good question, and there is a very active program early on that dovetails with the historical site assessment, that's done at decommissioning, to move forward in that progress.

And, groundwater monitoring and NEI 07-07, is active through D&D. Through decommissioning, right to license termination.

MR. FEDORS: Yes, but just to be a little more explicit, I mean your goal during decommissioning is to characterize the subsurface, to meet the criteria to terminate.

MR. M. DAROIS: Correct.

MR. FEDORS: And, evaluating how do you remediate, you might have different objectives there, compared to meeting the objectives of a final status survey and termination.

You know, it's you need input for your dose modeling from the subsurface, or you need to make sure you're meeting, you know, the release criteria.

MR. M. DAROIS: Right. And, the groundwater monitoring program, and where wells are, is partially driven by those objectives.

MR. FEDORS: Yes.

MR. M. DAROIS: A lot of times wells are installed, soil samples are collected and analyzed during well installation, that helps inform the decommissioning process.

MR. FEDORS: Yes.

MR. M. DAROIS: That are also part of the Groundwater Monitoring Program, is part of 07-07.

MR. FEDORS: Yes, great. Remediation, you might be looking at the high concentration areas that, that focus.

Or cutting off the source, or --

(Simultaneous speaking.)

MR. M. DAROIS: Right, and that changes --

MR. FEDORS: -- release, you need to go with, what's the magnitude and extent across the site?

MR. M. DAROIS: Correct.

MR. FEDORS: So that you're, know that you're going to meet criteria in every area.

Got you. Thank you.

MR. KLUKAN: Thank you, Randall, for the question. And, thanks for the response.

Others, thoughts on the presentations, as well as any of the discussion questions you see here?

And again, these were included on the NRC's public meeting, or included as a link on the public meeting notice webpage on the NRC public website.

So, just kick it off here, we'll start with the first question at 5, and see if anyone has any thoughts on this one.

What are some of the inputs to develop

risk ranked systems, risk ranks for systems structures and components in work practice, and how would this benefit subsurface investigations?

Any thoughts or comments on this? Again, feel free to enter them directly in the chat, or to if you'd like to, raise your hand.

Again, if you're on the phone, you hit *5 to do so.

(No audible response.)

MR. KLUKAN: It looks like Timothy Eckert has posted a question in the chat with respect to RG 1.70, standard FSAR of NPP's subsection 2.4.13.5, design bases for subsurface hydrostatic loading.

Offers a choice between one, plants not employing permanent de-watering systems, and, two, plants employing permanent de-watering systems.

Safe to assume that most of the fleet chose option one, but is there an available list of any plants that chose option two?

For example, did Rancho Seco with their very deep groundwater opt for option two.

Thanks for the question. I'll put it to NRC chatter to industry if they have, can provide any responses to Timothy.

So, again, feel free to jump in if you have any response to that.

I see that Robert Stewart posed, with respect to presentation 5 questions 1 and 2, for systems et cetera, that are risky, would have some locations, or would have locations that the information could be used to inform the CSM, the geostatic simulations, and check and cover could fold into the analysis.

Thanks for that comment, Robert, again, you know, for your participation throughout this conference.

Others thoughts on any of the questions here, not just the first one with respect to 5 or 6.

But for example, how can, you know, let's further touch upon the second one. How can the hydrological CSM support focused, biased, investigation areas?

Any thoughts or comments on that? Or questions if you want further information about what exactly the NRC is asking here?

(No audible response.)

MR. KLUKAN: And, we have a hand up so I'm going to go to you, Matthew. Please go ahead.

MR. M. DAROIS: Yes, I just want to address Tim's question a little bit. I'm not familiar with the number of plants that went with active de-watering for hydrostatic load reduction versus the ones that did not, option two.

But I know there certainly are a large number of plants that do have active de-watering, or hydrostatic load.

That is, in terms of this discussion, understanding that in your hydrogeologic conceptual site model is certainly very important. It drives contaminant distribution, and fate transport.

And, certainly, that needs to be considered during decommissioning when a lot of those systems are turned off.

Because you no longer need safety, classical and safety related structures, seismic structures in place. And, a lot of those tech specs go away when the fuel is offloaded.

So, that can have a dramatic effect on the aquifer. And, also the distribution of contaminants.

So again, that is one of these triggers where you need to be ready to reevaluate your CSM, and reevaluate where you're monitoring.

And, maybe you need some additional characterization to monitor for potential releases associated with turning those, those pumps off.

Rebound of the aquifer, and then a change in the fate and transport of any residual activity, or future activity of risk associated with decommissioning.

(Pause.)

MS. BARR: Brett, we can't hear you, you're muted.

MR. KLUKAN: That's the second time I've done that today. You would think after what, like two, two plus years of this I'd be better at this, but apparently not.

So, I was just thanking Matthew for that response, and Timothy added, let me open up the chat here, that I think that would be a big choice on how to decommission.

And, Timothy, thank you for the comment, as well as the earlier question.

Kalene Walker wrote, if radionuclides are found in groundwater, what methods would be used to justify that end-state has been achieved?

I'll look to the NRC staff. We're in the industry to provide any responses to that question, to the extent they can.

Looks like we have, so Boby, you have your hand up as well as Matt. I'm not sure if you kept your hand up, or.

DR. ABU-EID: Yes. Yes, I think in response to this question you need to ask, is the dose impact that is coming from groundwater.

And, we have scenario and we have of course, you know, EPA they have groundwater limit, so of course you need to comply with that.

In our case, we have 25 mrem/yr for all pathways, including groundwater. So you need to assess the potential dose impacts when (unintelligible) the public using the exposure scenario.

What kind of exposure, before achieving the end state. If you cannot achieve the dose criteria, this means still you did not achieve the end state. You need to do some kind of remediation.

MR. KLUKAN: Thanks, Boby.

And, then, okay, thank you for that.

And, thank you again for the question,

Kalene.

Other thoughts? And, Cynthia also responded as well, that the licensee would have to demonstrate that they can meet our release criteria in 10 CFR Part 20, Subpart E.

And, I think Cynthia is responding back to you again. You further ask, Kalene, what kind of remediation would be done to the groundwater.

Focusing back on the questions we have up on the screen, let's, we have about 10, well 13 minutes left before we have to move on to our next topic.

Any, let's focus on some of the questions in 6. For example, let's just start with the first one.

Any thoughts on this? How many subsurface samples would be considered adequate in the proposed method to determine total activity inventory?

Any thoughts, or comments, or feelings, if you will, with respect to that?

I see that Debbie Fagan has added, with respect to Presentation 5, Question 2, which is, how can the hydrological CSM support a focused, biased, investigation area, or areas.

She has written, hydrological information and its validation could be used for the Bayesian variogram estimation, and direction of the oh boy, anisotropy.

I apologize, that is not a word that I can say out loud. Hopefully I said that correctly for those of you on the phone. If not, I apologize.

But thank you for that, Debbie.

Other thoughts on, again, any of the questions here?

(No audible response.)

MR. KLUKAN: Other questions you have for the presenters?

(No audible response.)

MR. KLUKAN: So, Robert Stewart has added, again, I'm reading this out for the benefit of those participating on the phone, because we do have a couple people.

With regard to 5.iii, which is how can local changes to climate trends affect subsurface investigations?

Robert is right, and I think this is a fascinating question. There is ongoing work by USGS and the U.S. Geological Survey, to estimate future sea levels that are bound to be useful.

With respect to question 6.ii, which is what would the proposed of surface surveys include direct measurements in addition to sampling.

Robert has written any samples you can get from the premium lab type measurements, to quick and dirty field methods, can be used by geostatic modeling.

And, I think Cynthia has written in a response to Kalene, your earlier question, which is what kind of remediation can be done to groundwater.

Pump and treat, permeable reactive barriers, et cetera. Performance groundwater monitoring would be needed to ensure stability of any remedial alternative, and ensure risk is adequately assessed.

And thank you for providing that response, Cynthia.

Looks like we have a hand up.

Boby, looks like you have your hand up again. Please, feel free.

DR. ABU-EID: Yes, I think we need to think also about more smart approaches for remediation, with the new technology for remediation.

(Unintelligible) sometimes very difficult could impact actual the aquifer, but there are other processes that they can be used.

For example, use of nano material for research and remediation of sea germ (phonetic) and other stuff.

This is something to be in progress, and it has been tested by EPA, and there is a report about that. So, nano materials technology, this could be one approach.

Other approach is for remediation of tritium contamination. It is very difficult because tritium to deal with it, is very difficult to separate it and try to react.

But at Berkeley, they have some kind of approaches, it is used actually for hydrogen, for hydrogen recovery. And, this could be used for tritium.

It's called metalloid organic compounds for absorption using very large surface area.

That sounds like technology maybe you need to think about more advanced technology, that can be used for remediation.

Thank you.

MR. KLUKAN: Well, thank you, Boby, for adding that.

And, before we go back to Matthew, Cynthia added as well, the Appendix, I think response to you, Kalene.

The Appendix App in NUREG-1757, Volume 2, Rev 2, discusses surface water and groundwater monitoring, modeling, and assessment of risk.

Again, that's 1757, NUREG-1757, Volume 2, Rev 2, Appendix F.

So, Matt, or Matthew, back to you.

MR. M. DAROIS: Yeah, sure, I just had a comment. There's been some discussion, you know, in the chat about remediation methods and we just heard a comment, and I just wanted to, you know, weigh in on that. I mean, we've got to look at the cost benefit of, you know, remediation methods versus removal.

You know, so pump and treat can be pretty time consuming and have a low relative success rate in cleaning it up, especially in accelerated decommissionings, which is what we're talking about here. We're talking about prompt decommissioning, so really a very comprehensive cost benefit analysis has to be done.

And I just want to, you know, make a comment that most of the radionuclides at a nuclear power plant when seen in practice, again over the last 20-plus years, a lot of the radionuclides don't migrate very far in groundwater. There are some exceptions to that, but most of the source term is close to the system structures, components, and work practices that we've been discussing.

So, when you're in active decommissioning, you have all of the personnel, all of the heavy equipment, and the means to dispose of that material. Sometimes it's more practical from an economic and a technical standpoint to just simply remove it versus trying to pump and treat it.

These facilities are going to be -- the license is going to be terminated. It's going to go away, so in a lot of cases, in most cases, removal, bulk removal to levels down below 10 CFR Part 20, Subpart (e) are the best option.

MR. KLUKAN: Thank you very much for that, Matthew, for that response and insight, so thank you.

Debbie has written with respect to 6.i, which is again how many subsurface samples would be considered adequate in the proposed method to determine the total activity inventory.

Debbie writes the number of samples, if determined statistically, would depend on the desired decision error rates, the known or expected amount of variability, spatial or otherwise, and the desired width of an interval competence or tolerance. So, thank you for that comment, Debbie, appreciate it.

We have another hand raised. Let me move back over. So, it looks like Carl. So, why don't we go to you and then we'll go to Eric? So, Carl first. I think you may need to -- I think you may have just muted yourself, Carl.

MR. GOGOLAK: I'm sorry.

MR. KLUKAN: There you go. You're good now.

MR. GOGOLAK: Okay, thank you. I think that here is where composite sampling could come in. It's very important to decide how deep you should go and where exactly you should take samples, and it may not be the same for every level.

So, you have to bear that in mind is that in the subsurface it's going to depend not only where you are in the X, Y coordinates, but where you also are in the Z coordinate.

MR. KLUKAN: Thanks for sharing that comment, Carl, much appreciated. Eric, we're going to turn to you next. It looks like you're already unmuted, so go ahead.

MR. E. DAROIS: Yes, so this is in regards to the comment again 6.i. So, I mean, the vision here is that we're looking at a subsurface structure, a basement. We've got a survey.

If the objective is to determine the total activity, you know, our focus is let's survey the areas that we know have elevated levels of radioactivity based upon direct measurements.

So, you know, do we have to survey every square foot? Probably not because you're going to be informed by the historical site assessment part of this. Where was contamination? Where were systems, structures, and components? In other words, you'll probably focus on the lower third of the structure. The upper third is just walls. It's very unlikely to be contaminated.

So, although we can apply a lot of

statistics to this, at the end of the day, we just need to make sure that our estimate of total activity is conservative and there's a number of ways of going about that.

So, you know, I'll go back to what Carl said a half-hour or an hour ago, that let's try to keep this simple. We can apply elegant statistical tests to this, but we can also apply a very simplistic approach to this if the characterization supports it. So, you know, there's some ifs in there and I understand that, but that's my perspective anyway.

MR. KLUKAN: Well, thank you for sharing your perspective, Eric. We appreciate it. So, Matthew, you have your hand up again, so, you know, feel free.

MR. M. DAROIS: Oh, sorry, I forgot to take it down, my bad.

MR. KLUKAN: Okay, no worries. So, going back to the comment or the chat section, Timothy Eckert has written has there been any research into injecting a chemical absorbent, AKA sodium polyacrylate, to hold any water in place?

And again, I open it up to the NRC, or to industry, or any of our presenters to, you know, comment on that. Again, has there been any research into injecting a chemical absorbent such as sodium polyacrylate to hold any water in place?

We also have a comment from Kalene Walker. Regarding groundwater contamination, sometimes the releases happened a long time ago and communities are not notified and just have to live with that contaminated water. Again, you know, thank you for sharing your views, Kalene, and for participating in this meeting.

And Timothy wrote just to clarify what that sodium polyacrylate is it's material used like primarily, I guess, in diapers, so fun fact, so thank you for that, Timothy.

So, again, if anyone has any thoughts on that, we have a couple of minutes left before we have to switch over to our next -- so, Carl, you have your hand up. Feel free. And I think you're muted right now, Carl, if you're trying to talk.

MR. GOGOLAK: I was not. I didn't have my hand raised I didn't think.

MR. KLUKAN: Oh, that's okay, no worries. All right, Eric, it looks like you just raised your hand, so go ahead.

MR. E. DAROIS: Yeah, I'm just going to answer Kalene's question in my perspective only in regards to nuclear power plants. It's my understanding, and probably NRC is better equipped to verify this, that we've never had a decommissioning, a nuclear power plant decommissioning where community groundwater has been impacted. It's all been quite low levels and every plant has successfully demonstrated compliance with 10 CFR 20 Subpart (e), and usually those groundwater doses in the future are quite, quite low, so that's -- I know there are other facilities that may be exceptions, but I'll address just the nuclear power plants. That's all I got.

MS. BARR: I'll just add on that, this is Cynthia, that all of the power plants do have their effluent release reports and their offsite dose calculations, and those reports are public and sent out on a periodic basis, so all of that's reported to the public. So, I just wanted to supplement what Eric had said, so thank you.

MR. KLUKAN: Well, thanks, Eric and Cynthia, appreciate it. So, in this last minute we have here before we move on because I don't want to cut our next presentation short, but Timothy, you have your hand raised and you're unmuted, so please feel free to go ahead.

MR. JOHNSON: Yeah, can you hear me?

MR. KLUKAN: Yes, we can hear you.

MR. JOHNSON: Okay, I just wanted to respond to Tim Eckert's question quickly that in the, you know, Department of Energy environmental management world, there's been a lot of research and even commercial application around sequestration of subsurface contaminants.

You basically inject a chemical that freezes the contaminants in place so that it can't move and therefore can't migrate into the groundwater. So, there is a large body of research and application on that.

MR. KLUKAN: Of course, I was muted. This is like a record for me. Timothy, thank you for the comment and now I'm going to turn it over to Tom, before I muck this up any further, to open us up for the next presentation. So, Timothy and everyone else who commented during that section, thank you very much.

MR. AIRD: Okay, thanks again, Brett, for facilitating that. I think we had some very good discussions.

We will now move onto some more technical presentations, and first up according to the agenda is a talk from Amanda Anderson from the Department of Energy. She'll be speaking on specific DOE challenges with subsurface investigations, and so, Amanda, feel free to talk away and then just say next slide whenever you need to change the slide.

MS. ANDERSON: All right, appreciate that. And this is actually a collaboration between myself and Brian Harcek, who is at our site in Los Alamos. He sent a note to me saying he did join, but he is having some connection issues, so hopefully he'll be able to stay connected, but he should be available, I think, for the discussion part. Next slide, please?

So, in the Department of Energy, our radiological clearance and radiation protection of the public and environment is, our requirements for that are under DOE Order 458.1, and we do all of this under the Atomic Energy Act from 1954 as amended, and within that order, we have the requirements for clearance of property from Department of Energy.

And to clear anything that has any

potential whatsoever of containing residual radioactive material, you have to demonstrate that it does not contain residual radioactive material either by process and historical knowledge and/or radiological surveys.

If you can't do that, you need to evaluate and appropriately monitor and survey the property that you're leasing, and to do that, we also use two different dose constraints.

One is for personal property, so that would be like materials and equipment and it's one millirem per year. For real property, which is the stuff we're talking about today, we are talking about land and fixed structures like buildings that are in place. The dose constraint is 25 millirem per year.

So, those dose constraints are established to ensure that we do not exceed the 100 millirem per year dose limit to the public in any circumstance when we're talking about clearance of property. Next slide, please?

And so, for clearance of property in the order, we do refer to the MARSSIM and MARSAME as methodologies that we consider acceptable for determining how you're going to release property, whether it's personal property or land and structures.

And so, for land clearance activities, you know, we use the MARSSIM for clearing property, planning characterization, final status surveys. And as I think we've mentioned earlier today though, there are limits on the scope of the MARSSIM.

So, I think NRC was saying earlier that the way that you do it at NRC is very similar to how we do it in DOE, which right now, it's on a case by case basis because we don't have the consensus standard, and that is because the standard for the interagency standard, the MARSSIM, the scope of MARSSIM is really the top six-inch layer, so the surface soils.

And that was because, and I think we mentioned this probably earlier today too, that when it was initially developed, the MARSSIM, that there were assumptions about the type of contamination and the surface contamination being the leading source of surface contamination, and it was really written to support the cleanup of rulemaking efforts for which the supporting data was mostly limited to the surface and to building surfaces. Next slide, please?

So, the issue that we face in DOE is that it's not always that straightforward for us. We have various situations where we have subsurface contamination, but not necessarily surface contamination, and it can --

You know, it's just below the layer, so different questions come up for us like for what would be an appropriate 3D survey model? And one of the questions that, again, we've heard earlier today is well, once we determine that we might have subsurface contamination, how deep do we need to survey? Next slide, please?

So, what we wanted to do today was just explain one of our cases that we've recently dealt with in the Department, so particularly in our program that's environmental management.

And the Office of Environmental Management was stood up in 1989 to basically clean up legacy sites from dating as far back as the Manhattan Project, and as you can imagine, it's a little more challenging because the recordkeeping was a little bit different back then when you're doing things like historical site analysis.

In this case, we're talking about a

parcel of land out on top of one of the mesas out there that was used decades ago for production and purification of plutonium and polonium, and it had gone under extensive remediation and cleanup under the American Reinvestment and Recovery Act in 2013.

One of the areas that was extensively excavated and cleaned up and, you know, we were pretty sure we got or we know we got everything from there was Material Disposition Area B or MDA-B.

So, if you look on the graphic there, MDA-B was like a trench that you can see inside of that, the red hashmark area. Within that, there's another area outlined in yellow. That was MDA-B and that was just a complete excavation.

And, you know, one thing I'll say too with a lot of these, you go to an area like Los Alamos and there's a need for development and the county does want land, and so we do our best to clean up what we can, and the objective is to clean up land that we can then transfer to the county for development as they see fit.

Earlier on, there were other areas, which it's kind of hard to see on this graphic, but you'll see it on the next graphic, where we had also previously transitioned land that was deemed not to have potential contamination. Next slide, please?

So, this one, I tried to zoom in a little bit more. You have a better graphic of MDA-B, which is within what we're calling Parcel A-16-a, and then off to, and correct me if I'm wrong, Brian, on this, but directionally the south and the west of MDA-B, you see A-8-b, which formally had like a coal ash pile, and then there's another area around that.

So, that picture is showing the historical area where we had worked or where the Department had worked in, and that dates back to 1946, so we're going back quite a long time when we're talking about the historical site analysis. Next slide, please?

Okay, so for those areas, those parcels, they had already been transferred, and they had been transferred to the county and a commercial developer. They were separately working on properties that they were developing, building new areas, and so they were doing some excavation.

And in February of 2020, they found some metal objects as they were excavating, and when they examined further, they realized they were probably from the Manhattan Project days and that they were probably contaminated.

Analysis of samples near where they were digging did indicate that they had contaminated levels, but they were at extremely low levels, and so they did not pose a risk to the public.

And one thing I want to say about this, because we talked about receptors a little bit too, this is the type of scenario that when you transfer it to the public and you do all of your different receptor scenarios, really the highest receptor or the one that would be of most concern would be the construction worker excavating the site. Next slide, please?

And then in May of 2020, we found additional materials in the southwest of the excavation area of Parcel A-8-b, and I don't have a pointer with me, but if you look at kind of where the corner of that green box and the orange box, like right outside of the corner there, I believe that that is where we found those materials.

And the data from those discoveries indicated it could be from a different waste site than the one that was initially encountered in

February, so we realized we had an issue, suspended work. We were working with the county on this because, again, the land was already transferred, and the area was fenced off.

Then, through forensic investigation, it was realized that these objects were from the earliest days of the Manhattan Project and were lacking what we normally find with some of these isotopes, the americium-241 signature.

So, that's something that we hadn't really expected, and trying to detect that then in the field is difficult, and, of course, no surface indication that we had contamination at depth. Next slide, please?

So, both parcels had undergone MARSSIM surveys prior to the transfer of control from DOE to the country, but, you know, we obviously realized now we have to come up with a new survey plan.

The historical site analysis went through an upgrade. We found when we dug deep, not literally dug deeper, but went deeper into the historical files, we did find things that showed us where things could have been as far as where some stuff could have been tossed out during the Manhattan Project.

For 8, and as I said earlier, so A-8-b, which is the green, that green little box, that, from historical analysis, was determined to be unimpacted due to having the coal pile and residential areas there.

And this one, you know, we can, in discussion, Brian can explain this more of where they were going to put the sewer line, but then they decided to move it to a different area.

For that area, we used visual inspection for laboratory-related debris and found none, and they also did potholing. About 16 different locations were chosen and there was nothing found there. Next slide, please?

And I think -- I see Boby's comment. I caught that too. I think -- I don't know if you were talking about the acronym, but I know on the slides, there was an A that was left out, so I apologize for that.

The updated survey plan, so the areas that we were a little more concerned about and we're calling impacted were A-16-a and A-8-a, and those were combined into one area and treated as one property for the purpose of investigation.

And again, when we did the -- when we went back and took another look at the historical site analysis, we were fairly sure that we would find a waste pit that was approximately 1,000 square feet in area, and the potholing there was set up to ensure that we would find that, and that, I believe, is still ongoing.

Is that correct, Brian? And Brian may not be able to speak. I'm not sure. He was having some connection issues.

MS. BARR: Amanda, if Brian is on and you need him to speak, ask him to raise his hand so we can find him.

MS. ANDERSON: Oh, okay, yeah, Brian, if you're on --

MS. BARR: We can't see everybody unless their hand is raised.

MS. ANDERSON: Okay, Brian, can you raise your hand? Okay, I don't think I see him, Cynthia. Oh, wait, I do see him. He's in the list of attendees.

MS. BARR: Okay, he's now a presenter.

MS. ANDERSON: Okay, thanks.

MS. BARR: Sorry about that.

MS. ANDERSON: No, that's okay. I know it can be tricky. But basically, that -- and I see his hand is raised.

So, we wanted to show you this is one of the types of things that we deal with in the Department. It's not -- we often can't just say, well, we're not going to release the land. I mean, that's not really the objective or we can't just always dig up everything.

At least in this case, I think it's a fairly, I'd say small parcel of land, but it's, you know, relatively small compared to some of our other areas that we look at.

So, I think for us in the Department, we're looking at what NRC is doing with this guidance, because even though we can do case by case, we think it would be better to have a little more standardized approach that, you know, we can encourage people to use. Brian, do you want to add onto that now that you're a presenter?

MR. HARCEK: No, I think you've covered it very well.

MS. ANDERSON: Okay, did I get all of the parcels right? And I apologize if I didn't. I sometimes lose track of the A-8-a, b, and 16, so hopefully I got some of that right.

MR. HARCEK: No, you got that right. The only thing I would like to add along those lines is that the investigation for MDA-B, we thought we covered everything, but when an outside assessment group went through, they found that we had some holes in it.

So, the plans were basically looked at to, whatever we could add on top of what the MARSSIM surveys were for previous to transfer of control is what we did.

So, the A-8-b and the A-16-a in that little intersection between the green and the yellow, that became the point of where we had some issues in that when we looked at it and called A-8-b unimpacted, it was based on the historical analysis.

But all due diligence, we said we're going to do some more areas in there, but then we started doing the digging in A-16-a right outside the boundary to the east of A-8-b in the yellow, that's where the contamination was located approximately 10 to 15 feet away. So, when we started getting into that, we were very careful that we were doing overexcavations to make sure that we didn't have anything going in.

And one of the things that Amanda mentioned was that we actually had two cleanup goals here. One was because we did have the personal property, the debris and stuff, we had to use the one millirem limit, plus we also had to use the 25 millirem limit when we got down to the soils. The undetectability was a handicap as she put it.

MS. ANDERSON: Right, yeah, yeah, thanks, Brian, for bringing that up. I should have mentioned about that. You know, in this case, I mean, we have ways that are heterogeneous and we have discrete objects and they're at depth, and so we're looking at this as like it's land and we're looking at real property, but then as we start digging it up and we're finding discrete objects, that's now personal property.

And so, just like Brian was saying, we took another look and we said, well, we need to use the one millirem dose constraint for the individual items of debris because now that's materials and equipment. We're taking it out of the ground and stuff, but for the soils, that would still be under the real property constraint.

The other thing I want to mention about this as well, I kept mentioning the historical site analysis. I think one of the things we noticed, whether you're using MARSAME, MARSSIM, or anything else, there is a lot of focus on things like the final status survey and, you know, that type of thing, and cleanup levels.

In the MARSSIM, both of those documents, they do talk about historical site assessment. I think -- you know, I don't know that it can be more emphasized in new guidance, but that sometimes perhaps gets a little shortchanged and I would encourage anyone doing things like this, that historical site analysis, it's worth it to really do your due diligence on.

And I will leave it at that. I'm not sure if I'm at the time limit or not, so.

MR. AIRD: No, Amanda, we're right on schedule. Very good.

MS. ANDERSON: All right, thank you.

MR. AIRD: So, thank you so much, Amanda. And just as a reminder, Amanda and Brian will take questions and answers during our final, our third and final discussion period at 4:30.

And so, let me just check here. With that, we move onto our second to last presentation for today, and this, again, is from Pacific Northwest National Lab.

This time, Tim Johnson and Fred Day-Lewis will be talking about geophysical methods and how they can be used to inform subsurface investigations. They'll be giving these presentations live and sharing their screens, and afterwards, we will take our final break for the day.

MR. JOHNSON: Can you hear me okay?

MR. AIRD: Yes, I see your slides too.

MR. JOHNSON: Okay, so Fred and I are going to talk about electrical resistivity and other geophysical methods that we have used mostly on DOE, EM, and DoD projects to investigate contaminated sites and maybe with a little bit of spin on how these --

MR. GOGOLAK: I'm sorry, but we can't see your slides and your voice is not coming through very clearly.

MS. BARR: We can see your slides, but you are a little faint if you can get a little closer to the microphone.

MR. JOHNSON: Is that better?

MS. BARR: Yeah, it's a little better. It sounded like you were just talking louder though.

MR. JOHNSON: Yeah, I don't know what's up with my microphone. I'll just try to talk louder.

MS. BARR: It's okay. I mean, we can hear you, and both Tom and I can see your slides, so I'm not sure why Carl can't see them.

MR. JOHNSON: Okay, so we're going to start with -- Fred's going to start and he's going to talk about a toolbox that he's put together and used to identify what types of geophysical methods will work under different circumstances.

And then he's going to hand it over to me and I'm going to talk specifically about electrical resistivity tomography and provide you a few examples of that and how we've used that in site investigations and contaminant studies, and then we're both going to give you a few subsurface imaging examples.

MR. AIRD: Tim, can you stop for a second? I think some people might be having trouble seeing the slides. Could you share your whole desktop or -- I think you might be sharing an application instead and I don't think people can figure out how to see it, but I'm seeing your slides, but some people might be having difficulty.

MS. BARR: Tom, do you have the slides? Maybe you can go ahead and advance them for him.

MR. AIRD: I could do that too. Is that easier?

MR. JOHNSON: They've changed a little bit. Can people see them now? I shared my full screen.

MS. BARR: Yeah, go ahead and start the slide show. I'm seeing the same thing I was seeing. Okay, well, now people can see them.

MR. AIRD: That fixed it, I think, okay.

MS. BARR: I guess you needed to redo it. Thanks.

MR. JOHNSON: Okay, so just restating here, Fred's going to talk about our toolbox for choosing geophysical methods under different circumstances, then I'm going to talk about what electrical resistivity tomography is, and then we're both going to provide a few imaging examples, one of ERT and then Fred's going to show an example of time domain electromagnetic imaging.

Okay, I'm going to turn it over to Fred here. He's going to talk about the toolbox.

MR. DAY-LEWIS: Okay, thanks, Tim. Although we're focused on two methods today, the electrical and time domain EM methods that Tim mentioned, we want to start off by stressing that there's really no silver bullet with geophysics.

No single tool will work at every site or for every problem, and there's a lot of synergy between methods, so we often use and interpret them jointly.

There's a whole toolbox of methods that can be divided up different ways according to the physics underlying the measurements or how the measurements are collected.

We're defining the toolbox or splitting it up according to the latter paradigm here, how the measurements are collected, whether they're collected in boreholes with logging tools, or between wells with crosshole imaging, or from the surface, from land surface with surface geophysics.

And we include also here conventional hydrologic measurements because geophysics should never really be done in a vacuum. We also need calibration or ground truth for the geophysical data, so that comes in the form of conventional hydraulic testing, sampling, concentrations, all of the hydrologic and engineering measurements that we traditionally make. Next slide, please?

So, this table, I won't drill down into, but the basic idea is that different geophysical methods inform different geophysical properties. Very few people really care about those geophysical properties.

They're things like chargeability and electrical resistivity, but what those are useful for is informing interpretations or estimations of relevant hydrologic properties and parameters, things like depth to bedrock, depth to water table, water content, porosity, hydraulic conductivity, and so forth, information that's needed for understanding sites, developing or refining conceptual site models, or for input in the case of parameters like hydraulic conductivity, to flow and transport models for the sites to make predictions.

Again, these methods are acquired or the measurements are acquired in different ways in the column way over on the right. Today, again, we are just focused on two methods, electric resistivity and electromagnetics, but there are many other methods.

And we're not focusing on these today to the exclusion of the others, but just because these methods are very well suited to the problem at hand, not to say that the other methods don't play important roles in CSM development or other tasks that are relevant to the problems we're talking about today.

And I'll just mention that there is a tie in here to geostatistics. There's a lot of interest and work in the hydrogeophysical community in using measurements from geophysical methods as conditioning data for geostatistical simulation, not usually of concentrations, but rather of aquifer properties. Next slide?

So, we've developed a number of method selection tools in the community and I'll just showcase two briefly today. The first one is on fractured rock geophysical method selection and the second will be on groundwater surface water method selection. We have another tool in development for method selection in support of remediation monitoring that might also be relevant here.

These tools are based in Excel, very easy to use, and they're not aimed at geophysical experts, but rather at people interested in using geophysical information, so project managers, regulators, people who are interested in geophysics, but might be wary of it, might not know how to fit it into a project, might not know how to select between methods, or might just want to be a little bit better informed while dealing with contractors who are proposing different geophysical investigations in support to hydrogeologic or engineering work at a site.

And I'll just caveat this by saying that these are only a guide. No one is going to walk away using these tools as an expert, but hopefully you're armed with more information than you came in with. Next slide?

This is what they look like. It's a little bit like a Consumer Reports' table if you were looking to buy a car. This works similarly where you plug in criteria and look for whether it satisfies your needs.

So, here we've got parameters for the site entered on the left, and then also the goals for the investigations, and this method selection tool uses logic and conditional formatting in Excel to identify methods that are promising for the application at the site as described, so you come away here with green and red lights on different methods.

In reality, there's probably a lot of yellow lights here, but those are flagged really as green to go forward. We didn't feel like we wanted to parse this down to the granularity of red, yellow, and green. Click, please, just once?

There are appendices associated with every one of the methods listed so that you can gain more information about the different tools that are in here. Click again?

And this is again public domain, open source, available online for download. Next slide?

This is just a quick view of the groundwater surface water tool with over 30 different methods for understanding exchange of groundwater and surface water and -- sorry, I'm seeing a chat there. We'll try to respond to that at the end. Click, please?

And again, there are appendices associated with all of these tools that would be useful for site characterization, potentially remediation monitoring, and other problems. Next? And now I'll turn it back to Tim.

MR. JOHNSON: Okay, so I'm going to focus specifically on electrical resistivity tomography as we discussed. And when I'm presenting the ERT, I like to start with a medical imaging example because that's familiar to people.

And this is a method called electrical impedance tomography where they actually attach electrodes to a human subject and they use those electrodes to image what's on the inside.

So, those measurements work by they select two electrodes and they inject current between those electrodes, a small, you know, a small level of current, and then they measure the corresponding voltage across all of the other electrodes in pairs.

And by doing that with different current injection pairs, potential measurement pairs or voltage measurement pairs, they build up a set of measurements called a survey.

That survey is processed through a tomographic inversion algorithm to produce an image of what's on the inside. In this case, that image is in terms of electrical conductivity.

So, here you can see the heart, kind of a -- I'll note, this is important to note that these are imperfectly resolved images, and so you can see the electrical conductivity of the heart is higher here because it's full of blood and all of the ions that the blood's carrying, low conductivity because the lungs are filled with air, and then you can faintly see the spine here and the surrounding material.

So, the analog in the subsurface is we place electrodes on the subsurface and we take measurements the exact same way. The only difference here is that we can't get all the way around the subject.

So, these electrodes can be placed either on the surface or they can be placed in boreholes. We collect the same type of data due to processing and we get a tomographic image.

So, here you can see kind of the geologic layering in terms of electrical conductivity where we have a low conductivity layer here, underlain by a higher conductivity layer, and then these surface materials.

So, as I noted, we're imaging electrical conductivity, and Fred also noted that this might not seem particularly useful, but the reason it is useful is because of what governs or controls electrical conductivity of the subsurface.

And I've noted there's an equation here that we don't have to get into, but conductivity is controlled by porosity. It's controlled by moisture content, surface area of the soils, groundwater composition, and that means the fluid conductivity, and I'll show you some examples where fluid conductivity increases with contamination, although that's kind of a rare case under most contamination levels, and it also increases with temperature.

So, for example, if you see an anomalous increase in conductivity, that may be caused by moisture content from leaking pipes. In terms of porosity, changes in conductivity can be caused by voids or changes in compaction or soil type.

And I mentioned fluid conductivity in some cases is a direct relation to contamination if the contaminant levels are high enough, and then the other three, and so, changes in these things can indicate where you might have a problem or where you might target some sampling activity, for example.

So, here are a few examples of electrical resistivity characterization. So, this is along the Columbia River and this red outline were former infiltration ponds where there is uranium contamination, residual uranium contamination left from operations there.

So, each one of these black dots is an electrode we placed on the surface to do river water infiltration monitoring as the river stage goes up and down. And I'm not going to show you that today, but I'm going to focus on this little site here where we did characterization imaging just in 2D.

There were electrodes at the surface and we collected the image, and you can see these different layers of the subsurface.

Without any other information, we don't know what those layers mean, but we do, based on historical records, we know that these coarser layers or these lower conductivity up on top was gravel and cobbles, and then a finer soil which is higher conductivity because it harbors more water was the backfill material, and then this native material. So, it's important, as Fred noted, that we also have other supporting data to be able to interpret these images.

So, this image on the right is actually a static characterization image of the electrical conductivity around cooling water, just discharge pipes at a nuclear power plant.

This is a project that was funded by EPRI, and in fact, Tim Eckert, who has been on the line, is the program manager of this particular project, but it shows how we are, in this case, imaging in the presence of pipes, which is important presumably to be able to do based on what I've seen today. There will be a lot of infrastructure left underground, and so this is also a possibility.

And this shows, you know, some of the layerings under here, and this increase in conductivity here was actually caused by a cooling water discharge that happened through a vacuum breaker line that was above that pipe there. I'm going to the next slide here.

So, this is an example from the Hanford Site. This is a much larger scale example. This is called the B tank farms at Hanford, and so these three tank farms that you see here have 750,000 gallon tanks. There's 36 of them that are filled with high-level nuclear waste from plutonium production back during the Cold War.

The high-level waste went into tanks, but they had all of these outer infiltration galleries where they would let the lower level waste infiltrate into the ground, and because of that, there's contamination above the water table, which is about 100 meters deep in this area.

So, we placed electrode lines all across here. They're not shown here, but this is about 800 meters across to give you an idea of the scale. And what I'm showing over here on the right is the corresponding ERT image and I'll just start that to do a fly around.

These contours you see are elevated electrical conductivity contours in the vadose zone and they are caused by contaminants that were just discharged into these infiltration galleries, mostly by high nitrate concentrations. So, in this particular case, we're actually seeing or delineating where the contamination is.

In most cases, the contaminant levels aren't high enough that they cause an increase in conductivity. However, if they were discharged in the vadose zone, they might be accompanied by a corresponding increase in saturation or moisture content.

And in that case, moisture content usually in the vadose zone is, you know, when there's a discharge like this, it can be high enough to delineate where the elevated moisture content is that would indicate a suspect zone from a leaking pipe, for example.

Okay, I'm going to show one more. This is an actual treatment or a remediation, and what's happening here is this is at the same site along the river that I showed you earlier and there's uranium contamination above the water table.

And the objective of the cleanup contractors in this case was to infiltrate a chemical, this polyphosphate, and this chemical, as it infiltrates through and it comes in contact with the uranium, it co-precipitates a solid phase that traps the uranium in place and keeps it from moving.

And so, there's no way to sample this except with a borehole, which is really expensive, and so we went in with ERT and watched this infiltration as it happened in real-time. So, I'm going to go ahead and start this.

There were some initial injections below the water table here and then you'll see the polyphosphate start to infiltrate down through the subsurface as they turn these soaker lines on, which are indicated by these white dots.

So, we had a fast breakthrough over here and we had kind of a poorly performing part over here. It stopped here for a second and then they increased the flow rate, and you'll see the polyphosphate moving down toward the water table.

And then those infiltrations were finished and they stopped, and what you'll see next is it start to dissipate as the polyphosphate moves down through the subsurface and becomes less concentrated, but this was very helpful to the contractors because they could see the performance of their delivery without having to drill wells.

This is the same polyphosphate injection, except in this case, they're injecting them in wells, and so there are screened portions in these wells and the objective was to get this polyphosphate in this contaminated zone above the water table.

So, we imaged this for them also in real-time using time lapse ERT. You can see initially the polyphosphate spreads across the water table, and they injected it in this zone first and then this one, and so it kind of spreads down that way, and then they'll inject here and here.

And that pulsing you see or that breathing, that it looks like it's breathing is because they're injecting during the day and then they stop at night, and so at night, it kind of dissipates and moves down through the subsurface and then the concentration isn't as high.

So, again, this was very helpful to them because they could see in real-time where the amendments were going and being treated, so this might be something of use if a particular site is going to undergo remediation, in situ remediation, for example. Go to the next slide.

Okay, I'm going to turn it back over to Fred now. He's going to talk about time-domain EM imaging.

MR. DAY-LEWIS: Okay, thanks, Tim. Tim, I'll just mention there are some questions in the chat if you got time.

So, ERT is extremely powerful, both for

characterization and monitoring. As Tim showed, it's well-suited to the monitoring problem where, once electrodes are in place, data can be acquired continuously over long periods of time, sometimes producing results, 3D imaging of the subsurface very rapidly and in almost real-time.

ERT, however, is not amenable to covering very large areas because it does require electrode coupling to the ground, so there are electrode stakes that are installed into the ground or installed at land surface or in boreholes.

At sites where that's difficult to achieve or at sites where it's required to cover much larger areas than are possible with ERT, time-domain EM provides a solution. We're after the same electrical conductivity, the same physical property, but using a different technology.

This generates an EM field in a transmitter loop as you see in the upper right. That EM field produces secondary fields that are received at a receiver loop, and from the data, we can analyze for subsurface conductivity structure in 2D or 3D.

This doesn't require coupling to the ground so it's entirely noninvasive, and the tools can be pulled behind an ATV as you see in the middle, or behind a boat as you see in the lower right, or actually it can also be flown. There are helicopter and fixed-wing platform TDEM systems as well. So, data collection can be very rapid. We can cover large areas in a short amount of time. Next slide?

And this is just an example from a recent journal, a fairly recent journal article on the time-domain EM technology, which is really new to the community. PNNL just acquired a system in the last year and has begun using it at sites. I was involved in field work with EPRI actually a couple of months ago at a field site.

And so, what you see here is glacial structure, an electrical conductivity structure, and a cross section at lower right, and then horizontal slices through that in the upper right. So, again, no ground contact are required and this can be towed behind an ATV, a boat, or a helicopter or plane. Next slide?

And I see we're just a couple of minutes over time, so I'll just quickly go through this summary here. We began by describing method selection tools and the logic behind geophysical method selection, and the synergy that comes with interpreting multiple lines of evidence.

We covered electrical methods, which are well-suited to characterization, and especially well-suited to monitoring because long-term installations are possible, and then EM, focused on time-domain EM because of the ability to collect data over very large areas very rapidly. All right, thanks very much.

MR. AIRD: Thank you, Tim and Fred for that presentation. Again, for our audience, if you have any questions or comments, you can put them in the chat now, but both PNNL and our previous DOE speakers will be joining our final discussion session at 4:30 Eastern Time today.

Before that discussion session, we have one final presentation from David King from Oak Ridge Associated Universities. He'll be speaking at 4:10, right when we get back from our break. So, we're going on our final break now and we'll be back at 4:10.

(Whereupon, the above-entitled matter went off the record at 4:04 p.m. and resumed at 4:10 p.m.)

MR. AIRD: Welcome back, everyone, hope

you had a good break. We're in our final stretch now. And before our final discussion session, we do have one final talk today, and that final talk will come from David King.

David King is from Oak Ridge Associated Universities, ORISE, and David will be sharing his screen and walking through his presentation today.

So with that, David, feel free to take over.

MR. KING: Well, I hit the share button, let me know when you see it.

MR. AIRD: I can hear you, David. Could you try sharing again?

MR. KING: Okay.

MR. AIRD: I'm not seeing it yet. I have your presentation, anyway, David -- oh, now I see it.

MR. KING: It took a moment for the electrons to catch up.

MR. AIRD: Yeah.

MR. KING: Okay, so I work for ORAU, or ORISE, Oak Ridge Institute for Science and Education. And my organization goes around the country doing independent verification surveys for the Department of Energy, the Nuclear Regulatory Commission, and the

Army Corps of Engineers. I mean, tens of sites, hundreds of sites around the country over the years, somebody. Maybe up to 500 sites over time, if somebody bothered to count.

And what we see a lot of times are -- we see so many things over the years. A lot of times it turns into a lessons learned opportunity. And the objective here is to, you know, share some of the information that we've seen. It's not to point fingers at anybody or try to disparage anybody's effort.

But it's an opportunity to share information. Maybe you will have a similar situation at your site and you would avoid making the same kinds of mistake. And also to just, the whole idea of continuous improvement.

We want to talk about how we can do a better job. And performing our surveys, whether it's surface or subsurface, and lessons learned are always good things to share. Maybe there's something here that you hadn't thought about on your project.

So there's -- you'll not find any information about the specific contractors or the sites or anything in here. So maybe you'll recognize your site, maybe not. But the point here is to share the lessons learned and learn from it and maybe apply it to your own site.

Now, many of these lessons learned could have been addressed during DQO development, whether using MARSSIM or whatever kind of survey you're performing.

One of the root causes -- and if you're going to do a root cause analysis, you have a lessons learned incident at your site, a lot of times you can go back to the plan and you see that the data quality objectives may have been minimalistic. Or maybe they were taken from one site to the next site without a whole lot of thought about, you know, site-specific conditions.

You have these -- a lot of times the projects, DOD projects or whatever, are complicated. And it's -- it's easy, but not necessarily recommended, to take a plan that you planned at one site to the next site without thinking a whole lot about what you're doing.

So, again, what we've recognized is a common root cause is the author's -- the final set of survey plans or the characterization plans, whatever it may be, have not taken the time. They have not considered the site-specific information or conditions.

And the objective of these projects are to make sure that you go through the DQOs and at the end of the project you have the right type, quantity and quality of data. So you can make informed decisions at the end, and maybe not recognize there's a problem at the end of the project that you could have headed off by better planning and better DQO development.

So lesson learned one, we were at site and we were measuring a shallow borehole. It is our common practice when we perform, you know, a sample, we'll do a measurement at the surface of the borehole before we collect the sample.

And then after we collect that bore -- that sample, we'll put the detector in the hole and see if there's additional contamination. We do expect radiation levels to go up, a little bit up, if we're putting, for example, sodium iodide detector down the hole. It's just that now the geometry has changed.

Now you have contamination or whatever it may be. Maybe it's not contamination. But you have a source surrounding a detector, as opposed to a planar source at the surface. You do expect some amount of increase in your detector response, but we found that it went well above what we expected.

Maybe it went from, say, 10,000 counts per minute to 20,000 counts per minute, and 25,000 counts per minutes. That is an indication of contamination.

The folks at the site didn't like what -- that we were doing that. They thought it was, I don't know, cheating or something that we were looking down below the surface. But it turns out their final set of survey plan did not even consider the possibility that there would be subsurface contamination.

They were thinking in, I guess, two dimensions, and we were thinking in three. Not necessarily a difficult thing to do. But we thought that was kind of odd that, first of all, they protested, and then they didn't even consider the possibility that there may be some contamination just below the -- below the surface, beyond top six inches or 15 centimeters of soil.

And you can kind of extend this if you have a good imagination to the subsurface. Let's say that you got a deep subsurface investigation. Deep as in maybe below several feet or a couple feet. And you may instruct your technician to go and collect a sample and maybe even composite.

And I've seen these kinds of rules. You collect a small amount of sample at some depth X and at 2X and 3X, and not consider the possibility there may be contamination somewhere between X and 2X. No screening, you know, no surveying of the core as it comes up.

And so the idea here is if you're blindly following a procedure that results in a missed opportunity, as you see in the graph, you probably want to collect a sample, a judgmental sample, a grab sample at that contaminated layer. Sometimes the plans are so rigid and the technician is told to follow the rules without thinking about maybe there's contamination somewhere in addition to where they're told to sample.

And similarly, if sometimes if it's a site contaminated with radionuclides, you might use a downhole gamma logger. Same deal here is that a technician may be told to collect a measurement at X and 2X and 3X. It's the same kind of thing we get when we're doing surface surveys of maybe a field or wooded area or something.

A technician would be told to collect the data, not listen, not pay attention to what is his detector is telling him, just to go collect the data. And by doing so, you might have the responses collected in a data logger using GPS and somebody will map it up later and make a decision.

Well, the technician collecting the data should also think about what he's collecting here, the response of the detector, and then maybe he provides some input. Maybe he would pause if there was a hotspot in an area and investigate a little more, collect additional data for better decisionmaking later.

And, as depicted here, maybe that technician would pause at this contaminated layer, collect a judgmental measurement at that point, and that provides us additional data. And most times additional data. It's good.

So from the example on the surface, now, this was in an excavation, so technically it's a subsurface. It was the surface of an excavation. The technicians in this case were told to go and walk straight lines, collect a radiation survey, perform a radiation survey, collect the data. It would be mapped up, but they were told not to listen.

The main thing that they were told to do is walk straight lines and do 100% coverage of the area. And somebody in an office would decide where a followup sample may be collected.

Well, they did their duty and they turned the data in. And some technician told them, looking at a map, go back to this location and collect the sample at this hotspot. And which they did. Surveys went back to the hotspot location that were provided and collect the sample.

The problem was, they were given the wrong coordinates. So they didn't know where the hotspot was because even though they did the survey, they weren't listening or paying attention. And they could have told the technician at that point, well, I think that's not exactly where the hotspot is. But that opportunity was not presented.

And also, when they went and collected the sample, they didn't look around. They didn't take their detector and look and see if indeed the spot was where they should be collecting the sample.

So you know, here we are with missed opportunities. The surveyor should have been listening and providing input to the GIS technician. And then also checking at the spot where they were to collect the sample.

In another case, surveyors were logging the data, again not listening. But the data loggers were averaging over five seconds. Our crew, we average over two seconds, but we're also listening.

For the case of this project, the technicians were not listening. They were logging all the data, but the data were being logged over a five second-period and everything was being averaged out. So when the project reported their result, they said we have no hotspots.

Unfortunately for them, we did listen and we found lots of hotspots. And 13 to be exact. And we went back and told the customer that we found 13 hotspots. And there was a lot of confusion about why we said there were 13 and they said there were zero. It turns out because two things, they were not listening and they were integrating over a five second period.

You know, we do ISOCS measurements of all sorts of media. One of the problems that we've observed is that when you're performing an ISOCS, it looks at, oh, I guess about a ten-meter radius. And effectively it characterizes soil across a bowl. But you miss opportunities for hotspots in this case.

If hotspots are important to your site. Sometimes they are, sometimes they're not. Radiation -- radiological contaminated sites, a lot of times we spend a lot of time looking for hotspots. And if you're not aware how the ISOCS or in-situ gamma spec system averages, you might miss opportunity to find those hotspots.

Again, it may not be important. It could be all you care about is an average. But you should be aware that hotspots may exist and you won't find them if you're just doing a wide-open in-situ measurement such as with ISOCS. And of course you need to address these kind of things in your DQOs.

Another investigation we were involved in, the dose model was performed assuming that the -- this was concrete and they were sampling through the concrete. The dose model was based on a two-inch thick contaminated layer.

So we had DCGLs, cleanup goals, based on a two-inch thick concrete layer of contamination. The contractor was collected two-foot-deep holes, and they sent the whole core to the laboratory.

And so this is a case of dilution is a solution, because if you composite two feet, you're going to -- with the assumption that all the contamination is the top two inches, you're going to dilute a lot of that sample. And you may end up saying that you have met your goals when in fact you have not because you've, you know, you've diluted, like I said.

Lesson learned five was about a subsurface investigation. We were essentially handed a plan to implement. This is the site that was to have several geoprobe boreholes down to bedrock, which is about 30 feet in this case.

One organization wrote a plan and then we were told, ORISE was told, to go an implement this plan. Which is odd enough. A lesson learned maybe that don't have one group write a plan and another group execute the plan.

Whatever the case was, we got the

project. And we went to the site to see how we would even deal with this plan and found out immediately that the plan was unimplementable as written because several of the boreholes were on a steep slope. A few of the borehole locations were in a secure area where we could not even get access. One borehole was positioned on top of a pit that had six feet of gravel in it.

You couldn't put a geoprobe in any of those locations. And so a site visit by whoever the authors were, or the stakeholders involved, would have very quickly identified some of these problems.

It took us five minutes to figure out that we had a problem. But anyhow, we reported it, the lesson learned, and made some adjustments.

Okay, so, you know, related, sometimes it's unsafe to go into an excavation. If it's a steep excavation or maybe it's a sheer wall, heading up or down, either way, we have used detectors on poles.

This is more of a troubleshooting session, maybe less of a lesson learned. Sometimes we need to collect data from an excavation or a steep area, and we've collected measurements by putting detectors on a pole and lowering down, on wheels, or something like that. Using a boom.

I was involved, peripherally involved on a project where they had an ISOCS on a -- on a boom. And so they're taking measurements on a sheer wall, where it was unsafe or impractical to get people up there. But they were using in-situ measurements. That was very effective.

We've sampled from a bucket if it's a deep hole. You, I mean, if you're relegated to this, it could be that you just need to send a bucket down there and bring it up and can collect samples that way.

The point being sometimes it's very difficult to have the physical -- or send a person to collect a physical sample. And so you can bring the sample to the person or you can send the instruments where people can't go. It's better to have some data than none.

Another lesson learned, and this is very applicable to downhole logging, for example. A lot of times when you have instruments, a downhole logger back at the lab or wherever these instruments are calibrated, you're using a five- or six-foot cable.

And then you go to the field and you're going to perform the survey using a 25-foot cable. Well, that's going to change the way the detector responds.

So the lesson learned is that you calibrate your instruments using the cables and equipment that you're going to use in the field. The -- a long cable increased resistance in the circuitry and will diminish your response.

In this one case, we found that the technicians who was performing a survey on a wall, the detector was several feet away, you know, because it was a 25-foot cable. And this person was supposed to be listening, but they used a 25-foot cable for convenience because they can just the -- the rate meter on a table and walk away and not have to carry it around.

The problem is that it was very obvious the person wasn't listening because the noise, the clicks that were coming out the detector, were several feet away. There's no chance that the person would have been using headphones, again because of the distance.

And of course the detector was not responding the way it was supposed to because it was calibrated with a five-foot cable and they were using a 25-foot cable.

So in conclusion, as I asserted from the beginning, a lot of times when you go through the DQO process, you think -- a lot of the problem we have it the lack of thinking. You think about the problem and you may come up to a good solution and eliminate, not 100%, but a lot of times you can eliminate these mistakes that result in a lessons learned.

And especially when you -- sites don't go through the process of developing site-specific DQOs. Hopefully there's a combination of site-specific DQOs and a good amount of thinking. And then you won't make a presentation like this.

So that is -- that's the last. I'll take it back to you.

MR. AIRD: Thank you, David, for that really interesting and relevant presentation. I think we may have saved the best for last. But with that, that concludes our formal presentations of the workshop.

And now we move into our final discussion period, Discussion Period C. During this final half hour or so, all the DOE, PNNL speakers, as well as

David King, will be available to answer some of your questions or comments. And then we also have the potential discussion questions listed here for those three previous talks.

And with that, I'll turn it over to Brett.

MR. KLUKAN: Thanks, Tom, much appreciated.

So before we begin, I just want to acknowledge that while the presentations were ongoing there was a lot of great back-and-forth between Timothy Eckert, Fred, Timothy Johnson, Rob Stewart -- Robert Stewart -- and Boby as well in there. And as well as Kirsten Chojnicki.

So thanks, all of you, for engaging in that back-and-forth. And again, staff will capture your comments in that. So, but given that we have a limited amount of time, we have three presentations to get to, I'm going to start with asking if anyone again has any questions about the presentations.

And again, if you would like, you can just enter into the chat. Or you can, you know, raise your hand within the Teams application. Or if you're on the phone, press *5, again that's *5, to let us know that you on the phone would like to raise your hand, ask a question, or pose a comment.

So Tim had, Timothy Eckert just wrote: Many of the lessons learned are fixed with a decent procedure that has reviewed, procedure in quotation marks, has been reviewed to have the test. Thanks for -- for providing that perspective, Timothy, as well your other questions and comments.

And backing up one, Timothy, you also asked when is such -- when such a borehole is created for a sample, is hole left with a liner, or is something else put in place to avoid cross-contamination.

So if anyone from the staff or the presenters would like to address that, you know, please feel free to raise your hand or to enter it into the chat.

But with that, again, if there are questions for the presenters, if you haven't ready asked in chat, you know, feel free to add them now to chat or to raise your hand and I'll call on you, and we'll get this discussion underway.

So with that, I turn it over to you. What questions or comments do you have on the presentations, or with respect to any of the discussion questions, the proposed discussion questions that we have up on the screen right now?

And again, feel free to put it in the chat, raise your hand, or -- oh, we got one first. So Amanda, it looks like you're unmuted, so go ahead.

MS. ANDERSON: Yeah, just the comment, I saw, I think you said Tim Eckert, about things that a lot of the lessons learned can be fixed in procedure. I would add, though, I think to David's point on the lessons learned, I think it has to go beyond just procedure.

I think that when we're looking at things, especially like with any kind of decommissioning or with any kind of cleanup or remediation, over the independent verification can be a little bit of an afterthought for the whole -- the project as a whole. So as a project is moving forward, you know, they may be charging forward in a way where they're not even thinking about this stuff.

And I think, David, you probably have a few lessons learned on that where if you're not integrating with the IV team in the beginning, then you get to some these things. And so I think it's also a thing of sure, procedure, but making sure that project directors in particular are well aware of IV requirements and needs.

MR. KLUKAN: Thank you for -- Amanda, thank you for providing that perspective and that insight. Again, we appreciate that, as well as your earlier presentation, so thank you.

Thoughts on what Amanda just said or on other things you heard during the presentations, or again, with respect to the questions. For example, with respect to the DOE presentation, what topical areas would benefit from additional guidance related to subsurface investigation? And as well, how could new substance be guidance, be used in a DOE setting?

Any thoughts or considerations with respect to those questions, you know, please feel free to raise your hand or put them in the chat.

Amanda, do you -- do you have further to add on that point?

MS. ANDERSON: I think just in general, I think we do benefit by having, you know, like right now we've MARRSIM and we've got MARSAME, which are interagency consensus documents, which I think are very helpful. It's always helpful to have a consensus methodology rather than trying to do it case by case.

Because when we're doing it case by case, it can be different people across the complex who are looking at this and doing different ways.

And something that was striking to me, and I know I think I've seen that, David, before in your some of your lessons learned reports. But when you were talking about the borehole, the subsurface.

So if you don't have -- if the primary contamination is not at the surface, it's, you know, somewhere below, that's what you're trying to figure out. Depending on how you take that sample, you can dilute it. And that's the thing that's not, I think, always obvious. So in that kind of respect, that can help us.

But I think too like in the case study that, you know, we talked about with Los Alamos, it's a thing too of like how many -- how many sample should we take, how far should we go. I think when we went back in and, you know, what we're doing today, we're probably going -- we are, I know we're going more than what we need to because we really -- we really want to make sure everything is fine.

But initially, after that whole big cleanup that we did and stuff, we did do MARSSIM, and you know, it wasn't -- I don't think it was -- we should have done more due diligence with historical analysis. And there should have been more sampling. But I think it would have helped us back then to have better consensus guidance.

MR. KLUKAN: I mean, again, thanks, thanks for sharing that, we really appreciate it.

So and David King just sort of reflect on what you said. My thoughts, exactly, Amanda. Following procedures is a good -- is good, but a spirit of continuous improvement is better. The executing procedure should identify issues when the plant is not aligned to reality.

And then Timothy Eckert asked, The ERT process has been used in large, open land areas. Does it work well in close quarters where the asset to be quarried is close to many other barriers to the holes, like several additional security fences. So again, I would open that question up to anyone.

It looks Fred, you might want to respond to that, so please feel free.

MR. DAY-LEWIS: Yeah, thank you. I was

just starting to write back in the chat. That's a good question.

ERT can work pretty well around subsurface structures, pipes, tanks, and so forth. I think Tim Johnson showed an example at a power plant actually around some pipes. He didn't show it here, but one of the objectives of that study was for leak detection.

So it definitely can be used around subsurface structures and pipes, especially if their locations are known well, like from a CAD or other information. And then the structure can be put into the model.

EM techniques tend to be problematic around especially high voltage power lines, railroad tracks, and steel fences. We can't get very close to those with the EM techniques. But electrical resistivity is far less prone to those issues.

One of the limitations on our -- on ERT that we didn't mention is in well construction. So if you have a steel case well, that becomes problematic. So we typically work with PVC wells or put the electrodes on the outside of the PVC. Or just install them without a well by direct push, that's another way to do it. Thanks.

MR. KLUKAN: Thanks for sharing that, Brett. Again, I appreciate that, as well as the earlier presentation.

So Amanda, you have your hand up, and so did you have something further to add on that point?

MS. ANDERSON: No, forgot to put it down, sorry.

MR. KLUKAN: All right, just wanted to check. So we actually, and thanks for asking the starting-off question, Timothy. So you actually have another question, again, this is Timothy Eckert for those of you on the phone.

I think ERT is detecting wetness more or less resistivity, i.e., -- scrolled up on me -- salt. Is the ERT affected at all by the wetness, if the wetness is contaminated or? Is there a defined list of contamination that yes, changes are -- they're -- resistivity. I don't know why I'm having such problems with that word.

But any thoughts or comments on that question? And go ahead, Fred, whenever you're ready.

MR. DAY-LEWIS: Okay, thanks. Yes, ERT is sensitive to saturation, so that's one of the things that we can use it for is actually to find the depth to water table or look at saturation on the vadose zone.

We've used it before to monitor desiccation processes. So desiccation is a, it's an environmental remedy that was considered and monitored at Hanford for vadose zone treatment to limit infiltration and thereby reduce movement of contaminants downward toward the water table. So yes, ERT's very sensitive to saturation.

As to being sensitive to contaminants, we're sensitive really to the specific conductivity and the total dissolved solids in the fluid, or the fluid type, if it's a different phase fluid. Like I mean, we can certainly see pure phase NAPL if it's -- you know, if there's enough of it and it's close to the electrodes.

But if we're talking about parts per million, parts per trillion contamination, that generally doesn't have a conductivity contrast.

MR. KLUKAN: And again, thanks, Fred, and thanks, Timothy for the questions.

So turning over to some of the proposed questions, or the proposed discussion questions, and

I think this has been, you know, to a certain extent, potentially addressed already. But I'm going to open it up to add to the discussion. It's has ERT been used in nuclear power plants or other sites with residual subsurface activity.

I don't think, at least I didn't catch that we necessarily covered that during the presentation. Maybe addressed and I missed it and I apologized. But any thoughts on that or how that would work at a nuclear power plant?

So anyone, feel free to jump in there. Not trying to pin everything on Fred again. So, but any thoughts on that one?

MR. DAY-LEWIS: Sorry, Brett, which one was that? I was responding to another chat. Or, you're muted now, I apologize.

MR. KLUKAN: No, so the -- no, no, no worries. This is the first question of eight. How has ERT been used in nuclear power plants, or NPPs, or other sites with residual subsurface radioactivity.

So you may have already touched upon this and I may not have caught it. So but if there's anything else you'd like to add, or you know, with respect to this, please feel free.

MR. DAY-LEWIS: Sure. It's regrettable Tim Johnson had to drop off the call for another commitment, because he's done a lot of ERT work I think in support of nuclear power plants, and I have not at this point. I just started at PNNL a year ago after a long time at the USGS working on other things.

So I know that Tim's been involved in work for leak detection and touched on that in the presentation today. He's also done a lot of work where there's residual subsurface radioactive -- or radionuclides, at Hanford and other DOE sites. So certain at Hanford we've dealt with those -- those kinds of considerations in the field work and field operations.

So projects there, again, focused on things like leak detection, groundwater-surface water interaction, infiltration, the desiccation monitoring that I mentioned before, and then other injections or releases of amendments to treat subsurface contamination and sequester radionuclides or other contaminants in place, as Tim talked about.

MR. KLUKAN: Thank you very much, Fred, again, for all your --

MR. DAY-LEWIS: Oh, you're very welcome.

MR. KLUKAN: So Eric, I think you have your hand up, so feel free whenever you're ready.

MR. E. DAROIS: Yeah, I do. And only to say that I know Matt's been involved with doing similar ERT surveys at operating nuclear plants particularly. He apparently must have stepped away from the meeting.

But most of the work, as I recall, that he's done is not so much been involved with contaminated systems but identifying, you know, surface water leakage or circ water leakage, which is non-contaminated systems in subsurface piping that's carrying these fluids that are generally has no residual radioactivity.

And they've been -- we've been very successful in identifying where along the line there's been some leakage to subsurface environments. So that's been -- that's been a very effective tool for us, so.

Matt, if you're on, you can weigh in, but I don't know if you are.

MR. KLUKAN: Well, thank you, Eric. And again, Matt, if you want to add something, please feel free to raise your hand and we'll be glad to hear from you.

So Cynthia, you have your hand up, so I'll turn it over to you next.

MS. BARR: Thank you, Brett. I just wanted to go back to 7.i and see if Eric or anybody else could comment on what areas they think we need additional guidance that would benefit our licensees that are undergoing decommissioning.

And I had mentioned some that we were working on that we know about in my presentation, like elevated areas, the basement substructures specific to reactors, surveying and dose modeling considerations associated with that. Obviously developing an optimized subsurface survey design when you don't have a hole.

So if you don't have a hole, it's a whole lot harder to survey. If you already have a hole because you remediated or you have an open excavation, that's a completely different problem. So that's a lot easier.

But you know, as Amanda was alluding to, how much do you have to do or how much information do you have to provide to positively affirm that this area is acceptable for release and that you don't have any subsurface contamination.

So obviously that's the big one. The reactor basement substructure, the basement fill model, the elevated areas. But is there anything else that you guys, anybody in the audience thinks we could develop guidance that would be helpful to our licensees? Thank you.

MR. KLUKAN: Well, thank you, Cynthia. And so again, if anyone has any guidance that they would like to throw out there or additional guidance the NRC should develop, feel free.

I just want to capture this and we'll move on to our speakers. Timothy Eckert writes in the comment section, this is for those that are on the phone, Where the ERT has seen little use in nuclear, just a few. But as mentioned earlier, the contamination of water does not seem to affect the tool.

Matt has done several nuclear power plants with ERT, and like Eric says, leakage was not contaminated. So again, thank you, Timothy, for all your participation today.

It looks like Eric, you have your hand up again, so please feel free.

MR. E. DAROIS: Well, I only have my hand up because Cynthia solicited me, so.

MS. BARR: I did, thank you.

MR. E. DAROIS: I mean, in regards to subsurface, I think I've said my piece a little bit here, that, you know, I think there's work to be done on the subsurface structures for sure and how that should be approached, so I don't have to repeat any of that.

But I think you guys are on to -- or you guys, the NRC is on to the right focus. You know, having been involved with the discrete radioactive particle issues, I think that needs to be solved for sure. And I think there's some interesting conclusions that could be drawn out of that, but we'll save that for another session.

But certainly, you know, when I mentioned in regards to whether we should do a 100% survey on subsurface basements if they're going to be backfilled, I think we really need to visit that revisit whether we need to do 100% survey, you know.

It's easy for us to say well, that's a MARSSIM Class 1 survey, but is it really? Because

MARSSIM doesn't address subsurface. So is it really a MARSSIM Class 1 survey, and does it need to really involve 100% scan.

So we've been kind of caught in that little bit of a conundrum that's been quite expensive and timely -- or time-consuming, I should say. So that's -- that's really, that's my reactions, Cynthia, I hope that helps.

MS. BARR: Yeah, it does. We do have some work going on in that area, because I know that's an area that you guys are interested in.

You did mention earlier, though, so this whole, I should say this whole classifying -- classifying it as a Class 1 area and using MARSSIM would be acceptable, obviously. But yeah, there could be allowances and flexibility associated with the fact that it is going to be filled in and it's, you know, very significantly below grade.

So yeah, so we're definitely looking at that particular issue. But during your presentation, you also said that you don't think we need 100% scanning, but that we could do sampling -- or either sampling or scanning to focus on elevated areas.

And so I was just curious on what methods were you suggesting to look at those elevated areas. What types of instruments are you talking about and do you have any thoughts on the importance of elevated areas for these reactor substructures?

MR. E. DAROIS: Yeah, I do. I mean, I look back to what we did 20 years ago, Cynthia, and I, you know, it was really just a conservative approach. We looked at, okay, where's all the highest levels down here. I mean, you can do that with a walkover survey with a gamma instrument.

And we quantified what the contamination levels are, whether it's through sampling or direct measurements. Because it's a combination of both.

But you end up with a body of evidence where you make some conservative calculations and say, well, here are the highest levels, but we're going to apply this to the entire surface areas of the structure to estimate the conservative inventory, total curies, if you will.

And it, you know, so it's not prescriptive, but it's conservative. I don't know how to write that down in guidance, but that's what we did historically, and it seemed to work and it seemed to give us all a comfort level that we're not underestimating potential dose significance. So.

MS. BARR: Okay, well, I mean, just to follow up on that, because that's actually question one, what techniques have been used in survey excavations in other hard-to-access locations that may be unsafe for surveyors to enter. So is there typically a concern about the safety of the surveyors and that you need to use ISOCS versus, you know, using a hand-held instrument and walkover survey?

I mean, what's typical at reactors sites and --

MR. E. DAROIS: Yeah, no, there's clearly some of that that happens. You know, and there's some other techniques that are available that are maybe lesser used as hollow core sampling, which is a whole different topic. But there's ways to remotely sample material, if you will.

But ISOCS is -- ISOCS is a great tool, but the -- and I think what we got caught into in more recent times is, you know, ISOCS has a field of view that's a circular field of view of a surface, right. You got a collimator or you're backed off 10, 12 feet away from the surface. So you've got a field of view that's represented by a circle.

So if it's a MARSSIM Class 1 survey unit, you've got to do 100% survey. So these circles, as you move across the surface, all have to overlap to be able to guarantee 100% scans coverage.

But that doesn't make any sense if we're using an inventory model. Because you know, you don't have to do 100% coverage, and by doing 100% coverage, you've got to do hundreds and hundreds of measurements.

So is it effective, is it -- is it worth the time and expense in order to come up with a total inventory, rather than just focus on the areas of the highest activity and make conservative assumptions after that?

I don't -- hopefully I'm making myself clear, but that's what I think a lot of our licensees, well, some of the licensees have been faced with recently, is assuring 100% coverage when that doesn't gain you much in the end.

MS. BARR: Right. No, I think I understand your point on the 100% coverage, I was just curious how we hone in those elevated areas without doing a walkover.

DR. ABU-EID: Yeah, this is Boby, I think we're coming to the end, but on to confirm that. We're not looking for 100% coverage for subsurface, we are looking for exactly where the contamination, what kind of releases.

Site conceptual model, where they are, and then focus on that area, and then try to do some sampling that convince the reviewer that you did address all the contamination subsurface, and you met the criteria that we have for the dose, whether for the subsurface or for the groundwater criteria.

So that's really what we are looking for. I don't think that we're contemplating that you have 100 monitoring wells that you need to do a dig there in order to harm the environment rather than actually to remediate in a smart way.

So I hope that you give that message for subsurface that we're looking for -- we're after the contamination, where it is. We are not after 100% survey for subsurface and digging more monitoring wells for 100% coverage. Thank you.

MR. E. DAROIS: If I could respond. In regards to subsurface structures, I think -- I think licensees recently have had to do 100% surveys because they're MARSSIM Class 1, for the structures.

I think subsurface soils is a different matter.

But to, Cynthia, to respond to you, you know, we've got better -- we've got some interesting technology that's come to light in the last five or ten years involving -- involving gamma spectroscopy with visualization and LIDAR scanning, right. All of that.

So we can put a unit in a basement and let it scan, do gamma scans with LIDAR and identify where the hotspots are and focus our attention on that, which doesn't require people to get into these places but you put equipment there. So you know, I mean, this is all fairly new, and these are just some ideas I'm throwing out there.

But I think if we can inform our decisionmaking and our sampling strategy using those kind of tools, we could come a long way.

MS. BARR: All right, thanks, Eric. No, that sounds interesting. I just wanted to say we're having a NEA, Nuclear Energy Agency, workshop at the end of November on innovative characterization and D&D technologies.

But I've heard, you know, from a lot of the member countries about different technologies, usually in higher risk applications using gamma spectroscopy. So anyway, you might be interested, so I'll keep in touch with you. And yeah, so I appreciate all the feedback, and --

DR. ABU-EID: We are looking forward for learning.

MS. BARR: Okay.

DR. ABU-EID: We are looking forward for learning from you about any innovative technologies we'd love to be aware of. And then maybe in a future discussion we can talk more about it.

MR. E. DAROIS: Great, I love it, thank you.

MR. KLUKAN: Thank you very much, Eric. Again, I'm just echoing Cynthia and Boby here, but thank you very much for participating. And the same goes to all our participants as well as presenters.

Timothy had suggested that we make available the toolbox Excel spreadsheet that was mentioned as being in the public domain, that we -- the workshop should help to distribute such spreadsheets. It may be more fitting doing more user-friendly tool. And I can, in response, Fred posted some links.

So thanks both to Timothy and to Fred for your contributions to the chat.

I just wanted to capture this before we ended up. Ray Vaughn we haven't heard from yet, posted this in the chat: I haven't heard any mention today of reverse engineering practices that help achieve a desired outcome and lessons learned. Have the technicians who weren't listening learned that those to whom they report don't want unsolicited information?

In probabilistic modeling, the modelers learn that if the clients have a desired outcome, they can help to achieve through their choice of input parameters.

Thank you, Ray, for contributing to the chat. Again, it looks like we have in the two minutes remaining, Cynthia, you have your hand up again, so I'm going to turn to you.

MS. BARR: Oh, no, I just -- I was -- I was going to respond back to Timothy, though. I think Eric probably wants to respond back, though. I think he's just saying they have LIDAR with a gamma spec, two different instruments. I don't know if he was making a joke or what there.

MR. E. DAROIS: Yeah, no, it's all an integrated system for sure, yeah.

MR. KLUKAN: All right. Thank you, Eric, for clarifying that. And any -- we have one minute left, any final thoughts before I turn it back over to Tom? All right.

Well, thank you, everyone, and again, thank you for participating and for, particularly with respect to the discussion sections. So yeah, so I've enjoyed this opportunity. I've learned a lot as your facilitator.

So with that, have a great evening, everyone, and I'm going to turn it back over to Tom to kind of close out this conference today. So thanks again from me, I really appreciate it.

DR. ABU-EID: Thank you, Brett. You did an outstanding job. Thanks for everybody who participated in every aspect of this workshop.

MR. AIRD: Yes, and I want to echo what Brett and also again thank our speakers who volunteered an enormous amount of time and energy to put those presentations together and an enormous amount of time and energy just sticking around to answer all of our questions. So I really, truly appreciate that.

I just want to highlight again that you can please check out what's in new -- What's New in Decommissioning website at the link on this slide here if you want to see new updates or materials from past workshops.

And again, feel free to contact myself or Cynthia Barr if you have any questions. Our contact information is on the public meeting website if you want to check it out again.

And a final thanks to Brett for facilitating today's meeting and helping out with all of our great discussions. It was a huge help, a very huge help.

And then I just want -- hope you all found this workshop very useful and hope to see you all in the future. So thanks again for attending. Bye.

(Whereupon, the above-entitled matter went off the record at 5:00 p.m.)