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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS (ACRS)

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REGULATORY POLICIES AND PRACTICES SUBCOMMITTEE

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FRIDAY,

FEBRUARY 24, 2017

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ROCKVILLE, MARYLAND

The Subcommittee met at the Nuclear Regulatory Commission, Two White Flint North, Room T2B1, 11545 Rockville Pike, at 1:00 P.m., Matthew Sunseri, Chairman, presiding.

COMMITTEE MEMBERS:

MATTHEW W. SUNSERI, Chair

RONALD G. BALLINGER

DENNIS C. BLEY

CHARLES H. BROWN, JR.

MARGARET CHU

WALTER L. KIRCHNER

DANA A. POWERS

JOY REMPE

JOHN W. STETKAR

DESIGNATED FEDERAL OFFICIAL:

DEREK WIDMAYER

NRC STAFF PRESENT:

THOMAS AIRD, RES

STEVEN GARRY, NRR

THOMAS NICHOLSON, RES

MARK THAGGARD, RES

C-O-N-T-E-N-T-S

P R O C E E D I N G S

1:01 p.m.

CHAIR SUNSERI: Good afternoon. This meeting is -- will now come to order.

This is a meeting of the Advisory Committee on Reactor Safeguards Subcommittee on Regulatory Policies and Practices.

I am Matt Sunseri and I will be chairing this meeting of the Subcommittee. ACRS members in attendance are Ron Ballinger, Margaret Chu, Dana Powers, Joy Rempe, Charles Brown, Walter Kirchner, John Stetkar and, I believe, Dennis Bley will be -- yeah, Dennis is here. Dennis Bley is here.

All right. Derek Widmayer of the ACRS staff is the designated federal official for this meeting.

The purpose of today's meeting is for the NRC staff to discuss the draft final Regulatory Guide 4.25, Assessment of Abnormal Radionuclide Discharges in Ground Water to Unrestricted Area at Nuclear Power Plant Sites.

The Subcommittee will gather information, analyze relevant issues and facts and formulate proposed positions and actions as appropriate to further consideration by the full committee.

The ACRS was established by statute and is governed by the Federal Advisory Committee Act. That means that the committee can only speak through its published letter reports.

We hold meetings to gather information to support our deliberations. Interested parties who wish to request time to provide comments can contact our office after the Federal Register notice of meeting is published.

That said, we also set aside time for spur of the moment comments from the public attending or listening to our meetings.

Written comments are also welcome. The ACRS section of the U.S. NRC public website provides our charter, bylaws, letter reports and full transcripts of all full and subcommittee meetings including all slides presented at the meetings.

Detailed proceedings for the conduct of ACRS meetings was previously published in the Federal Register on October 17th, 2016.

This meeting is open to public attendance and we have received no received no request for time to make oral statements.

A transcript of today's meeting will be kept. Therefore, we request that the meeting participants use the microphone located throughout the meeting room when addressing the subcommittee.

Participants should first identify themselves and speak with sufficient clarity and volume so they can be readily heard.

There is a telephone bridge line established for this meeting so we request that participants on the bridge line please keep their phone on mute and minimize interference with the audio reception in the meeting room.

At this time, I ask the attendees in the meeting room to please silence all cell phones and other devices that make noises to minimize disruptions.

And I remind the speakers at the front of the room at the front table to turn on the microphone indicated by illuminating the green light and speaking and, likewise, turn off the microphone when you are not speaking, and the button is at the base of the microphone, not the -- not the light.

We will now proceed with the meeting and I call on Mark Thaggard, the deputy director of the Division of Risk Analysis of the Office of Research to make introductory remarks. Mark?

MR. THAGGARD: Okay. Thank you. I appreciate that -- the introduction. As indicated I am the -- my name is Mark Thaggard. I am the deputy director of the Division of Risk Analysis in Office of Research.

My division has had the primary lead in developing this document. I want to first say that I appreciate the Subcommittee giving us the opportunity to present the work that we put in developing this document on such a nice day. I mean, I couldn't think any other place I'd rather be.

Mr. Tom Aird, who's a hydrogeologist in my division, he's going to lead us through the presentation and with him is Tom Nicholson, who's a senior level advisor -- senior level scientist in our division.

I think most of you know Tom. We also had some additional staff over on the side here. Bill Ford from the Office of NRR, Steve Garry also from

NRR, and Jack Parrott from NMSS over there in case there is some additional questions that you have.

I also want to recognize Undine Shoop, who's a branch chief in NRR. She -- her division is the sponsor of this work. So we appreciate their support in this.

So with that, I will -- I am going to turn the presentation over to Tom, and I can't go wrong by saying. I believe it's going to be Tom Aird. Tom's going to walk you through the presentation.

MR. AIRD: Thank you, Mark. Good afternoon, everyone. So today's presentation is the draft Regulatory Guide 4.25 titled Assessment of Abnormal Radionuclide Discharges in Ground Water to the Unrestricted Area at Nuclear Power Plant Sites.

Here is our agenda for the day. So I'll start off with some background about this Reg. Guide, essentially explaining why the Reg. Guide exists and where it comes from, and then I'll move into some of the highlights of the guidance, explaining why -- what is contained within the guidance.

And then my colleague, Tom Nicholson, will take over and explain the endorsed ANSI/ANS-2.17 standard and what exactly it pertains to. And then I will conclude the presentation with a brief overview and background of the simple groundwater transport model found in the Reg. Guide appendix.

So, first, some background. In the late 1990s and 2000s, instances of abnormal subsurface residual radioactivity were discovered at nuclear power plant sites undergoing decommissioning and the primary radionuclide of concern was tritium.

But other radionuclides were detected like strontium-90, cesium-137, cobalt-60, amongst many others. And in September 2006, the NRC's Liquid Radioactive Release Lessons Learned Task Force final report was published.

In this report, the endorsed standard - ANS standard was mentioned as a potential guidance document and in August 2007, NEI issued NEI 07-07, Industry Ground Water Protection Initiative, and this initiative was adopted by operating nuclear power plant sites.

Some more background - in 2008, EPRI issued its own report, Ground Water Protection Guidelines for Nuclear Power Plants.

This report served as a technical basis for further NEI documents and then in June 2010 the

NRC's Ground Water Task Force's final report was published and in this report the ANS 2.17 standard was further identified as a potential groundwater guidance document.

We have a user need from NRR to the Office of Research. This user need concerned the inspection of review guidance concerning monitoring and modeling of water releases at nuclear power plant sites.

This Reg. Guide in a draft form was published - not published. It was submitted for public comment on December 11th, 2015 with a, roughly, 60-day comment period, the comment period ending about a year ago in February 2016.

Approximately 60 comments were received during this time and also last year around this time the endorsed ANSI-ANS standard was reviewed and reaffirmed.

CHAIR SUNSERI: Hey, Tom, just one question. On the - the user need from 2012 does this document fulfill the full user need or were there additional pieces of that user need?

MR. AIRD: My understanding is it filled it, the appendix especially.

CHAIR SUNSERI: Okay. Thank you.

MR. AIRD: So last part of the background, the Reg. Guide purpose - this text here was lifted directly from the Reg. Guide itself.

So I will say that the Reg. Guide describes an approach that the staff - the NRC staff considers acceptable for use in assessing abnormal discharges, of radionuclides in groundwater from the subsurface to the unrestricted area in nuclear power plant sites.

The illustration here is a potential scenario described in the Reg. Guide where you have an abnormal release to, in this case, an unconfined aquifer due to groundwater transport and flow.

The abnormal release leaves the site, crosses the site boundary as an abnormal discharge. This is just a potential scenario, one of many and it’s not drawn to any scale - purely illustrative.

Moving on to the applicability of the Reg. Guide, listed here are a few of the applicable regulations cited within the Reg. Guide, the first and primary one being 10 CFR 50.36a(a)(2), which is concerning reporting of releases and quantifications on those per radionuclide and then you have 10 CFR 20.1406(a), (b) and (c), which is concerning the minimization of groundwater contamination.

And if general design criteria found in Appendix A, specifically ground general design criteria 60, which is titled Controlled of Releases of Radioactive Materials to the Environment and General Design Criteria 64, which is about monitoring radioactivity releases.

Just want to highlight that a more complete list of applicable regulations and guidance can be found in the Reg. Guide itself. These will be a mixture of NUREGs, design certification documents and other Reg. Guides.

Here, this slide presents the actual guidance found in the Reg. Guide. So it states that the ANSI-ANS 2.17 is being endorsed. It provides a method acceptable for use to evaluate the occurrence and movement of radionuclides in a subsurface resulting from abnormal releases at commercial plants.

Starting with number one, licensees should develop a conceptual site model of their sites if they not already have one, such as the characterization of the subsurface and surface facilities.

Once they have the CSM, the conceptual site model, developed they can then use this model to determine whether or not the site possesses simple or complex hydrogeologic conditions. This should be done by a hydrogeologist.

And the last part is that simple conditions - simple hydrolic conditions would allow for the use of the - an included appendix example. Complex or otherwise - complex conditions would require a site specific model to be developed to account for the site specific characteristics using a risk-informed approach outlined or highlighted in the ANSI document itself.

I'll go into further detail later about what is considered simple conditions - simple hydrolic conditions.

CHAIR SUNSERI: Yeah, I just had a - just a quick question on this - the sequence of things. It almost looks like a procedure but I presume you decide whether or not you have a complex or simple situation first and then you develop. So two actually precedes one in this list, right?

MR. AIRD: It's a -

MR. NICHOLSON: Go ahead, Tom.

MR. AIRD: I'm important to have a conceptual site model for your site anyways and most of the time for other activities you need the CSM anyways.

So they should already be developed for the majority of the sites. One of the things that NEI 07-07, the industry's groundwater protection initiative, talks about is the need to create a conceptual site model.

So they've committed to that as well as putting the monitoring wells to detect any releases that may occur prior to leaving the site.

Now, the development of a conceptual site model begins with your site characterization. If you go to the FSAR, you'll see that there has already been some discussion of all sites as to what the groundwater conditions are.

That may not be sufficient. You may have to do further characterization. At the time they put in their monitoring wells as they committed to under NEI 07-07 you have additional information.

So the question is is where are these so-called potential pathways that may take a radionuclide that releases from a structural system component in a nuclear power plant to an offsite exposure location.

It could be to a river. It could be to a lake. It could be to somebody's individual groundwater well. So the argument is is this characterization, modeling, conceptual site model and monitoring all proceed and that's what this Reg. Guide is all about is to help people understand that.

By endorsing ANS 2.17 that is an industry consensus standard that describes all of that. And so therefore the conceptual site model should be developed and that should be the first thing that you understand, even before you put your wells in.

MEMBER CHU: Can I ask a question?

MR. NICHOLSON: Sure, Margaret.

MEMBER CHU: What would trigger the application of this guideline? When you already see contamination in your monitoring wells and stuff? I am just curious to see -

MR. NICHOLSON: Yes.

MEMBER CHU: You have to wait until you've -

MR. NICHOLSON: Yeah. When NEI 07-07 was put in place the industry committed - the nuclear industry committed to having conceptual site models and monitoring.

Now, at what point do you then begin to

think about releases? Obviously, it's when you detect them in your on-site monitoring wells.

So that's generally the beginning of it and I can - we have been to many sites where this has occurred and when you find it then you go on this survey of trying to find out the source of that radionuclide, primarily tritium, and then you may put in additional wells and you may ask the question how do I estimate or quantify the flux of the contaminant offsite.

And that's part of the 10 CFR 50 description is you have to quantify each radionuclide that exceeds background significantly and you want to say its source to come from a condensate tank, a conveyance pipe spent fuel pool wherever it may have occurred from and you usually put your wells in closer to the source so you get a better definition of the plume. Okay.

MR. AIRD: Thank you, Tom.

MEMBER BLEY: Before you go into more the details of how we expect people to do this, I read through all the regulations you cite in the beginning of the Reg. Guide and all but maybe one really are about minimizing releases and one goes a little further.

When you called this a risk-informed approach, to me that implies thinking about public health consequences and not spending more effort than they dictate. Yet, you don't calculate public health consequences.

MR. NICHOLSON: Yes, you do. You have to do a -

MEMBER BLEY: You do the dose and then you complete -

MR. NICHOLSON: Yes. There has to be - yeah. The Reg. Guide provides information for other documents that do an offsite dose calculation model.

So the whole concept here is how much is the groundwater contributing to an offsite release. Once you provide that information, then the health physicist, using their models, then calculate what the potential dose is.

This model quantifies it but doesn't perform dose calculations. Yeah, right.

MEMBER BLEY: So the whole idea is setting up a model so that you can be risk informed?

MR. NICHOLSON: Yes.

MEMBER BLEY: If something happens.

MR. NICHOLSON: Mm-hmm.

MEMBER BLEY: But we are not quite risk-informed in how we build the model. We build the model -

MR. NICHOLSON: No, it's -

MEMBER BLEY: - based on the structures that are there and the -

MR. NICHOLSON: But the thing is the conceptual site model is really the one area that has the greatest uncertainty, to be quite honest.

So therefore you may have alternative conceptual site models that you want to investigate and part of performance monitoring is to go back and ask the question did I really understand the site well enough that that conceptual model is correct or are there alternative conceptual site models.

So and we also look at uncertainty, not just in the conceptual site model but in the parameters and in the scenarios that may actually occur.

And the whole idea, of course, is you want to - and ANS 2.17 talks in great detail about assessing the potential impact.

The argument is if it is a tritium release with very low concentrations and you have a significant distance to the property boundary you can actually ask the question what would be the quantity of tritium leaving my site.

So what is the picocuries per liter with regard to concentration and what is the potential dose. Up to this point it’s been extremely low, which hasn’t even come close to 25 millirem per year.

MEMBER BLEY: Even for some of the fairly significant -

MR. NICHOLSON: Yes.

MEMBER BLEY: - cases? We actually went to visit one a couple years ago where it was one of the more -

MR. NICHOLSON: And I’ve been involved -

MEMBER BLEY: - public -

MR. NICHOLSON: - in many of those sites and the first thing we do, of course, is we try to identify the source of the release.

Then you ask where you’re monitoring wells you need to add additional monitoring wells and then how do you then estimate what potentially could go off site.

And so therefore in all cases that

determination has been made by the licensee and our regional inspectors have gone to the sites.

I’ve accompanied them on many of these and we ask what is the estimated release, and in all cases it’s been extremely low. But we are prepared, and I am sure the licensee is also prepared --

MEMBER BLEY: Plus, you melt the core it’s going to stay extremely low.

MR. NICHOLSON: No, there has --

MEMBER BLEY: Yeah.

MR. NICHOLSON: -- been examples where it’s been high at the source of release but it has diminished dramatically by the time it transports to the site boundary.

MEMBER BLEY: Correct.

MR. NICHOLSON: Yeah. It depends upon the radionuclide, too. So strontium-90 is of great concern as opposed to tritium, which is less of -- and that has to do with drinking water standards.

So go ahead, Tom.

MR. AIRD: Okay, that’s fine.

MR. NICHOLSON: So as regarding the current status of this Reg. Guide I said earlier that it was sent out December 2015 for public comment.

Public comments were received.

They've been -- all have been addressed in the Reg. Guide including its appendix have been revised and amended accordingly. The majority of the comments were from NEI but the remaining were from private individuals, private companies.

So the final item listed here is a training course that has - PDC training course that is in development by Office of Research staff members for this Reg. Guide and specifically the model included in the appendix in this operation and the current plan is to have this training course fully developed and given within six months or a year.

CHAIR SUNSERI: So just for transparency here, the bullet that says all public comments have been addressed in the Reg. Guide revised, I read through the 25 or 40 pages -- I can't remember -- of comments and the disposition, and I noticed some of it your disposition not necessarily accepted the comment but the reason why it was not applicable or something like that.

So my question is is of the things that you may not have incorporated into the Reg. Guide was -- is there anything you felt was overly controversial or, you know, you were torn on whether or not you should go in or not and you didn't put it in or --

MR. NICHOLSON: If the public --

MEMBER BLEY: -- thinking of substance that didn't get in, I should say.

MR. NICHOLSON: If the public comment was outside the scope of this Reg. Guide then --

MR. AIRD: There were many really well formed public comments relating to dose and, you know, the health effects, which was outside the scope. But those are the only ones that stand out in my mind.

CHAIR SUNSERI: Yeah, as I said, I read through them and at least in my mind I thought you did a decent job with it but not being an expert in this area I just thought I'd ask.

MR. NICHOLSON: Tom mentioned the training course. Undine Shoop and her staff, working with us, put together a research request and we responded back officially.

And so that is now under development and we will provide that training to the NRC staff, particularly the regional inspectors, the health physics people who have to go to the site and review if there is a release.

So we will work with them to provide that training and it will be done in-house. Tom? My colleague, Tom Nicholson, will now explain in depth the ANSI-ANS standard and its application.

MR. NICHOLSON: Thank you, Tom. ANS 2.17 actually was developed back in the late 70s and was issued in 1980. It lapsed because after 10 years the standard rule lapsed and it hasn't been updated.

We were in the process in the early 90s of thinking about doing this and we started to do it when the first groundwater task force was put in place.

Stu Richards was the chair and we brought this up and everybody was enthusiastic about great, if there is an industry consensus standard let's work on that, which we did.

And then the second task force was put in place - the groundwater task force - after more releases were identified and assessed.

And so we went forward and actually published that ahead of schedule in December of 2010 and it came about six months after the groundwater task force report.

The standard is an industry consensus standard and applies to radionuclide releases that affect groundwater, water supplies derived from groundwater, water - surface waters affected by subsurface transport.

It includes exposure pathways across the groundwater-surface water transition zone and the question that came up earlier this does not give you information directly on dose assessment. It provides background knowledge and information for those who do dose assessments.

So this is primarily intended for hydrogeologists and modelers. Next, Tom.

One of the things that the ANS standard provides, and you asked earlier about risk, and this is - and a performance - risk analysis performance assessment - EPRI did a very interesting review for NEI and they looked at the relative rank of radionuclides based upon what is the inventory already at a site.

It could be in the rad waste tank, condensate tank, whatever - its abundance, activity and transfer characteristics. And notice that tritium is the fourth. Number one is strontium-90.

And part of this is because the EPA drinking water standard for each of these radionuclides is quite different.

So for strontium-90 it's eight picocuries per liter. For tritium it's 20,000. So that kind of gives you a sense of why certain radionuclides may be more important.

Now, the benefit, of course, of strontium-90 is it can be absorbed. So when you do a calculation for strontium-90 you put in the - your chemical properties that would cause retardation. With tritium there is no retardation. Next, please.

CHAIR SUNSERI: So when you say absorbed you mean absorbed by the ground and prevent further migration, right?

MR. NICHOLSON: It's slow. Yes. Yes. It can be - they call it monitor natural attenuation is what industry has now chosen as their preferred remediation option.

And monitor natural attenuation says that within the geologic -- hydrogeologic unit if there is significant clays or other properties it may hold up some of those radionuclides, not others.

So that's the concept. Next, please.

MEMBER POWERS: I'm a little puzzled about the table.

MR. NICHOLSON: Okay.

MEMBER POWERS: This is based on what's in aqueous form on the plant site?

MR. NICHOLSON: This is what they have identified with regard to nuclear power plants, what's in their rad waste tanks, their condensate tanks, in the pipes - the normal distribution of radionuclides within the structure system's components.

And so based upon that information and its transport properties of that specific radionuclides, they ranked them this way. This comes from EPRI report.

And we thought it was of value if you're looking at it from a performance assessment standpoint. These could be your performance indicators.

So if you put in wells, the question is what radionuclide are you looking for. At one nuclear power plant they were very focused on tritium.

But we asked the question did you look for other radionuclides hard to detect and the answer was no. So we suggested looking at this table that came from EPRI and they found strontium-90.

So the question is do I only worry about tritium. Well, it depends upon the release - the release mechanism in this scenario and then you ask the question okay, are there other radionuclides that might be associated with that structure system component that may also migrate and look for those as well.

MEMBER POWERS: This table is somewhat prescreened in the sense of they considered its transportability through clays or something like that?

MR. NICHOLSON: Mm-hmm. But it's also the inventory on site.

MEMBER POWERS: Of course, I -

MR. NICHOLSON: What's in the spent fuel pool, what could be in the -

MEMBER POWERS: - if I am on a site that does not have clay there may be a variety - I am thinking particularly of arsenic and antimony - that might be quite important to me.

MR. NICHOLSON: Oh, yes. Yes. And the licensees have their own chemical departments at those sites and in discussing with them the regional inspectors focus on that.

And so they asked the question, okay, where do you think that radionuclide came from - which structures this component might have failed and then what could be the fate of that and could there by other associated radionuclides besides that one and they do a very detailed analysis close in when they find a potential source.

It could be a drain that malfunctioned or a pipe that leaked or a spent fuel pool that may have leaked that doesn’t have a tell-tale.

So in many cases, the question is asked what are the potential inventories. This is only for a sense of what to look for and not to just focus entirely on tritium.

MEMBER POWERS: Okay. So the purpose of the table somehow illuminated is don’t just look at tritium. It is not just look at these radionuclides.

MR. NICHOLSON: Right. So it kind of helps you -

MEMBER BLEY: You’re not worried that people will take that second view. This is a guidance and so I have to look for - these are the important ones.

MR. NICHOLSON: No, no, no. They are the ones that I would be focused on in my initial analysis if I was a licensee and a chemist at that site, saying okay, what was the source of the contaminant - what did you find and what were the radionuclides and which one are of great concern.

And, obviously, for me I'd be very much more worried about strontium-90 than hydrogen-3, tritium. Okay?

MEMBER POWERS: It seems to me maybe an additional column would be useful, which would be the groundwater standard.

MR. NICHOLSON: Which would be what?

MEMBER POWERS: The groundwater standard for them.

MR. NICHOLSON: Yeah. Yeah. Well, I have that here, the EPA drinking water standard. I can run down the numbers for you.

MEMBER POWERS: It's not for me.

MR. NICHOLSON: Yeah.

MEMBER POWERS: It's to make the table totally illuminating -

MR. NICHOLSON: Okay.

MEMBER POWERS: - is to put it in another column but the - the drinking water standard on it because that actually makes the point you made orally, which is there is a huge difference between strontium-

90 and tritium.

MR. NICHOLSON: Right.

MEMBER POWERS: And so if you're going to focus on something, probably tritium isn't the first on my list.

MR. NICHOLSON: No. Okay. Thank you for that comment. Next slide, please.

There is a sequence of - since this is a performance assessment approach we - the ANS staff writing team put together a sequence of activities to help somebody go through the approach.

So the first one, of course, is to identify the appropriate regulatory and design requirements and use the requirements to specify performance objectives, performance indicators and performance thresholds and you just mentioned that yes, that would be a good list to begin with if you're thinking about your performance indicators.

And then after you do that you then identify and assess the relative significance of a subsurface radionuclide scenarios and transport pathways.

And after you think about that and do that, you then conduct site characterization studies focusing on facilities and site hydrogeology. This is site characterization beyond what was there initially in the FSAR.

Develop - fourth point - develop one or more conceptual site models - you may have more than one conceptual site model because of the uncertainty - of radionuclide transport using information from the site characterization studies that account for features, events and processes identified during site characterization.

Then develop a mathematical model used to demonstrate compliance with performance objectives. It could be - we brought up before 10 CFR 50.36a(a)(2), which says that you have to quantify for each radionuclide if there is any offsite releases and report them on an annual basis to the NRC.

And then implement a performance compliance monitoring program that is used to improve the conceptual and the mathematical models and to demonstrate compliance with the regulatory requirements in the performance objectives. Next.

So the standard - the ANS standard goes through, provides a scope, definitions of terms, which is very helpful in acronyms, the performance assessment methodology, the site characterization that should be done to develop the conceptual site model and the hydrogeologic characterization that may be necessary.

If it isn't a simple site - if it's a complex site it could be a fraction metamorphic rock - it could be a solution, limestone or carbonate, it could be a variety of geologic environments, that characterization then should feed back into the conceptual site model.

If the contaminant plume is only moving through the water table aquifer then you may say, for the moment I'll just look at the overlying glacial alluvial, whatever the overlying units are, on top of the bedrock.

Do I need to go into the bedrock? Well, it depends upon whether the contaminant has gone down into the bedrock. In some cases it has. So you have to then characterize that fractured rock.

And then after you do that, then you go look at your mathematical models. You can have simple analytic models.

You can have complex numerical models and in all cases you have to think about calibration, their predictive capability and their updating, based upon the performance monitoring, and then you do an uncertainty assessment.

The performance confirmation monitoring is probably one of the most difficult things because where do I put my wells, how do I sample it and how do I feel confident in the data that's been collected - the water quality - and then, of course, information management - what do I do with all the information I've collected and how do I constantly update that.

In some cases, at some nuclear power plants that have had releases they now have a long-term groundwater monitoring program in which they report on a quarterly basis and performance assessment monitoring - confirmation monitoring.

Information management is part of that. Next, please. And, of course, it provides lots of references.

MEMBER REMPE: Could you talk a little bit about the frequency in spatial resolution for the calibration data that's obtained? Is it continuously or how often and how do you decide that it's sufficient?

MR. NICHOLSON: One of the dilemmas you

have is whether the site has a complex hydrogeologic framework, and in your performance monitoring you may be surprised.

You may start seeing concentrations that are very high or very low. The question is do I fully understand the contaminant plume and its behavior.

It may be subject to things like snow melt, recharge, offsite groundwater piping or onsite groundwater pumping.

So the question - the answer to your question is you have to look at the existing monitoring wells and ask am I getting a clear enough picture to fully understand what's going on or do I need to have additional not only monitoring wells but additional characterization.

At one nuclear power plant site it was in a fractured rock and so therefore we had to think in terms of how do you then do down-hole geophysics to see if the fractures are connective connectivity and if there is fracture filling and do they absorb the radionuclides.

So it becomes a real issue of when you go between the characterization, the conceptual site model and then the numeric models and then the monitoring.

You often do have to go back and ask for better information. So a complex site in which the property boundary is close, you would have to probably put in a lot more wells. If the contaminant is moving through a fairly well understood simple system and the potential receptors are at a great distance, then you can have less monitoring from the standpoint of I think I know what's going on - I'll put in monitoring wells to confirm my understanding of that. And this Reg. Guide is to help you understand that and the ANS standard goes into some detail with regard to the question you just asked.

MEMBER REMPE: The standard does. The Reg. Guide didn't.

MR. NICHOLSON: No.

MEMBER REMPE: The standard is a little more -

MR. NICHOLSON: Yes.

MEMBER REMPE: - but I just wonder, in your opinion, it's enough guidance now -

MR. NICHOLSON: Yes.

MEMBER REMPE: - that the licensees will understand.

MR. NICHOLSON: Yes.

MEMBER REMPE: Okay.

MR. NICHOLSON: But it all comes down to your conceptual site model and your testing of it using the performance confirmation monitoring.

MEMBER REMPE: Okay.

MEMBER KIRCHNER: Tom, what's a typical requirement in terms of - not being a hydrologist - a number of the sampling wells and how do you confirm your model? Do you intentionally put a tracer into - as a source and then detect it or -

MR. NICHOLSON: You could do that. Matter of fact, at one plant they did put in tracers to try to understand where the - that was in a fractured rock.

You always have at least one well up gradient of the potential source so you know the background and you know the potential gradient - the driver.

Then you put the contaminant well - the detection well, obviously, close to the boundary of your site so that you can see it before it goes off site.

MEMBER KIRCHNER: Do most sites tend to

have a gradient where you analyze the site and you know you need to put the wells on the southern perimeter or the northern side or -

MR. NICHOLSON: Yes. You can if it’s a water table aquifer -

MEMBER KIRCHNER: Right.

MR. NICHOLSON: - that does not have significant fluctuation. But the answer’s yes.

MEMBER KIRCHNER: Yeah.

MR. NICHOLSON: So they’ve done this at all the nuclear power plants. The NEI 07-07 made a commitment that they will put in wells to understand if a release will be detected and the ANSI standard which predates that NEI 07-07 actually talks about that, where to put your well so that you understand the contaminant plume and its behavior - the magic where there is behavior.

MEMBER KIRCHNER: Yeah.

MR. NICHOLSON: So you’d have at least three, four, five wells but the dilemma at most of these plants is it comes from a variety of sources. So I’ve been at some plants and they said well, I think it came from the rad waste tank over there so they put wells over there.

No, it didn't come from there. They've already detected at the site boundary well. Somebody said okay, let's go look over here.

So you go on this survey to try to find the source of the contaminant and the way of doing it, of course, as you pointed out, is you do understand the general gradient of groundwater flow direction. If you understand that -

MEMBER KIRCHNER: Right.

MR. NICHOLSON: - and that's part of the conceptual site model, then you can know where to start putting your wells and how to sample them, and that's extremely important - the sampling aspect. Next please.

MEMBER KIRCHNER: Thank you.

MR. NICHOLSON: You're welcome.

MR. AIRD: Joy, this maybe wasn't exactly your question but on Page 9 of the ANSI standard it states that there are definitely five - it states that the conceptual site model should be updated every five years.

MEMBER REMPE: I was more the calibration -

MR. AIRD: I know. Yeah.

MEMBER REMPE: - so I think I - mic on - but I think I've got - my concern addressed it. Thank you.

MR. NICHOLSON: Okay. Yeah, the calibration comes from you monitoring data, and it isn't just chemistry. It's also gradients. So what you want to know is there is what's called direct performance indicators and indirect. So I've been at these plants where they actually do - go out and do the sampling.

So you measure the pH, the Eh, the conductors as well as collect a sample that you later take to lab and you determine whether it's tritium, strontium-90 or whatever. So this set of data - and that's part of that information management - you try to understand your conceptual site monitor and say uh-oh, the calibration doesn't work because I am seeing things in my performance compilation monitoring that I didn't model or anticipate.

So now you have to change your conceptual site model and you have to change your parameters within your numerical models. Next.

MEMBER CHU: Question? Can I ask a question?

MR. NICHOLSON: Yes.

MEMBER CHU: How often do you see abnormal releases from power plants?

MR. NICHOLSON: As it turns out, it's more common than previously thought. As plants age, they often will have pipe releases.

But they will not be large, meaning significant high levels of contamination but they will be releases from tanks - from condensate tanks, pipes, whatever.

So the question is is the closer you look the more you'll find things. The question is there is significance, and that's the purpose of the Reg. Guide and the ANSI standards to say how important is this - can I just keep a record as required so at decommissioning time they know where the contaminant plumes are and then you go do remediation and clean it up to the standard or do I feel an obligation to do some immediate remediation.

MEMBER CHU: So this Reg. Guide is very important. That's what you're saying.

MR. NICHOLSON: Yes, it is.

MEMBER CHU: Yeah. Okay.

MR. NICHOLSON: Yeah.

MEMBER STETKAR: Tom?

MR. NICHOLSON: Mm-hmm.

MEMBER STETKAR: You mentioned pipe problems and tank problems, and I think we are all aware of events that happened. The industry has implemented underground and buried piping -

MR. NICHOLSON: Mm-hmm.

MEMBER STETKAR: - programs. Do you have enough experience to see whether they've actually improved the situation? They've been in place now for three, four, five years - something like that.

MR. NICHOLSON: Mm-hmm. We are aware of - the NEI had an initiative on subsurface piping and the NRC staff --

MEMBER STETKAR: Well, and it's also been implemented for plant license renewal concerns. So --

MR. NICHOLSON: Mm-hmm. So it appears as if as people start focusing on potential releases they have a better understanding. They've put their monitoring wells on locations and they also can do corrective action.

They do what is called a root cause analysis when there is a release and the question is is it a certain pipe, is it the age of the pipe, what is the potential problem that caused this.

MEMBER STETKAR: I'm asking - Margaret asked are these releases routine and you said well, somewhat more routine than you might otherwise expect because as plants age you get more releases.

I am asking you have you seen any improvement in the operating experience since the industry implementation of the underground and buried pipe initiative.

MR. NICHOLSON: I can only talk about the plants I've been to. I don't know directly the answer to your question. But I have seen at the plants I have been to that yes, they focus on that. That's important.

MEMBER STETKAR: Okay. Thank you.

MR. NICHOLSON: Because the potential failure of structures' components obviously is what leads to the releases. So next, please.

Okay. One of the things that the ANS standard did, especially our chairman, Todd Rasmussen, was very important and influential in putting together in Appendix B.

It's not part of the standard but it's a help and it's a summary of tables, and it helps identify what - the information that's necessary for defining, updating and visualizing the conceptual site model, the summary of information parameters required for characterizing site facility, the - for hydrogeologic characterization modeling, information management, performance confirmation monitoring.

So in the back there are tables that actually identify the properties and goes into some discussion and refers back to what's in the document. So it gives some structure if people are asking the question well, what performance measurements do I need in order to develop my conceptual site model, do the modeling, whatever.

The standard, as I said earlier, was reaffirmed in 2016. If you look at the authors of the - of the standard you'll see they came from a very excellent background of both industry, DOE labs, NRC, so the breadth. And a lot of the information we have in here evolved to some extent from both the experience in the field, the industry - EPRI, we were aware of the EPRI reports - and then also a lot of the DOE people and USGS brought information that they had been doing on things like high-level waste.

So all this came in together as the

standard. So that's all I have. Tom, I'll turn it back to you.

MR. AIRD: Thank you, Tom. I will now go over some background and the mechanics behind what was included in the appendix of this Reg. Guide.

Starting first with some of the key assumptions of the included appendix model, the first things to consider is the assumptions.

So you need to use this - in order to use this simple groundwater tritium transport model, you need to start with simple hydrogeologic conditions. These would include but are not necessarily limited to things like uniform steady-state flow, 100 percent saturate flow and homogenous geologic properties. Complex conditions would preclude the use of this model.

MEMBER KIRCHNER: So Tom, how many - pardon me. How many of the plants out there in the fleet can use a simple model?

MR. AIRD: This was - this model was calibrated, I know, on three sites - using data from three sites.

MEMBER KIRCHNER: Either Tom.

MR. NICHOLSON: Okay. We looked at three

sites. Actually, two of the ones we couldn't use because the site was complex. The third site was simple enough.

So the question is is how many. We don't know how many, but relatively few, probably, because a lot of these sites are complex hydrogeologically.

What makes it complex is where the contaminant release occurs and whether it just moves in the water table. If it moves in the water table, that's simple. But if it moves down into a fractured bedrock or whatever, that adds complexity.

And then if there are multiple plumes then now you have a problem with we have residual radioactivity plus the new release and how do we differentiate between past releases and new releases. So that adds to the complexity.

So to answer your question, relatively few. However, if you do a detailed hydrogeologic modeling you can simplify it if you understand, based upon the performance monitoring confirmation data and the complex model you could simplify.

You can't start simple and then go complex. Actually, the conceptual site model should be 3D. It should reflect the complexities.

Then you ask the question where did the release occur and is it moving in a very simple manner and I can use the appendix model or is it more complex and I have to do a more sophisticated model.

MR. AIRD: And, Tom, you just mentioned this but complex conditions could include things like absorption of radionuclides, preferential flow paths like fractures and falls and transient flow or unsaturated flow conditions.

MEMBER KIRCHNER: So just, again, not being a hydrogeologist, do you go from a Mac computer model to a supercomputer model when you go to a complex situation?

MR. AIRD: I don't think you need a supercomputer model. This can be done on your - on a normal computer using, like, code like MODFLOW OR TOUGH2.

MEMBER CHU: Another comment - wouldn't you think most nuclear power plants know their site enough?

MR. AIRD: Uh-huh.

MEMBER CHU: They probably know it's pretty complex or pretty simple already, at least preliminary.

MR. AIRD: Mm-hmm.

MEMBER CHU: Am I correct?

MR. AIRD: Yes.

MEMBER CHU: Okay.

MR. AIRD: Yeah, I would imagine so. Mm-hmm.

The next thing to consider for the occluded appendix model are the model inputs, the model outputs.

So using your conceptual site model, you would know the site hydrogeologic properties, things like hydrogeologic connectivity, porosity and site gradient.

You use these properties and you couple that with a measured data from the wells, primarily, in this case, tritium concentrations and picocuries per liter. You combine these two inputs.

You add them into the simple flow tube model and the flow tube model outputs your desired quantity, which is the total annual activity discharge to the unrestricted area.

This slide explains what is - when I say flow tube models this slide kind of explains what a flow tube model is.

So starting in the upper left you have a block model. In this system you have inflow and outflow in one direction only, in this case in the horizontal J direction.

Subdividing this block model into a flow tube model you just - you subdivide it as the big area in the middle left depicts.

You still have the same inflow and outflow, and then to highlight or to exaggerate the features of the flow tube model the figure in the lower left, this exaggerated version, indicating how the flow tubes are independent of one another and do not communicate with each other.

So for all three models, the underlying assumptions are that you have flow - adductive flow in one direction only. The flow tubes do not communicate with one another and you have 100 percent saturation conditions.

MEMBER BLEY: That sounds like a pretty strong assumption.

MR. NICHOLSON: It is, and it may not - it may not work. I mean, that's why you have to have your conceptual site model to say do those assumptions work.

EPA and the ITRC have developed these kind of models, okay - mass flux models. So you're constantly asking the question do those assumptions hold or not.

If they don't hold, then you have to go to more sophisticated or complex models.

MEMBER BLEY: That kind of takes us back to Walt's earlier question. If you don't - after you build your model dig a couple of wells, do some tracer studies, how do you know if they work?

Or if that's what the licensee does when you guys - when the staff looks at your models how do you know if their assumptions were reasonable and if they work?

MR. NICHOLSON: There's a variety of ways of trying to confirm a model, both a numerical model and a conceptual site model.

Part of it is I brought up earlier both the performance indicators, meaning the concentration of the radionuclides but the indirect performance indicators as well - the pH, the temperature, the conductance, whatever.

If the system is understood, then as you go through your numerical modeling, it should hold together.

But if things start to break down, if you do a check with an analytic model and you're getting strange transport quantities then you say wait a minute, something's going on here.

And it has happened at some of the sites with regard to when you look at the performance data you have to go back and recalibrate that conceptual site model, especially -

MEMBER BLEY: That's what I am asking you. What - which level of - what kind of performance data are we looking for to conform the models?

MR. NICHOLSON: Well -

MEMBER BLEY: PH in various locations?

MR. NICHOLSON: Yes, temperature.

MEMBER BLEY: I mean, that - that's what I didn't understand before. What do they have to - what do they have to do to confirm the model?

MR. NICHOLSON: Well, I am not going to go into details but if you have -

MEMBER BLEY: Well, a few wouldn't hurt.

MR. NICHOLSON: - but if you have a site that is on an estuary -

MEMBER BLEY: Okay.

MR. NICHOLSON: - do you want to look and say is this well being influenced by the estuary, the pH, the conductance. And so therefore I don't fully understand that model.

I have to say yes, in fact these are site conditions and processes I have to capture and that may explain why as the tritium migrates towards that large body of water all of a sudden you don't see it because the tremendous dilution factor of the estuary, the tidal pumping.

So those are the kinds of questions you keep asking about You keep saying okay, what are the indicators both direct and indirect. So conductance, pH, temperature -

MEMBER BLEY: As measured at a well or -

MR. NICHOLSON: Yes, measured in a well.

MEMBER BLEY: Okay. That's what I was getting at.

MR. NICHOLSON: When we go to these -

MEMBER BLEY: Not just going back and looking at the model and saying no, that doesn't look like -

MR. NICHOLSON: A particular site - I am not going to say where it was - but I was there with the state people and the regional inspector and they said, we are going to be monitoring these wells - would you like to go see, and I said sure, I'd love to go see it.

So we went to look and they had procedures on how they were to sample the well. So you take the cap off the well, you measure the temperature.

Then what you do is you slowly - not extremely - you pump water out until you get stability. And then when it's the proper temperature and it's no longer a whiskey color but more of a kind of a cloudy color, then you say okay, I am now ready to take my samples.

If you take it prematurely then you may be taking a sample that is basically stagnant and it has not been in communication with the groundwater around it.

So there are procedures that industry has that they adhere to when they do a sampling procedure - the protocol - and, of course, you then have to sign saying yes, I was there when the sample was collected and you have a chain of custody.

So the state, the NRC and the licensee have - and sometimes it's not their staff but a contractor come in and do that. So you're collecting this information. That's why information management is so important.

So what is the temperature of groundwater - well, generally the temperature of groundwater is the average annual ambient temperature, okay. So if the temperature of the well is, like, 85 degrees Fahrenheit there is something wrong. If the temperature is very cold that could be wrong as well.

So there are these indicators that tell you yes, in fact, I understand the system is behavior the way I think it is, and if it isn't - if the data tells you no, you don't understand. So that's what -

MEMBER REMPE: So there was once -

MEMBER BLEY: That helps some.

MEMBER REMPE: - in the standard where they talk about differences in simulated data versus measured data within 10 percent, which I thought was amazing it would have that little variability considering it. But that's kind of -

MR. NICHOLSON: Yes.

MEMBER REMPE: - what you're looking for, within 10 percent, which I thought was, again, pretty amazingly accurate considering the -

MR. NICHOLSON: And at the sites we have been to the licensee takes tremendous emphasis on collecting the sample properly and then they all split it sometimes with us and sometimes with the state.

And so it’s very important to know what the properties are at the time of collection, not when it goes off to a lab and it’s being analyzed there. You want to know in situ what are those indicators.

CHAIR SUNSERI: So I am looking at this slide here and I just have a question. I am not a modeler. But it would seem to me, I mean, it’s portraying three different models.

But I could look at it as just one basic model with a different number of nodes at the end and if I am on the receiving end of this thing why should I care if I am receiving the flow through a garden hose or through a garden hose with a spray nozzle on the end of it?

I mean, that’s what this picture looks like to me, and was the complexity of the modeling necessary to achieve the end result?

MR. AIRD: I think it might become a little bit clearer later. But as the size of the flow tubes vary, the concentrations of whatever you’re looking for might spike or go down. That's not the right slide.

So the modeling blocks themselves vary in size based on how many monitoring levels you have across the transect. My best explanation I can give you at the moment.

CHAIR SUNSERI: Okay. Thanks.

MR. AIRD: Okay. So going back to the model presented for the illustration from slide five, this time you have a monitoring well system, which is implemented as indicated by that dark red line very close to the site boundary.

In this case let's say you have four wells going across a site. The 3D illustration in the lower left hand corner shows you wells one, two, three and four.

The well heights here are extremely exaggerated just for clarity purposes. They don't normally stand hundreds of feet into the air.

But taking this 3D illustration and looking at the 2D transect you have then the four wells with the screened intervals, where the wells are sampling in the water table with a 2D illustration.

So your - the user dependence model would then subdivide this transect, in this case into four different modeling blocks.

The modeling blocks - the widths of modeling blocks are dependent on the number of wells you have. So if you have four wells - in this case you'd have at least - you would have four modeling blocks going across.

The heights of the modeling blocks are determined based upon your site's geologic properties. So if you have a sand layer and a silty sand layer then you'll have two blocks on top of each other.

The illustration on the right - the two-figure illustration shows the modeling blocks in relation to the 3D model. So taking that transect on the left and imposing it back onto the model in the lower right hand corner.

MEMBER POWERS: On the previous figure why wouldn't you take three blocks? What boundary is coinciding with the wells?

MR. AIRD: Why we wouldn't take three wells?

MEMBER POWERS: Why wouldn't you do three blocks with the boundaries coinciding with the wells?

MR. AIRD: You want the boundaries of the block to be right at the well as opposed to -

MEMBER POWERS: Yeah. Well, it doesn't have to be right at it but -

MR. AIRD: Well -

MEMBER POWERS: I mean, it seems to me it would be just as legitimate or just as useful to break it up into three as it is to four. I mean, you did it for illustration purposes. I know. I just wondered -

MR. NICHOLSON: No. The argument is that when you sample in monitoring well what is the volume around it that you're sampling and its nearest neighbor - what is the distance between those two and how do you then represent that system with regard to transport.

Now, because this is a very simple flow tube model for fully saturated steady-state conditions, you're assuming horizontal flow.

So the question here is then -

MEMBER POWERS: The advantage of my way is I don't have to make such assumptions because I got wells on each boundary. If they are not about right then I know what's in between is not -

MR. NICHOLSON: Sure.

MEMBER POWERS: - not kind of uniform.

Whereas you don't know where things have changed this way because you're monitoring, roughly, in the middle of your block.

MR. NICHOLSON: If you - if you did a numerical model you could probably use the approaches you're discussing.

But this is a simple flow tube model and this is generally the way that it's being done so that you're representing the volume around that monitoring well and the flow that occurs through there - the gradient and the quantity of the contaminant, in this case, tritium. Does that help?

MEMBER POWERS: Well, I mean, all you're doing is saying I have to make an assumption and -

MR. NICHOLSON: No, you don't have to make an assumption. You can say -

MEMBER POWERS: You have made an assumption -

MR. NICHOLSON: Yes. Yes.

MEMBER POWERS: - in doing this -

MR. NICHOLSON: Mm-hmm.

MEMBER POWERS: - and you have no mechanism to validate that assumption based on this kind of a model.

MR. NICHOLSON: Oh, I think you could argue that the sampling well, depending upon the spacing between the wells, obviously, as the wells become further apart then that assumption could be called into question.

But if the monitoring wells are fairly close together I think this is a legitimate approach and the question is is you have to characterize it.

If you read both the ANSI standard and the Reg. Guide, you have to characterize the plume - the tritium plum.

If you're getting mixed messages, meaning some monitoring wells show the plume over there, another one over here, then you can ask the question are my assumptions correct.

And they may not be correct and so therefore this model may not be appropriate.

MR. AIRD: The ultimate goal of the appendix model is the quantification of the tritium at the site boundary.

So this model goes through block by block so if you want to know the tritium blocks at the site boundary for the fourth block you need to know the bulk water flux through that block using basic algebra, Darcy's law, and the tritium concentration for that block, which is - would be a measured quantity in picocuries per liter from well four for our given month.

The tritium flux at the site boundary is - the formula for it as the bottom there and is calculated into - in picocuries per day.

This is essentially the same thing but it does the logical thing. If you want the total tritium flux at the site boundary then you just do a summation of the tritium flux through each of the individual blocks.

So to know the total tritium flux for this example you would just sum the tritium fluxes for block one, block two, block three, block four.

What's not mentioned here is the potential radioactive decay from the wells to the site boundary. For tritium with a half-life of 13 years or so this effect is negligible.

So but the model actually does take into account the radioactive decay for tritium by measure - by taking the distance between the well transect and the site boundary.

In this case, it's about 170 feet. And so the water travels that distance quite quickly and so the 13.2-year half-life is - results in negligible effect.

So now -

MEMBER KIRCHNER: Tom, could I interrupt again? Just coming back to Dana's point, so what's a typical positioning of the wells?

Do you - I guess the model is only as good as the sampling from the wells. Do you take it from a fairly significant axial sample?

MR. AIRD: It can, depending on the perforations in the well. So you could have one well that - a single well that samples from one layer and then 50 feet below in another. It depends on how they finished the wells.

MEMBER KIRCHNER: So your choice of well type, so to speak, how many axial location and such, is a function of your initial site characterization and -

MR. AIRD: Mm-hmm, and how they completed it.

MEMBER KIRCHNER: Okay.

MR. AIRD: So moving on to the slides - I mean, the figures from now on are lifted directly from the appendix in the Reg. Guide itself.

So the background is over. The Excel file itself can be found at ADAMS, and this was all - this is all data from a real nuclear power plant site.

So going back to the - this is a site with - you're looking from an aerial view. So imagine that this - or a map.

So you're looking down on the site. You have a nuclear power plant infrastructure. You have your modeling well transect, which is the green horizontal line going across, with 12 monitoring wells in that transect, each dot representing monitoring wells and it's a label, and that transect in this case is a 180 feet from the site boundary.

So taking that green transect but now looking at it from - as a transect so from the subsurface. So you're looking at each - each vertical line is a monitoring well. The dark black lines highlight the sampling interval.

So most of the wells are sampling from the sand layer, the white or their - two of the wells are sampling from the silty sand layer.

This actually - this diagram here is not in the Reg. Guide. I just did this for illustrative purposes.

So I manually created these modeling blocks and imposed them onto where they would approximately be on this transect.

Some of the model - some of the block widths are incredibly tiny and actually not depicted here but for just quick illustrative purposes I created this slide to help illustrate what modeling blocks look like.

This is - the colors aren't in the appendix but I - this, I would consider, as the model dashboard.

So you first start with the blue box at the top of the model dashboard and you input the site hydraulic properties like the hydraulic connectivity, the site porosity, the gradient.

In this case, you have a sand layer and a silty sand layer. So each of them has their own hydrolic connectivity, their own specific discharge and their own porosity. And then you input in the red box.

This is where all the modeling well, the geometries, the widths, the heights of these modeling blocks are calculated.

Combining the hydrolic - the blue, the hydrolic properties, and the red, modeling block geometries, you can then calculate bulk water flux in cubic feet per day for the - just, you know, feet per day, excuse me, through each of the modeling blocks for the same layer and the silty sand layer.

And the final purple box on the lower end of the figure is just some useful background information that you'd find on the plant dashboard, primarily transport times and tritium flux calculation equations.

So another - the second sheet in the Excel file is tritium concentrations that were measured for each of the monitoring wells in picocuries per liter.

So this - these were done for each of the 12 wells and then for a one-year period. The green ND stands for not detected.

You can see here highlighted by the red circles you have the tritium plume detected in two locations. Notice how it was only detected in the yellow sand layer.

So the calculation part of the worksheet, you calculate the tritium flux for a given block. So you take the bulk water flux that you would find on the plant dashboard, you multiply that by the tritium concentration for that block - what you just saw on the previous PowerPoint slide - and then you'd - there is sometimes - I mean, you have to use a conversion factor as well.

And so you - that's calculated by the model for each of the modeling blocks on a separate worksheet. So this is kind of like an interim step.

And then the - this is the final part of the model, the final part - the Excel file. So this is the quantities they're actually looking for.

So tritium concentrations are summed for each of the months, for each of the layers. There is some conversion from, you know, picocuries per day to curies per day, and then those are some for that year, giving you the 12-month tritium activity discharge at the transect.

This value here takes into account radioactive decay of the tritium. This value just sums the silty sand activity and the sand layer activity since there was no tritium in the silty sand layer that this number remains unchanged.

And then this -- these -- this number highlighted by that red circle is then -- if you want to convert it to the average tritium concentration discharge using the -- potentially defining it by the bulk water volume.

And so this is our -- the final slide of this presentation, and so to reiterate once again, the endorsed industry consensus standard, ANS 2.17, provides a method acceptable for use to evaluate the currents and movement of radionuclides in the subsurface resulting from abnormal releases at nuclear power plant sites. All the comments have been received and addressed.

And finally, we hope to get this Reg. Guide published, hopefully in the near future. And with that, we will open up for questions if there are any. Thank you.

CHAIR SUNSERI: Thank you. So do any of the members have questions? Margaret, do you have a question?

MEMBER CHU: Yeah. Through your example, the contamination is not bad, right?

MR. NICHOLSON: No. It's very low.

MEMBER CHU: Yeah, it's very low. So in reality what do you do with that information?

MR. AIRD: You would go to Reg. Guide 1.21

and then report it as an abnormal discharge, correct?

MR. NICHOLSON: Mm-hmm.

MEMBER CHU: And then just let it go, right?

MR. NICHOLSON: Well, the licensee -- the licensee has the responsibility to report it to the NRC and their annual effluent report if it is significant.

So the question is, is it extremely low, yes. Then that's one issue. If it's very high, then it has to be reported. Steve --

MEMBER CHU: And then what after reporting the high consequence? Then what?

MR. NICHOLSON: Steve, do you want to address that issue?

MR. GARRY: Sure. A lot of times the regulations in 10 CFR 50 --

CHAIR SUNSERI: Could you say your name, please?

MR. GARRY: I'm sorry. Steven Garry, NRR, the radiation production branch. As Tom said, we start with the regulations in 10 CFR 50.36a that says report the presence of all radionuclides.

And then in tech specs we add a

requirement where they estimate the dose to members of the public.

So we have to quantify - the first step is to quantify the releases from the site and then the second step is to run it through a dose model, and the dose model is based on the land use census where we require the licensees to go around and look at the site with in a five-mile boundary and see what's going on, see where people live, see what their habits are as far as gardens or how many people live there, just whether they have milk animals and so forth and we develop essentially an exposure model - what are the pathways of exposure.

And one of the pathways is groundwater. Another pathway is service water. And so they identified that adjacent families that have wells and they monitor those wells if they are likely to be affected.

So the first step, which is the Reg. Guide, is estimating - we already estimate the quantity released is gaseous effluence and a surface water effluence.

So this adds the next dimension, which is groundwater discharges, and the data that Tom showed there is exactly - I mean, it is an example of one of the sites and where Tom went and verified the model or used the model at that site and estimated the curies released.

Now, the curies released there, as you saw, were .499 curies, or half a curie, and that compares to a surface water discharge, roughly, five curies for BWRs and 500 curies for PWRs into surface waters.

Generally speaking, like Tom mentioned earlier as well, there hasn't been - since the plumes are slow, slow, slowly moving or move to a large surface water, even though it's a groundwater discharge some sites it comes back up into the adjacent river or lake and gets so diluted we can't even detect it offsite.

I think we have detected tritium offsite at two sites. One was Indian Point - I am sorry, Braidwood.

But that was due to a five-mile cooling tower blow down line that had leaked millions of gallons of water. So that was really a surface leak that then sat on top of the ground.

Another one was Turkey Point where they

were able to detect tritium just outside of their cooling canal systems and one sample.

But other than that, the bottom line is - in my opinion, is that the adjacent service water bodies are so large and provide so much dilution that you can't see the tritium that's coming from groundwater, and that's been our experiences.

Then an environmental monitoring program will verify that by performing groundwater samples or monitor drinking water samples in some of the most likely to be affected neighborhoods.

CHAIR SUNSERI: Any others?

MR. NICHOLSON: Thank you, Steve.

CHAIR SUNSERI: All right. No other questions from the committee. I am going to open the phone lines now and see if anyone listening in would care to make a comment.

If anybody's on the line - anybody would care to make a comment?

All right. We are going to close the phone lines and turn to the audience. Anyone in the audience care to make a comment?

All right. So no additional comments. Like to go around and hear from individual subcommittee members at this point in time if you have any additional comments or remarks that you'd like to make.

In particular, I would like to hear from you whether or not you would like to recommend a presentation of this topic to the full committee.

So we will start with Joy.

MEMBER REMPE: I appreciate your efforts and your presentation and I don't see a need to bring this to the full committee. Thank you.

CHAIR SUNSERI: Charlie.

MEMBER BROWN: Yeah, thanks. It was informative. If they are going to publish this in May, that means I guess they are going to send it out. It's not for comment. You said you'd already received comments. Isn't that correct?

MR. NICHOLSON: That's correct.

MR. AIRD: That's correct.

MEMBER BROWN: So I presume their comments were - you didn't - we didn't talk about those any. So I presume they were either positive or noninfluential relative to what went on in the Reg. Guide? Is that -

MR. NICHOLSON: I would say so. I think I would characterize most of the comments as need for clarification.

MEMBER BROWN: Okay.

MR. NICHOLSON: We put in probably more information and tried to make it plain English and logical, and where people made recommendations we evaluated whether that additional information would be good enough.

We generally did not have any comments that significantly changed but it affected, obviously, the plain English aspect.

MR. AIRD: The glossary was expanded significantly.

MR. NICHOLSON: Yeah.

MEMBER BROWN: I guess my next question is relative to this. This is - I actually divide this into two questions. This is a new Reg. Guide and we have been looking for this kind of stuff for decades. I mean, the ANSI standard is out there but there has not been a specific Reg. Guide relative to this type of monitoring?

MR. NICHOLSON: There have been Reg. Guides dealing with environmental monitoring and there has been discussion about groundwater monitoring but not in the level of detail that the ANS standard has or to some extent the Reg. Guide itself.

So the main reason for the Reg. Guide is to endorse the ANSI standard ANS 2.17, which has been updated and we think it's within a performance approach and it's an industry consensus standard. So we think that it is of great benefit to both the staff and to the industry.

Now, the technical chair of ANS 2.17 - was issued in December of 2010. He actually at his own expense came in here and gave us, the staff, a briefing of ANS 2.17.

It was distributed to industry. Industry asked the first question was has it been endorsed by the NRC and the answer is no, and the way you endorse it, of course, is with a Reg. Guide.

So that's what we have been working on for the last four or five years now trying to get this to the point where everybody agrees that yes, in fact, the ANSI standard and the Reg. Guide that endorses it and our licensing staff, in cooperation with our counterparts in the region, asked for a very simple model that could be used to estimate the quantity of tritium being released. So that was part of the user need.

MEMBER BROWN: So this Reg. Guide actually - the ANSI standard doesn't provide a model, it's just - just a standard for what's acceptable or not acceptable or -

MR. NICHOLSON: Mm-hmm. It doesn't -

MEMBER BROWN: - and with action?

MR. NICHOLSON: Mm-hmm. You make the choice yourself. If you're industry you have to, as I said earlier, NEI has already said that we will protect groundwater - the groundwater initiative.

They will - made a commitment that they are going to concept - site model and put in monitoring wells. So the question is is there some way that we could help both the licensee and our staff both in the regions and the headquarters if they have to do a review of a quantification of releases of radionuclides offsite.

MEMBER BROWN: Okay. So this is -

MR. NICHOLSON: And this provides a -

MEMBER BROWN: - this then is a model that the sites can use?

MR. NICHOLSON: Yes. If -

MEMBER BROWN: Developed by NRC?

MR. NICHOLSON: It could be used by the staff and it could also be used by the licensee.

MEMBER BROWN: Okay. But they are - I looked quickly through these standards and didn't see a specific description of a model, per se.

MR. AIRD: No, but, like, it says on Page 12 of the standard paragraph one it cites with limited hydrogeologic complexity and exposure risks. Calculations using simplified mathematical models may be used and I would consider this a simplified mathematical model.

MEMBER BROWN: Okay. Is this - is this a continuous model that's used throughout a year where you may - groundwater can vary in an area relative to rainfall, drought.

MR. AIRD: Mm-hmm.

MEMBER BROWN: Plant discharges that are -

MR. AIRD: Yeah.

MEMBER BROWN: - unexpected or what have you.

MR. AIRD: That's why -

MEMBER BROWN: So this is a - this would be a multiple measurement type or multiple periodicity throughout a period? And it's not a static - you don't do it once and then you walk away.

MR. NICHOLSON: No. No.

MR. AIRD: You could continuously update it but I think -

MR. NICHOLSON: Well, the information management part of the ANSI standard addresses your question. It says that you're supposed to incorporate and use the monitoring data from your performance monitoring wells.

So we talked about the direct performance indicators, the concentration of the radionuclides, and the indirect one. You're collecting information constantly.

So the data management says okay, not only do I collect this data and maintain it but I go back and reevaluate my conceptual site model and the monitoring wells - are they still appropriate and effective or should I revise my conceptual site model and I may have to put in additional wells or I cannot use certain wells anymore because the plume has bypassed those wells - it has moved down.

If there is new wells put in then that would be part of your information management program.

MEMBER BROWN: Is there a health - is

there a limit on this where action has to be taken?

MR. NICHOLSON: Well, it goes back to what Steve Garry has just talked about. The question is you have to identify the significance of the release with regard to offsite is it a threat to the public - is it in violation -

MEMBER BROWN: Okay. Is there - is there a metric against which they can do that right now?

MR. NICHOLSON: Yes. Yes.

MEMBER BROWN: Who provides that metric about what's okay and not okay? Is it in the -

MR. NICHOLSON: Well, if it exceeds 25 millirem per year then that is the problem. But nobody gets even close to that right now, okay.

But if they were to have a release of, let's say, strontium-90 that exceeds that then yes, we would sit down, I am sure, the licensing staff and the regional inspectors and say okay, what kinds of action are you going to take - what kind of corrective action are you going to take A, to stop the plume - the leak, identify the leak and stop its source, and then to monitor it and you may have to take appropriate remediation if necessary.

MEMBER BROWN: Is there some -

MR. NICHOLSON: Make sure you preclude any offsite releases.

MEMBER BROWN: Okay. Is there something in the license that says they have to do this and do all sites do this? Did they, you know, put down these wells?

MR. NICHOLSON: Ten CFR 50.36a(a)(2) and some other regulations do address this issue of how you have to assess releases - abnormal releases, report it to the NRC and report it on an annual basis.

MEMBER KIRCHNER: So Tom, what's the periodicity of -

MEMBER BROWN: So yeah, let me finish, okay?

MR. NICHOLSON: Okay.

MEMBER BROWN: Excuse me. I am not trying to be - I just lost the bubble.

So what you're telling me they fundamentally everybody - all sites have to have some way of assessing groundwater radionuclide releases of some sort?

MR. NICHOLSON: If they occur, yes.

MEMBER BROWN: How do they know they occur if they don't dig a well?

MR. NICHOLSON: By having monitoring wells and -

MEMBER BROWN: That's what I mean. They dig -

MR. NICHOLSON: Yes.

MEMBER BROWN: - they put down wells -

MR. NICHOLSON: Yes.

MEMBER BROWN: - and they determine if they've got them?

MR. NICHOLSON: Yeah, they have wells and they are always looking at those wells - yeah.

MEMBER BROWN: I just wanted to know. I am just - I don't know anything about this so I am asking questions.

MR. NICHOLSON: Mm-hmm.

MEMBER BROWN: Okay. I am generating humor amongst my colleagues here but that's fine with me. I am used to that -

MR. NICHOLSON: Yeah.

MEMBER BROWN: - as an electrical guy. Don't pump water around me - there is no toilet.

MR. NICHOLSON: So the regional inspectors and headquarter staff go out to these sites -

MEMBER BROWN: Okay.

MR. NICHOLSON: And when they do their environmental reviews they ask the questions you're asking.

MEMBER BROWN: Okay.

MR. NICHOLSON: Have you seen anything and which wells have you seen them.

MEMBER BROWN: Okay.

MR. NICHOLSON: What could be the potential source of that contaminant - have you identified its source and have you taken the appropriate corrective action to stop the leak, and then have you quantified the potential offsite release of that contaminant and is it a threat to the public.

MEMBER BROWN: Okay. Thank you.

MR. NICHOLSON: Mm-hmm.

CHAIR SUNSERI: Charlie, do you -

MEMBER BROWN: I have no additional interrogatories.

CHAIR SUNSERI: Do you have an opinion on should the full committee -

MEMBER BROWN: I don't know why we would have a full committee meeting, myself.

CHAIR SUNSERI: Okay. Thank you. Walt?

MEMBER KIRCHNER: Just adding on to

Charlie's question. So what's - when you start this program at a site, obviously, you have site characterization in hydrology space and that informs where you put your wells.

But what's the periodicity - the requirements of sampling and such? I missed that somewhere going through all of this for your - for your sampling wells. I mean, these are your picket fence - something's got to trigger somewhere so -

MR. NICHOLSON: Steve, do you want to answer that question?

MR. GARRY: Steve Garry again from NRR. There is no explicit requirement to have a groundwater monitoring well.

So most sites have not had them up until some approximately 2005 when several leaks were discovered and the public became interested.

And at that time, the Nuclear Energy Institute and the industry came up with a voluntary initiative and they volunteered to put in the monitoring wells and provide the monitoring data to us.

And that's really when the wells were installed and when the whole program kicked off.

MEMBER KIRCHNER: And how frequently are they sampling?

MR. GARRY: Typically, it’s monthly or quarterly, depending on the levels and how recent they’ve known about a leak or whatever, but typically monthly or quarterly they pull a sample.

MEMBER KIRCHNER: Thank you.

MR. GARRY: The results are all provided by the industry. All those sampling results are in the annual effluent or environmental reports.

CHAIR SUNSERI: Any -

MEMBER KIRCHNER: I don’t think so, but I thank the staff. Very informative. And I observed - I always through hydrology was more complicated than thermal hydrolics for the core.

But you’re doing yours on an Excel spreadsheet and if you could tell us how to do core design with that it would save a lot of computer time.

MEMBER BROWN: This is like - this is like electrical engineering where it’s rules of thumb.

CHAIR SUNSERI: So Charlie, you had another comment?

MEMBER BROWN: Yeah. You said this didn’t really tell - some leaks were discovered and how - so how would - and this is like in 2005 or something - you said 2004 - and then how were they - if you didn't have wells how were they found? Was this actually in stream water or river water or -

MR. GARRY: No, they were - they were basically discovered on site because by the time it gets offsite you're not going to detect it.

MEMBER BROWN: I wouldn't think so.

MR. GARRY: Right. We have an information notice that was published in 1979 talking about unplanned leaks from pipes and so forth.

But then it was fairly quiet for the next 10 or 15 years and I think it was in 2005 or 2004 - excuse me - the Salem nuclear plant had a spent fuel pool leak and then a year later Indian Point had a spent fuel pool leak that was observed on the side of the spent fuel pool.

And from there they did some groundwater sampling and then the public got interested and we started having a lot of public meetings and the commission got involved.

We have had several ACRS briefings on it and all of that then triggered the industry response to put together the voluntary initiative and really go after it and determine what it was that they had in the groundwater and provide the voluntary communication to the local and state authorities, provide reports to the NRC and get it all out in the transparent world.

MEMBER BROWN: It just seems like it's taken several decades before we ever start. I remember some of those discussions that we had in some earlier meetings.

But I had always thought that was just something that went clear back to 1958 -

MR. GARRY: I'm just - yeah.

MEMBER BROWN: - or whenever the first plant got built and then from then on. But it sounds like it wasn't - it didn't - didn't open up until sometime later even though - even though you had a - the idea was you would make sure there was nothing getting out there from the public.

MR. GARRY: I talked to a couple of the original authors of some of the regulatory guides that were here back in the 70s and so forth and they said that they thought about the groundwater pathway but had just determined that it was not risk significant.

There wouldn't be a big dose or whatever from it. The bigger pathways was the known gaseous effluent pathways and the surface water discharges. So that's what they concentrated on.

MEMBER BROWN: Okay.

CHAIR SUNSERI: Yes?

MR. NICHOLSON: But to help answer your question as well - thank you, Steve, that was very good - at some of the sites that I've been involved in there were wells on site.

One of the wells at one site -

MEMBER BROWN: - existing wells -

MR. NICHOLSON: Yes, there was existing wells and when one of the plants were sold to another one, they had what was required a due diligence well and they were worried about in the transformer yard to see the contaminants that, obviously, the state and EPA were concerned about and that's where they discovered the tritium in the one.

(Off microphone comment.)

MR. NICHOLSON: Yeah. But, I mean, and then some - at some sites where you had onsite use of groundwater you actually had water wells on site. They detected it there.

So some sites had wells, some didn't. But

Steve was correct.

CHAIR SUNSERI: John, any comments?

MEMBER BROWN: Very informative, I would say.

MEMBER STETKAR: I'll try to get - be brief. No comments. No committee.

CHAIR SUNSERI: Thanks. Dennis?

MEMBER BLEY: Yeah, I don't think we need a committee. But thanks, this was very informative. I think the Reg. Guide's pretty short and tight and - I do have one sort of comment.

This is - this is too whiny almost for a comment. But since once of you was an author of the ANSI/ANS standard, the table Dana brought up isn't really well explained there.

And then if you look at the reference in the standard to where that came from it's not to an EPRI report, which would have been nice, but probably cost too much money, but it's to a 2008 RIC presentation, which is damn hard to find. I've just been trying to find it because I wanted to see the story behind it.

MR. NICHOLSON: We -

MEMBER BLEY: If you were making any

little notes in the Reg. Guide something to explain that table a little bit to people it might be helpful. That's the only thing I am seeing. Yeah.

MR. NICHOLSON: Okay. Thank you.

CHAIR SUNSERI: So as a public service announcement, I see there is a RIC advertisement for a presentation on this topic at the forthcoming RIC you can attend, Dennis.

MEMBER BLEY: Yes, but I think I may have heard that presentation today. Is that true or -

MR. NICHOLSON: No.

MEMBER BLEY: No? It's a different one?

MR. NICHOLSON: This one is the next phase.

MEMBER BLEY: Ah.

MR. NICHOLSON: Now we get into remediation. If you have containment plumes at a site and monitored natural attenuation may not be sufficient -

MEMBER BLEY: Charlie will probably come. He wants to -

MR. NICHOLSON: - then what additional work may be required.

MEMBER BLEY: Okay. Thanks. That's good.

That’s nice to know.

CHAIR SUNSERI: Dana, any comments?

MEMBER POWERS: Well, I was prepared to argue that this was an excellent tutorial and to suggest some augmentation of the tutorial for the full committee.

But after Charlie’s interrogation I am reserved about that. I will say that when you do -- should you do a tutorial on this I think it would be useful to do two things.

One is to show an actual hydrolic model from something like an early site permit, application or something like that and to make note of the fact that we do require people for their site permits to have both a hydrolic model and alternatives when they exist.

I am not explaining them in vast detail but the same level at which you explain your model just to make that tangible to people because that is a time consuming thing for the applicant to put together.

He does have to drill wells and things like that to get his hydrolic model all put together. I think you have an example at the same level of detail that you explain your simplified model would be useful.

But I would see it, again, as a tutorial for the balance of the committee and not so much as a review and approval of the draft guide that endorses an ANSI standard.

If there is time on the agenda for a tutorial it's wise to do. The -- if there is a presentation that would probably be required it is in fact phase two, the remediation effort.

CHAIR SUNSERI: Thanks, Dana. Margaret?

MEMBER CHU: Thank you very much for the presentation. I thought it was very clear, and I like the simple model approach because my experience tells me many, many time even if it's a complex situation eventually you simplify into something like a tube model, okay, because there is some driving forces even when it's complex.

So that's good, and thank you. And the only comment I have maybe it's when you read it's not clear what is the next step was my question. Maybe you can put it in the background, just, you know, a few sentences maybe to make it clear.

And I, personally, don't think, you know, we need to bring it up to the full committee. Thank you.

CHAIR SUNSERI: Thanks, Margaret. Ron?

MEMBER BALLINGER: Again, I appreciate the presentation. You've now allowed me to understand the proposed apocalypse that was supposed to happen at the -- at the Yankee Rowe site.

But I don't think this should be necessary to come up before the committee. Thank you.

CHAIR SUNSERI: All right. So we have heard from all the members and I want to extend my appreciation to both you all for the great presentation today.

You marched through it in a timely fashion, clear and I have no further comments. I also believe that do not need to review this at the full committee.

So, we are adjourned.

(Whereupon, the above-entitled matter concluded at 2:36 p.m.)

Draft Regulatory Guide 4.25

Assessment of Abnormal Radionuclide Discharges In Ground Water to the Unrestricted Area at Nuclear Power Plant Sites

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

Regulatory Policies and Practices
Subcommittee Meeting
February 24, 2017

Thomas H. Aird
Thomas J. Nicholson
Division of Risk Analysis, Office of Nuclear Regulatory Research

Room T2-B1, Two White Flint Building, Rockville, MD

Agenda

- Background
- Highlights of the Guidance
- Use of ANSI/ANS-2.17-2010 (R2016)
- RG Appendix Simple Ground Water Model
  - Model Background
  - Model Overview

Background – Identified Need

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

- In late 1990s and early 2000s, instances of abnormal subsurface residual radioactivity discovered at NPP sites undergoing decommissioning

- NRC *Liquid Radioactive Release Lessons Learned Task Force's (LLTF) Final Report ,* September 2006

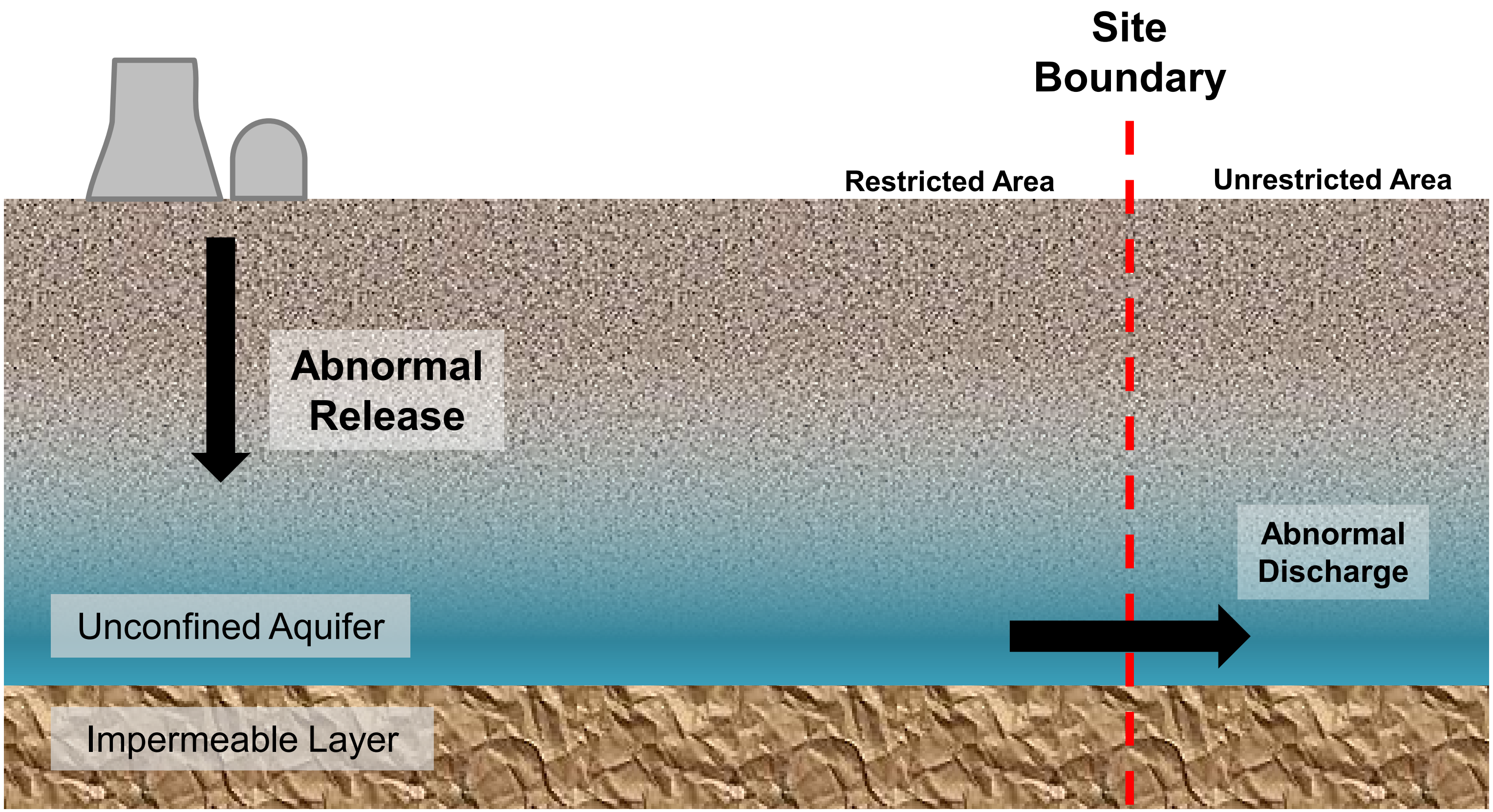
- In August 2007, NEI Issues NEI-07-07, "Industry Ground-Water Protection Initiative"

Background – Identified Need
- Continued -

- In 2008, EPRI Issued EPRI Report 1016099, “Ground-Water Protection Guidelines for NPPs: Public Edition”
- June 2010, NRC Groundwater Task Force Final Report
- NRR User Need NRR-2012-006 submitted to RES
- December 11, 2015, RES issued Draft Regulatory Guide DG-4025 for public comment
  - Public comment period ended February 9, 2016
  - 61 public comments received
- ANSI/ANS-2.17-2010 (R2016) was reviewed and reaffirmed March 2016.

Background – RG Purpose

This regulatory guide describes an approach that the staff considers acceptable for use in assessing abnormal discharges of radionuclides in ground water from the subsurface to the unrestricted area at nuclear power plant sites.



Simple illustration of a potential scenario described in RG. (Note – Illustration not drawn to any scale.)

Background – RG Applicability

United States Nuclear Regulatory Commission
Protecting People and the Environment

Applicable Regulations

- 10 CFR 50.36a(a)(2) –reporting of releases and quantification per radionuclide
- 10 CFR 20.1406(a), (b), (c) –minimization of ground water contamination
- Appendix A, General Design Criteria for Nuclear Power Plants
  - GDC 60, Control of Releases of Radioactive Materials to the Environment
  - GDC 64, Monitoring Radioactivity Releases
- A more complete list of applicable regulations and applicable guidance is found in RG 4.25

Staff Regulatory Guidance

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

ANSI/ANS 2.17-2010 (R2016), being endorsed in the RG, provides a method acceptable for use to evaluate the occurrence and movement of radionuclides in the subsurface resulting from abnormal radionuclide releases at commercial nuclear power plants

1. Licensees should develop a conceptual site model for their sites

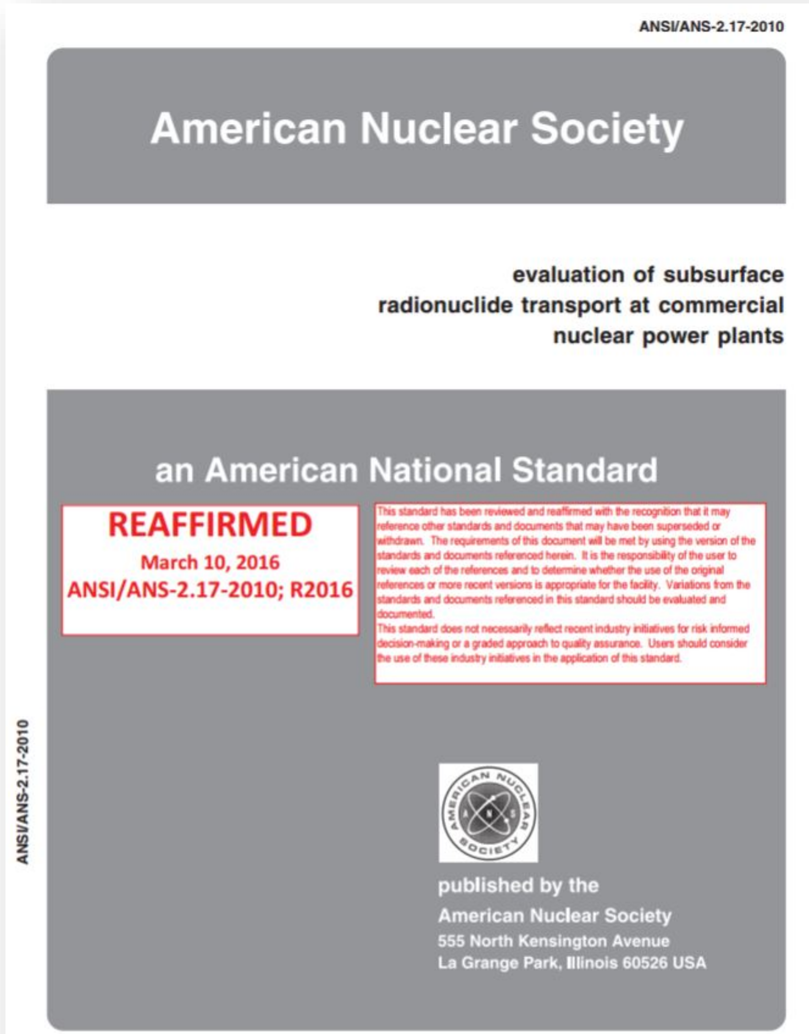
2. Using the developed model, determine if the site possesses simple or complex hydrologic conditions

3. Simple conditions allow for the use of the Appendix example. Otherwise a site-specific model should be used to account for site-specific characteristics using the guidance in ANSI/ANS-2.17-2010 (R2016)

RG 4.25 Current Status

- Sent out for public comment in December 2015
- 60+ public comments received
- All public comments have been addressed and RG revised
- PDC training course on Appendix model, as requested by NRR, currently under development

ANSI/ANS-2.17-2010 (R2016)


ANSI/ANS-2.17-2010

American Nuclear Society

evaluation of subsurface
radionuclide transport at commercial
nuclear power plants

an American National Standard

REAFFIRMED
March 10, 2016
ANSI/ANS-2.17-2010; R2016

This standard has been reviewed and reaffirmed with the recognition that it may reference other standards and documents that may have been superseded or withdrawn. The requirements of this document will be met by using the version of the standards and documents referenced herein. It is the responsibility of the user to review each of the references and to determine whether the use of the original references or more recent versions is appropriate for the facility. Variations from the standards and documents referenced in this standard should be evaluated and documented.
This standard does not necessarily reflect recent industry initiatives for risk informed decision-making or a graded approach to quality assurance. Users should consider the use of these industry initiatives in the application of this standard.

ANSI/ANS-2.17-2010

published by the
American Nuclear Society
555 North Kensington Avenue
La Grange Park, Illinois 60526 USA

Evaluation of Subsurface Radionuclide Transport at Commercial Nuclear Power Plants

- This standard applies to abnormal radionuclide releases that affect:
  - ground water
  - water supplies derived from ground water
  - surface waters affected by subsurface transport
- Includes exposure pathways across the groundwater–surface-water transition zone
- Standard does not provide dose calculations guidance

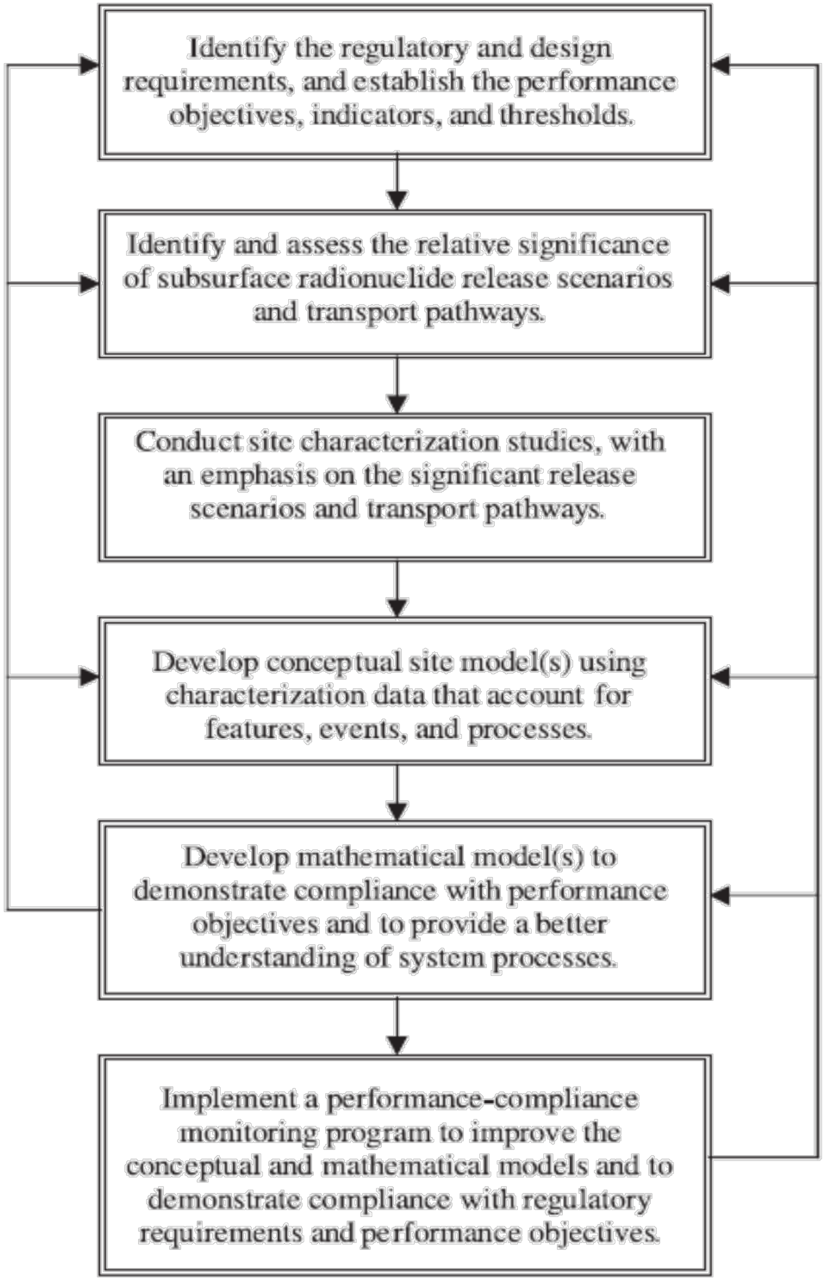
ANSI/ANS-2.17-2010 (R2016)

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Relative Rank	Radionuclide	Half-Life[1] (yr)
1	Strontium-90	28.90
2	Cesium-137	30.08
3	Cobalt-60	5.27
4	Hydrogen-3[2]	12.32
5	Cesium-134	2.07
6	Iodine-129	1.57×10^7
7	Nickel-63	100.1
8	Carbon-14	5700
9	Plutonium-238	87.7
10	Americium-241	432.6

[1] From the National Nuclear Data Center, Brookhaven National Laboratory.
[2] Hydrogen-3 is an alternative name for tritium.

Ranked list of radionuclides at commercial nuclear power plants based on their relative abundance, activity, and transport characteristics
[Table 1 in ANSI/ANS 2.17]



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Protecting People and the Environment

ANSI/ANS-2.17-2010 (R2016)

Flowchart describing performance activities and the relationships among these activities
[Figure 1 in ANSI/ANS 2.17]

ANSI/ANS-2.17-2010 (R2016)

Standard provides guidance to hydrogeologists and modelers on:

- Site Characterization
  - Conceptual Site Model
  - Hydrogeologic Characterization
- Mathematical Modeling
  - Calibration, Prediction and Updating
  - Uncertainty Assessment
- Performance Confirmation Monitoring
- Information Management
- References

ANSI/ANS-2.17-2010 (R2016)

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Appendix B - Summary Tables of Information and Parameters Cited in the Guidance

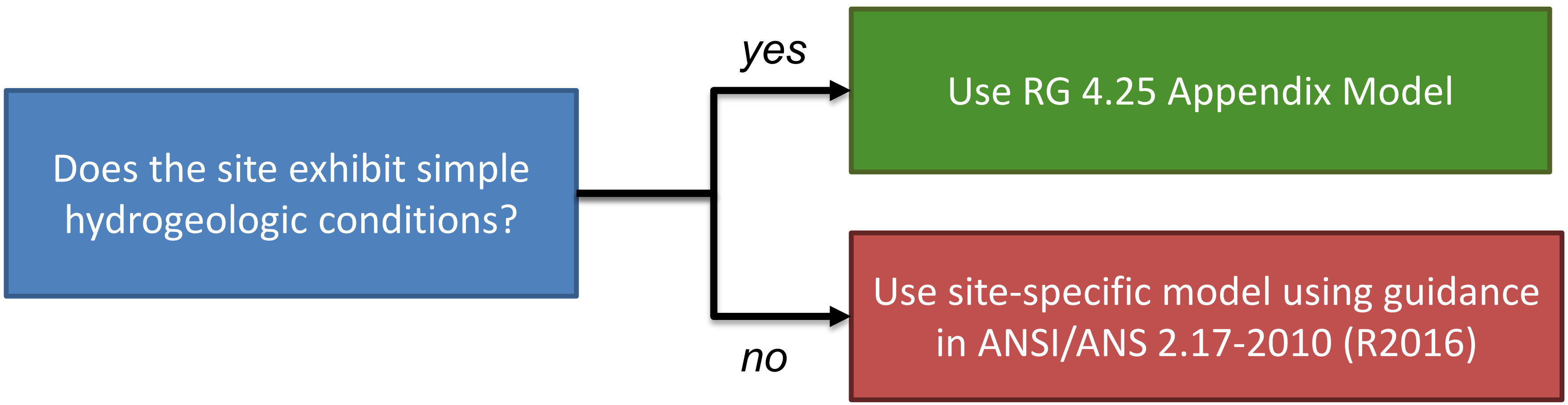
- Information for Defining, Updating and Visualizing the Conceptual Site Model
- Information and Parameters for:
  - Characterizing Site Facility
  - Hydrogeologic Characterization
  - Hydrogeologic Modeling
  - Performance-Confirmation Monitoring
- Summary of Information Management

<u>Standard was reviewed and reaffirmed in 2016</u>

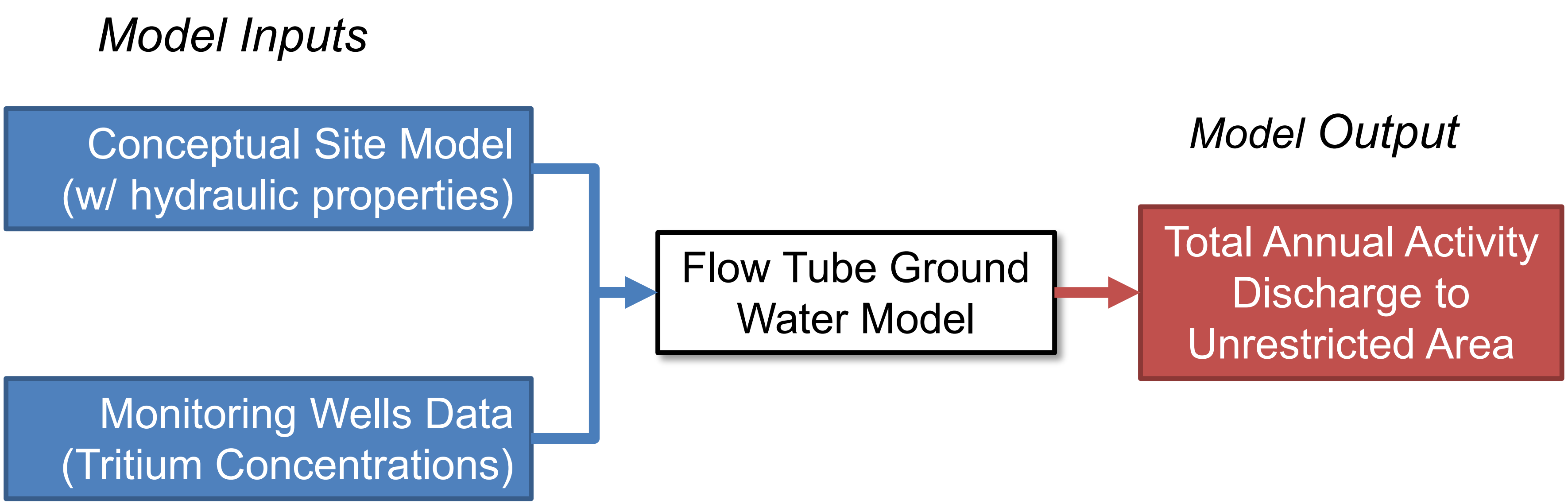
Background on RG 4.25 Appendix Model

Appendix Model Background: Key Assumptions

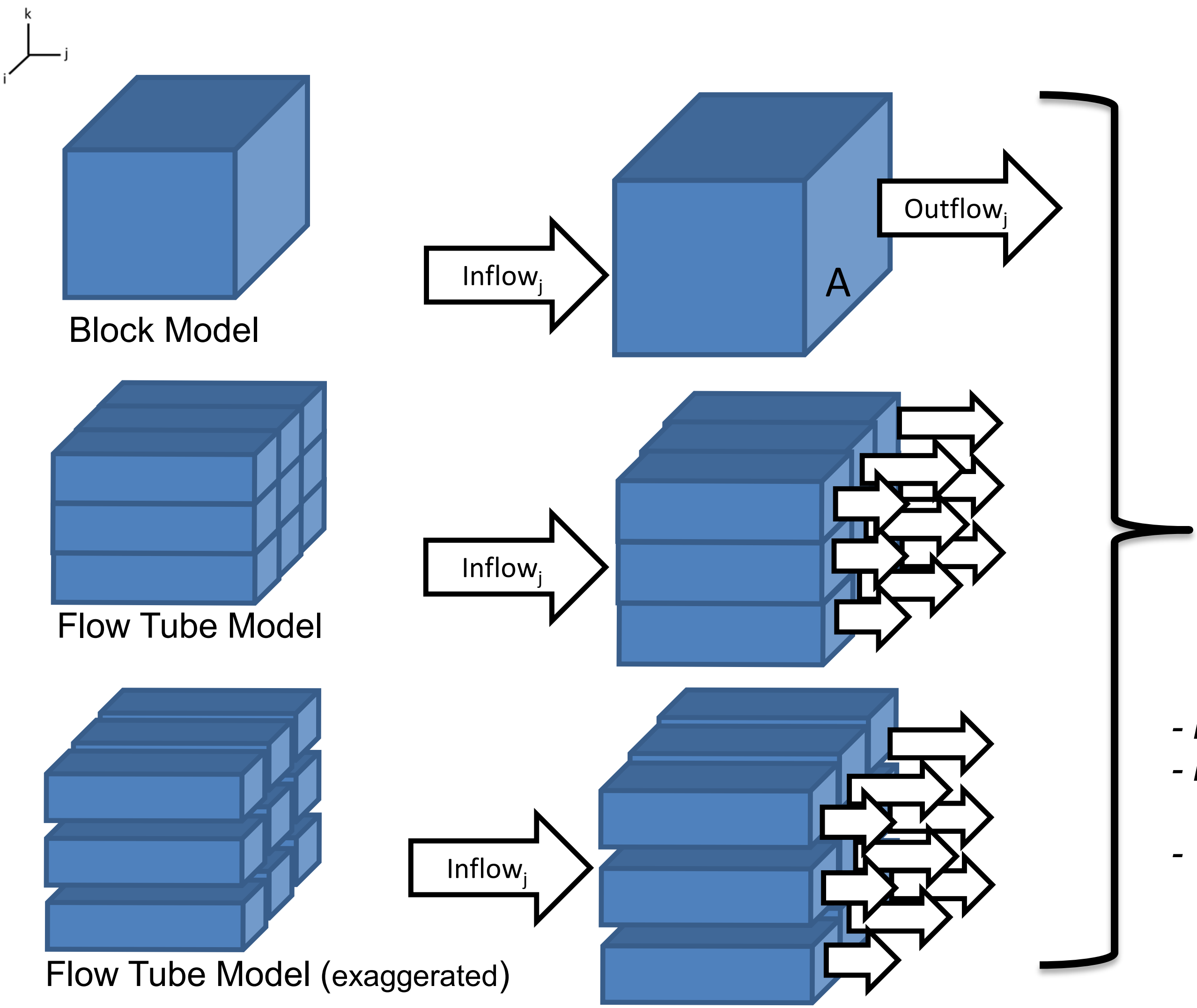
- The appendix model provides a simple ground-water tritium transport model that is acceptable for use with simple hydrogeologic conditions
- Complex conditions preclude the use of this model



Appendix Model Background: Overview



Appendix Model Background: Physics



<u>For All 3 Models:</u>

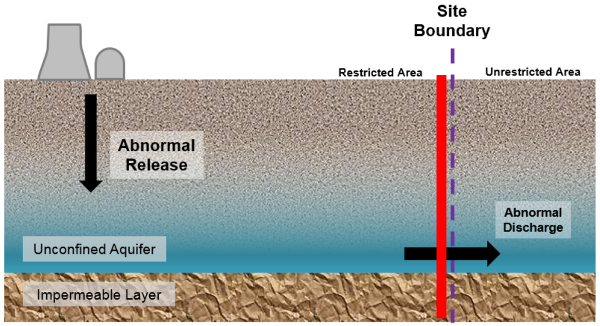
$$\sum Inflow = \sum Outflow$$

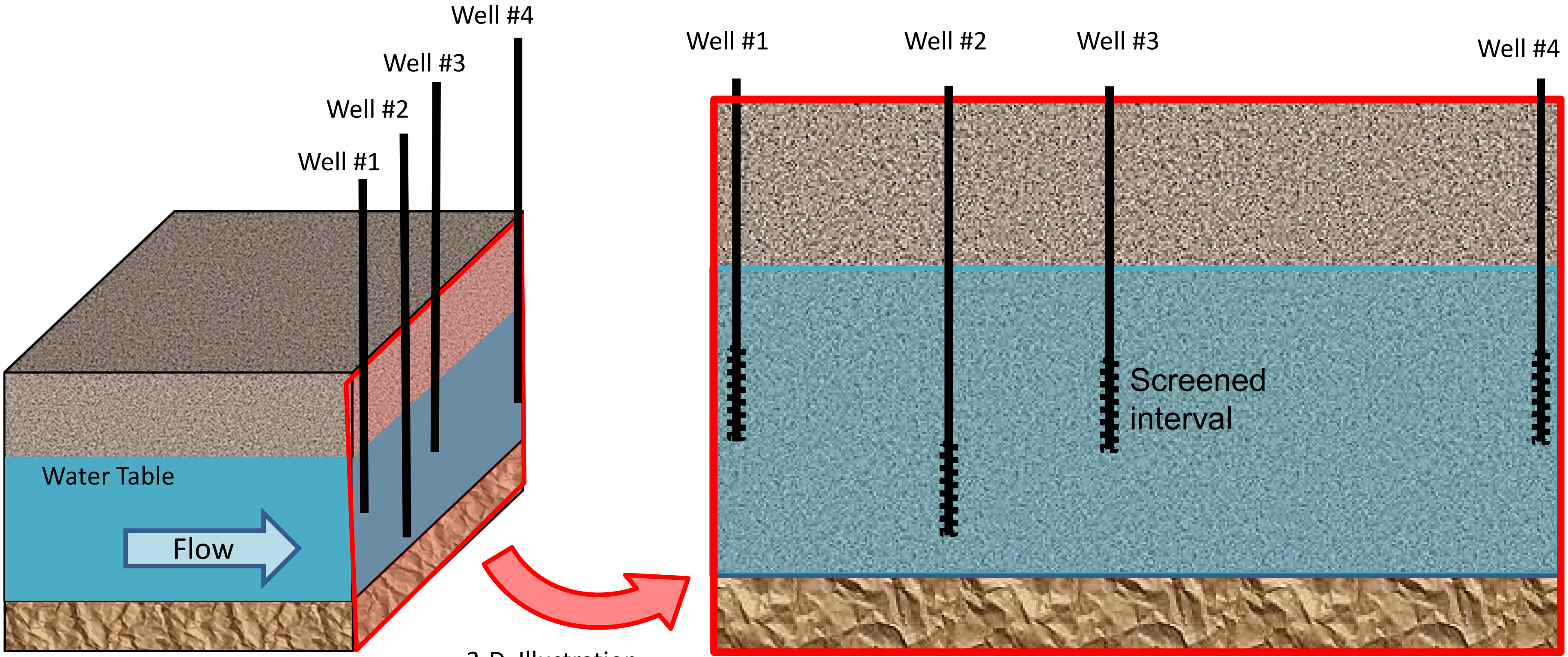
<u>Limitations:</u>

- *Flow in horizontal(j) direction only*
- *Flow tubes do not communicate with each other*
- *100% saturation*

Appendix Model Background: Application to an Ideal Site

The **red** line represents monitoring well locations near the site boundary

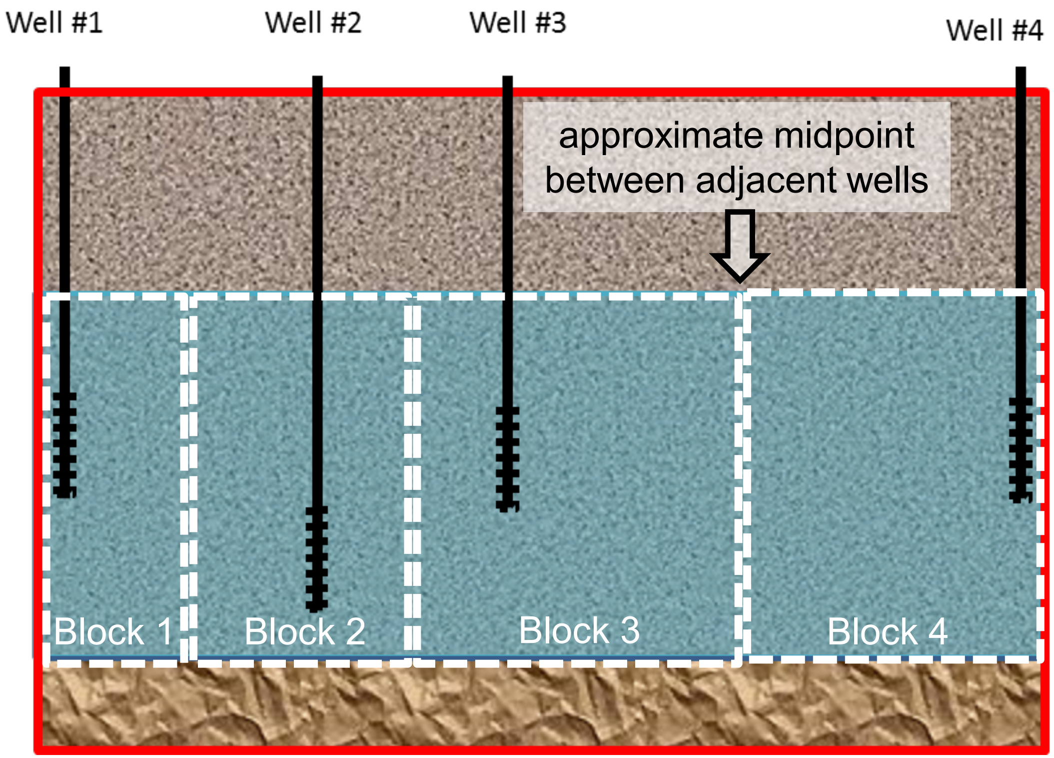


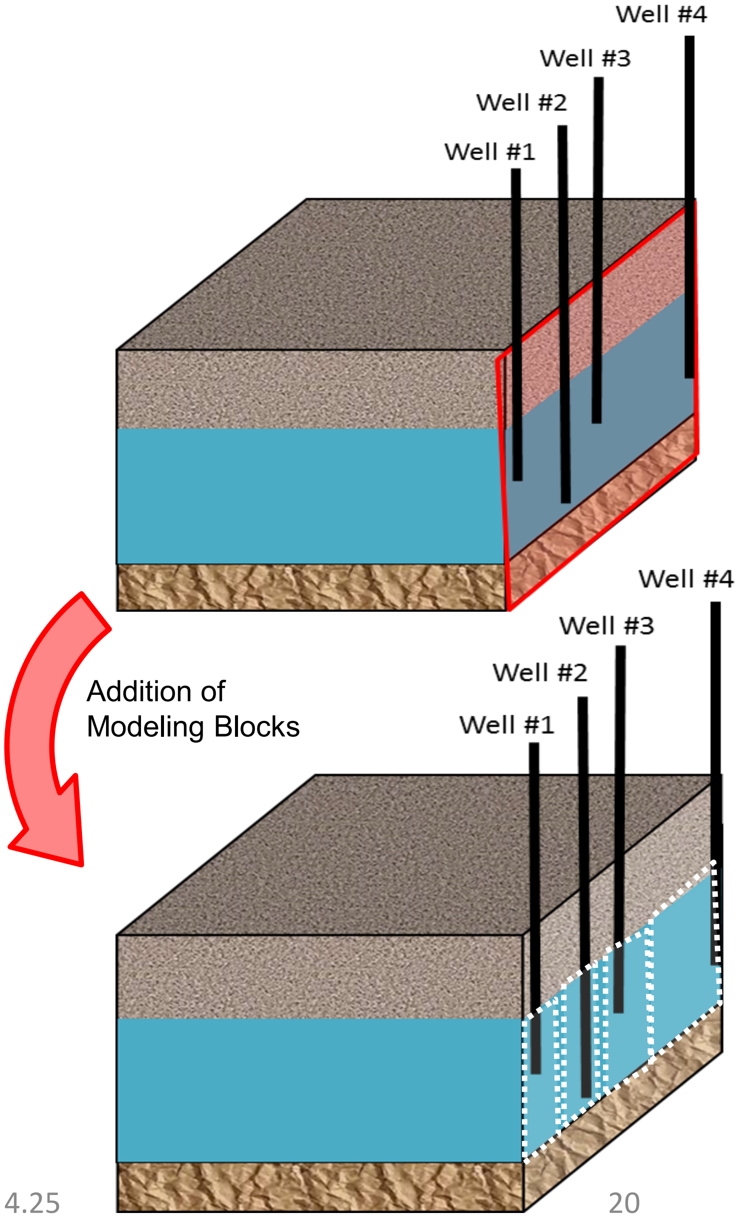


3-D Site Illustration

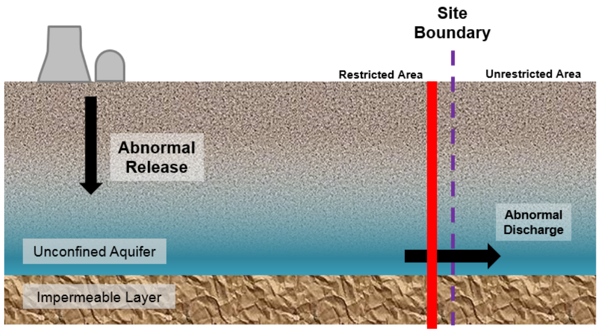
2-D Transect

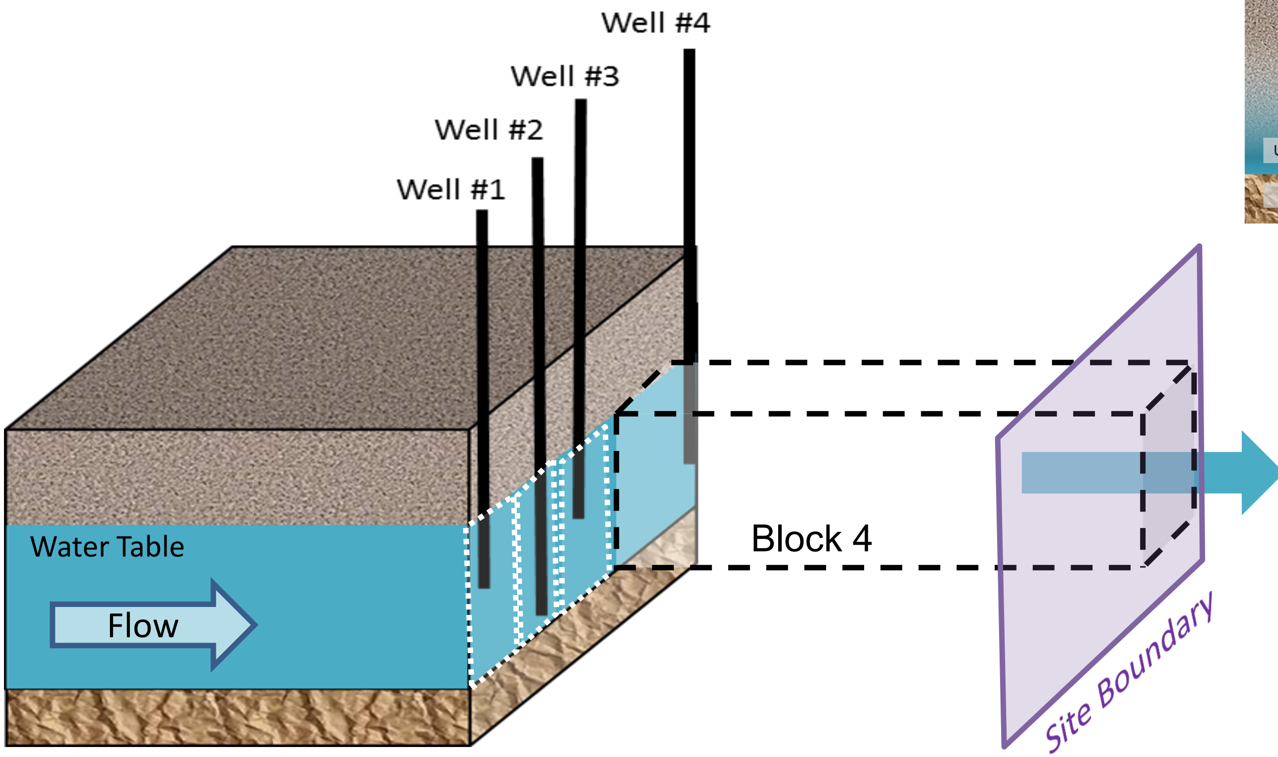
Appendix Model Background: Subdividing Monitoring Wells Transect into Modeling Blocks





Appendix Model Background: Tritium Flux Calculations





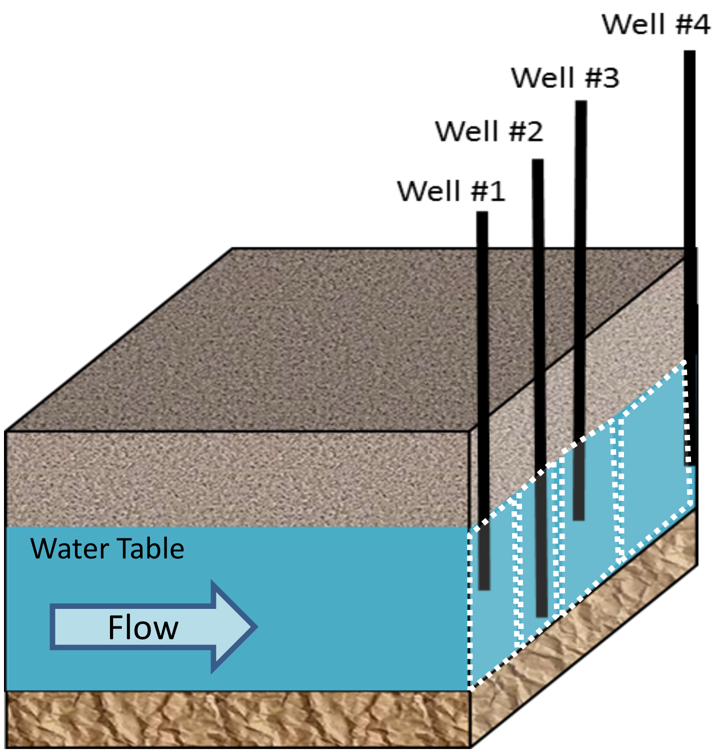
What is the tritium flux at site boundary for Block 4?

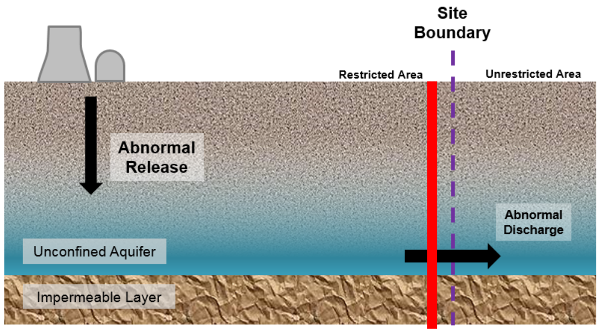
To Calculate Tritium Flux We Need to Know:

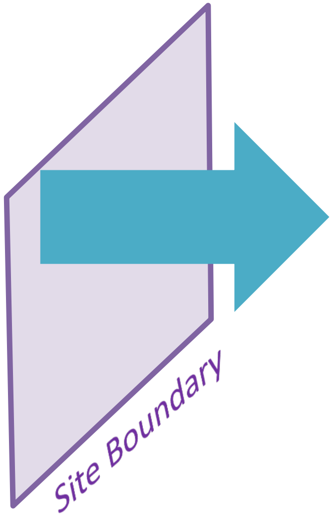
1. Tritium concentration of Block 4 (use well data records)
2. Bulk water flux of Block 4 (use Darcy's Law)

$$Tritium\ Flux\left[\frac{pCi}{day}\right] = Tritum\ Concentration\left[\frac{pCi}{L}\right] \times Bulk\ Water\ Flux\ [\frac{L}{day}]$$

Appendix Model Background: Total Tritium Flux Calculations







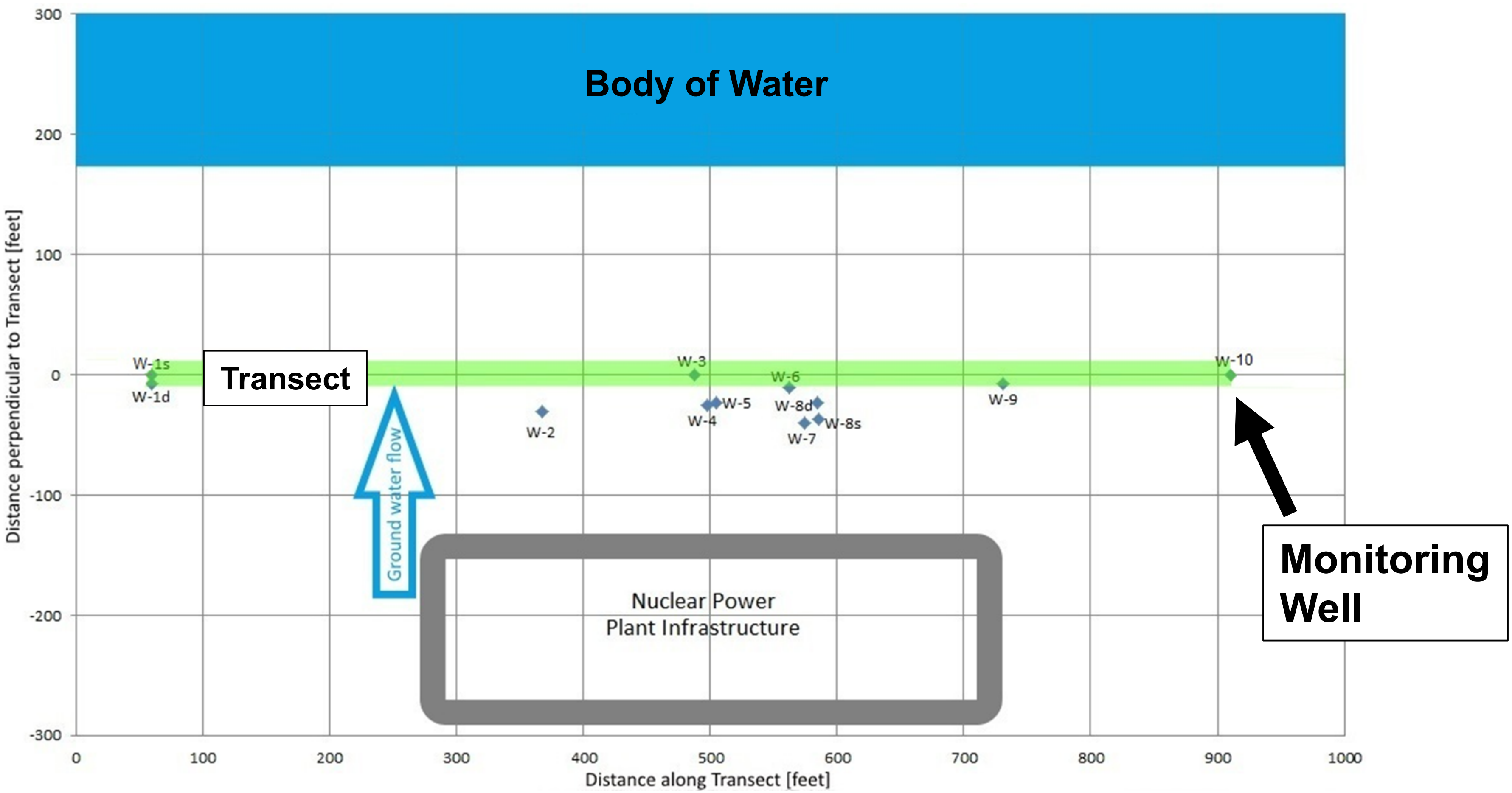
What is the TOTAL tritium flux at site boundary?

$$Total\ Tritium\ Flux\ \left[\frac{pCi}{day}\right] = \sum_{i=1}^{n}(Tritium\ Flux)_i$$ for n blocks

RG 4.25 Appendix Model

Simple Ground Water Model for
Estimating Subsurface Tritium Discharges
to Unrestricted Areas: Example

RG 4.25 Appendix Model: Aerial View



RG 4.25 Appendix Model: 2-D Transect

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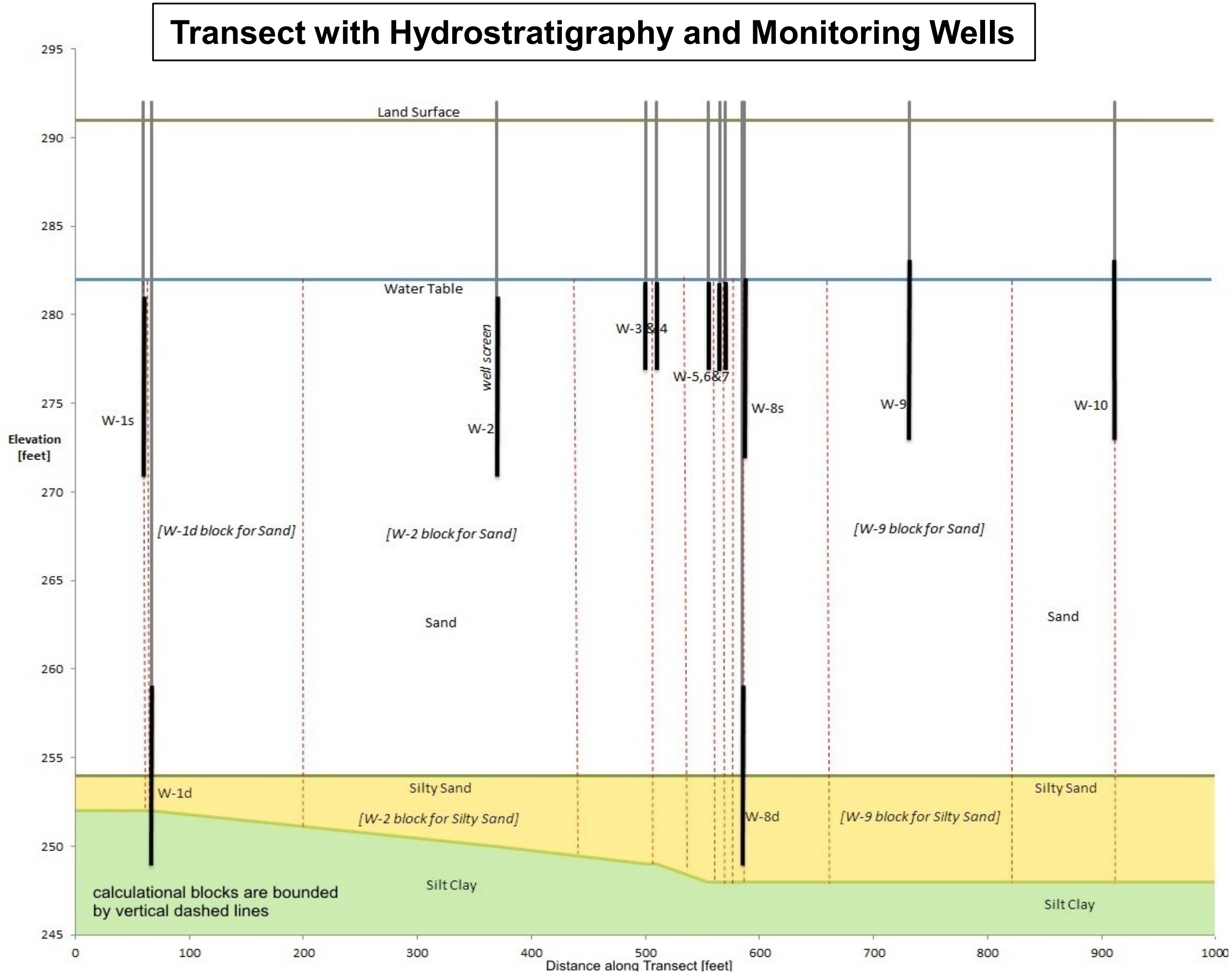

RG 4.25 Appendix Model: 2-D Transect and Modeling Blocks*

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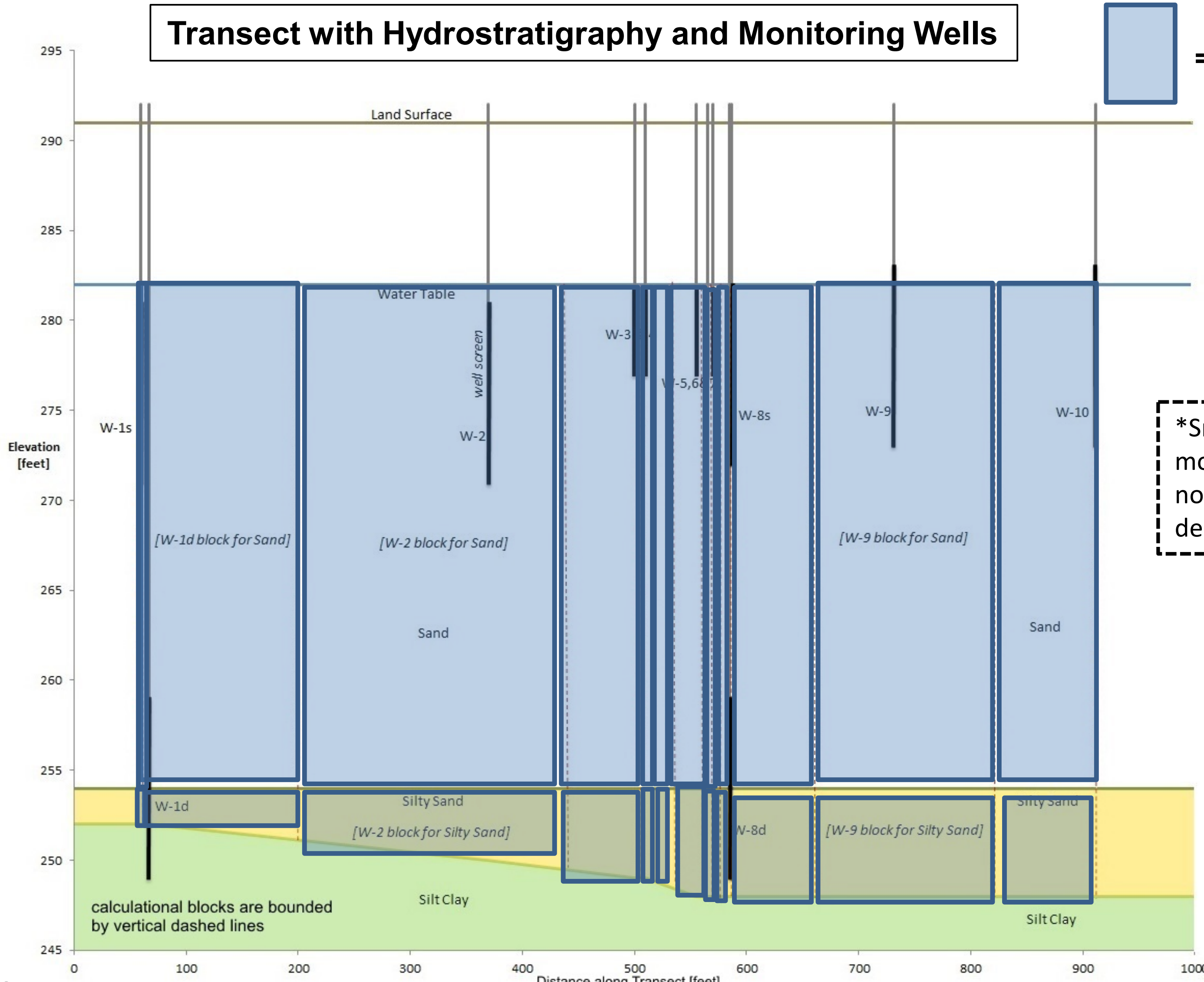

*Smallest modeling blocks not visually depicted

RG 4.25 Appendix Model: Overview

Worksheet in MS Excel™

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Site Hydraulic Properties

Material Properties:	K [ft/day]	Hydraulic Gradient	Specific Discharge [ft/day]	Porosity	Seepage Velocity [ft/day]
Sand	86.4	0.008	*0.6912*	0.3	*2.304*
Silty Sand	43.2	0.008	*0.3456*	0.3	*1.152*

The seepage velocity is the specific discharge, q divided by the porosity. The bulk water flux through a "modeling block" is the specific discharge times the modeling block area which is the width of the block times the saturated thickness of the block.

Well and Modeling Block Geometries

Bulk Water Flux Calculations

			W-1s	W-1d	W-2	W-3	W-4	W-5	W-6	W-7	W-8d	W-8s	W-9	W-10
Well or Boring ID			W-1s	W-1d	W-2	W-3	W-4	W-5	W-6	W-7	W-8d	W-8s	W-9	W-10
Distance along Transect [ft]			60	67	370	500	510	555	565	570	585	587	731	911
Elevations	Water Table		282	282	282	282	282	282	282	282	282	282	282	282
	Base of	*Sand*	254	254	254	254	254	254	254	254	254	254	254	254
		Silty Sand	252	252	250	249	249	248	248	248	248	248	248	248
	Screened Interval	Top	281	254	281	282	282	282	282	282	254	282	283	283
		Bottom	271	249	271	277	277	277	277	277	249	272	273	273
Modeling Blocks	Width [feet]		*3.5E+00*	*1.6E+02*	*2.2E+02*	*7.0E+01*	*2.8E+01*	*2.8E+01*	*7.5E+00*	*1.0E+01*	*8.5E+00*	*7.3E+01*	*1.6E+02*	*9.0E+01*
	Thickness [feet]	*Sand*	*2.8E+01*	*2.8E+01*	*2.8E+01*	*2.8E+01*	*2.8E+01*	*2.8E+01*	*2.8E+01*	*2.8E+01*	*2.8E+01*	*2.8E+01*	*2.8E+01*	*2.8E+01*
		Silty Sand	*2.0E+00*	*3.0E+00*	*3.5E+00*	*4.5E+00*	*5.5E+00*	*5.5E+00*	*6.0E+00*	*6.0E+00*	*6.0E+00*	*6.0E+00*	*6.0E+00*	*6.0E+00*
Bulk Water Flux [cubic ft/day]		*Sand*	*6.8E+01*	*3.0E+03*	*4.2E+03*	*1.4E+03*	*5.3E+02*	*5.3E+02*	*1.5E+02*	*1.9E+02*	*1.6E+02*	*1.4E+03*	*3.1E+03*	*1.7E+03*
		Silty Sand	*2.4E+00*	*1.6E+02*	*2.6E+02*	*1.1E+02*	*5.2E+01*	*5.2E+01*	*1.6E+01*	*2.1E+01*	*1.8E+01*	*1.5E+02*	*3.4E+02*	*1.9E+02*
Total Water Flux:		*1.8E+04*	cubic ft/day											

Useful Background Information

The tritium flux equation:

Tritium flux = Q*C*28.3168

where:

- Q = bulk water flux [cubic ft/day]
- C = tritium concentration [pCi/l]
- 28.3168 = the number of liters in a cubic foot.

Time of Travel to Large Body of Water (~175 feet away from the Transect):

Sand	*76*	days
Silty Sand	*152*	days

Since Tritium has a 4500 day halflife, there will be minimal decay from the time that it passes through the transect to the time that it enters the body of water; i.e., we wouldn't expect the concentrations to decrease much simply due to radioactive decay, but we'll calculate it on the "ActivityFlux" worksheet.

RG 4.25 Appendix Model: Tritium Concentration Data for 1 Year

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Tritium Concentrations in Monitoring Wells

	Date	Layer	W-1s	W-1d	W-2	W-3	W-4	W-5	W-6	W-7	W-8d	W-8s	W-9	W-10
Representative Tritium Concentrations for each Modeling Block [pCi/l]	10/15/2009	Sand	ND	ND	ND	ND	ND	ND	724	2238	20018	20018	ND	ND
		Silty Sand	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	11/15/2009	Sand	ND	ND	ND	ND	ND	ND	ND	24769	217351	217351	ND	ND
		Silty Sand	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	12/15/2009	Sand	ND	ND	ND	ND	ND	ND	ND	6769	40828	40828	ND	ND
		Silty Sand	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	01/15/2010	Sand	ND	ND	1046	ND	ND	ND	ND	47432	11029	11029	ND	ND
		Silty Sand	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	02/15/2010	Sand	ND	ND	1509	ND	ND	ND	ND	28324	889	889	ND	ND
		Silty Sand	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	03/15/2010	Sand	ND	ND	2696	ND	ND	ND	ND	24707	647	647	ND	ND
		Silty Sand	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	04/15/2010	Sand	ND	ND	2688	ND	ND	ND	ND	8752	8126	8126	ND	ND
		Silty Sand	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	05/15/2010	Sand	ND	ND	1707	ND	ND	ND	ND	13234	1492	1492	ND	ND
		Silty Sand	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	06/15/2010	Sand	ND	ND	2083	ND	ND	ND	ND	6902	7701	7701	ND	ND
		Silty Sand	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	07/15/2010	Sand	ND	ND	2944	ND	ND	ND	ND	5495	1886	1886	ND	ND
		Silty Sand	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	08/15/2010	Sand	ND	ND	ND	ND	ND	ND	ND	4722	1160	1160	ND	ND
		Silty Sand	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	09/15/2010	Sand	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
		Silty Sand	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

"ND" (Not Detected) – For calculational purposes, when tritium in ground water is not detected, the model assumes a zero concentration

RG 4.25 Appendix Model: Tritium Concentration Data for 1 Year

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Tritium Concentrations in Monitoring Wells

	Date	Layer	W-1s	W-1d	W-2	W-3	W-4	W-5	W-6	W-7	W-8d	W-8s	W-9	W-10
Representative Tritium Concentrations for each Modeling Block [pCi/l]	10/15/2009	*Sand*	ND	ND	ND	ND	ND	ND	724	2238	20018	20018	ND	ND
		Silty Sand	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	11/15/2009	*Sand*	ND	ND	ND	ND	ND	ND	ND	24769	217351	217351	ND	ND
		Silty Sand	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	12/15/2009	*Sand*	ND	ND	ND	ND	ND	ND	ND	6769	40828	40828	ND	ND
		Silty Sand	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	01/15/2010	*Sand*	ND	ND	1046	ND	ND	ND	ND	47432	11029	11029	ND	ND
		Silty Sand	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	02/15/2010	*Sand*	ND	ND	1509	ND	ND	ND	ND	28324	889	889	ND	ND
		Silty Sand	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	03/15/2010	*Sand*	ND	ND	2696	ND	ND	ND	ND	24707	647	647	ND	ND
		Silty Sand	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	04/15/2010	*Sand*	ND	ND	2688	ND	ND	ND	ND	8752	8126	8126	ND	ND
		Silty Sand	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	05/15/2010	*Sand*	ND	ND	1707	ND	ND	ND	ND	13234	1492	1492	ND	ND
		Silty Sand	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	06/15/2010	*Sand*	ND	ND	2083	ND	ND	ND	ND	6902	7701	7701	ND	ND
		Silty Sand	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	07/15/2010	*Sand*	ND	ND	2944	ND	ND	ND	ND	5495	1886	1886	ND	ND
		Silty Sand	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	08/15/2010	*Sand*	ND	ND	ND	ND	ND	ND	ND	4722	1160	1160	ND	ND
		Silty Sand	ND	ND	ND	[illegible]	[illegible]	[illegible]	[illegible]	ND	ND	ND	ND	ND
	09/15/2010	*Sand*	ND	ND	ND	[illegible]	[illegible]	[illegible]	[illegible]	ND	ND	ND	ND	ND
		Silty Sand	ND	ND	ND	[illegible]	[illegible]	[illegible]	[illegible]	ND	ND	ND	ND	ND

"ND" (Not Detected) – For calculational purposes, when tritium in ground water is not detected, the model assumes a zero concentration

Tritium plume detection

RG 4.25 Appendix Model: Tritium Flux Calculations

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Date	Layer	Tritium Flux through each Modeling Block [pCi/da							
10/15/2009	Sand	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.98E+06	1.23E+07
	Silty Sand	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/15/2009	Sand	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.36E+08
	Silty Sand	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
12/15/2009	Sand	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.71E+07
	Silty Sand	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
01/15/2010	Sand	0.00E+00	0.00E+00	1.24E+08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.60E+08
	Silty Sand	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
02/15/2010	Sand	0.00E+00	0.00E+00	1.79E+08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.55E+08
	Silty Sand	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Tritium Flux [pCi/day] **=** Bulk water flux [ft^3/day] **x** Tritium Concentration [pCi/L] **x** 28.31 L/ft^3

Source: Overview Worksheet **Source: Tritium Concentration Worksheet** **Conv. Factor**

RG 4.25 Appendix Model: Tritium Flux Calculations

Summation Table

Total Transect Tritium Flux						
	Sand			*Silty Sand*		
Date	**pCi/day**	**Ci/day**	**Ci/year**	**pCi/day**	**Ci/day**	**Ci/year**
10/15/2009	*9.09E+08*	*9.09E-04*	*3.32E-01*	*0.00E+00*	*0.00E+00*	*0.00E+00*
11/15/2009	*9.84E+09*	*9.84E-03*	*3.60E+00*	*0.00E+00*	*0.00E+00*	*0.00E+00*
12/15/2009	*1.86E+09*	*1.86E-03*	*6.80E-01*	*0.00E+00*	*0.00E+00*	*0.00E+00*
01/15/2010	*8.77E+08*	*8.77E-04*	*3.20E-01*	*0.00E+00*	*0.00E+00*	*0.00E+00*
02/15/2010	*3.74E+08*	*3.74E-04*	*1.37E-01*	*0.00E+00*	*0.00E+00*	*0.00E+00*
03/15/2010	*4.84E+08*	*4.84E-04*	*1.77E-01*	*0.00E+00*	*0.00E+00*	*0.00E+00*
04/15/2010	*7.30E+08*	*7.30E-04*	*2.67E-01*	*0.00E+00*	*0.00E+00*	*0.00E+00*
05/15/2010	*3.42E+08*	*3.42E-04*	*1.25E-01*	*0.00E+00*	*0.00E+00*	*0.00E+00*
06/15/2010	*6.29E+08*	*6.29E-04*	*2.30E-01*	*0.00E+00*	*0.00E+00*	*0.00E+00*
07/15/2010	*4.64E+08*	*4.64E-04*	*1.69E-01*	*0.00E+00*	*0.00E+00*	*0.00E+00*
08/15/2010	*7.77E+07*	*7.77E-05*	*2.84E-02*	*0.00E+00*	*0.00E+00*	*0.00E+00*
09/15/2010	*0.00E+00*	*0.00E+00*	*0.00E+00*	*0.00E+00*	*0.00E+00*	*0.00E+00*
12-Month Tritium activity discharge (at transect):			*5.05E-01* Curies			*0.00E+00* Curies
2010 annual activity discharge from each layer:			*4.99E-01* Curies			*0.00E+00* Curies
2010 Annual Total Tritium Activity discharged via ground-water to water body:					*4.99E-01*	Curies
2010 Transect Average Tritium Concentration discharged to water body:					*2.71E+03*	pCi/l

RG 4.25 Summary

- The endorsed industry-consensus standard, ANSI/ANS 2.17-2010 (R2016), provides a method acceptable for use to evaluate the occurrence and movement of radionuclides in the subsurface resulting from abnormal radionuclide releases at nuclear power plant sites

- Public comments received and addressed

- Plan to publish RG 4.25 in May 2017

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QUESTIONS?