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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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606TH MEETING

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

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WEDNESDAY

JULY 10, 2013

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ROCKVILLE, MARYLAND

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The Advisory Committee met at the Nuclear Regulatory Commission, Two White Flint North, Room T2B1, 11545 Rockville Pike, at 8:30 a.m., J. Sam Armijo, Chairman, presiding.

COMMITTEE MEMBERS:

J. SAM ARMIJO, Chairman

JOHN W. STETKAR, Vice Chairman

HAROLD B. RAY, Member-at-Large

SANJOY BANERJEE, Member

DENNIS C. BLEY, Member

CHARLES H. BROWN, JR. Member

MICHAEL L. CORRADINI, Member

DANA A. POWERS, Member

JOY REMPE, Member
MICHAEL T. RYAN, Member
STEPHEN P. SCHULTZ, Member
WILLIAM J. SHACK, Member
GORDON R. SKILLMAN, Member

ACRS CONSULTANTS PRESENT:

RONALD BALLINGER, ACRS Member Elect
PETER RICCARDELLA, ACRS Member Elect

NRC STAFF PRESENT:

HOSSEIN NOURBAKHSH, Designated Federal Official
JONATHAN BARR, RES/DSA/AAB
ANDREW CARRERA, FSME/DILR
DAVE ESH, FSME/DWMEP
ED FULLER, RES/DSA
MELANIE GALLOWAY, NRR/DLR
TINA GHOSH, RES/DSA/AAB
KATHY HALVEY GIBSON, RES/DSA
CHRISTOPHER GROSSMAN, FSME/DWMEP
DEBORAH JACKSON, FSME/DILR
CHRIS McKENNEY, FSME/DWMEP
PAT SANTIAGO, RES/DSA

ALSO PRESENT:

JOE JONES, Sandia National Laboratory*

LINDA SUTTORA, U.S. DOE

*Participating via telephone

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P R O C E E D I N G S

8:29 a.m.

CHAIR ARMIJO: Good morning. The meeting will now come to order. This is the second day of the 606th Meeting of the Advisory Committee on Reactor Safeguards. During today's meeting the Committee will the following:

(1) State-of-the-art reactor consequence analyses/uncertainty analyses;

(2) Proposed revision to 10 CFR Part 61; and

(3) Preparation of ACRS reports.

The meeting is being conducted in accordance with the provisions of the Federal Advisory Committee Act. Mr. Hank Hossein Nourbakhsh is the Designated Federal Official for the initial portion of the meeting.

We have received no written comments or requests to make oral statements from members of the public regarding today's session.

There will be a phone bridge line. And I believe Sandia has some people on that line. To preclude interruption of the meeting, the phone will be placed in a listen in mode during the presentations and Committee discussion.

A transcript of portions of the meeting is being kept. And it is requested that the speakers use one of the microphones, identify themselves and speak with sufficient clarity and volume so that they can be readily heard.

Before starting the meeting, I'd like to introduce a new member, Member Elect Dr. Pete Riccardella who is joining us for the first time today. Dr. Riccardella offers 45 years of experience in the nuclear industry. In particular, he is an authority on the application of fracture mechanics to nuclear pressure vessels and piping problems.

Dr. Riccardella has had significant involvement with the American Society of Mechanical Engineers during his career. In 2001, he became an honorary member of the ASME Section 11 Subcommittee on Nuclear Power Plant In-service Inspection. And in 2005 was named an ASME fellow.

Dr. Riccardella was a founding member of Structural Integrity Associates which has been an industry leader in failure prevention and failure analysis for the nuclear industry. Welcome aboard, Pete.

(Applause.)

With that, I'd like to now turn the

meeting over to Dr. Bill Shack who will introduce the presentation.

MEMBER SHACK: Okay. We're going to discuss the SOARCA Peach Bottom uncertainty analysis today. Again, we had a preliminary review of this report back in April of 2012.

I think it's important because in many ways it's the most ambitious attempt to characterize uncertainty and a fairly complex problem we've had since NUREG-1150. And so it's interesting to look at the accumulation of knowledge and techniques that's been developed since that time.

And we sort of think of it as representing perhaps the state-of-the-art in uncertainty analysis. This is why it merits a considerable amount of attention from the Committee. And I'll turn it over to the staff.

MEMBER POWERS: Dr. Shack, before we turn that over to the staff, I will acknowledge an organizational conflict of interest with this work. I did not participate in any aspect of the work, but it is sufficiently closely involved with my organization. I will not be participating in any way in this discussion.

MS. GIBSON: Yes, I just wanted to

acknowledge our partners at Sandia that are on the phone that worked closely with us on this project.

And as you noted, you often ask us questions during these presentations about uncertainty. And our answer is usually about the sensitivity analysis that we've done. This time we can actually answer your questions on uncertainty. And we're very proud of that.

And I wanted to just take a minute to thank you for the previous times that we've briefed you on this uncertainty analysis approach that is somewhat unique and novel, the chosen parameters and the insights from the preliminary analysis. We also got input on those things from our SOARCA External Peer Committee.

So we've had quite a few brilliant minds on this project. And we're excited for you to hear about the completed project and the good work that Tina and her team at Sandia, others in the NRC and a few other contractors on this project.

But, first, I'll introduce Jonathan Barr of my staff. He's the project manager for SOARCA.

MR. BARR: Thanks. I'm a reactor systems engineer in the Office of Research in the Accident Analysis Branch and probably the last project manager for the SOARCA project.

(Laughter.)

I'll just sort of introduce this and talk about the agenda. And then Tina will discuss the actual uncertainty analysis.

MEMBER SHACK: There's a Surry uncertainty analysis coming. You're young enough.

MEMBER STETKAR: This is a career path.

MS. GIBSON: He's the 12th project manager we've had for the SOARCA project.

MEMBER REMPE: He's coming in for the home run though.

MR. BARR: It's a big project. So I'll start with a little background on the best estimate analysis and where that stands.

And then Tina will start with the conclusions of the uncertainty analysis, the distribution of results. She'll talk about the most influential parameters, a comparison of weather uncertainty to the epistemic uncertainty.

And then she'll get to some separate sensitivity analyses that were done on various issues. She'll touch on a few other areas of content in the uncertainly analysis report.

And then I'll finish up with some next

steps and path forward for bringing this report to final publication.

The best estimate analysis for SOARCA is documented in four primary reports which I have here, the main report. We have the nice color brochure and then we have the two thick reports for each of the two pilot plants studied, Peach and Surry.

Those four went public in January of 2012. In the following time, we received comments from the public and held some meetings with the public. Also a RIC meeting to get some feedback. We then revised all four of the documents to address some comments, add some clarification in certain sections.

The four reports were then sent to the Commission in June of last year along with a Commission paper in which we provided the conclusions of the study and also recommendations for some follow-on research. You heard mention the Surry uncertainty analysis which is one of them. And then a similar type of analysis to the Peach Bottom and Surry analysis for an ice condenser plant.

In December of last year, the Commission sent us an SRM approving those recommendations based on available resources and relative priorities with other high priority projects, notably a Level 3 PRA project.

We published the final version of the main report in November of last year. The brochure went final the following month. And then more recently we have the technical reports going final. There's a very long queue in the publishing office. It takes a long time for them to review these and get these out.

MEMBER STETKAR: Jonathan, before you leave this, something that I really need to understand. You have a bullet that says those were best estimate analysis reports. The results of the uncertainty analysis in most cases showed that the mean value of the results is substantially different from the results in those reports.

So I need to understand how you as the staff define the words "best estimate." We usually define best estimate as either the mean, the expected value of something, accounting for the uncertainty. Some people say that it's the median because there's an equal likelihood that a value could be higher or lower than that.

But regardless of whether I use the mean or the median, the numbers in those other reports differ quite substantially from the numbers in the uncertainty analysis. I'd like to understand how the staff defines the term best estimate.

DR. GHOSH: I think we had a discussion about this last April. And we tried to explain what we did for the best estimate. In fact, while we were doing the uncertainty analysis, the team thought very long and hard about whether we should update the best estimate if there was anything that we had found that would cause us to think that what we had done for the deterministic analysis was not right.

And in the end we decided that we would keep the SOARCA project estimates as they were for the following reasons. That was a deterministic analysis as you know. And what was done was the best sort of collective knowledge in terms of the severe accident modeling community, both from MELCOR and MACCS.

For each parameter the kind of best value was chosen in terms of what collectively we thought is the appropriate value for any given single parameter. And those were plugged in to a deterministic analysis to get what was called the best estimate result.

As you know in the uncertainty analysis, quite a few of the results turned out to be in terms of the release magnitudes and also the health risk turn out to be higher. And that's primarily because we ended up having two additional subscenarios within the long-term station blackout.

So the SOARCA scenario was the one where we have an early stochastic SRV failure which is one group of scenarios in the uncertainty analysis. But in the uncertainty analysis we had some that progressed to a main steamline creep rupture where you have a significantly higher release or one where the SRV failed quite a bit later which allowed core damage to begin before you had SRV failure. And there you had higher releases, too.

The one we evaluated, the entire body of knowledge that we had, the team still felt pretty confident that the most likely scenario was still an early failure of the SRV. And we talked about this in April as well that one of the challenges we had in trying to assign the distributions. We don't have any data. We don't have any hard experimental data or certainly not any real life data where we have SRV testing at severe accidents and pressures and temperatures.

So we took our best guess at coming up with the distributions, the failure distributions, for those parameters. But the truth is that it's highly uncertain. We don't know what the real distributions of those parameters are.

MEMBER BANERJEE: Could I ask you a question here?

DR. GHOSH: Yes.

MEMBER BANERJEE: We deal with this all the time. If you don't know the distributions, you can do non-parametric statistics, a sampling of these. And you can get a measure of the uncertainty provided you know the bounds. And this is commonly done all the time.

DR. GHOSH: Right. We're not sure we even know the bounds. I think that's --

MEMBER BANERJEE: You don't need to know the distributions. That's all I'm saying.

MEMBER STETKAR: One of the points, we're going to be short on time here. So I don't want to belay this too much. The fact of the matter is even if you look at some of the uncertainty distributions after you've had your experts go back and really think about the uncertainties. The mean values of even the parametric uncertainties in many cases are different from the point values that you use.

Forget the overall results for the moment. Even on a piece parts case, when you went back and thought carefully about the uncertainties the experts or the available data or whatever process you used to develop those uncertainty distributions resulted in different mean values or different median values from what was characterized as the expert's best estimate, using these words, before they thought about the uncertainty.

And the only point and we talked about this in April is that the way studies ought to be done is the experts and the data ought to be minded for the available uncertainties first and derive a best estimate from that. And then in some sense you might be able to characterize those point estimate deterministic analyses as may be close to what you would expect the best estimate to be.

And the only reason I raise this is going forward in the uncertainly analysis report you've established the term "SOARCA base case" or something like that to kind of characterize the 7110 results if you will which is fine.

But here now we're starting to see these words "best estimate" again. And they start to tend to take a life of their own. People start to defend them as if they're what we really should characterize as a best estimate result.

So I caution you going forward. I mean

you're not going to rewrite those NUREGs but going forward to be really sensitive to that.

MEMBER CORRADINI: So can I just ask it differently? In the short one, the only one that anybody will read, the pretty one, does it say best estimate or does it say base case? I think that's what John is getting to. From an illustrative standpoint, I assume it says base case, a deterministic base case, engineering base case rather than best estimate.

MR. BARR: I think that this one does not use either of those terms because this only minimally discusses the uncertainty analysis.

MEMBER CORRADINI: But what do you characterize the deterministic analysis as? I do think to the extent that engineers have this tendency to run out there and do a calculation.

MEMBER STETKAR: I just did a word search. Best estimate doesn't appear in that document.

MEMBER BLEY: I want to follow up a little bit because what I thought I heard you say is after you went to all the effort to do the full uncertainty analysis and put in the best distributions including the limits that you could come up with you have more confidence in your base case analysis than you do in the uncertainty analysis. And that I don't understand at all.

DR. GHOSH: I think it's more that the same team that did the SOARCA project also we had the same subject matter experts for the uncertainty analysis. And it's more that we revisited what had been done in the SOARCA project to see if we had uncovered anything that we would have changed, that we should said, "No, we did it wrong. We can't call this" -- I don't want to use the words best estimate anymore but that we would have updated the SOARCA project NUREGs.

In the end, the thought was that we wouldn't. The original project as it was including the values that were chosen for the parameters if we had to do a deterministic study, it's still our best guess.

As I mentioned for some of the key distributions in the uncertainty analysis there was so little data to go on in terms of assigning the distribution. Again, we kind of used the collective wisdom of the team.

MEMBER BLEY: That's what you use for the point estimates as well.

DR. GHOSH: Yes, and it's the same group

of people.

MEMBER BLEY: It's the same limited data. But the uncertainty analysis allowed you to at least encompass the range that you thought would be involved.

DR. GHOSH: Right. So some of those distributions are fairly wide. Part of the thinking was that we have a good guess. If we had to pick one number we're confident that this is the good number to pick. But since we don't really know we want to see --

We think that it might be and I think you saw some of the distributions. It might be an order of magnitude higher. It may be five times higher. You know double. Whatever it was for the particular parameters. It might be, but we don't think that's the most likely.

MEMBER STETKAR: Tina, you have to be careful here because some of the things that I'm hearing you say is that people didn't think very carefully about those uncertainties.

DR. GHOSH: No, no, that not it at all.

MEMBER STETKAR: I mean if they really believe the uncertainties, the ranges and the shapes of the distributions, then their real belief is that the expected value is the expected value. They should feel confident in that expected value because they've carefully thought about how large it could be, how small it could be and the shape of the probability in between those bounds whether it's flat or pumped up in the middle or skewed out or however you want to characterize it.

MEMBER CORRADINI: Before she answers, can I ask a question? I guess you guy are going to go on about this which is great. But I want to ask from a process standpoint if this was like 1150 where I prepared in it and I assume this is what you mean by the subject matter experts.

I would assume there's a lot of healthy discussion about what the range is and what the shape is, at least the range. Forget about the shape. The shape I would make it uniform just because I don't know what it is.

DR. GHOSH: Yes.

MEMBER CORRADINI: But the argument about the ranges. What I guess John is asking is if somebody has a real belief that they're sure it's early failure of the SRV and they fight for that, did the ranges that eventually come out of this uncertainty, just the collective population had said, that person A was absolutely sure it was early term? And he could have a deterministic reason. And subject matter expert B was very uncertain and because of just the range of the subject matter. In other words, you took a wide range.

That at least in 1150 is how we got to wide ranges because person A was sure it was this way and person B was sure it was this way. And to cover the bases of all the subject matter experts, you've got a wide range with a uniform distribution. So I'm trying to think of the evolution of how you determined it.

DR. GHOSH: I would characterize the distributions we settled on as consensus distributions. It's not that each expert had a distribution and we averaged them or something. We collectively decided on what is a distribution that we could live with.

MEMBER BANERJEE: Could I ask you the question again?

DR. GHOSH: Yes.

MEMBER BANERJEE: Why this focus on parametric statistics as opposed to nonparametric? Why do you put this emphasis on the shape of the distribution?

DR. GHOSH: I apologize if I'm unduly putting emphasis on the shape. I mean everything, both the range and the shape. I think we have more confidence in terms of coming up with a good range. The shape is even harder within the range.

But you know we know from past uncertainty analyses that the range is more important in looking at the --

MEMBER BANERJEE: So you know what I'm referring to. The Wilkes theorem, right.

DR. GHOSH: Yes, yes.

MEMBER BANERJEE: So why is this? Do you ignore this? Is it unimportant?

DR. GHOSH: No. It's just the only thought I --

MEMBER BANERJEE: I'm just trying to understand why this emphasis on shape.

DR. GHOSH: It's not just on the shape. I think that the bottom line is that for some of the -- And we say this in the report. I think we're very explicit.

MEMBER SHACK: But the input parameters eventually end up that they have to have a shape.

MEMBER STETKAR: There may be a shape if indeed there's a state of knowledge or some data to support a higher probability somewhere in that range. So it just doesn't mean that we don't know anything about everything.

MR. FULLER: Excuse me. Can I offer something here that might straighten out this discussion a little bit?

CHAIR ARMIJO: Tell us who you are.

MR. FULLER: This is Ed Fuller, Senior Technical Advisor in the Office of Research. I think looking back at the results of this study there are certain biases in a couple of the distributions which emphasize one end of the range or another. And those biases as you'll probably hear particularly with respect to safety relief valve behavior have to do with what the situation becomes when the temperatures get very hot in the safety valves and the stems and so forth.

And so the biases towards failure at that time. And you can put a uniform distribution in if you want. And the stochastic approach is somewhat that way. You know if you look at this issue you see there is early stochastic failure is one of the possibilities which SOARCA looked at.

And then you have also looked at in SOARCA what happens when the valves get hot, when the main steam line gets hot. And then you get the possibility that certain things could be induced after that.

So you have to draw the distinction between the early part of the distribution which is fairly linear. And then later on when you really get the bias towards the high temperatures.

MEMBER BLEY: Before you leave, Ed, it seems to me that what you're calling a bias is what you folks put into the distribution to account for the fact that you don't fully understand the performance up at that end.

MR. FULLER: That's true because no data.

MEMBER BLEY: Which seems a reasonable thing to do.

MR. FULLER: Yes.

MEMBER BLEY: And I would then tend to acknowledge that that's part of the thing that might drive a mean up. But it's reasonable. It's the best engineering judgment you have.

If you gave that kind of thought to the way you did the distributions, it seems to me the results of the uncertainty analysis is what you want it to be.

MEMBER STETKAR: That's the thing you ought to believe in.

MEMBER BLEY: Yes.

DR. GHOSH: So let me -- Sorry.

MR. FULLER: May I sit down now?

MEMBER BLEY: Yes.

DR. GHOSH: Let me, I guess I'll say one other thing and then maybe we can talk more as we go along. One of the things that we think is most valuable from doing this uncertainty analysis even though we are not completely sure of a lot of the important parameters, exact distributions or ranges, the main thing is we wanted to see when you put everything together which set of parameters is really driving the uncertainty in your consequences. And that's kind of the most valuable thing that we get out of it.

The exact probability distributions I wouldn't put as much weight on because there's a lot of uncertainty in what we put into it. But we learned a lot in terms of what is potentially important, which parameters interact together.

And like other past projects, when you have very complex systems with synergistic effects and so on, you can have hundreds of uncertain parameters. But in the end it's really just a handful of things that are really driving the uncertainty in your results. And that's kind of what we were after. And I think we did get a lot of valuable insights on that.

The exact minute probabilities of the various outcomes I would not put as much emphasis on as understanding the entire range of system behavior and what are the important uncertainties that are driving that behavior.

MEMBER BLEY: I agree with you a lot. My last comment is if you have trouble believing that you've got the exact range exactly right why are you confident that you have some point estimate right? I mean you've got the same factor effecting and at least you're acknowledging that uncertainty when do the uncertainty analysis. You're not just picking one out of the cloud.

Go ahead.

MEMBER REMPE: Just quickly I've heard the informal discussion, but I didn't see it in the report. Maybe I missed it because it is a long report. But there is a lot of documentation somewhere on the input parameters. Because expert opinions will vary when you get a new set of experts.

And the thought processes, I think that should be emphasized somewhere that maybe I don't miss in the report if it's not in the report now. But that the process has been documented. So in the future if people go back and look at a particular parameter, they can trace what has been done a bit more. And that's true.

DR. GHOSH: We tried to, after we met last April, beef up the documentation namely in Chapter 4 on the parameter distributions themselves. And we put in some additional discussion in Chapter 1 in terms of our overall process. But we can revisit that again.

MEMBER REMPE: Especially with the higher level surrogate parameters. I could not find a discussion that explained what particular lower level parameters went into this higher level ones and how the process is done. But that is documented somewhere.

DR. GHOSH: Okay. We will revisit that and make sure that there is enough there. We tried to do more, but it's one of those things when you're the people doing the work. It may seem like you've said everything there is to say.

MEMBER REMPE: I could have missed it, too. But I think that's something that I would be very interested in seeing information on.

DR. GHOSH: Yes. Thanks. We'll take another look at that.

MR. BARR: Finish up with the background area, in addition to the primary SOARCA reports we have few others that support them. We are almost finished with the best practices report for each of the two codes views, MELCOR and MACCS, that describe best practices for using those codes in these type of analyses and highlight some of the differences between models and parameter values compared to test studies.

And then also a report that described distributions for non site specific parameters for offsite consequence was completed recently. And this is also referenced heavily in the Peach Bottom uncertainly analysis.

We briefed the ACRS last April, the Subcommittee, and then May of last year in the full Committee. And we're now here today. And then we'll talk maybe at the end if the group decides that there should be another meeting later on.

DR. GHOSH: Okay. So I'm going to start with the overall conclusions. I think we might have shared some of this back in April because we already had some insights. But I'll just repeat them here.

One of the main objectives of the uncertainty analysis was to see whether the SOARCA results and conclusions were robust, knowing that there is a lot of uncertainty in the systems. And after doing this study, we would say that the uncertainty analysis corroborates the SOARCA study conclusions, the following conclusions, that public health consequences from severe nuclear accident scenarios, the ones that were modeled, are smaller than we had previously calculated. And in absolute terms, they're very small.

We see that even with a lot of the uncertainty we see in the source terms. The releases are still delayed enough that there is enough time to take the protective action measures such as evacuation and the long-term base still dominates the health risk. This is from people coming back to their homes if they've had to be evacuated.

There is essentially zero early fatality risk. We say "essentially zero" because we have very powerful computers. And we can calculate extremely small numbers.

So in a handful of the realizations we did we did calculate a number. But it is so small that a lot of people just kind of laugh when they see numbers in those ranges. But the computers did calculate non-zero number. But we say essentially zero early fatality risk.

This insight which we already knew last year and we already shared with you, a major determinant of the source term magnitude and the health consequences is whether or not we see a main steam line rupture. And that is, of course, if you have a main steam line rupture it bypasses the wet well scrubbing. So it's leads to higher consequences. And in some subset of the realizations we did see a main steam line rupture.

The health effect risks vary sublinearly with source term and this is again because the long-term phase dominates the health risk. And people are not allowed to come back until the dose is below what we call the habitability criterion. Some people call it the return criterion which is EPA has guidelines and each state sets its own. So we use the Pennsylvania State guideline for that.

And we saw that our analysis confirmed the known importance of some things that we already knew going into the analysis and we certainly also got some new phenomenalogical insights. And I'll talk about that a little bit later.

And we saw that using multiple techniques to post-process the Monte Carlo results was much better at providing an explanation of which sets of variables together were driving the uncertainty in the results.

You know we originally had only started with the linear rank regression. But that doesn't capture the interaction effects among the variables. So about halfway through the project we added three more advanced techniques and that proved to be very valuable.

Before I go into the distribution of results, I understand there was some question about what we actually did, the mechanics of the analysis, what we did to get the results. So if you don't mind I just want to flip first to one of the backup slides which is slide 42 in the package.

Slide 42 just has the overview of what we did with respect to the two-step Monte Carlo process.

MEMBER CORRADINI: You anticipate a question obviously.

DR. GHOSH: Yes, I did.

MEMBER BANERJEE: Do you use Monte Carlo because you wanted the shape of the outcome distribution? What was it?

DR. GHOSH: When I say Monte Carlo, maybe it means different things to different people. I just mean that we ran the MELCOR model 900 times and then we ran the MACCS model 900 times.

MEMBER BANERJEE: I mean there's a procedure you know when you do Monte Carlo.

DR. GHOSH: Yes.

MEMBER BANERJEE: You are doing Monte Carlo because you want the outcome distribution. I'm not trying to -- I'm just trying to understand why you're doing this.

DR. GHOSH: Because as I said the main point of the project was to see the possibilities. So basically we ran our models 900 times and we got 900 answers with respect to how the source term might come out and what the health risk associated with it is.

MEMBER BANERJEE: You did a strictly parametric study.

DR. GHOSH: Yes. That's one of the things we weigh out in the front. You're absolutely right and we should call this a parameter of uncertainty study.

MEMBER BANERJEE: Yes.

DR. GHOSH: We looked at just a couple of the model uncertainties and a separate sensitivity study. But we did not include the conceptual model uncertainty in the study. So this is just in the parameters, both in the MELCOR model as well as the

MACCS model.

MEMBER CORRADINI: So to put it differently just to clarify Sanjoy's even though there might be differences in models you focused on given the models how do I noodle with the parameters within the models.

DR. GHOSH: Right. And since I think you all know MELCOR has a lot of lumped parameters and it's kind of a lumped parameter code. So some of the parameters that we varied represent different possible mechanistic models. From that standpoint, we're kind of getting at some of the model uncertainties.

But in terms of the actual implementation, we didn't vary the structure of the models. We used the existing MELCOR and MACCS models and we varied the parameter values.

MEMBER SHACK: I think that comes back to Dr. Rempe's earlier question about the surrogate. You really are lumping things together. And it would be helpful to be clearer as to what you think you're covering with those parameters.

DR. GHOSH: Right.

MEMBER SHACK: Which is why they deserve probably more discussion.

DR. GHOSH: Sure.

MEMBER REMPE: And how they were combined because it's unclear if you used the original model or not or what was done.

DR. GHOSH: Okay. I appreciate that. We'll take another look at Chapter 4 to make sure that it's more clear with respect to what we did and what it represents. Appreciate that comment.

And in terms of the mechanics of how we got the results, here is that word again. Let's everybody ignore the first two words. For the SOARCA project we had, on the left, basically the one deterministic value for all of the parameters that we plug into the MELCOR model and got a source term. So one source term signature in terms of timing and release over time.

And then the MACCS model, we had one value for all of the MACCS parameters. We took the source term, plugged in all of the deterministic point values for the MACCS and then the MACCS code was run approximately 1,000 times in order to account for the weather uncertainty.

So what you get out of the deterministic, what we're calling the deterministic run, is actually a distribution of results which represent the uncertainty due to weather. That's the curve that you see on the left side at the bottom.

MEMBER CORRADINI: Can I say it back to you differently?

DR. GHOSH: Yes.

MEMBER CORRADINI: So for every single calculation of a vector of parameters you do a 1,000 weather calculations.

DR. GHOSH: That's right.

MEMBER CORRADINI: So you do a 1,000 times 900 if they're all successful.

DR. GHOSH: That is exactly right. Yes.

MEMBER BANERJEE: For this Y, typically how large is that Y? Is it just the class of the weather? The wind speed? Stratification? Is it a large number of parameters or is it just the Pascal class and the wind speed?

DR. GHOSH: For the weather parameters, it's only five or six variables. And these are based on for a given plant you get the weather data from the weather station. I guess they call them the --

MEMBER BANERJEE: Direction, wind speed, a few things like that.

MEMBER RYAN: Stability class.

MEMBER BANERJEE: Stability class, right.

DR. GHOSH: It's only a handful of things.

And then basically the approach we took which is fairly standard, we binned the weather into similar categories in terms of how much rain and so on. In this case we used about 1,000 weather trials from that year of data because that would capture the statistics of the differences.

And I'll talk later. To make sure that that was good enough, we also used all of the data points from that year. It turns out 1,000 is good enough.

MEMBER CORRADINI: So I have probably an incorrect view of this and you'll correct me. That's one way to do it. Another way to do it is to pick a multi year span and randomly pick a real time and do a hindcast of real time. Do you get about the same result?

In other words, if I picked two years and I did 24 calculations by just binning 24 picks over two years of real weather, would I end up getting about the same thing as 1,000? Same sites. Forget about the sites. But I actually went backwards in time and said "In the last two years at Peach Bottom I had this weather. And out of those two years I'm going to pick a real weather hindcast here and another here and another here and look at those 24 versus

1,000 that are forecasts. Do you know what I'm asking?

DR. GHOSH: Yes. Are you asking if we only did 24 trials?

MEMBER CORRADINI: I'm asking is there another way to do this that's more representative of whether we've actually seen it at the site versus a forecast.

DR. GHOSH: Okay. The forecast, maybe I didn't explain that.

MEMBER CORRADINI: No, I think you explained that well.

DR. GHOSH: We are using the real weather at the Peach Bottom site.

MEMBER STETKAR: That 8760 points.

DR. GHOSH: Yes.

MR. BARR: From the year 2005.

MEMBER STETKAR: You have 8760 points.

MEMBER CORRADINI: Just one year of data.

(Simultaneous comments.)

MEMBER STETKAR: And your sample is a start point.

DR. GHOSH: Exactly.

MEMBER STETKAR: So it's 12:00 noon on February 18th.

MEMBER CORRADINI: Okay. So you use 1,000 hindcast. Okay.

MEMBER STETKAR: And the next 48 hours.

DR. GHOSH: Forty-eight hours, exactly.

MEMBER CORRADINI: I misunderstood that.

MEMBER STETKAR: It's only from one year.

DR. GHOSH: It's from one year.

MEMBER STETKAR: So you don't get like a 10 year variability and the extremes of the weather.

MEMBER CORRADINI: Okay. That's fine.

DR. GHOSH: In the past we have looked at the year-to-year variation and it's on the order of 10, maybe 20, percent depending on the site. It's not a huge compared to all the other uncertainties that go into the analysis.

MEMBER CORRADINI: Thank you. That helps. I guess I missed that. Sorry.

MEMBER STETKAR: Times the 20 percent starts to add up after a little while though.

MEMBER BLEY: The risk comes from that 20 percent.

MEMBER STETKAR: The risk tends to come from the 10 percent here and the 10 percent there.

DR. GHOSH: It all has to do with if you have the 20 percent lined up in the same direction versus --

MEMBER STETKAR: It would be a little probability but it's not zero.

DR. GHOSH: For each of the realizations and also for the point estimate we get a distribution that's the weather and a distribution from the weather. Then for the uncertainty analysis what we added now is that instead of one MELCOR source term, we ended up with -- In this case it was 865 source terms. We had 35 that for really numerical simulation it would have taken too long for us to wait for the MELCOR run to finish. So we just kind of aborted them. And because we used the simple Monte Carlo sampling that's okay. And we don't mess up our statistics.

In that case, we had 865 source terms. And for each of those 865 source terms, we took one sample, one vector of sample values for all our MACCS uncertain parameters. So that now goes in. And for each of those we again did about 1,000 weather trials. So we ended up with 865 curves that each curve in essence represents the weather uncertainty.

But we did is --

MEMBER STETKAR: Wait, wait. Hold on a second. Let me stop.

DR. GHOSH: Sure.

MEMBER STETKAR: Because I --

MEMBER CORRADINI: I was waiting for you to stop her.

MEMBER STETKAR: No. I really need to understand this process. And I'm going to get to MACCS in a second, but what you just said is what I read in words. But it's not what I heard what you explained mathematically. So let me take one MELCOR realization. We've got 865. One.

DR. GHOSH: Yes.

MEMBER STETKAR: One run of MELCOR.

DR. GHOSH: Right.

MEMBER STETKAR: How many results does that one run produce when you combine MACCS and the weather?

DR. GHOSH: So there are two answers to that.

MEMBER STETKAR: No. I want one answer. I want how many. It's going to be either 984 or one. And I want to know which of those two answers.

DR. GHOSH: For the purposes of the report?

MEMBER STETKAR: No. I want to understand how you did it. I want to understand how the math was done.

DR. GHOSH: We have the entire curve. So we did 984 for each source term.

MEMBER STETKAR: Okay.

DR. GHOSH: We have a curve for each source term.

MEMBER STETKAR: Over the weather.

DR. GHOSH: Over the weather.

MEMBER STETKAR: Good. Thank you.

DR. GHOSH: But what we report is the mean value.

MEMBER STETKAR: Okay. I don't want to get to the report because I need to understand what was done first.

DR. GHOSH: Sure.

MEMBER STETKAR: So I understand what you did with the weather which is good.

MEMBER CORRADINI: Wait a minute. Can we get that on the record?

MEMBER STETKAR: No, that's good.

MEMBER CORRADINI: Okay.

MEMBER STETKAR: But why did you only take one sample for each MACCS input parameter for that one MELCOR realization?

DR. GHOSH: Yes. The thing is we wanted

to do an integrated analysis to see which set of variables was also most important to the health consequences. They're not just for the source term.

MEMBER STETKAR: I hear you saying those words. I want to understand mathematically why you only took one sample from each MACCS input parameter for that realization.

DR. GHOSH: Right. So let's say that we didn't have MELCOR and MACCS. If we had one megamodel.

MEMBER STETKAR: Right.

DR. GHOSH: We could have modeled everything.

MEMBER STETKAR: Right.

DR. GHOSH: We would have just had one epistemic variable vector.

MEMBER STETKAR: And I don't want to use the word epistemic. Just sample.

DR. GHOSH: Yes, one sample value for each uncertain variable across the metric.

MEMBER STETKAR: Amen. And you might have needed 10 million samples to get convergence.

MEMBER CORRADINI: How do you know that you needed so many more than 865?

MEMBER STETKAR: I know that 865 is not

enough.

MEMBER CORRADINI: How do we know that?

MEMBER STETKAR: Because we know how uncertainty distributions combine when they're broad, skewed uncertainty distributions. We know this from experience.

DR. GHOSH: Yes.

MEMBER STETKAR: We've reasonably captured -- Let me cut to the quick here because we only have an hour and a quarter. We've reasonably captured the uncertainty perhaps depending on what you define as reasonable in MELCOR within about plus or minus 20 percent convergence which is not all that reasonable. We've not at all captured the uncertainty in MACCS.

And let me just give a simple example. Single realization from MELCOR. Let me take a parameter called e speed, evacuation speed, of the populace. The populace evacuation speed doesn't depend at all on the what the release category is. So I should have an uncertainty distribution in evacuation speed for that single realization. Right now, I have a single value.

MEMBER CORRADINI: But can I make the same argument within the severe accident? I can make the same argument that ex-vessel phenomena have nothing to do with in-vessel phenomena. Therefore, I have to have a single realization come out of the ex-vessel and a handful of --

MEMBER STETKAR: There at least they are sampling and looking at the convergence of the results from MELCOR and making arguments that 865 was good enough to reach reasonable convergence on the uncertainties and the output parameters that they were interested in.

MEMBER CORRADINI: But your argument --

MEMBER STETKAR: So the in-vessel/ex-vessel stuff is all tied up in there.

MEMBER SHACK: Let me try it a different question. John is arguing that -- I think he would agree that if you took enough samples if your approach would work. How do you convince yourself with 865 samples you've got reasonable convergence?

DR. GHOSH: We documented our convergence analysis in the report. What we did -- It's okay. I mean you may not like what we did. Let me explain what we did.

MEMBER SHACK: We want to know what you did.

DR. GHOSH: We originally had started with a sample size of 300, not because -- Of course, I would have loved to do 10,000 but you know. Nine hundred we do think is a reasonable amount. But we started originally with 300.

What we did was we ended up doing three replicates of 300. So we did a MACCS analyses with three MELCOR replicates of 300. So we have three separate uncertainty analyses in essence with the sample value of 300.

Then we also took the super sample. We ended up having 865. We took the super sample and also did the statistics there. So we have four sets of statistics for the MACCS results. We have the three replicates of 300 each. I mean it actually comes out to on average 290, 280 something and the super set of 865.

And then we compared how much variance there was in the statistics we turned, the mean, the median.

MEMBER STETKAR: Let me stop you there. So far you've described convergence of the MELCOR sampling and I understand what you did there. I might disagree with the 20 percent is reasonable. But I understand.

So far you've not discussed at all convergence, the integrated MELCOR/MACCS weather sampling. You've not discussed that at all.

DR. GHOSH: Okay.

MEMBER STETKAR: So we're interested in how do you demonstrate that you've taken enough. Think of a single -- that was a good way -- integrated MEL/MACCS weather model that if you had that fully integrated model that 865 samples are adequate to reach convergence if I did a full Monte Carlo sampling of that integrate model. An adequate convergence of the results of that integrated model, not just the 900 and 300, 300 and 300 MELCOR stuff. I understand what you did there.

So think through all the way through to the end.

DR. GHOSH: Yes, I understand. I don't think 865 is a bad number and for the following reason. Again, we did the three replicates and when you compare across the replicates and with the super sample, our statistical measures don't vary that much.

MEMBER STETKAR: MELCOR. Okay.

DR. GHOSH: No, no. For the health consequence they vary like 10 percent.

MEMBER STETKAR: Okay. But let's take a situation where your sampling from MACCS always gave you the same input. You're only selecting one. Then you'd see the results and the convergence from your integrated MEL/MACCS just replicate the uncertainty in MELCOR.

And if I look at in the study the uncertainty in the MELCOR results it's roughly a factor of about 50 -- fifth to the 95th. If I look at 13, 14, if I look at the results from your integrated analysis with MELCOR, MACCS and the weather, it's roughly the same range which says I'm not adding any uncertainty from all of that weather and MACCS which bothers me a lot.

DR. GHOSH: Yes. So that's the second piece of the puzzle which is why we think that 865 is enough. There is actually a pretty strong dampening effect when you go from the source term to the health consequence because the long-term phase is what's dominating the risk. And you have a back stop against how much LCF risk you can impart on people because you're evacuating them if there's too much radiation there. There's too much contamination there. And they're not allowed to come back until for Peach Bottom you get below the habitability criterion of 500 millirem per year.

So that's why in fact you see that the source term variance is larger than the LCF risk variance because you have this dampening effect between the source term and the health consequence.

MEMBER STETKAR: Is that dampening effect though an artificial product of the way that you did your limited sample?

DR. GHOSH: I don't believe so. I mean I think phenomenalogically we can explain that.

The other thing I just want to point out is there are a lot of uncertain parameters in MACCS. But it turns out there is really only a handful that really only drives the uncertainty and the results. So on face value when you look at the number of parameters it sound like 865 there's no way that that could be enough. But the vast majority of them don't make a very significant contribution to the uncertainty and the results.

So I think when you then evaluate how many parameters are really driving the variance and you see the 865, you then can also consider that there is this dampening effect between the source term and the health consequence. And we did the convergence analyses with the three replicates and the 865.

We can never say definitively without a doubt that this is absolutely correct. But we feel fairly confident in terms of convergence.

MEMBER STETKAR: Did you ever take a single, a couple -- it's dangerous to take one -- but two or three MELCOR replicates that would kind of drive in the consequence analysis like a late SRV failure with an early battery failure or something like that? You know select a couple. And then run the weather and MACCS with a false sampling of all of the input parameters and see what that distribution looked like for each of those runs. Did you ever do that?

DR. GHOSH: We haven't done that yet. But I think we can recreate something like that because we have so many source terms that are within a -- With 865 realizations we can go back to our results and kind of look at the range of MACCS results. But we could do that.

MEMBER STETKAR: But you'd need to change the way you do the sampling. I mean you would need to take that one MELCOR replicate and actually do N samples of all of the MACCS input parameters. You'd need to change your sampling algorithm now. And then examine convergence, how many samples, what does the shape of that distribution look like, how broad is it.

And how many samples from MACCS and weather since they're integrated does it take to get convergence in that distribution? That would be a real confidence builder. If that distribution was really narrow, that would be a confidence builder.

MEMBER CORRADINI: Narrow compared to what?

MEMBER SHACK: The distribution they now get.

MEMBER CORRADINI: That's what I thought you were getting at.

MEMBER STETKAR: No, this is not the distribution for the overall results.

(Simultaneous comments.)

No. Well, for latent cancer fatalities or whatever the consequences are.

MEMBER CORRADINI: But I guess I'd agree with what you're asking them to do if you were saying is the spread here within the spread they got from that.

MEMBER STETKAR: No. This is lighter.

MEMBER CORRADINI: If the spread is wider in that worries me.

MEMBER STETKAR: What do you mean if the spread is wider?

MEMBER CORRADINI: I mean I'm just picking something that -- Let's pick land interdicted. If the land interdicted spread from their 865 by this integrated approach is here and they took one realization from MELCOR and did like one billion, whatever the necessary number you feel comfortable with, and they're spread from just MACCS alone within that, then I'd say their 865 is --

MEMBER STETKAR: No because that uncertainty -- It depends on how broad that uncertainty is, Mike. Everything is driven by tales of the distribution. So if you're artificially constraining the results --

If you're looking at the uncertainty in MELCOR only and presuming that the uncertainty in MACCS is small then the uncertainty that you see will be the uncertainty in MELCOR. If the uncertainty in MACCS is large, the uncertainty in the results is going to be the compound of that.

MEMBER CORRADINI: But you have to compare it something to know.

MEMBER STETKAR: All I'm asking them to do is to take two or three MELCOR realizations and do essentially what they did for MELCOR, run N where N is big enough samples of the MACCS input distributions and the weather and look at what the distribution of latent cancer fatalities are for that single run.

MEMBER CORRADINI: I understand.

MEMBER STETKAR: That will give you a sense of how big the spread is from MELCOR from MACCS.

MEMBER CORRADINI: So they see the spreads and then they've got to compare it to something.

MEMBER SCHULTZ: No they have to -- in order to validate.

MEMBER STETKAR: What they're comparing it is they only have a single value the way they're doing it right now. They have a single value.

MEMBER SCHULTZ: Tina gave a description of why she felt comfortable about the way it had been done so far.

MEMBER STETKAR: And if the results of those would be small then I'd feel a lot more comfortable.

MEMBER CORRADINI: Small compared to what?

MEMBER SHACK: Let me try my shot at that. I think what they've done is they've now got the combined MACCS/MELCOR epistemic uncertainty by their approach. They think they've got a converged answer.

I think what John is asking is to look at the MACCS epistemic uncertainty. And again you've got the epistemic uncertainly in MELCOR alone because you've got the 865 samples.

So you've got MELCOR alone. You've got MELCOR/MACCS combined. He wants to see MACCS identified. And I think the fair comparison with the uncertainty that you have in the combined MACCS/MELCOR uncertainty.

MEMBER CORRADINI: That's got to be a comparison. Otherwise you're not going to know what to compare to.

MEMBER STETKAR: You can't think about uncertainty and evacuation speed for this particular source term in terms of the composite uncertainty and evacuation speed -- I'm just picking that as one variable -- over the full range of source terms.

I mean obvious -- It's not obvious. If the uncertainty in the latent cancer fatalities for a specific realization for MELCOR was much larger than the overall uncertainty and results, that would be really condemning. I wouldn't expect it to that bad.

MEMBER CORRADINI: I understand what you're asking them to do. I think I get that. I understand what you're asking them to do. But I'm not understanding what criteria you're going to put on that result to decide it's converged.

MEMBER STETKAR: You can determine whether the results are converged. That's just a sampling criteria.

MEMBER SHACK: They think their results have converged now.

DR. GHOSH: We think that we converged.

MEMBER SHACK: Right.

DR. GHOSH: Can I --

MEMBER STETKAR: Dennis, you helped.

MR. BARR: I think what John is suggesting would be an extremely valuable result.

DR. GHOSH: Sure.

MEMBER SCHULTZ: I mean you described why you felt and why you concluded that the distributions in MELCOR are as they are and in comparison to the total which are similar. You described why you feel that's appropriate given what you speculate would be the result of the evaluation that John is describing.

If you can demonstrate that you have validated your thoughts about it. And those conclusions I think are going to be very important about offsite consequence analysis. Very important conclusions about it that we haven't fully validated.

MEMBER SHACK: Let me just ask another techie question again. You examined the convergence in the MELCOR sampling by bootstrapping the final result. Why didn't you do that for the combined one?

DR. GHOSH: Yes. It's a good question. You know we used the Latin hypercube sampling for the MACCS runs because we don't have the same issue we had with MELCOR. The MELCOR we knew that some of the runs wouldn't run to completion within a reasonable amount of time. And we kind of had to abort them because they would take a year to converge or something.

MACCS doesn't have that same problem. We felt that Latin hypercube sampling is the preferred method usually going in. After this conversation, I'll have to re-evaluate that. But usually we say that with Latin hypercube sampling we get a better estimation of the tales of the distribution which is why Latin hypercube sampling is usually preferred.

So for the MACCS we used Latin hypercube sampling. But once you do that, you can't use the same bootstrapping method that we used for the MELCOR results which use simple random sampling and where we could use the distribution.

MEMBER SHACK: But when you've got the final distribution can't you bootstrap off of that because it's just a distribution at that point whether you got it by simple random sampling or Latin hypercube?

DR. GHOSH: Yes, I think --

MEMBER SHACK: When you use the T distribution that somehow builds in so much presumption about the shape of the distribution.

DR. GHOSH: Yes. I'll tell you what. Let me take it as a homework assignment to re-evaluate what else we could do. And I also understand the suggestion.

MEMBER SHACK: One more question on the mechanics and that is --

DR. GHOSH: Yes.

MEMBER SHACK: You've done the one MELCOR sample, the one MACCS sample, the 984 aleatory.

DR. GHOSH: Yes.

MEMBER SHACK: You then average the aleatory once for each of those because you're isolating an epistemic uncertainty. And that's really what you're presenting in the report.

DR. GHOSH: That is exactly right. So the distributions we'll talk about later, they are the distributions of the means from --

MEMBER SHACK: The aleatory runs.

DR. GHOSH: Right. Exactly.

MEMBER STETKAR: Why did you do that? Because now I understand better -- No, I actually understand. That is good that you actually run all

984 weather samples. But when you presented the results, why didn't you capture that uncertainty in the weather? In other words, actually convolute those distributions for the results rather than just taking effectively the mean of the weather multiplied by each of the other realizations?

DR. GHOSH: Right. I mean we were trying to be consistent with the SOARCA project. But one thing in terms of the metrics that we report. But let me offer this.

One thing we did do and this is in part sparked by both questions from the SOARCA peer review committee as well as the ACRS is we looked at comparing the contribution from the weather uncertainty compared to the epistemic uncertainty. So we took particular source terms that were representative of kind of like a low/medium/high and then looked at the spread and the uncertainty from weather versus the epistemic uncertainty from all of the trials to get some sense of the relative effects of weather versus the epistemic uncertainty.

And I'm actually going to talk about -- if I get to it -- that later today. So we did do that.

MEMBER STETKAR: Reading the words is difficult to find out what you did.

MEMBER SHACK: When you did that single replicate, you did that one only again with one MACCS sample. I would have found that one much more comfortable if you would have had the single MELCOR source and then did a number of MACCS replicates and the weather.

MEMBER STETKAR: And the weather.

DR. GHOSH: For the aleatory weather, okay. Point taken. I think I understand.

MEMBER STETKAR: By the way, I think the study uses the terms "epistemic" and "aleatory" as if they are purely defined. And indeed they're not. The vast majority of things have contributions from both aleatory and epistemic. I'll grant you weather is aleatory.

DR. GHOSH: Right.

MEMBER STETKAR: To my mind, it dunnit make any difference and that's done with no S because I'm trying to make a point here. It dunnit make any difference whether I have epistemic or aleatory uncertainty when I'm combining those uncertainties.

It does when I look back and try to understand how I might reduce that uncertainty because I'm --

MEMBER BLEY: Depending on how you

generate them, it can have a big difference on the shape you applied of what those distributions look like.

MEMBER STETKAR: That shapes of the distributions. But in the mechanics of the process I ought not to think of method X of combining aleatory uncertainty and method Y of treating epistemic uncertainty.

MEMBER BLEY: Can I sneak in a comment? Something that would be really helpful would be to make a bed sheet 11 by 17 foldout with a map of the arithmetic you do and right up front. So you look at that and see what's coming and how you did all of this.

MEMBER CORRADINI: For the techies. Not for the general public.

MEMBER BLEY: Yes. Most of this report is not for the general public.

MEMBER STETKAR: This is not a general public report.

MEMBER BLEY: No.

DR. GHOSH: Yes, we'll do that. I think we attempted to do that in a simplified diagram. But I take your point. We can do that.

MEMBER BLEY: And the other question I had and it's been asked before I didn't hear an answer I really understood as to why you only took a single sample from each source term. Why didn't you multiply sample?

DR. GHOSH: And again --

MEMBER BLEY: Is that explained somewhere because I couldn't find anything I understood?

DR. GHOSH: No. I think this goes back to the reason we had to do the MELCOR and the MACCS separately is because we don't have a megamodel of the whole.

MEMBER BLEY: I got that.

DR. GHOSH: If we had a megamodel of the entire model we would do exactly what we did here which is you only take one vector of all the uncertainties. Because we have two separate models, we have the flexibility to look at them separately. But we did not do that because again theoretically if we had had a mega model which is what we were after to look at the relative contributions of the uncertainties with the entire system together with respect to the health consequences you would only take one vector at a time.

MEMBER CORRADINI: Can I ask a question? If you had the mega model and 900 is not enough for his warm feeling of convergence, is 1800 enough? Does anybody know statistically what it is?

MEMBER STETKAR: Yes, there are normal ways approximately for this point.

MEMBER BLEY: You don't know.

MEMBER STETKAR: That's the thing. You don't know.

DR. GHOSH: Yes.

MEMBER BLEY: It's an algorithm to look at your results. It's not --

MEMBER CORRADINI: So you keep on checking by subdividing the sample and see if you're got it. I wouldn't say it that way but you could say yes.

MEMBER STETKAR: If you want to think of it.

MEMBER SHACK: You're looking at multiple samples, yes.

MEMBER STETKAR: As you take more samples, the convergence should narrow.

DR. GHOSH: Right.

MEMBER CORRADINI: Okay.

MEMBER STETKAR: It doesn't necessarily --

MEMBER CORRADINI: So you're saying -- So my question then becomes how much is enough.

MEMBER STETKAR: You typically set your

own convergence limits. You say that you want to feel comfortable if my mean value is converged to within ten percent or two percent or 20 percent.

MEMBER CORRADINI: Okay. I thought that where you were going. But you don't feel comfortable with 20 percent which is what they're seeing.

MEMBER STETKAR: I'm not trying to address that issue.

MEMBER CORRADINI: I understand that. But they may feel comfortable and you don't simply because on what you want to see as the final convergence value.

MEMBER STETKAR: Right. Because some of the 20 percent that they're missing for example may be part of that tail that wags the dog if we were doing the full sample out through MACCS. But first I'd like --

MEMBER CORRADINI: I'm happy.

MEMBER STETKAR: -- to have a better understanding of what they did.

DR. GHOSH: Let me also offer one last thing and then hopefully we can get back to my slide eight of my presentation. You know doing the 865 and we can disagree about whether or not we think that's enough we did see quite a range of behavior.

And in looking at the early fatality consequence values, that was purely a model verification exercise. There were so few none zero results and we analyzed the outliers. And we got some real tale behavior and I'll talk about that. And it's in the single realization analyses.

So that's another thing. It's a combination of what specifically we would do but also phenomenalogically if we're seeing that range of behavior and some new things that we haven't seen before.

MEMBER STETKAR: I mean it's fortunate in some sense that you did take enough samples that you at least saw that because it sort of alerted you to the fact that there might be things going on that you hadn't thought about before just from the base case for example.

DR. GHOSH: Right.

MEMBER SHACK: One last comment. One of the reasons I think that gets so confusing is the word "mean" shows up so many times. We have mean cancer fatality. But you have that for individual runs. You have that for the combined aleatory runs. You have that for the combined epistemic runs.

If you could sort of go through and define what you were averaging through each set of figures I think it would reduce the confusion. I know John and I both had a hard time figuring out exactly what you were doing.

DR. GHOSH: Yes. I appreciate that. We just finished writing a set of conference papers and oh my gosh. Our table titles were like five lines long to be able to explain exactly what's shown in the table. Yes, I appreciate that.

And perhaps a figure such as Dr. Bley is suggesting would help. We'll take a stab at that.

If we could go back to slide eight. If there are no more questions on the mechanics I hope. Right?

MEMBER SCHULTZ: At this time.

DR. GHOSH: At this time, okay. Good. So we'll talk about the results first. First, this is the MELCOR results. It's the source term. And we focused on cesium and iodine initially. And this is because cesium in essence drives the long-term health risks and iodine is, of course, traditionally a significant contributor to early or prompt fatality risk where there is an earlier prompt fatality risk.

But just a little side note, I think for future work we'll probably look at additional radionuclide groups as well. It turns out that cerium is important, the cerium group is important, in some cases. So I think in future work we're certainly going to take a closer look at that.

MEMBER CORRADINI: Why is that? I don't think I know why.

DR. GHOSH: While the long-term phase dominates the written cancer fatality risk, in some of the realizations you do have a significant contribution from the plume going overhead once you get past the 10 mile EPZ, emergency planning zone. So the cerium group from the plume going overhead makes a more substantial contribution.

MEMBER CORRADINI: And the assumption is that outside the ten miles nobody moves.

DR. GHOSH: No, no. It's not that nobody moves. You don't have the automatic evacuation, but you have hot spot, what's called hot spot, in normal relocation.

MEMBER CORRADINI: Okay.

DR. GHOSH: But there are more people exposed. They may be small doses, but you still have more people exposed.

MEMBER CORRADINI: Okay. Thank you.

MEMBER BLEY: Can I make a presentation

suggestion?

DR. GHOSH: Sure.

MEMBER BLEY: There are many other places where we regenerate spaghetti curves and then somehow untangle it and come up with the confidence curves. Nobody needs to see all the work you did to come up with spaghetti curves anymore. It's more confusing than helpful I think.

DR. GHOSH: Okay.

MEMBER BLEY: And nobody does it anywhere else. Once you've done that you can put an order to it. It's just confusing I think after that.

DR. GHOSH: Okay, sure. So you're suggesting just keep the statistics.

MEMBER BLEY: Get rid of the gray stuff.

DR. GHOSH: Keep the statistics curve and not -- You know I came from the Yucca Mountain world. We love the horsetail graphs. And a lot of my team are also from former Yucca Mountain folks. But point taken.

MEMBER SHACK: Understand something. I like the horsetails.

MEMBER BLEY: There are lots of places you could see them in other analyses where they finally got rid of them because they really cause people trouble.

MEMBER SHACK: I think they give you a real picture of --

MEMBER BLEY: What the world looks like.

MEMBER SHACK: -- what the world looks like.

MEMBER BLEY: They do. But I think they cause more confusion than value.

MEMBER STETKAR: In many cases in this report, the understanding of the underlying messages gets absurd a bit by the vast numbers of numbers that are cited. And the horsetail plots is an example of that. All of those other citations of large numbers of numbers are difficult.

MEMBER SHACK: Means are what confuse me.

MEMBER STETKAR: Single value means is what confused me. But that's okay.

DR. GHOSH: I apologize. We had competing objectives of being as thorough as possible for posterity versus clarity. But I understand.

So the only point for this one is that -- I'm sorry. Can you go back just a minute? This was a subset of scenarios that had early stochastic failures. They are the ones that are most similar to the SOARCA project's projection. And that's why this curve is shown.

And also just to give you an idea. The colored dashed lines are examples of what we call the single realizations that we looked at to analyze in detail so that we could see what was driving different ranges of behavior. The next slide.

This is now the entire set of 865 which includes also the main steam line creep rupture cases as well as the weight SRV thermal failures without main steam line creep rupture.

You have a question.

MEMBER CORRADINI: I have a question but it's modeling. And I've been ruled that I'm out of order if I ask it.

DR. GHOSH: Okay. The next slide. The next slide we have the iodine results.

MEMBER STETKAR: I think we've already decided we're going to have another subcommittee meeting. And I think we need to explore those issues at that meeting.

MEMBER CORRADINI: Yes, sir. You got your half an hour. That's okay.

(Laughter.)

MEMBER CORRADINI: That's on the record. I'm sorry. Forty-five minutes.

MEMBER STETKAR: I'll get another ten in the next brief.

MEMBER CORRADINI: You're the vice chairman. You have the power.

MEMBER SHACK: We haven't even started discussing this in the Committee forum yet.

DR. GHOSH: So slide 11 is the MACCS results. And again this is the statistics on the means from the weather trials. So this is the distribution of the means.

These are the conditional results. And just as a reminder the scenario frequency we had going in for long-term station blackout was about 3×10^{-6}.

MEMBER STETKAR: Tina, is there a real -- You keep trying to make SOARCA a PRA. Why do you need to keep -- No, you do because there are many places in this report where you keep coming back to that frequency and comparing it to the quantitative health objectives with caveats saying "Yes, we only looked at one sequence and the numbers are small."

But indeed especially in this report, there is no reason to do that. This is literally the uncertainty and conditional consequences.

DR. GHOSH: Okay.

MEMBER STETKAR: And I think especially

whenever -- Granted that this is a techie report and it's not necessarily for public consumption. But indeed it's a publicly released report. When the public reads those things, they're not going to appreciate all the nuances. They're only going to show that the NRC did a comprehensive uncertainty analysis that concluded that the risk from long-term station blackout is so far below the quantitative health objectives that we don't care about the risk from nuclear power plants. That's what they're going to conclude.

And we can't say that from this report. We've not evaluated uncertainly in the frequency of even that one scenario. We've not evaluated uncertainty in the human reliability which we know contributes very strongly, the three different actions that are presumed in this scenario.

So I think that those comparisons with absolute frequencies and especially comparisons with the quantitative health objectives are not appropriate especially within the context of this report.

DR. GHOSH: Okay.

MS. GIBSON: We still have to have somewhere to give the public perspective. So if you have suggestions.

MEMBER CORRADINI: I have one way which is if you want to do it on a relative basis like John has said at least if I remember. It's been so long that I can't remember how SOARCA started. But if I'm remembering correctly Commissioner McGaffigan basically suggested the 1982 study was way too conservative. You might want to go back and simply compare everything to the 1982 study.

I know some people around the Committee would think I've lost it. But it just seems to me if you want to do it on a relative basis that's what was the genesis of this whole thing. I mean, am I remembering correctly?

MEMBER SHACK: You're remembering correctly. It's a bad idea.

MEMBER CORRADINI: Even though it's a bad idea. I was waiting for you to say something.

MEMBER STETKAR: I'm not going on the public record make suggestions about specifics. Let me just reiterate. I think that especially in the context of this report extending it to make any type of conclusions about absolute risk in terms of frequency and consequences is not appropriate. And it's especially not appropriate when you make comparisons against quantitative health objectives which apply for the full risk from that nuclear power plant, not even the risk from one scenario. Just take that.

MEMBER CORRADINI: But then on the other hand none of us agree with each other.

DR. GHOSH: If we could go to the next slide. Again, this is the prompt fatality risk and you can see that once you get beyond 2.5 miles there is only a handful of realizations that you get in non zero resulted. Or the 95 percentile is zero even though the median and 75th is across the board. But there were 13 percent of realizations that calculated non zero results.

Actually, this was nice. It was really a model verification exercise. And we looked at some of the single realizations where we got outlier results and confirmed that if you have a really bad day and all the stars align against you just right, you can get a prompt fatality. So it was kind of a model verification.

But when you look at overall the statistics they are extremely small numbers. And you would still say there is essentially no risk. But in your worst case scenario, you can have some risk.

The next slide, slide 13, actually go

straight into slide 14. I just want to point out what are the most influential parameters in terms of the source term magnitude. I think we talked about some of this already last April. So this is probably more for reminder.

There are a couple of parameters that come together that really determine how your accident is going to progress with regard to are you going to have an early stochastic failure of the SRV which is kind of your better set of scenarios with respect to magnitude. Or is it going to fail later? And if it fails later, whether you have main steam line creep rupture.

So the SRV stochastic failure rate which is the first one, it's a lambda. That's why it's abbreviated SRVLAM. I just put in the abbreviations here. It's probably not that important, but we also use them in the report. They're connected to the MELCOR variables.

That one along with the fourth bullet, the fraction open area of the SRV, that's sampled in case it fails to reseat because of thermal seizure. Those two variables largely determine which way the accident progression is going to go which is also a large determinant of your eventual source term.

MEMBER CORRADINI: So these far and away, one and four are far and away from a model from an uncertainty standpoint given a model assumed drives the results.

DR. GHOSH: That's right. And the first one really is the most important.

MEMBER CORRADINI: Then, two, three, five, six, seven are like all in a kind of mush together.

DR. GHOSH: Yes. And they're also important for different reasons. I'll just quickly go through right now.

MEMBER CORRADINI: All right.

DR. GHOSH: The chemical form of cesium, this one was a surprise. For the high temperature scenario, cesium hydroxide ends up being beneficial because you have chem absorption on the upper steel components inside the vessel.

This model existed in MELCOR and we checked after we saw this to see whether this is a legitimate model. And it turns out that it seems that people agree that it is. So we were kind of surprised.

We had expected that cesium hydroxide would lead to larger releases. But in fact for the larger source term scenarios like main steam line creep rupture if you sample the cesium as cesium hydroxide it actually -- there is actually smaller releases. It kind of counteracts how much you can get out because of the chem absorption.

And the cesium molybdate does not chem absorb. So that still gets out. So that was an interesting one. Which speciation is beneficial depends on which accident progression subscenario that you have.

MEMBER CORRADINI: So if the Committee will allow. I guess I'm intrigued by this because my first question is did your subject matter experts resolve that this made sense because of what's going on in PHOEBUS and what they prognosticated occurred at Fukushima. How did you come to the conclusion? The one person we'd ask is now declared himself ineligible and he's gone.

DR. GHOSH: Yes.

MEMBER CORRADINI: But I'm very curious about this.

DR. GHOSH: We could have talked to him on the chem absorption model though. At least that is a legitimate model in MELCOR.

So what we put in to it were the bins in terms of the split between the hydroxide and molybdate. That was based on the PHOEBUS experiments.

But at the time, we did not have the latest PHOEBUS results which showed that.

I think the consensus is now that probably the best split is about 70 percent cesium molybdate and 30 percent cesium hydroxide. We did not have that result at the time of the uncertainty analysis. So our bins are 50/50. All cesium molybdate or all cesium hydroxide and then --

MEMBER CORRADINI: As terms of what it could be.

DR. GHOSH: Yes. Exactly. So that's what we put into it.

MEMBER CORRADINI: Okay.

DR. GHOSH: And then what we got out of it is that you know which chemical form is more beneficial in terms of releases depends on which accident.

MEMBER CORRADINI: So that's my question on the second bullet. Am I allowed a question on the third bullet?

So there is an Oak Ridge/Sandia report that went into gory detail about excessive phenomena relative to Fukushima. And the conclusion from that is the MELCOR model is wrong. Just wrong.

DR. GHOSH: Yes.

MEMBER CORRADINI: Okay. And a side model, an auxiliary model, that was used by Oak Ridge and Sandia shows pretty much no dry well liner failure. Was there some -- Maybe I missed it. Was there somewhere where you essentially by a tale excluded a dry well liner failure to see that effect? I'm very curious of what that effect would be relative to source term because it's not clear to me it's conservative by having dry well liner failure?

DR. GHOSH: We did not change our models after Fukushima happened. We didn't change our scenario definition or the models. I'm sure as the community learns more from Fukushima we'll be updating things. But it wasn't part of this project.

MEMBER CORRADINI: Okay.

MEMBER REMPE: And in fact there was no -- Basically, if the debris leaves the vessel and contacts the outer wall, it's assumed to fail. There is no heat transfer analysis or anything that's calculated is what I read in your report on page 96. So there's not much of a model here.

MEMBER CORRADINI: And I won't criticize. I just wanted to make sure that you -- I'm sure you were aware of the Oak Ridge/Sandia work.

DR. GHOSH: The other thing is I think the ex-vessel modeling we're pursuing additional things in MELCOR right now.

MEMBER CORRADINI: That's fine.

DR. GHOSH: But we use what we had in existence.

MR. FULLER: This is Ed Fuller again. I'm not sure I know exactly what the report that you're referring assumes in terms of water on the floor when the vessel is breached.

MEMBER CORRADINI: They assume basically up to the pipes to the wet well. So about 12 to 18 inches of water.

MR. FULLER: Okay. But in this analysis there is no water addition. So you've got basically a dry pedestal and dry well floor.

MEMBER CORRADINI: Station blackout and the pump seals don't fail and there's no water leakage? I find that --

MR. FULLER: Well, there may be a little. I don't know the details of these MELCOR cases because we don't see them in detail. But what we're talking about if anything is a very small amount of water relative to what you'd be looking at in a Fukushima analysis. And so I think we're talking about apples and oranges. Okay.

MEMBER CORRADINI: Okay. All right. The only reason I bring it up is that at least in all the analysis I've seen by the labs pump seal failure and leakage into the dry well is pretty much guaranteed as you cook everything.

And the model in MELCOR cooks even longer than MAP cooks which means I should have leakage of water up to the nozzles which means I've got 12 to 18 inches of water always there.

I'm sorry that I'm still back in physics land. But I can't help myself.

So the last one is number five and maybe six together. The rail door I'm not going to touch. But five and six together. When I read this, I could misinterpret. And again we can delay to a meeting, but at least to get on the record that there should be a functional relationship with all the in-vessel modeling.

That is this parameter can be over here and this parameter can be over here makes me worry. Rather functionally they should be tied so that even though I'm uncertain they should be uncertain in a functional direction. Was that considered by the subject matter experts?

DR. GHOSH: Yes, it was. In fact, in our

peer review committee when we had interim reviews, they asked us to think very carefully about what correlations there should be. And we did correlate some of the MELCOR parameters which we documented in there.

MEMBER REMPE: But I never saw in the documentation anything that talks about the composition of the MEL which would have really affected several of the parameters that I saw. For example, if you've done a heat transfer analysis, the size of the breach in the dry well liner whether it's metallic or ceramic.

And so I guess that's why I keep pushing to let's see some more detailed documentation of what the thought processes were for the experts and did they really -- Again, every expert is going to have a different opinion. But there is a concern about correlated variables still.

DR. GHOSH: Okay. Thanks.

So we can go to the next slide. And this is an example of the regression results. As I said we used four techniques. We had started with just the rank regression. But that doesn't capture interactions among the variables.

And we got better results using the

quadratic, the recursive partitioning which is my personal favorite and the MARS. And you can see that in the more advanced methods the columns two through four that T_I column shows you the magnitude of the interaction effects between that variable and others.

And you can see they are fairly high. I mean the SRV has an interaction effect of 0.7 which is pretty high. And that makes sense because that coming together, for example, with the SRV open area fraction largely determines how the accident progression goes just as an example.

We can have the next slide, Slide 16.

MEMBER CORRADINI: I'm sorry. In theory I read this and I know this purposefully. So the T_I is the interaction primer. But the ranking with the S_I is really kind of absolute importance. Am I right?

DR. GHOSH: Yes, the S_I and theoretically how much of the variance is explained by that variable alone.

MEMBER CORRADINI: Okay. Thank you.

DR. GHOSH: Then for the MACCS results, this is the list of what are the most important parameters that affects the variation in the individual latent cancer fatality risk. And here you see there's a mix of MACCS and MELCOR variables.

The first one that comes up as most important across all of the methods is the dry deposition velocity. At Peach Bottom I think it rains less than 10 percent of the time. I can't remember the exact percentage. So the main wave that you're getting contaminants from the radioactive plume to the ground is through this constant, slow dry deposition that occurs.

And then over time it's mainly the ground shine that's getting people in the long phase. And I guess a little bit further from suspension. So it makes sense that this dry deposition velocity is so important.

Then you see a group of MELCOR parameters that largely determine the source term magnitude. So that also makes sense.

And then the last two parameters are the residual cancer risk factor and the residual dose and dose-rate effectiveness factor. What those are is that in the MACCS right now I think we're limited to about eight organ-specific cancer risk factors that we can define. But there are more than eight organs that we actually would want to model.

But we had basically was health physics expert help to define a last organ, a residual organ, that kind of represented a bunch of different soft tissue. We used the pancreas as a representative kind of soft tissue. And all of the uncertainties in those various organs was basically mapped on to this residual organ.

It makes sense that the uncertainty in that residual cancer risk factor and the dose and dose-rate effectiveness factors show up as important.

The only other thing I'll note here is that because we assigned uncertainties to those counteract to some extent the dampening effect that you get between the source term and the latent cancer fatality risk. We're sampling what the actual -- how harmful given millirem can actually be. So that has a somewhat counter acting effect.

MEMBER RYAN: Did you pick the pancreas for a particular reason?

DR. GHOSH: I think that was meant to -- I would have to go back to our documentation.

MEMBER RYAN: The reason I ask is that there's a biological rule about radiation sensitivity and the more specific in function the more radiosensitive an organ is. It's the Law of Beergonie and Tribondeau. And the pancreas is one thing that is sensitive. It's very radiosensitive.

So I was wondering why that one and not some other.

DR. GHOSH: I'm sorry. Maybe I don't explain very well. We have a report that the way the factors and the mapping was done. It's very stylized for SOARCA. We had Oak Ridge help us with mapping that because we were limited to the eight organs. We used the pancreas, but I don't think it's the case that we used the distribution and the sensitivity.

MEMBER RYAN: But using the pancreas to represent a group of kind of other organs.

DR. GHOSH: Right.

MEMBER RYAN: You picked the most radiosensitive one to use.

DR. GHOSH: I think it's more that. But we changed the input for that. So I think that it's more that we mapped all of the soft tissue organs onto the input variable.

MEMBER RYAN: It's really not kind of represent the pancreas or?

DR. GHOSH: Right. And I need to get back. It's been a while since we did that. So I need to double check what we did. And I can get back to you on the specifics.

MEMBER RYAN: Okay.

DR. GHOSH: But it was meant to be this catchall to map a bunch of soft tissue onto.

MEMBER RYAN: And so it's better to just have a name than just call it other.

DR. GHOSH: Yes.

MEMBER RYAN: It's in the codes. That's okay.

MEMBER BLEY: Tina, does this last one try to cover the differences between healthy young middle aged people and children and frail folks and that sort of thing?

DR. GHOSH: Yes. Actually, the dose rate effectiveness has to do with how big the doses are for over a given period of time.

MEMBER BLEY: Is there anything that tries to account for the fragility factor or whatever we would call it?

DR. GHOSH: So all of these numbers and the distributions were based on Federal Guidance Report 13 which I think the EPA puts out. And we had one of the authors of that report help us map everything on for SOARCA. The way they came up with the factors was to take a -- This is my understanding -- static snapshot of the entire U.S. population that includes everybody. So it includes the children, more vulnerable populations perhaps such as the elderly and so on. So these factors are supposed to have all of that included.

And I don't know if you saw that part of the report. You'll see the uncertainty distributions are actually pretty wide for those factors. So it should be in there in the distributions.

MEMBER BLEY: Okay. I'm sure it is.

DR. GHOSH: If you go to the next slide, again these are most influential parameters for the prompt fatality risk. And this was really a model verification exercise. All of these make sense.

The deposition parameter is more important for being able to get a prompt fatality because that's the only way you can very quickly get large concentrations of radionuclides down to a particular individual.

There was a handful of parameters, MELCOR parameters, that describe both the source term magnitude. And here battery duration shows up which also makes sense. Because battery duration is directly to the timing of the release. So when you have the shortest battery durations you get the earliest release which also enables you to possibly get a prompt fatality.

The early health effects threshold and beta shape factor for the red bone marrow also makes sense because that's the most vulnerable organ or tissue -- I don't know what to call it -- in terms of deterministic effects if that make sense.

And then linear crosswind, dispersion coefficient, that basically describes how wide your plume can get as you're traveling away from the site. And the tighter plume you have the larger concentrations you can get to an individual. So that also makes sense that that shows up as important.

If we go to the next slide, Slide 18, then we did this sensitivity study to look at the relative contribution of the weather uncertainty versus the epistemic uncertainty. Questions have come up and in fact we were just talking about it earlier this morning.

The first thing we did because this question also comes up is that we used 1,000 weather trials from actual weather data. And the question is what if you used all 8,760 weather starting point. Would you get the same answer?

And so we did that. And it turns out that the difference is very, very small. The next slide shows them. They're on the order of one to two percent for the LNT dose response model.

And then what I think was the more interesting one, we looked at comparing the effect of the weather uncertainty to the epistemic uncertainty. And that will be in a couple of slides.

So if we go to Slide 19, that just shows the differences that we computed from using all the weather trials. Again very minuscule for the LNT dose response model.

And then Slide 20, we basically picked three realizations in order to look at what would be the relative contribution of the weather uncertainty and epistemic uncertainty. We tried to pick something like a high, medium and low.

So realization 62 which is actually in the middle is kind of a representative high outcome. 170 is somewhere in the middle. And the first one is the low.

And if we go to the next slide, it's interesting. We found that the weather uncertainty typically is on about the order of an order of magnitude for a given source term and MACCS run. But the epistemic uncertainty is quite a bit wider. So we conclude that. This is just an example for the 10 mile circular area.

So we tentatively conclude that the effects of the epistemic uncertainty do seem to be larger than the effects of the weather uncertainty for a given result.

MEMBER STETKAR: We don't have time for that and we'll revisit it in the next meeting. But there was something confusing about those comparisons because the realizations that you characterized as what you thought were going to be the sort of middle and kind of higher and lower seem to shift in relative importance when I did the weather uncertainty.

But just look at that. Maybe I was misunderstanding those curves and we don't have enough time to do that right now. But there was one area where I thought that we explicitly capturing the weather uncertainty and the overall results might provide a better picture of what's actually happening.

DR. GHOSH: Yes. And my apologies. I think part of the confusion stems from the fact that we put the high result in the middle. And we are fixing that in the report so that it follows naturally.

For example, the blue curve is listed in the middle in the legion. But that in fact is the high source term. The red is the medium source term and the green is the low source term.

We realized that after the fact that it's confusing to present it that way. And we're fixing it in the report. So the legion will have and the table will have 62 and 170 flipped so that it goes in a natural order from low to high rather than having the high in the middle.

MEMBER STETKAR: Okay. Go on. I wasn't sure what the effect of the MACCS epistemic uncertainties would be on it. When you picked the single realization with the single MACCS sample I didn't know. Okay. I had a high source term, but how did I end up in the MACCS distribution?

DR. GHOSH: Okay.

MEMBER STETKAR: We'll have to dig into this later.

MEMBER SHACK: Those are problems with the way you've done the single realization analyses that there's really only one MACCS sample associated with that.

MEMBER STETKAR: But even that's okay because here we're just theoretically sampling the weather I think.

MEMBER SHACK: Yes, but if you're trying to make an argument.

MEMBER STETKAR: No, no.

DR. GHOSH: I understand. Yes. Actually, I guess we would have the answer to that because we could look at the means from those three curves against the distribution of the consequence results. And I don't --

I think you're right. We did not talk about that in the report. So thank you for that comment. I'll put something in the documentation.

All right. So then we --

MEMBER SHACK: You could also identify what Cap 11 is which is a group that shows up in here and it's not defined anywhere.

DR. GHOSH: It's not defined in -- Oh, my apologies again. Cap 11 was a typo.

(Laughter.)

My apologies. We found that after we gave you the report. We're fixing that as well.

MEMBER SHACK: I guess I don't have to worry about Cap 11 anymore.

DR. GHOSH: No, no. Sorry about that.

Now I wanted to talk about one of the sensitivity analyses we did because of a recommendation from this Committee. And this was looking at -- we did this separate from the uncertainty looking at if we had lower head penetration failures, what the effect might be compared to --

MEMBER REMPE: Before you go on.

DR. GHOSH: Yes.

MEMBER REMPE: The recommendation from ACRS was talking about the drain line, not the instrument tubes or the control guide tubes. And the reason why the ACRS did that was because the drain line doesn't have any in-core structures. It's about five centimeters in ID without any investment, no in-core probe. So it's an open flow area.

Also it's SA105-106 steel which has a lower ultimate strength. So it's more likely to fail. And that's the conclusion from the prior document that we referenced in the letter.

DR. GHOSH: Right.

MEMBER REMPE: And we are aware the TMI that the melt did refreeze. If you look at the pictures from what melt got into the instrument tubes at TMI which doesn't have a drain line it was in the region between the traveling in-core probe and the interior diameter of the penetration.

So I really am puzzled why. I mean that was stated in the recommendation.

DR. GHOSH: So let me answer that. Yes, absolutely. And we tried to talk about that in the report. So let me tell you the story as much as I know it.

We had to use the existing models that we had in MELCOR. So what we had were models for penetration failures. We didn't have a separate model for the drain line.

However, if we go to the next slide, what we tried to do is we did about 15 MELCOR ones and we failed different numbers of instrument tubes. And we also looked at the effective area of that drain line because we recognized that that was the primary concern.

So I think the sensitivity we did we did it with what we had available to do in MELCOR. And we tried to approximate what we might have seen or could have done had we had a model for the drain line looking at the affected area of the tubes that we failed.

MEMBER REMPE: But did you use stainless steel instrument tubes is what is typically found in a BWR instead of a carbon steel tube. That's what the drain line is. Or you just varied the area or what did you --

DR. GHOSH: I might ask Kyle Ross to pipe in. We use what we had in the Peach Bottom model.

Kyle, if you're on the line, can you answer? Did you hear that question?

MEMBER STETKAR: They varied the area.

MEMBER REMPE: Just the area, no materials.

MEMBER STETKAR: I didn't read that they varied the materials.

DR. GHOSH: Right. So it would be whatever the Peach Bottom tubes are.

Kyle, are you on the line?

(No verbal response.)

MEMBER REMPE: For this presentation, we're going to have a subcommittee meeting where we can talk about it.

DR. GHOSH: Right.

MEMBER REMPE: But what I read in the report was that we got that instrument tubes failed, but it replugged at TMI. But there was no discussion about in-vessel structures.

But it's much easier to go out through a drain line. That's why again the write-up is I think maybe something that should be a little possible.

DR. GHOSH: The reason we pointed out that it replugged in TMI is that in the model we have available in MELCOR it does not model replugging.

So the results we have is that the stuff just flowed out and we don't have a way to model that replugging. That's why we pointed out that this is something that we don't have right now.

MEMBER REMPE: I think it should be a little more explicit about the reason it replugged the TMI was that there were little driplets in a small annular area.

DR. GHOSH: Okay. So we varied -- we looked at failing anywhere between two to 38 instrument tubes which are about 1.5 inch diameter. And on average 13.5 tubes failed. As I said, we did 50 MELCOR calculations. Not all of them ran to completion. But we had a number of a tens of realizations that did.

And we also sampled the heart transfer coefficient between the penetrations and the core debris and the failure temperature at which the penetration would fail.

And we think that the smaller areas in the sampled range are representative of what you would get if you had that drain line. You said it was five centimeters.

MEMBER REMPE: Five as opposed to three for the ID. But maybe 3.0 something, I haven't forgotten. But there is a very large area that's got traveling in-core probe. Fission chambers, thermocouples inside there, too. So there's not much of a --

DR. GHOSH: Right. So we think the smaller areas in that range could be equivalent to that drain line.

And we go to the next slide, Slide 25. We saw that the penetration failures generally occurred about three hours before the gross lower head failure in our normal SOARCA calculations. And they were relatively insensitive to variations in the other sampled parameters, the heat transfer coefficient or the failure temperature.

And usually relocation of the core debris to the reactor cavity through the penetrations began within about six minutes of the first penetration failure. And the penetrations didn't ablate significantly.

If we go to the next slide 26. The potential influence on the relative cesium release is potentially large. We saw fractional releases in the range of 0.6 percent to 0.7 percent with a mean of four percent.

And this is the note I think we were just discussing. We know that there was plugging that was observed in TMI. But that phenomena is not modeled right now in MELCOR. So that's just a note for the reader so that they can interpret the results accordingly.

Then the other sensitivity analysis, we did a bunch of sensitivity analyses. But the other one I was going to talk about today is with respect to habitability criterion.

We did not include varying the habitability criterion as part of the integrated uncertainty analysis because that's really a state decision. And we know what the Pennsylvania state guideline is. That's what we used.

But just to see what the potential effects would be, we varied it between 0.1 rem per year -- that's 100 millirem per year -- to 2 rem per year. And the habitability criterion is actually 500 millirem per year which is in between. And we used a number of other criterion.

CHAIR ARMIJO: That's Pennsylvania, right? The 500?

DR. GHOSH: That's right.

CHAIR ARMIJO: What's the EPA?

DR. GHOSH: The EPA is 2 rem in the first year followed by 500 rem the following four year.

MEMBER CORRADINI: It's essentially the same.

DR. GHOSH: Except that first year.

CHAIR ARMIJO: Yes, the first year is different.

MEMBER CORRADINI: But I would think in the first that's -- Given you had a release I would think the first year is immaterial.

DR. GHOSH: No, because that's -- I don't think it is because that's when you allow people to come back. So you allow people to come back a lot sooner if you allow them to get 2 rem per year. So there is a difference.

MEMBER CORRADINI: So you see the difference.

DR. GHOSH: You see the difference.

MEMBER CORRADINI: I meant the stair stepping. I understand.

DR. GHOSH: Right. And a side note, the 2 rem per year case we did is probably close to the EPA tag even though that second year is limited to 500 millirem per year because the doses drop off so rapidly after that first year.

CHAIR ARMIJO: Would you happen to know what the gap at Fukushima for their return criterion? I heard it was much more conservative.

DR. GHOSH: I don't know the latest answer to that.

CHAIR ARMIJO: I don't know if anybody else does.

MEMBER CORRADINI: What was the question?

CHAIR ARMIJO: The Japanese criteria for return. I heard it was much more conservative, but I don't know the number.

MEMBER SCHULTZ: It is much more conservative. But I don't believe it's established yet.

MEMBER RYAN: I don't think it's a number yet.

MEMBER SCHULTZ: There were public statements made by officials. And they're trying to determine what value would be.

MEMBER RYAN: I'll let you know in a month when I come back.

CHAIR ARMIJO: Okay. We're going to send Mike. Ask that question, Mike.

MEMBER RYAN: It's on my list.

DR. GHOSH: So the results are not surprising. The only thing I'll point out is because the 10 mile radius we evacuate there's actually a larger effect of the habitability criterion because everybody leaves and then comes back.

Once you get to the 20 mile and up radius, there is some dose that's coming from the plume passage overhead. So you see a smaller effect. But you still see some effect.

And the results aren't surprising. So I think I'm not going to cover them here in the interest of time. We can skip that slide.

Slide 30 shows an example for one of the alternate dose response models we used. This is for the background, what we call the U.S. background, which is actually the use of threshold of the combined average background plus medical dose. That's the 620 millirem per year in the U.S.

And here you see for the 10 mile a much, much larger difference. Don't allow people to come back until they're below the dose threshold. I mean you're not accruing much dose at all. And certainly in absolute terms those doses are quite a bit smaller.

MEMBER CORRADINI: I know we're running at the end. So you want to complete it. I guess between

Slide 28 and Slide 30.

DR. GHOSH: Thirty.

MEMBER CORRADINI: Thirty.

DR. GHOSH: Yes.

MEMBER CORRADINI: Maybe I'm missing it. Explain the difference I guess.

DR. GHOSH: They are two different dose response times.

MEMBER CORRADINI: I know that, but I'm not catching it though. So could you say it again slower? I'm sorry.

DR. GHOSH: Sure. Okay. Once we use the dose threshold models, you use this average U.S. background dose as a threshold as well as what we called the Health Physics Society which I'm not showing here. This is just an example.

So here we don't start accruing latent cancer fatality risk until you get beyond 620 millirem per year a dose rate.

MEMBER STETKAR: And by definition anybody who comes back doesn't accrue any latent cancer fatalities.

DR. GHOSH: Right. Exactly. So you can see the 10 mile risk is minuscule because the base line 500 millirem per year is already below that threshold. And the 0.1 rem, 100 millirem, per year is even smaller. But that doesn't make much difference. What that dose is the dose to the 0.5 percent of the population that doesn't evacuate. That's the only thing that you're getting in the 10 mile radius.

MEMBER CORRADINI: So the percentages are?

DR. GHOSH: The percentages are the difference between the base case risk and if you change the habitability criterion to those numbers.

MEMBER RYAN: How did you get 620 again?

DR. GHOSH: It's the average combined background plus medical dose.

MEMBER RYAN: Medical dose go all over the map.

MEMBER CORRADINI: But that's the average though.

DR. GHOSH: It's just the average.

MEMBER RYAN: What kind of average?

DR. GHOSH: Across the U.S. population. It's documented in our SOARCA project.

MEMBER RYAN: Okay. That's not an easy number to say this is the right number. Some procedures have very high doses like tens of rem to large portions of the body like cardiac catheterization and all that sort of stuff, brain scans. And there are lots of other diagnostic things. I'm just trying to figure out how you decided who got what amount, how you got a "average." I don't know what an average is in the population.

CHAIR ARMIJO: What it even means, yes.

DR. GHOSH: I assume we have a reference for that. But I guess for our purposes we use the 620 millirem per year. And it was meant to represent something like an average but of a very highly uncertain number across the population.

MEMBER RYAN: Well, it's plus or minus half a gazillion. You know it's big number.

DR. GHOSH: Sure.

MEMBER STETKAR: In truth it varies by the population because if you're in modern, urban, fairly wealthy setting you're going to get a lot more dose than if you're out in a rural area where you pretty much just die.

DR. GHOSH: Oh boy. I think we can actually skip ahead to Slide 32. I just wanted to point out some of the other content in the report that we don't have a chance to talk about today. We did to a separate sensitivity analysis for the timing of the operator actions that are accredited, manual depressurization and station blackout scenario.

We didn't feel we could include that in the integrated uncertainty analysis. But we wanted to see what the potential effect would be of having different timing of that action. So we reported that.

We looked at hydrogen generation insights. Up front we have a Fukushima comparison which is largely qualitative, although we have some graphs in there. And then we did some --

MEMBER CORRADINI: This is in the uncertainty.

DR. GHOSH: In the uncertainty analysis, right.

MEMBER CORRADINI: I'm sorry to go back to this. So it references the other report which has the relatively -- I guess it's Sandia, Idaho and Oak Ridge together.

DR. GHOSH: Right.

MEMBER CORRADINI: My recommendation is you also consider this other one that I have mentioned that was Sandia and Oak Ridge were commissioned to do on ex-vessel variability.

DR. GHOSH: Yes. Fukushima is one of those things. I think we're just going to keep getting more and more knowledge as we learn more.

MEMBER CORRADINI: Okay. The only reason

I'm emphasizing that is it's the same tools you guys use. That's why.

DR. GHOSH: Yes.

MEMBER CORRADINI: And although as Ed pointed out -- I don't know if Ed is still here --

MR. FULLER: I'm here.

MEMBER CORRADINI: Ed pointed out the differences in the going into assumptions. I do think that since you're using the same tool set it's a relevant reference to have as part of the report. That's all.

DR. GHOSH: Okay. Then we did stability analyses for results and the statistical convergence. We talked about some of that. We tried to document at least what we did as best we could for posterity.

We have an appendix on the probabilistic analysis methodology. And we have a discussion of the MELCOR version changes since the SOARCA project was complete. We did some updates in between to get to kind of base line for the uncertainty analysis and what their effects were.

And then we have an appendix where we go through the peer review and ACRS comments from your letter back in May and then kind of our resolution to those comments. That's it for me and I'll turn it back over to Jon.

MR. BARR: All right. Just to quickly wrap up for questions. Plans for the future, this is to address comments that we get from the offices that are reviewing this right now. That will happen the rest of this month.

In September there will probably be a series of presentations, some at the PSA conference on this uncertainty analysis and different parts of it, MELCOR part of it and MACCS, other areas.

Also I believe there will be a presentation on this to the CSARP meeting which will also be late September.

Once all the comments are addressed, the plan would be to get this ready for publication by some point this upcoming fall. I assume Tina will be giving a research seminar to this offering to the agency to share some of the insights learned from this with the NRC staff.

And then another bullet to add on here would be an additional meeting with the ACRS at a point to be determined in the near future. Wrap up and address any additional issues that are needed.

DR. GHOSH: And just to add to that we won't be finalizing the report I think before we meet with you again. So I guess we're expecting hopefully in mid September we can come back. The report is not going to be final before that.

MEMBER SHACK: Now again one of the things we want to focus on in that subcommittee meeting is a more thorough discussion of the parametric modeling and such. Will you be able to provide some of those calculations, replications, a MELCOR replication with multiple MACCS by that time do you think? Or would a letter from us encourage you to do that or?

MEMBER CORRADINI: Discourage you or none of the above?

DR. GHOSH: I mean it is something that would be interesting to do. We can do it. I think we will just have to see how our resources go in terms of our competing demands on our time and so on.

MEMBER CORRADINI: The labs are Johnny-on-the-spot. I'm sure they're listening now and already starting to turn the wheels.

MS. SANTIAGO: It's a matter of resources. This is Pat Santiago. We only have as we said yesterday limited resources for a number of different projects. So we were not really including or expecting any additional funds. But we will look for them certainly. And then we'll discuss that and find out what we're able to do.

MEMBER SHACK: More questions or comments?

(No verbal response.)

My goodness. We ended up on time.

MEMBER CORRADINI: That's because we allowed some people to go first.

MEMBER SHACK: I thank the staff very much for a bravura performance. I think they did a very good job. And we'll be looking forward to the subcommittee meeting.

CHAIR ARMIJO: Okay.

MEMBER SHACK: Back to you, Mr. Chairman.

CHAIR ARMIJO: Thank you, Bill. We'll take a break now and reconvene at 10:45 a.m.

(Whereupon, a short recess was taken.)

CHAIR ARMIJO: Okay, we'll reconvene and we'll turn it over to Dr. Ryan to lead us through the Part 61 presentation.

MEMBER RYAN: Thank you, Dr. Armijo. We had an excellent subcommittee meeting not too long ago with the folks who are going to speak with us today.

(Knocking.)

CHAIR ARMIJO: Thank you.

MEMBER RYAN: We covered a lot of ground in that subcommittee meeting and I think developed some really important understandings of what the staff has done to develop the vision that they developed today. So I'm hoping that we can get into that discussion in a little bit more detail with other members on kind of the background and the thinking. So that was a very helpful and positive subcommittee meeting.

With that, I'll be happy to turn it over to Deborah Jackson from FSME who is going to introduce our meeting today.

MS. JACKSON: Thank you very much. As Mike said, I'm Deborah Jackson and I'm the Deputy Division Director for the Division of Intergovernmental Liaison and Rulemaking, FSME. And we're here today to provide the full Committee an update of the Part 61 since our last meeting in September of 2001, and also inform you of the information that's been sent to the Commission scheduled for July 19th in a couple of weeks.

So the rulemaking began when staff received direction from the Commission to engage on a limited scope rulemaking to require site-specific analysis for the disposal of large quantities of DU. And based on Commission direction early last year, we revised the regulatory basis document for the Part 61.

And today, Andy will provide you an update of the preliminary proposed rule for Part 61 and what's going to the Commission as I stated earlier.

So with that, I'll turn it over to Andy.

MR. CARRERA: Thank you, Debbie. Thank you, Mr. Chairman, and ACRS members. My name is Andrew Carrera. I'm the project manager for the Part 61 rulemaking. And up here I have with me Dr. David Esh and Christopher Grossman who are mainly here for scenery, as well as --

(Laughter.)

-- subject matter experts who will help me in answering any of your questions.

The last time staff came before the full Committee with a proposed revision to Part 61 was on September 8 of 2011 at which point the staff also received a comment letter from the Committee. Since then, the staff received additional direction from the Commission via January 2011 SRM. As a result of the new direction, Commission direction to revise the rule, staff again engaged the public, government organizations, and DHRS, Radiation Protection and Nuclear Materials Subcommittee which is headed by Dr. Ryan in the revised rulemaking effort.

Based on earlier comments, including the

Committee's 2011 letter, as well as a recent interaction with the ACRS Subcommittee, the staff revised a proposed rule language. And the staff is here again today to brief the full Committee on the revised proposed language for Part 61 rulemaking.

In preparation for this meeting, the staff also provided the Committee with a preliminary Federal Register notice for discussion purposes of today's meeting which contained staff proposed rule language. Please note that it is a preliminary document. It's still making its way up through the NRC management chain. It hasn't gotten to the Commission yet, so when this is all said and done, it went through the process. It may look a little bit different from what you are seeing now.

Slide 2, please.

So the purpose of the rule now is the specify requirements for site-specific technical analyses for the safe disposal of all low-level waste streams. And to specific requirements for the development of a site-specific waste acceptance criteria and to specify other rule changes to facilitate the implementation of the requirement and better align the requirement with current health and safety standards. And for the rest of the presentation, I will discuss each of these requirements at a high level and then I will delve into the details of the proposed rule language when we get to the proposed rule parts.

And the proposed preliminary FRN, Federal Register Notice, that the staff brought in front of the Committee, also discusses these requirements at great length and with regards to what they are and what they do.

Slide 3, please.

So the center piece of this rulemaking includes requirements for site-specific technical analysis and requirement to develop a site-specific waste acceptance criteria for disposal of all low-level reactive waste streams. For site-specific technical analysis requirement, the staff proposed to add requirement to demonstrate protection of general population within the 10,000 year compliance period and to minimize the releases of radioactivity to the extent reasonably achievable at any time during the post-10,000 year period. This requirement comes in the form of a performance assessment.

Staff also proposed to add a requirement to demonstrate protection of inadvertent intruders within the 10,000 year compliance period which includes stated dose limits, 500 millirem, and to minimize exposure to any inadvertent intruder to the extent reasonably achievable at any time during the post-10,000 year period. And this requirement comes in the form of an inadvertent intruder.

Next slide, please, Slide 4.

The staff also proposed to add requirements to demonstrate how to dispose of the system to limit the potential radiological impact from long-lived waste during the post-10,000 performance period. And this requirement comes in the form of a long-term analysis, and I will refer to it from now on as a performance period analysis.

So you have performance assessment that would be within the 10,000 years compliance period and then you have also intruder assessment, inadvertent intruder assessment that would be within the 10,000 years compliance period. And then just performance period analysis will look at the impacts post-10,000 year.

The staff also proposed to have a requirement for updated site-specific technical analysis as part of the license amendment for disposal facility closure.

Slide 5, please.

Staff proposed to add requirement for the development of a waste acceptance plan which includes the development of the waste acceptance criteria, the establishment of waste characterization methods, and development of a waste certification program in proposed Section 61.58.

Slide 6, please.

In addition, staff proposed other supporting changes such as a new definition and concepts to support the site-specific technical analysis requirements, require the use of Part 20 dose methodology which is based, currently based on ICRP which stands for International Commission on Radiological Protection, Publication No. 26, and also allow the use of up-to-date ICRP dose calculation methodologies.

MEMBER SHACK: Those of that don't think in terms of No. 26, what date version of that ICRP is that?

MR. McKENNEY: This is Chris McKenney. I'm the head of Performance Assessment Branch. That's the 1977 version with the ICRP-30 of 1981.

MR. CARRERA: But we also allow the licensee to use the updated one. It's got to be at least ICRP 26, 1977.

MEMBER SHACK: But you allow them to use the more recent --

MEMBER RYAN: Oh, absolutely.

MR. CARRERA: The staff also proposed revision to Appendix G, 10 CFR Part 20 and its associated NRC forms as part of the program to support the implementation of the proposed site-specific waste acceptance requirement.

So in the next set of slides, I will talk through the proposed rule changes of the site-specific technical analysis, site-specific waste acceptance plan, and touch a little bit on the supporting changes, new definitions, concepts, etcetera. And the staff is also developing the guidance document to support the proposed rule language and it would be available to the public if the Commission approves the publication of a proposed rule later this year. The draft document is currently not available to the public, but it was shared with the ACRS Subcommittee and discussed with the Subcommittee at great lengths a few weeks ago.

MEMBER RYAN: Andrew, I think that's a very important point for the rest of the audience and the record to show is that we had some very important I think detailed discussions about the technical aspects of what the language in the guidance really -- in more depth during the discussions we learned about. I think that's ultimately going to be a very important part of the rollout and implementation of anything that comes from the rulemaking effort. That's really where the concepts and the requirements of the regulations are put into play.

And as we all know, in performance assessment you can ask a question you can never answer or you can ask lots of questions that you can answer really straight forwardly and then put together a picture of the behavior of the system or whatever. So I think that exchange reflects, in my view, the work that the team, your team, has done to help put an entire package together. So I just want to give the audience a flavor of that exchange.

MR. CARRERA: Thank you, Dr. Ryan, for your encouragement.

Slide 8.

In the proposed Section 61.41, which is the performance objectives for the protection of the general population from releases of radioactivity, it would contain two paragraphs, paragraph A and paragraph B. In paragraph A, the staff proposes to add requirements to demonstrate protection of the general population within the 10,000 year compliance period.

And please note that the red text that you see on the screen are revised text that replaced or add to the current CFR Part 61 regulations and they are in a small font to differentiate it from the other summary slide I have up there as well.

So in the proposed paragraph A, the staff will retain the 25 millirem dose limit and the ALARA practice and propose a requirement that the compliance within this paragraph must be demonstrated through the analyses that meet the requirement as specified in Section 61.13(a) which is the performance period for within the compliance 10,000 years compliance period.

MEMBER RYAN: So for everyone's benefit, 61.13(a) just really is the 10,000 year number.

MR. CARRERA: Yes, I apologize. I did say performance period, but actually it's the compliance period.

MR. GROSSMAN: Just to clarify, the compliance period is defined in 61.13(a) as the -- 61.13, I'm sorry, this is Chris Grossman of the staff. I forgot to mention my name. 61.13 is the specification of the analyses themselves. So the performance objectives reference back to the analyses.

So (a) is the performance assessment essentially.

MR. CARRERA: Thank you. Let's see how performance assessment can satisfy the performance objective in 61.41.

Slide 9, please.

In the provided preliminary Federal Register notice, also discussed the performance assessment at great length. But in summary, what I have on the screen the purpose of the performance assessment, which is found in Section 61.13(a), is to identify and examine the features, events, and processes on the performance of the disposal system and then provide an estimation of the annual dose to any member of the public while taking into consideration the uncertainties caused by these feature events and processes.

Slide 10, please.

In proposed Section 61.13(a) that you see on the screen here contains eight subparagraphs. Subparagraphs (a)(1) and (a)(2) contain requirements to consider the features, events, and processes as well as the likelihood into the calculation of the annual dose to any member of the public within the 10,000 year compliance period.

And the staff is developing guidance

documents on how to successfully conduct your performance assessment as required by the proposed regulation.

Slide 11, please.

In proposed subparagraphs (a)(3), (a)(4), and (a)(5) of 61.13, contain requirements for providing adequate technical basis and justification for models used in the performance assessment as well as the evaluation, the pathway that needs to be evaluated.

Slide 12, please.

Continue on 61.13, subparagraphs (a)(6), (a)(7), and (a)(8) contain additional requirements to consider uncertainties and variabilities into the calculations. as well as consider models that are consistent with current available data and current scientific understanding and identify and differentiate between the roles performed by the natural disposal site characteristic and designed features in limiting the release of radioactivity to the general population.

Slide 13, please.

So once the performance objectives for the protection of the general population from releases of radioactivity is satisfied for paragraph 61.41(a), which is for the within the 10,000 year compliance period, we need to take a look at what we need to do for the post-10,000 year period. In proposed paragraphs 61.41(b) requires that we demonstrate minimum releases of radioactivity from the disposal facility to the general environment to the extent reasonably achievable at any time during the performance period which is the post-10,000 year period. But the requirement would remain silent on what method is appropriate to demonstrate and we leave it up -- provide flexibility to the licensee to determine what information they'll need to look at for the long-term analysis.

CHAIR ARMIJO: What's the duration of the performance period?

MR. CARRERA: There isn't a set duration of the performance period. I will let Dave talk about that.

MR. ESH: We receive some comments from the performance period -- this is Dave Esh -- about should we establish a duration for it and ultimately we decided not to because the way we structured this, the performance period can be done in a lot of different ways. So somebody might want to do a cost-benefit type of calculation. They may just want to extend their technical analyses from their compliance period and actually calculate doses at longer times. Or they may be looking at comparative analyses of barriers and how the barriers are performing and limiting releases, that sort of thing.

In addition, the source terms can be a lot different from problem to problem and the engineer barriers that are present, so it's hard to have a one size fits all solution to the performance period analyses. Instead, you really have to give people the kind of the concept and the different ways they may go about it, but then in each particular application, a licensee and their agreement state regulator may come in and they may decide for our particular problem, here's how we're going to evaluate the performance period. And the duration may be limited based on how they do their analyses and the characteristics of their site or it may be longer. That's the approach we took.

We also structured it that the performance period analyses only apply if you have a certain amount of waste on a facility average basis. So we didn't want to be in the situation where if you had a minimal amount of long-lived waste everybody was going to be forced to do these long-term analyses. Only in special circumstances are these long-term analyses probably going to apply. And for the existing facilities, I don't know if it would apply to any of them right now. But when you move to a special waste stream, very massive quantities of depleted uranium, for instance, then you're probably going to be looking at doing this performance period analyses.

MEMBER STETKAR: But in that sense and Mike has tried to educate me on some of this stuff, not as well as I could have been educated, but it's my understanding that basically the radionuclides that you're looking at out over those long periods aren't all that sensitive. I mean what you're left with by that time isn't necessarily all that sensitive to the actual duration. Is that correct?

MR. ESH: Yes. It's more --

MEMBER STETKAR: I mean in general.

MR. ESH: You have probably like four or five main variables that can all affect magnitude and timing, but when you get into the performance period, it's usually more of an issue of because of the long half-lives of the material you're dealing with, you're mainly looking at shifts in magnitude, not necessarily shifts in when that impact may occur.

So whether you had a dose of 100 millirem at Year 20,000 or Year 40,000, it probably doesn't matter whether it's 20 or 40, and these are intended to be dealing with the uncertainty and variability in this type of problem, and look at it in a quantitative way, but in a qualitative interpretation of your quantitative information you produce. It's kind of an order of magnitude type look at the problem and say where am I? Is this something that's really risky or is it inherently not very risky? That's kind of question you're trying to answer.

MEMBER RYAN: Again, I point to the fact we went into a lot of detail in the discussion of all of that at the subcommittee and I think the real key to success of this is not so much the rule language, because that's very short, to the point. It really gets into the application of the tools that David is talking about to say well, how are we going to make sense out of this and make a judgment? And I think if the guidance is done in a complete and thorough way as I feel confident it will be, that there's a good chance it will be a workable situation.

MEMBER STETKAR: I'm just at this level trying to get some perspective on those time issues that we've talked about.

MR. ESH: In the future, when the guidance becomes publicly available and you desire to read 80 pages about FEPs, you'll be able to do that.

MEMBER RYAN: We'll invite you back.

MEMBER STETKAR: Eighty pages is something that you do over lunch.

(Laughter.)

MR. ESH: Not a nice lunch then.

(Laughter.)

MR. McKENNEY: Just wanted also impart a clarification based on the comments is that in the direction by the Commission, they did request that we set up a second time period, this performance period to be not a priori set as a time period. So in a way that also does jive with the Commission directions. They didn't want a set time period.

MR. CARRERA: And proposed paragraph 61.41(b) also requires that compliance with this paragraph must be demonstrated for analysis that meets the requirements specified in Section 61.13(e) which is the performance period analysis that we just discussed and it provides a very nice segue into that analysis.

So now let's see how the performance period analysis can satisfy this performance objective for the protection of general population from releases of radioactivity within the 10,000 year compliance period.

Slide 14, please.

Also, they provide a preliminary FRN which I will keep coming back to you with that. Also discussed the analysis at great lengths, but in summary I have up here the performance period analysis which is found in paragraph 61.13(e) applies only to doses close to site with certain long-lived waste. And looked at the potential radiological impact on the disposal site during the post-10,000 year.

What you see here is the proposed language for the performance period analysis requirement. There are two components to paragraph 61.13(e). One is the requirement for the analysis and the other is the screening values that would be found in proposed Table 1 F of 16.13(3). And we note that this requirement only applies to disposal sites with waste that contains radionuclides with site average concentration exceeding the screening values listed in Table A which I will put up in a second, if necessitated by site-specific condition.

The screening values in Table A only tells you if you need to do the analysis or not. However, the complexity of the analysis really depends on the type of information that you want to get out of the analysis to support your decision making for the disposal of long-lived waste.

In addition, the clause "if necessitated by site-specific condition" it is needed because it is difficult to determine the threshold or the absolute threshold for all sites because of site-specific condition, the threshold below which the protected risk would be acceptably low. And this clause affords the flexibility for additional analysis if warranted by site-specific condition.

Slide 16, please.

And here's the Table A of paragraph 61.13(e). And this is a new table developed specifically for the performance period analysis and the screening value that you see on the concentration column are largely derived from class A limit table in the current Part 61, Section 61.55.

And in the radionuclide column note that we proposed the use of long-lived alpha-emitting nuclides instead of the currently found alpha-emitting transuranic in Class A limit table to capture other long-lived nuclides, for example, radium, uranium, and thorium.

MEMBER RYAN: Just a second on the

concentration concept. That's a concentration in a waste as we see. I always think about site limits or site activity limits as an amount. It's a fractional release from the amount. How do I get from one to the other? I know how I would do it, but I'm just trying to get you folks to talk a little bit more about that.

MR. ESH: These concentrations are facility average concentrations. So it's container by container or barrel by barrel type of concentration. And the idea was that we didn't want to have a situation also where you have say one container of waste that's above Class A and then you have a lot of waste which is very dilute and that's going to trigger somebody into doing this long-term analyses because that's not the risk regime that we wanted to capture. We wanted to capture when you have a lot of long-lived waste that you're going to this analyses.

MEMBER RYAN: So you really focused on the fractional release from the entire inventory are much longer times than we think of.

MR. ESH: This concept is based on total facility inventory. It's reflected in a concentration because people will operate on a concentration basis.

MEMBER RYAN: And deliver it bucket by bucket.

MR. ESH: Yes, and they deliver it in increments and discrete amounts, but ultimately the disposal site operator, they're going to say I have a facility of whatever size and if I fill it up with waste at this concentration, that would trigger -- at or above these concentrations, that would trigger when I need to do the analyses.

There are special circumstances though where you may have concentrations below these, for instance, where you'd still want to do that analyses and we talk about those in our guidance document. They're pretty technical and it would be much too much information, we felt, for the regulatory requirements to put them in there, but we wanted some flexibility for people to do that if necessary.

And that's because of some of the things I talked about earlier. There's a lot of variability in the types of materials you're going to dispose of, the types of systems they go into, the types of barriers you use. All those things contribute to whether you have a problem that you should be looking at the longer-term impacts or not.

MEMBER RYAN: Thank you.

MEMBER BROWN: Can I ask a clarifying question for myself, please? When we talk about a facility, is this a building or this burial?

MR. ESH: Yes, these are near-surface disposal facilities which in Part 61 almost exclusively tend to be below-grade facilities.

MEMBER BROWN: How much below grade? Is it 10 feet?

MR. ESH: It varies. At some facilities may be as deep on the order of 40 to 50 feet, I believe.

MEMBER BROWN: The top of the material below the actual grade. That could be 40 to 50 feet below the surface?

MR. ESH: In some cases. In other cases, we have a facility where the top of the waste is actually above grade, so they make a mounted disposal facility where the waste is above grade.

MEMBER BROWN: Okay, second question is on your concentration, I guess this goes to what Mike asked you to say, but in my mind what this means then is a facility, say I'm just below grade and I own the facility and I've got five square miles and I go down 50, 60 feet, whatever, I bury stuff. I could fill up that entire volume with, I just pick one of these, under that concentration and not have to do any analyses at all as long as my average concentration over that whole five square mile or five by five mile -- not square mile, but 25 square mile, without doing any analyses. Am I reading this correctly?

MR. ESH: For the most part. You know --

MEMBER BROWN: I understand there's exceptions. But if you look at the requirements in the table, that's the implication I would take away relative to do a more detailed analysis that you called for.

MR. ESH: One of the key factors, and waste disposal and especially in low-level waste disposal, the dominant pathways tend to be water-dominated pathways in terms of release and then potential dose exposures. So in the case of a disposal facility, one of the key things you're looking at is the dilution factor of how much is released from the waste, it might be solubility limit, it might not be. It might have waste forms that have different dissolution and degradation mechanisms. But how much waste comes out and usually we look at things in the kind of a layer cake model in two dimensions. So 1D transport vertically through the subsurface to an aquifer and then horizontal transport through an aquifer to a receptor location where you might have a pumping water well, hypothetical water well, that sort of thing.

So the dilution factor is really the ratio of the flux rate coming from the facility to the aquifer and then you have a horizontal flow through the aquifer. So you have a volume of water that comes in the side in a unit volume of aquifer and that flux from the top is being diluted in it. So as you change the aspect ratio of your facility and say you made a really massive facility, if you put a massive facility over a limited size aquifer, then you're going to start running into issues with your dilution factor. But for normal ranges of dilution factors, as long as you meet these concentrations on a facility average basis, you're not going to have any trouble.

MEMBER RYAN: One thing I think is helpful to add to that, Charlie, is that -- correct me if you don't agree, David, but it's not only the site and how it behaves, but during the operational period, there is quite a lot of on-site monitoring in the aquifer and off-site monitoring and development of a very detailed understanding of a geohydrologic model from the surface down to the site on into an aquifer or a release point whatever it might be, so that after a facility is licensed, it then goes through a period of operations in decades. And during that period of decades, there's a lot of information gathering that certainly does go on and I think could go on to address whatever the requirements are in the guidance memo that say you need to understand how this is going to work over time. It's that body of information that then helps you to say well, we feel confident we now understand this site in some detail and this is how we feel it's going to behave over time and what the performance is going to be over time. So if you don't agree with that, let me know. I think that's generally how it all fits together.

MEMBER BROWN: One more question relative to this, maybe one more. Waste comes in from some place. It comes in a truck or a container or is it just dumped in or -- I didn't say anything about containment. Maybe it's there, but container -- I presume there's container requirements that you obviously bury the stuff in a container of some kind and I mean if the container was impermeable then dilution factors -- if it were impermeable --

MR. ESH: Indefinitely, for instance.

MEMBER BROWN: Indefinitely, for whatever that means, then that certainly reduces the risk of whatever, no matter how much you have spread around.

MR. ESH: It certainly does and that's why

I think moving to the site-specific analysis allows people to credit the things that they need to credit in their analyses.

So in the existing regulation, particularly for the intruder protection, the NRC developed the tables, the waste classification tables that somebody compares against to determine whether they're meeting the 61.42 performance objective in addition to some other requirements regarding segregation and barriers.

But that is done on a very -- the ability to consider site-specific characteristics is very limited in that sort of approach. In the approach in the revised rulemaking, somebody can consider the site-specific characteristics such as the barriers or containers that you mentioned. In current practices, almost all or I believe all waste is containerized. And it usually goes into some sort of engineered facility. So in some cases, concrete-type vaults are used below grade. In other cases, they're engineered natural materials such as clay layers and things of that nature. But it isn't just backing up a truck and dumping material in. That is what was done 40 years ago. But the practices have changed dramatically from 40 years ago to today.

And in fact, in the past, I ran across an interesting picture of -- there were men at the edge of what looked like a pond with barrels floating in it and they had guns. They were shooting the barrels to make them sink again because they had floated from the water that had filled up in the pond. That was their solution to seeing these floating barrels in the pond.

MEMBER RYAN: We have a comment, I think.

MS. GALLOWAY: Yes, this is Melanie Galloway from DILR. I just wanted to be clear that when we're talking about no assessment, we're only talking about the post-10,000 year period. Every facility will have to do the performance assessment. So I just wanted to make sure we weren't introducing some confusion by going a little bit too quickly.

MEMBER RYAN: For the record, you used the acronym for your organization. Would you --

MS. GALLOWAY: I did. It's the Division of Intergovernmental Liaison and Rulemaking.

MEMBER RYAN: Thank you very much.

(Laughter.)

CHAIR ARMIJO: Somewhere along the lines somebody has to ask the question why 10,000 years? Why is it justified? Why is it necessary? And what's the safety benefit? And if you require these analyses, how can you convince any reasonable person that those analyses have merit?

MEMBER RYAN: I want to put that on the record because that -- any time you want to do it, Dave, because we've gone over this during the subcommittee, but we haven't done it --

MR. ESH: We thought long and hard about that issue and did a lot of evaluation of it and it's reflected in the technical basis documents for the rulemaking. We looked at what's done internationally, what's done domestically, what's done in other programs, why it's done, the different approaches that are used. People use a lot of different approaches, but when we looked at what's been done at NRC, at NRC, we've had a guidance document since Year 2000 that was developed by the Performance Assessment Working Group. They had recommended 10,000 years for a compliance period for low-level waste disposal.

And there's a variety of reasons why that period was selected, but basically, if you choose a very short period, you aren't able to distinguish good facilities from bad or good practices from bad because basically you can all pass a short period. It doesn't take a whole lot in these waste disposal problems. So what happens is there's many things that can cause delays such as an engineer barrier or absorption of the radionuclides when they're transported from the source term to the receptor location. But the delay might just be that. It's not a reduction in risk. It's just a delay in risk. That risk will be realized at some point in the future.

Now what's the obligation in terms of time for protecting people? Well, the existing regulation, specially 61.42 -- 61.41, which is the protection of the general population from kind of all pathways is silent on the period of performance and that's partly why the Performance Assessment Working Group generated their guidance document in NUREG 1573 because there wasn't a number in the regulation and people did things differently. So we don't have any current sites that are licensed under NRC. They're all done in the agreement states. And the agreement states have looked at that differently and kind of very diverse interpretations of the requirements. But 61.42 says that an intruder must be protected at any time in the future right now, the existing language, prior to our rulemaking.

So somebody could say well, they only have to do 500 years now or whatever the interpretation might be. Well, that means you're interpreting any as

500. I can understand that people interpret it differently, but the language is what it is. But when we looked at the technical aspects of the problem, trying to balance that with the policy and the technical, the 10,000 year number would allow us to see the risks from most of the longer-lived waste in that 10,000-year period. It would also allow us to distinguish between the performance of facilities that are inherently say riskless or limited risk because of the type of material that's being disposed of and where you're achieving the low risk or the low estimates of doses because of things in your analyses. And that's important to know because the regulator has to look at the analyses, break them all down and say okay, are you getting these results that say you meet the requirements because you're using engineered barriers and you're crediting solubility limits or -- what is the reason why you're achieving these compliance numbers? You don't get that sort of information if you don't require somebody to do the analysis.

MEMBER RYAN: That's a different question. If I may just jump in, I don't have a very big inventory. So it's a system that you somehow have got to look at every element in the system and see what it's contributing toward the safety that you're getting. So that's a good point.

MR. ESH: The other main issue was we looked at say shorter numbers and we said well, what's been done in low-level waste to date? And two out of the four facilities have been licensed using 10,000 years or longer. And one currently has an analysis submitted to them using 10,000 years and longer. So three out of the four have used analyses of 10,000 or longer to evaluate the safety of their facility. So if you say to me well, how can you convince a reasonable person of these analyses, well, people have done that apparently because they've licensed facilities using analyses of 10,000 years and longer.

CHAIR ARMIJO: That's important to know, but have these been challenged in court? Technically, as an engineer, do you really believe that you can do an analysis taking all the uncertainties, environmental uncertainties, materials uncertainties, governmental uncertainties, 10,000 years -- the United States in all likelihood won't exist as it is today and maybe not at all. And there's nothing wrong with that, that's the way things change. But if somebody wanted to say well, I challenge that analysis, it's not adequate. It's not taking this into account, that into account, that into account. We believe this license should be re-looked at, re-analyzed. That's really what I'm worried about, that you've got something that's really impossible to achieve, but you do it anyway and nobody -- as long as nobody objects that's -- it's just paperwork.

MR. ESH: I understand your concerns, but the practical experience is that those are licensed and operating. They're not under continual challenge about the quality of the analyses. The other, I think, main concern with this from my perspective as say a risk uncertainty person is the message that I'm getting from you is that the uncertainty is very large, therefore why are you requiring this? Well, if the uncertainty is very large, how are you making a safety decision? How are you determining the safety --

CHAIR ARMIJO: I understood your initial thing. The reason it made a difference to me was that what you're really after is how can you determine which is a good waste disposal site versus a not good waste disposal site because anybody can meet a 100-year criteria.

MR. ESH: Yeah.

CHAIR ARMIJO: With cardboard boxes maybe, I don't know. So but then you go into this extremely long period of time to do what you could do today and say here, these are the criterion that constitute a good waste disposal site and this is what we're going to measure you against, depth of disposal, concrete barriers, whatever it is that you really want in these low-level waste sites, just say it up front and make it deterministic instead of this far into the future analysis that has so many variables that it's -- I find it very hard to believe.

You may not be challenged in court, but if it was, I don't think you could survive.

MR. ESH: I don't know about that because I'm sure they were challenged by people that wanted to challenge them, but the technical realities are is that this is uncertainty associated with time frame. But in my opinion it's no different than the uncertainties you deal with in an active reactor system, for instance. You're still dealing with tail risk and our estimation of probabilities of things that we haven't observed very much. So in this case, we haven't observed what's going to happen many thousands of years into the future from the societal component. And that's why we recommend you choose scenarios that are somewhat constrained, fix that part of the problem and then analyze the other technical aspects of the problem.

So there is uncertainty associated with say estimating radionuclide travel times, but I would say in many respects, those estimates are probably less uncertain than things like estimating piping failure in a reactor system under very extreme and to date not very well observed conditions. So you're dealing with a different type of uncertainty and you have to manage that uncertainty, but I don't think the right approach managing uncertainty is to say make the requirements easier. I think if you're dealing with high uncertainties, generally what you do is you employ a conservative approach. That's one way to manage uncertainties.

In this case, low-level waste disposal is not the end of the line. If you have material that's not suitable for near-surface disposal, they can be disposed of as transuranic waste or high-level waste if necessary. There's no need besides like a balance between financial costs and risk that you're trying to balance these two things. There's no necessity that you have to put all this material in the near surface. You need to do the regulatory analysis to determine when it should be in the near surface and when you maybe need to explore something else. If you set the requirements too light, you're never going to make that determination.

MEMBER RYAN: Sam, I think one important factor here is that site starts to operate, sees waste on Day 1 and they cut the ribbon and off they go. As a facility operates and I'm sure it's true for every facility that's operated, they learn more about the site as they go along, whether it's the geohydrology or the radiological conditions or anything else related to their operation, it's a learning experience. So I think that at some point you've got to give credit.

If a facility operates for 30, 40, or 50 years and they've got 50 years of geohydrologic data in and around the site at some reasonable distance which they all probably have, I know some of them have it now, that's kind of, I think, going to give them enough information to improve their understanding over time.

You start out uncertain, as David has mentioned, but I think some of the requirements are unspecific at including the knowledge and the hydrological environment you're in over time.

MR. ESH: And the primary issue is this,

if you don't have much material, your analysis will be very straight forward and not complex. There's no regulatory burden. If you have a lot of material that can cause risk, then your analysis will be more complex because you need to manage that risk. The requirements are designed to allow somebody to do that. So even though the compliance period is 10,000 years, if I designed a hypothetical facility that I was only taking cesium and strontium, yeah, what's the burden for running the calculation out to 10,000 years? All my material will be decayed in 500 years. There's no regulatory burden on me for needing to perform that analysis. Only if I actually have material that persists and can cause risk is it going to create a burden. But these aren't just calculations. I'd say in the intruder area, it's more of a calculation. In the performance assessment area, it's more of a model, but I'll use that term very loosely because you can't validate for these time frames.

I think it's part of your issue, but what's really important is the model support. So we have a lot of text that we put together on model support. I think the high-level waste program was doing that area very well. Eventually, they used things like field experiments, natural analogs, comparison of models and models. There's a variety of things they do to try to build technical confidence in the results which is what you're talking about. How can you develop confidence in the results?

Absolutely important. I agree with you totally on that aspect of it, but I believe you can achieve confidence in the results if you do those things. For a system where you have a lot of waste and it's going to cause risk, it's going to cause a lot of work to be able to develop the basis to support your calculations. For one, where your material doesn't cause a lot of risk, you can do some very simple things to develop the support for your calculations and demonstrate that they meet the requirements. So you know, give them what we have to work with. That's the best we can do to quote unquote risk inform and we think that that works and it's going to afford some flexibility to our --

CHAIR ARMIJO: That's very helpful, David, but if it is that straight forward and it is not burdensome for people to have really no problem and it forces the people who have long, very long-lived, large quantities to do things differently, that's great, but you could always start at the beginning and say if you have large quantities of let's say DU, massive quantities, you are not going to do your surface disposal. You're going to have to do something much better than that. Why not do that right up front, instead of pushing it through an analysis?

MR. ESH: We considered that especially because depleted uranium was the initiator for this whole process. But then when we looked at it we said hey, let's be a little smarter than this if we can because it's not necessarily just say uranium that wasn't reflected in the waste classification tables that could cause the problem, they could be any sort of waste stream that is much different than what was envisioned when that original analyses was done in the early 1980s.

So what we're dealing with is a system where we may have different waste that need to go into it, but if our requirements are rigid and set at a certain type of analyses and a certain point in time, then how are we going to ensure the safety for those things that are different? Instead, let's just require the technical analyses like we, the NRC would do if we did the analyses to develop a concentration table. Instead, let's set the requirements for somebody else to do those analyses and then they reflect the things like their site-specific environmental conditions and their actual waste forms and their containers and their barriers and all those sorts of things, their site geohydrology. All that can be reflected in their analyses and therefore maybe some sites can take a lot more waste under that approach and maybe would some would take less.

Maybe -- if you look at the response to comments in the early 1980's EIS when the NRC came up with waste classification tables, I think it was Los Alamos or one of the national labs wrote in and said hey, even though you base the concentration values in the waste classification tables on a humid site, something like plutonium would be much higher in an arid site because of the resuspension of it. You have that sort of complexity that when you try to reduce it into a table, it all gets lost. Where if you allow people to do the analyses then that sort of complexity can be reflected in their analyses, if they choose to.

They might choose to say hey, I don't want to mess with this, I'm going to do a conservative analyses and set my waste concentrations. I can take these and if I'm a for-profit business and I can make money off those concentrations, that's what I do.

That's -- it affords a lot of flexibility for people to balance this present-day cost versus protecting future generation decision.

I don't think the requirements are forcing people to meet some sort of NRC requirement with that respect. It allows them some flexibility in how they choose and design their facilities and the material they take to kind of answer that question. Ultimately, we all pay for the cost of those facilities.

MEMBER RYAN: The idea I take away from this is what's ultimately going to be more important is not the rule. The rule, of course, has its own standing, but it's the guidance document that the staff basically has said to meet these requirements in this setting we need to do this kind of analysis. So the old question I ask many, many times is when am I done. All this is is an attempt to say if you do these things and get the information and do the analysis, you might get done quicker than you think.

CHAIR ARMIJO: The other thing that bothers me about the 10,000 years is the Department of Energy specifies 1,000 years for their waste and I think includes depleted uranium. I'm not sure, but I believe it does. And so here we have the government regulating itself to a much lower standard than we regulate the private sector and that's something that should be avoided. Really, there's something wrong. If it's good enough for the government, why isn't it good enough for private sector?

MR. ESH: There's a couple points about that. First of all, in their incidental waste sites, most of those, they're analyzing out to 10,000 years and longer. So they look longer, just like this -- we have this conceptual framework of two tiers and looking for a certain period and then evaluating out further. In the analyses that they submit to us, they reflect that, that sort of conceptual behavior for the most part.

In addition, they have institutional control ability for -- they say in perpetuity, but when they do their analyses, they don't analyze it like they have in perpetuity, but because it's a government-owned site they believe they're going to have long-term ownership of it. That kind of alleviates the burden of what are the long-term impacts if you believe you're going to control the site.

The third point in that regard is when DOE -- DOE originally had 10,000 years for their analyses for their different waste and they had an expert group that they formed to look at that issue and that group recommended 10,000 years. And then DOE somewhere in the process, headquarters or whatever switching it to 1,000 years and they had a justification for that. But that justification, in my opinion, is not very strong and they went against the recommendation of their experts. So we had to factor that in. We know that DOE uses that for their waste disposal facilities, but we don't think that you're able to see this issue of the behavior of your facility and how you're achieving your risk limits with that short analyses and you don't even come anywhere close to capturing what could be the peak risk with that cut-off time frame.

So if there's a moral obligation to only analyze 1,000 years, that's an issue that the Commission could make a statement on and that's what it is. But we don't feel that we have any guidance on that aspect of the problem, but you're looking at all the other criteria, we came out where we came out.

CHAIR ARMIJO: Okay, thank you very much.

MEMBER RYAN: Another comment?

MS. SUTTORA: Yes, this is Linda Suttora with the Department of Energy. And I would like to object to a couple of things that were said. One is that we had originally considered 10,000 years. We considered a lot of things in analyses in developing 5820, Department of Energy Order 5820.2(a) and DOE order subsequent version which was 435.1(b). There was a lot of papers written in the development of those orders and the fact that one paper recommended 10,000 years would not constitute that we rejected the higher protectiveness.

I also object to calling 1,000 years lower protectiveness because, as we all know, most of the shorter-lived radionuclides are gone by 500 years, so we double that to be protective. We also always analyze out to peak dose and we take into consideration the peak dose and in fact, 10,000 doesn't even come close to discovering the peak dose of depleted uranium that's actually out past 40,000 years. So by saying 10,000 years --

MEMBER RYAN: It's probably outliving the planet.

MS. SUTTORA: Pardon me?

MEMBER RYAN: It's probably outliving the planet.

MS. SUTTORA: Yes, so -- by saying that 1,000 years is less protective than 10,000 years is actually warping the analysis because 500 years is pretty much all you really need to go to and that has been analyzed by many countries and many states and also analyzed by other organizations such as the National -- I can't remember what it stands for NAPA, which did a study on -- that they said just a few generations was enough.

So we should be very careful on what we say is more protective than another analysis. It's a different analysis, but since we always go peak, then we do always discover what the peak dose is and we may modify our disposal's activities based on where the peak might be, maybe put it deeper, maybe put a more substantial cover and all that.

CHAIR ARMIJO: I appreciate that. Thank you very much. I appreciate that. Okay, that was worth discussing because that's going to be an issue. Go ahead, Dave. Thank you.

MR. ESH: The only thing that I would have to add on that is that we were -- the initiator for this was the depleted uranium from the Commission. That's 08-147. When we looked at that, the peak dose -- the dose from your depleted uranium at 1,000 years is only about 1/1,100th of where it ends up. The dose --

MEMBER RYAN: It ends up dead.

MR. ESH: Around 1.6 million years, but it depends --

CHAIR ARMIJO: That's beyond my concern.

MR. ESH: But at 10,000 years, you're about at 1/10th of the peak dose. So if I'm sitting here as a regulator and trying to order with some stakeholders that I'm making regulations that are going to protect their health and safety, I don't know how if I only have 1/1000ths of the risk realized at 1,000 years that I say I'm doing that. It doesn't even come close.

MEMBER RYAN: But David, one point that I think is important for folks to understand is that 1,000 years or 10,000 years at some point we're all here and we've got a country and we're going to control this and we've got large regulations and smart people to take care of. I just think it's hard to project out in time who is going to be doing what when.

So to me, one thought is to focus on the first 1,000 years for the technical, a good, solid technical analysis where you've got higher probability and capability to make estimations and how things are going to behave, what behavior might be like and all that. A thousand and ten is where things kind of fall off the truck at least from my way of thinking about who's going to where, when, and what are they going to be doing?

MR. ESH: I understand what you're saying, but in some aspects I disagree with part of it in that I think that uncertainty in the societal aspect is much larger and probably occurs earlier. All you have to do is look at say what was going on here 50 years ago and 100 years ago and 200 years ago and how much it's changed over time. If you ask somebody 200 years ago what would we be doing today, they would have been way off with what they probably estimated. So society uncertainty, I think is very large which is why we say this is a regulatory analysis. It's the best we can do today to try to estimate what's going to happen with these problems. We're to constrain the societal uncertainty and we're going to allow people to technically evaluate the other parts of the problem. That's the way the performance assessment works.

Some groups internationally, they look at the full uncertainty and the human aspect of the problem which I think is counter productive. All is a game about speculating about what one group can do and what imagination they have compared to another group. It doesn't benefit anybody. But if we can pick scenarios that are based on basic human activities that we think people will need to continue like eating and living in a house and things like that, we think that's a reasonable regulatory analysis to ask somebody to perform.

So in that respect we think the uncertainties in 1,000 years are not much different than in 10,000 years. When you get to 100,000 or 1,000,000 years and you're talking about broad, landform evolution and those sorts of things now you're in a different ball game, but 1,000 to 10,000, not measurable differences in uncertainties. If anybody thinks there are measurable differences and uncertainties in natural systems or whatever, I'd like to hear about that.

CHAIR ARMIJO: But David, given that point, why don't you just say hey, there's are not going to be much difference after 1,000 years, 10,000 years. Why don't you just truncate it at 1,000 and you tell the public hey, we take care of future generations up to 1,000 years and from then on you guys have got to take care of yourselves. We can reasonably presume that future generations have some competence to take care of themselves, so it's just an analysis. If it becomes burdensome and expensive and it limits a siting or licensing of facilities, that's counter productive.

MR. ESH: I think you've misinterpreted something I said or I've misrepresented it. There's not much difference in the uncertainties associated with those two time periods, but there can be extreme differences in the risks associated with those two time periods. So in these problems, you transport material from the source out of the system. The natural system or the engineered system can create delays in those materials. So what you see in that initial 1,000 year period may be a tiny fraction of what you're going to see in the post-1,000 year period.

CHAIR ARMIJO: But we don't have to worry about it. You've chosen to worry about it, but I think we don't have to. You can just do an analysis and that's it.

MR. ESH: You can, but we don't have a lot on this from Congress, but there is some material in the '70s where they basically talked about this subject and my interpretation of it is they believe that the material should be managed for as long as it's hazardous and they mentioned 250,000 years.

That's all we have.

If you want to say well, Congress, you got this wrong --

CHAIR ARMIJO: Yes, I have no problem saying they got it wrong.

MS. JACKSON: Andy is barely halfway through his presentation. I was wondering if we could move on and maybe -- we have another topic that's going to bring a lot of discussion.

Any has about 20 more slides we'd like to get through.

MR. CARRERA: I'll wrap this up very quickly so you will have additional time.

MS. JACKSON: So we can have some additional discussion.

MR. CARRERA: Imagine five years with Dave of meetings like this.

MEMBER RYAN: I appreciate the discussion. It's been very helpful.

MS. JACKSON: It's been a very good discussion.

MR. CARRERA: Thank you.

MS. JACKSON: But Andy's put a lot of work and we want to make sure he gets to the slides.

MR. CARRERA: Thank you. Once we've

demonstrated compliance with the performance objectives in section 61.41, we now turn to performance objectives for the protection of inadvertent intruder in Section 61.42. The performance objectives for protection of inadvertent intruder also has a two-tier framework. It's based on a two-tier framework, 10,000 year compliance period component, and a post-10,000 year performance period component.

MEMBER BROWN: Does that mean accruing 500 millirem over 10,000 years?

MR. GROSSMAN: That's an annual.

MEMBER BROWN: I'm sorry. I sped right past the annual. I apologize for that.

MR. CARRERA: In proposed paragraph A of Section 61.42 contains recent requirement for the stated annual dose limit of 500 millirem which is what staff has used to support the one staff developed, Table 1 and 2 of the 10 CFR Part 61.

Paragraph A also requires that the compliance with this paragraph must be demonstrated through the analyses that meet the requirements specified in Section 61.13(b) which is the inadvertent intruder analysis.

Let's see how an inadvertent intruder

analysis can satisfy these performance objectives for the 10,000 year compliance period. Going back to the provided preliminary FRN, it also discusses the inadvertent intruder assessment in great length, but in summary the purpose of an inadvertent intruder analysis which is found in paragraph 61.13(b) is to examine the capability of intruder barrier and estimate the potential annual dose by considering uncertainties involved in the inadvertent intruder scenario.

In the guidance document we have additional discussion of the type of inadvertent intruder scenarios that we can satisfactorily use to demonstrate compliance with this requirement.

DR. BALLINGER: I have a question.

MEMBER STETKAR: Ron, you have to --

DR. BALLINGER: Ron Ballinger. How does this compare with the land occupancy requirement? Isn't the land occupancy requirement that we've been talking about a little while --

CHAIR ARMIJO: Habitability?

DR. BALLINGER: Yes, habitability. That's 500 millirem per year, right? So if this limit is 500 millirem per year and the land occupancy for just occupancy is 500 millirem per year, how is it an intruder? Maybe I'm missing something here. There's a land occupancy which we've been talking about which is that dose is 500 millirem --

MEMBER STETKAR: State of Pennsylvania.

DR. BALLINGER: In the State of Pennsylvania. Well, there's a land occupancy in every state. That's 500 millirem per year for Pennsylvania. So what we're saying is is that if we go to a waste disposal site in Pennsylvania, after the closure period if somebody goes there by definition they must be an intruder. Where am I missing something here?

MR. GROSSMAN: The purpose of this is to look at -- okay, so 61.41 deals with releases from the facility to the general environment. This is, I think, kind of an acknowledgement that because this material is in the near surface, the likelihood that someone may in the future intrude into the site or excavate some of the waste, the likelihood of that is a little higher than maybe other disposal concepts such as with high-level waste. So there was an acknowledgement that we need to be looking at that and so performance objectives are set up to protect someone who comes on to the site and inadvertently intrudes into the waste.

There's a distinction in the intruder

concept between advertent and inadvertent. An advertent intruder being someone who knows, actively knows that they're digging into something, they're taking those risks on themselves. This isn't designed to protect them. But for someone who doesn't -- isn't aware maybe through some bureaucratic error was allowed to come on to the site and build a residency --

DR. BALLINGER: What I'm saying by the land occupancy rule, they are allowed to do that.

MEMBER BLEY: And they are here. That meets the criteria.

DR. BALLINGER: Right.

MEMBER SHACK: You're giving them the same dose.

DR. BALLINGER: That's what I mean. I mean you're giving them the same dose. They're consistent.

MEMBER SHACK: They're consistent.

DR. BALLINGER: But why call them an intruder then?

MEMBER BLEY: This is for an intruder somewhere later when you know you put --

MEMBER RYAN: You can call it someone who has decided to live on a waste site if you want, but the common term that's used for somebody that's theorized intruding in a waste site is an intruder.

DR. BALLINGER: I understand that, but they're also allowed to live there as if it wasn't there. He's still an inadvertent intruder.

MEMBER BLEY: You wouldn't call the people going back to their homes in Pennsylvania intruders. In this case, it's an intruder who goes into a place you didn't expect him to go and you're holding them to the -- you're holding the site to not expose them worse than the guy you let come home after some accident.

DR. BALLINGER: Right.

MEMBER RYAN: Let's move on.

MR. CARRERA: Slide 19, please.

The proposed paragraph 61.13(b) has three subparagraphs, subparagraphs (b)(1) and (b)(2) contain requirement that the inadvertent intruder analysis must demonstrate that the waste acceptance criteria for disposed waste will be met and that adequate barriers will be provided. And we'll discuss the waste acceptance criteria in greater detail later in the presentation.

Slide 20, please.

Subparagraph (b)(3) contain a requirement for inadvertent intruder analysis to assume that an inadvertent intruder occupies the disposal site at any time during the compliance period and engages in normal and other reasonably foreseeable pursuit that unknowingly exposes the intruder to radiation from the waste. Also, there are requirements to identify adequate barriers, provide technical basis for the time period that the barriers are good for and consider uncertainties and variabilities in the analysis.

Again, the guidance document would cover in great depth on how we can satisfy these specifications.

Slide 21, please. Once the requirement in paragraph A is satisfied, paragraph B of Section 61.42 requires us to take a look at what we need to do for the post-10,000 year performance period. And paragraph B requires that we demonstrate minimum exposure to any inadvertent intruder to the extent reasonably achievable at any time during the performance period. And paragraph B also specifies that compliance with this paragraph must be demonstrated through the analysis that meet the requirements specified in Section 61.13(e) which is the performance period analysis that we discussed already.

Slide 22, please.

Finally, the staff proposed an addition to the introductory text of the current Section 61.13 to clarify that the required technical analysis must be submitted at the next license renewal or within five years of the effective date of this subpart, whichever comes first. And for the NRC licensees, effective date is one year after the publication of the final rule. The agreement states will have an additional three years to develop their compatible regulation at which point they'll describe the effective date.

MEMBER RYAN: Andy, will you just mention for everybody's benefit the number of sites now currently that are either an agreement state or not an agreement state.

MR. CARRERA: We currently have four disposal facilities in four separate agreement states.

MEMBER RYAN: Thank you.

MR. CARRERA: Slide 23, please.

So let us now switch gears to a different type of site-specific requirement that the Commission directed the staff to specify. And in January 2012 SRM, the Commission directed the staff to expand the limited scope rulemaking to provide flexibility for disposal facilities to establish site-specific waste acceptance criteria based on the results of the site's performance assessment and intruder assessment.

And to do that, the staff has recreated Section 61.58 and we titled it waste acceptance. The provided preliminary FRN also discussed adequate length of how the staff did that. In recreation of Section 61.58, the staff proposes a new requirement for the development of a waste acceptance plan which includes the development of waste acceptance criteria, establish waste characterization methods, and development of a waste certification program.

Slide 24, please.

So proposed Section 61.58 contains eight paragraphs. In paragraph A as directed by the Commission, the staff proposed requirements for the development of the waste acceptance criteria that is based either on the result of the site-specific technical analysis that we just covered required by Section 61.13 or the current waste classification requirements in Section 61.55.

Slide 25, please.

Paragraph A also contains requirements for the waste acceptance criteria to meet the minimum requirement for waste characteristics and imposes restrictions or prohibitions on waste materials or containers that might affect the facility's ability to meet the performance assessment. And the guidance document will have additional discussions of how we can satisfactorily develop a waste acceptance criteria to demonstrate compliance with this requirement.

MEMBER RYAN: I think it's helpful for the members to also realize that every site that I'm aware of has a license, but they also have a site criteria document of some kind that really gets into a lot of detail of how you would meet that kind of requirement in packaging and all the rest.

MR. CARRERA: Almost all, Chris, all of them will have a site that's based on similar criteria.

Slide 26, please.

Paragraph B of proposed Section 61.58 contains requirements for waste characterization. And items 1 through 7 of paragraph B represents the required minimum information that is needed for the characterization of the waste.

MEMBER RYAN: Just a quick question that caught my eye. What is a generating source?

MR. GROSSMAN: The generating source would be where that material was generated from.

MEMBER POWERS: It's what is a non-generating source.

MEMBER RYAN: That's a little bit fuzzy. So we'll have to think about that. It's a minor point.

MR. McKENNEY: In parlance, that would be the nuclear reactor or whatever and then because of the fact that characterization does not occur until the waste is about to be shipped to the disposal facility, at that point is when characterization occurs. So if a processor was doing the documentation to complete these seven items, they would know what reactor the waste came from because they are not the generating source. The reactor was the generating source.

MEMBER RYAN: So point of origin of the waste is a whole lot better description than what you're talking about. I just think you need to give somebody a set of the buzzwords and make sure they communicate what you hope to communicate. That one just jumped out at me.

DR. BALLINGER: I actually have another question. This is Ron Ballinger. This identity's activities and concentrations, do they actually have to be determined? Because I've received a lot of waste from utilities and it arrives with a little tag that says what's in it with a letter that says this came from such and such a place. And historically, these are activities that we've seen and therefore, we're just assuming that they're there. So you get something where there's an assumption made on the activities that are present and when you actually do an analysis to determine what they are, you find out they aren't there.

MEMBER RYAN: I'm going to guess that that's an in-processor location? When you receive these materials, are you a processor or a disposer or what were you doing?

DR. BALLINGER: We're going to do work on them. Examination.

MEMBER RYAN: Okay. You're not receiving waste. You're receiving a licensed material that you're going to either turn back or put into your waste bin.

DR. BALLINGER: Yeah.

MEMBER RYAN: That's not a 61 regulated activity.

DR. BALLINGER: All right. I'm just a dummy with respect to this stuff.

MEMBER RYAN: I guess I'm picking on it

because I don't want people to be confused about when you're shipping licensed material from one licensee to another is a very different circumstance whether you ship it or turn it over to a waste processor.

DR. BALLINGER: We're acting like an opiant. If something is coming -

(Laughter.)

MEMBER RYAN: Okay. Thanks.

MR. CARRERA: Slide 27, please. In paragraph C of the proposed Section 61.58 contains requirements for certification program to certify that the waste would meet the waste acceptance criteria prior to shipment to the disposal facility.

Slide 28, please.

CHAIR ARMIJO: Any, these are listed as new requirements, but I can't believe people haven't been doing this all along. It seems like it's what you normally would do. Were they somewhere else?

MEMBER RYAN: Sam, I think it's fair to say that the acceptance criteria that you would give a customer has this and many dozens of pages more that tells them what to do, how to do it, how to label it, how to paint it, how to bolt it. All that stuff is laid out, but these are now regulatory requirements that will probably guide that in a little bit more detail.

CHAIR ARMIJO: In the past they were in guidance documents and they've moved up to a regulation, is that what we're saying?

MEMBER RYAN: Not exactly. There was a requirement, but -- and I think these are just a little bit more detailed and I don't mean a lot, I mean a little bit more detailed in the regulation to get people categories of stuff and they'll still be implemented as I understand with site criteria and guidance documents that are generated and so forth. Is that a reasonable summary?

MR. CARRERA: Slide 28, please. In paragraphs (d) and (e) of the proposed Section 61.58 contain requirements that we must demonstrate compliance with this section at the next license renewal or within five years of the effective date of the subpart, whichever comes first. It also contains a requirement -- it also indicates how the waste acceptance plan would be treated for licensees and license applicants.

Paragraphs (f), (g), and (h) of Section 61.58 contain requirements for an annual review of the waste acceptance plan and updates of the plan would require -- would have to be consistent with the

Commission's policy in other sections of Part 61, namely 61.20 and 61.23.

Just note we discussed the site-specific requirements, the technical analysis and the waste acceptance plan material. We talked of changes, supporting changes such as new definition and concept to support the implementation of the site-specific technical analysis as well as changes to Appendix G to 10 CFR Part 20 and the waste manifest form because they are inherently linked to the required site-specific waste acceptance plan.

Slide 31, please.

So in Section 61.2 which is the definition section, the staff proposes a definition of long-lived waste to support the performance period analysis. And the preliminary -- and provided the preliminary FRN also discussed by the staff proposed to use this definition at great length.

CHAIR ARMIJO: Has ten percent been pretty much the practice in the past for the definition or is that a new number?

MR. ESH: There isn't a real I'd say practice with this. Internationally what you'll see is the long-lived is usually set by a half-life and quite commonly 30 years. So greater than 30 years is considered long-lived and less is considered short-lived. That was too constraining we felt. In this case, for Item 1 of this definition it works out to be roughly a 3,000 year half-life, so it captures something like americium-241 which we see in a lot of waste streams. And it's consistent with the existing tables in Part 61 where carbon-14 was considered to be long-lived. Under this definition carbon-14 would also be considered to be long-lived. So that's kind of how we came up with it.

And then it captures in-growth and decay or in-growth and progeny with Items 2 and 3.

MR. CARRERA: Slide 32, please. Also in Section 61.2, the definition section, the staff proposed definitions of compliance period and performance period. Also to support the site-specific technical analysis and also directed by the Commission.

Slide 33, please.

Also in the definition and consistent with the definition section and consistent with the National Defense Authorization Act for Fiscal Year 2013, the staff proposed the revision to the definition of waste to account for the reclassification of waste resulting from the production of medical isotopes that may have been permanently removed from the reactor vessels or subcritical assembly, for which there is no further use. And these wastes will be reclassified as low-level radioactive waste.

Slide 34, please.

In proposed Section 61.7(a)(2) which is the concept section, the staff proposes to add a new concept to clarify that there are waste that is Class A waste by default under Section 61.55(a)(6) such as depleted uranium, but may not decay to an acceptable level within 100 years. And for this waste, safety is provided by limiting the quantities and concentration of the materials consistent with the disposal site design and also can be demonstrated by compliance with performance objectives.

Slide 35, please.

In proposed Section 61.7(f)(3), the staff proposes to add a new concept that clarifies the purpose of post-closure observation and maintenance program. And it's mainly because we received comments on this.

Slide 36, please.

In proposed Section 61.7(g) the staff proposes to add a new concept to indicate that licensees will need to use a dose calculation method consistent with Part 20 which currently is based on ICRP publication No. 26, the year 1977. And also allows the use of more up-to-date later application of ICRP recommendation for dose modeling purposes.

Slide 37, please.

The purpose of Revision 2, Appendix G to Part 20 and the purpose of Appendix G is to address various regulatory information needs for the transfer of the disposal of low-level waste. These information needs include the information that demonstrates compliance with performance objectives in Part 61. And because the staff proposed requirements for waste acceptance plan, Appendix G, which is linked to the waste acceptance plan would also be revised to reflect a new waste acceptance criteria which characterization and waste certification requirements of proposed Section 61.58.

And Section 2 of Appendix G that you see on the screen here, the staff proposed that red text revision just for readability.

Slide 38, please.

And in Section 3(a) of Appendix G, the staff proposes revision to incorporate the waste acceptance criteria into Appendix G.

Slide 39, please.

In Section 3(c) of Appendix G, staff includes the waste acceptance criteria.

Slide 40, please.

Because the staff proposed revision to Appendix G which referenced a waste manifest form, the staff also proposed to revise a portion of the certification statement in NRC Form 540 and revise NRC Form 541 to allow the licensees to indicate a use of the waste acceptance criteria if it chooses.

That concludes my presentation on Part 61 revised proposed ruling. Thank you for staying with me. I know it's a dry subject and I tried to make it as sexy as I can, but that's the best I can do.

MEMBER SHACK: You didn't get enough excitement out of this discussion?

CHAIR ARMIJO: We didn't attack him this time, but we will.

MR. CARRERA: So for the path forward and assuming that the Commission approves the proposed rulemaking package, the staff will publish the proposed rule in the Federal Register for public comments in the fall or winter of 2013. That's assuming the Commission will approve the publication date. And the staff also plans to conduct at least one public meeting in 2014 to engage the public on this proposed rule.

The staff will -- once we receive comments on the proposed rule, staff will then consider all comments, address the comments, respond to comments in the final rule which is expected to come out in late 2014.

Thank you for your time.

MEMBER RYAN: Thank you very much, Andrew. Are there any other questions from members?

MEMBER POWERS: A question comes up to me in my mind. Do you anticipate having a public meeting? What parts of this package do you expect to get from those interrogators concerning from members of the public and from potential or actual licensees?

MR. CARRERA: I think definitely DD 10,000 years number would attract some attention and we're definitely going to get some interaction with Dr. Armijo on the inadvertent intruder and scenario.

(Laughter.)

MEMBER POWERS: Do you think he's particular intrusive?

(Laughter.)

I certainly do, but --

MR. CARRERA: It was inadvertent.

MEMBER POWERS: Advertent. Quite frankly, your defense in the 10,000 years was not particularly glib, smooth. You made a lot of plausibility. It's basically a plausibility or traditional -- following tradition was the argument that was advanced in defense of 10,000 years. Are you going to tone that down so that you can defend it a little more facilely under your interrogators?

MR. ESH: That's a good comment. I get a little frustrated by it --

MEMBER POWERS: I understand . I can see that.

MR. ESH: We've been debating it for multiple years now and --

MEMBER POWERS: I noticed that.

MR. ESH: It's something that's not really quantitative and you can't make it quantitative. It's a multi-faceted --

MEMBER POWERS: I thought your defense was flawed.

MR. ESH: It's a multi-faceted issue with a whole bunch of components and everybody has strong opinions and different opinions. So what are you to do about it?

We considered everything and I think our best discussion on the issue is in our regulatory basis documents that talks about why we recommended the approach that we recommended. It goes over the summary of the international experience, the domestic experience, some of the technical aspects, uncertainty. Shows like what happens in analyses, actual analyses when you look at dose projections and curves and how they can jump up tremendously, especially -- and that's the main issue technically is if your regulatory period is too short, you can say I meet all the regulatory requirements, but you have this massive risk or liability looming in the future. And if you go back and look at the documentation from the '70s about how Part 61 even came in to be, originally the disposal facilities were having a lot of trouble and some of those are now closed, are surplus sites because they had so much trouble.

So Congress said look, we need to do something about this. Let NRC make some requirement so we aren't having this trouble because we do not want our disposal sites to become a future liability. That was the main issue. We don't want them to become a future liability. The regulation came in to be.

So my concern in this area is if you don't set those requirements right, you're going to do just that. It is going to be a future liability. It's just a matter of the timing. But if you make somebody do the analysis up front, you can greatly reduce the likelihood that that will become a future liability. And so I think that's what the intent of what they wanted to do. It's good practice in terms of safety. I think there's a whole bunch of things that go into why you would want to do it the way we're recommending. But ultimately that's a decision that's made by our high-level decision makers including groups like yourself and whatever it is, it is.

MEMBER POWERS: Let me just suggest that maybe you can put together a defense on that 10,000 year and the other parts you think you're going to have friction in your public meeting and get Mr. Ryan have another subcommittee meeting and we can be devil's advocate for you and help you on that a little bit.

MEMBER RYAN: One part of the 10,000 year thing too is what do you receive? We've heard the arguments if you have uranium 10,000 doesn't make a big difference.

MEMBER POWERS: Isn't going to buy you anything.

MEMBER RYAN: But if you have some waste

you have that are easily managed within 1,000, but then there's a couple other ones that can get your out of 1,000 and 10,000, is there flexibility in one number. Do you have to have one number? That's to say you can justify one, ten or whatever. So that's a strategy there to think about.

MR. ESH: There is some -- as I tried to say, there shouldn't be a burden if, in fact, you say you want to dispose of short-lived waste or very low concentrations of long-lived waste. That technical analysis should be relatively straight forward. This requirement should not be causing you a burden. So what problems are trying to be solved by all the focus on this number?

There's a lot more important things in this regulation that are barely talked about and are much more significant than all the attention that's put on the compliance period. The compliance period is not going to determine whether facilities pass or fail in unto itself. It's the quality of the analyses and the evaluation that's done that will determine whether you make a Type 1 error or Type 2 error or type of decision-making process.

I understand it's something people like to talk about and we spend a lot of energy, but when it's all said and done, I don't think that's going to be the determining factor of whether the regulation was a good one or not.

MEMBER RAY: Well, if you were an applicant and you didn't have just short-lived waste, what difference would it make that you had to look at 10,000 years instead of 1,000?

MR. ESH: Sorry, say that again, the first part of it?

MEMBER RAY: If you were an applicant --

MR. ESH: Oh, an applicant, okay.

MEMBER RAY: And you didn't have just short-lived waste and you had to meet the 10,000-year requirement instead of 1,000, what would the effect of that be?

MR. ESH: In my opinion, because I've done a lot of performance assessment calculations. I've reviewed a lot of performance assessment calculations from all sorts of different groups, internationally, domestically, what have it. There is -- once you set up the calculation and develop the model's analyses, whatever, there is not a huge additional burden to extending the time frame between say 1,000 and 10,000.

MEMBER RAY: What is the burden?

MR. ESH: There's some burden because some systems will be different and change over that period of time. So like if you take a site like our complex decommissioning site at West Valley, for instance, high erosion, okay. The model that you might develop for 1,000 years might be quite a bit different than the model that you need to develop for 10,000 years because of that erosion. It changes your land form, your aquifer changes as the land form erodes. It's just an example of that might be a special case where you get a big delta between those time frames.

But for the most part, when you put in the expense of collecting your site-specific information for say rainfall and distribution coefficients and plant transfer factors and all that sort of information, that information is not going to be hugely dynamic between 1,000 years and 10,000 years.

MEMBER RAY: Let me ask about something that may not be as predictable as you're implying to me anyway. And that is changes in the meteorology, global warming, whatever name you want to give to it, things that make erosion different 5,000 years down the road than it is now. Are you having to imagine those things and include them in the analysis?

MR. ESH: Yes, so climate is a driving

function of some other process. Basically, the approach that we've taken in the past is anthropogenic effects on climate are too difficult or too uncertain at this point to accurately project their effects into these time frames.

MEMBER RAY: Well, that's the thing I think we find most disturbing is that wouldn't be the case. Somebody would say how about an ice age, what about a glacier?

MR. ESH: Well, what we do say is the natural cycling of climate has been pretty well known or is reasonably well established and in these waste disposal systems at the longer time, you would want to consider the natural cycling of the climate and for instance, in the application for the disposal facility in Texas, they did just that. But how did they do it? Well, basically at longer times they end up with I think it was a cooler and wetter climate state which is associated with more precipitation, more infiltration and then the associated effects on their system. That's commonly what we've seen. They also did that at Yucca Mountain, for instance, looking at climate states and climate analogs and they analyzed the changes in the system over time.

So the natural cycling, we think, it might change the timing of some of the processes, but the amplitude of the natural cycling is probably just as large or larger than the anthropogenic effects. So as long as you're considering the natural cycling you probably have handled the anthropogenic, even if you don't get the timing exactly right.

MEMBER RAY: What you're implying to me is what you're referring to as natural cycling is a bounded, quantifiable thing, not some unknowable.

MR. ESH: The fact that we've had repetitive pattern of ice ages and warmer periods like we're in now that you can't accurately predict the exact timing of them, but the relative magnitude and their effects you can to some extent. And it would -- there was an interesting show I saw about meteorites and this was in Sweden. When a meteorite hits, it forms a strewn field on the surface. It's basically the patterns of rocks that are dispersed when the meteorite blows up.

There's a meteorite field in Sweden that happened, they dated it and it was a long time ago and it's gone through something like 14 ice ages since then of glaciers coming and then going, coming and then going. Well, the strewn field is still a strewn field. So we have this concept in our mind of you have this ice age and you have this huge dynamic effects and everything is destroyed and ruined, but the evidence from at least that site says that well, that material still kind of has the general characteristics of what you see if it happened today.

So there's that sort of information out there. As I said, it's quantitative information that has to be interpreted qualitatively. That's the bottom line as you're as scientists and engineers are trying to make a decisions that you think is protective using the information you have, considering the uncertainty in the information. I don't think that we should be taking this approach of saying well, we don't know what the risks are, therefore, let's take the action. If you don't know what the risks are, you shouldn't take the action. You should do something else. I don't know what that something else is, but you shouldn't be taking the action if you can't define what the risks are with some reasonable level of confidence.

MEMBER BANERJEE: So these ice ages were not so disruptive, these patterns you see, that we could not design some sort of system to withstand that?

MR. ESH: I don't think you should be

thinking that way necessarily. This is low-level waste, as I said, and if I had very concentrated long-lived low-level waste that could cause a problem at the facility was destructed and it was dispersed in the surface, I don't have to necessarily put it at a northern site. I can pick a southern site that doesn't have the climate disruption and put it there and solve the problem that way.

MEMBER BANERJEE: That would be prudent.

MEMBER RYAN: You pick a southern site because there's no snow and the trucks don't have to worry about the weather and there's lots of practical things about why they tend to be in the southern climes.

MR. ESH: I mean we can make regulatory requirements as best we can, but ultimately scientists and engineers have to be making good decisions about these things and the two have to work together, but you have to rely on some judgment for some things.

MEMBER BLEY: You know at our last subcommittee meeting, you put a lot of focus on and I forget your buzz word for it, but the system to manage the quality of the analysis. I think that focus there probably would be helpful in the future.

MR. ESH: I talked about that a little bit earlier, but I think we get caught up in that these are computer calculations to produce a number and it's totally what this is not about. I mean ultimately you do need to compare a number to a regulatory requirement, but it's about developing the scientific and technical understanding to justify the number that you come up with. And that's why I said like the emphasis on the compliance period, the emphasis should be on the 99 percent of the work that goes into producing that number, whatever time it is. How do you assure the quality of that information considering that right now all these reviews are done in agreement states and a lot of our agreement states are really stressed in terms of their budgets and their staffing and things like that. How do you ensure the quality of their reviews given the complexity of some of this information? That's the key issue in my mind and I've had some of the licensees have said that to me. You know they said hey, we understand all the things technically that you're talking about in the regulatory requirements and what not, but then we have to kick this over the fence to our agreement state regulators. How do you make sure that they do a good review of it? Because we want a good review. We want to know what our problems are so we can correct them.

That's what the licensing process is about.

MEMBER SCHULTZ: It seems like what you've just described in terms of the engineering evaluation, the quality and the overall focus on that long-term range does belong in the performance period. And I think that's appropriate for beyond 1,000 years. Setting the compliance period at 10,000 years, I think opens up a regulatory process to all kinds of issues that engineers can answer, but others will enter into the discussion. And they will not have answers and they will not understand what you understand so well or what we understand so well and I think that causes problems and certainly future issues and near-term issues for the regulatory process.

MR. ESH: I understand that concern. I'll go back to what is the experience in that area and the experience is that half of the facilities have been licensed using that approach and another one is under review. So ultimately probably three quarters of the facilities will have been analyzed and licensed using that approach.

So whether it's a barrier and causes tremendous problems, I hope we hear from our licensees on that respect. We've heard from them and some of our agreement state regulators and just like I talked earlier about the diversity of opinion, some of them are in support of 10,000 years or longer and some of them are not.

MEMBER SCHULTZ: Good for rulemaking.

MEMBER RYAN: Any other comments or questions?

Again, I'd like to thank the staff today for a very formative briefing as we had last time and the insights you shared with us for all your work has been very, very helpful throughout the deliberations. I thank you all very much for your time and your efforts and your insights. It's work that I hold as high-quality work and lots of detailed thinking has gone into it. So we really appreciate it very much.

MR. CARRERA: Thank you, Dr. Ryan.

CHAIR ARMIJO: I'd like to thank the staff for a very interesting -- we always have good discussions. I appreciate your patience. We're going to break for lunch. I'd like to reconvene at 1:30, so almost a full hour instead of 1:45. Okay?

(Whereupon, at 12:32 p.m., the meeting was adjourned, and will reconvene at 1:45 p.m.)

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SOARCA
Peach Bottom Uncertainty Analysis (UA)

ACRS Briefing

Tina Ghosh, PhD
Jonathan Barr
RES/DSA/AAB

July 10, 2013

Agenda

- Background and overall conclusions of UA
- Distribution of results
- Most influential uncertain parameters and phenomena for source term and consequences
- Comparison of aleatory (weather) uncertainty to epistemic uncertainty
- Separate sensitivity analyses for lower-head penetration failures, and habitability criterion coupled with dose threshold response models
- Other content in the UA report
- Next steps

Background

- Best-estimate analysis reports:
  - NUREG-1935 Final published November 2012
  - NUREG/BR-0359 Rev. 1 published December 2012
  - NUREG/CR-7110, Vol. 1, Rev. 1 published May 2013
  - NUREG/CR-7110, Vol. 2, Rev. 1 published July 2013

Background (2)

- Other supporting reports:
  - Best Practices for MELCOR and MACCS2, expected late 2013
  - NUREG/CR-7161 on Distributions for non-site-specific uncertain parameters, published April 2013

- Briefed ACRS on UA approach, initial results, and insights – April 2012

Overall UA Conclusions

- Peach Bottom UA corroborates SOARCA study conclusions
  - Public health consequences from severe nuclear accident scenarios modeled are smaller than previously calculated, and very small in absolute terms
  - Delayed releases calculated provide more time for emergency response actions such as evacuating or sheltering; long-term phase dominates health effect risks because emergency response is faster than progression to release
  - “Essentially zero” early fatality risk projected

Overall Conclusions (2)

- A major determinant of source term magnitude and health consequences is whether or not Main Steam Line (MSL) creep rupture occurs (leads to higher consequences)
- Health-effect risks vary sublinearly with source term because people are not allowed to return to their homes until dose is below habitability criterion
- Analysis confirms known importance of some phenomena, and reveals some new phenomenological insights
- The use of multiple techniques to post-process Monte Carlo results provides better explanatory power of which input parameters are most important to uncertainty in results

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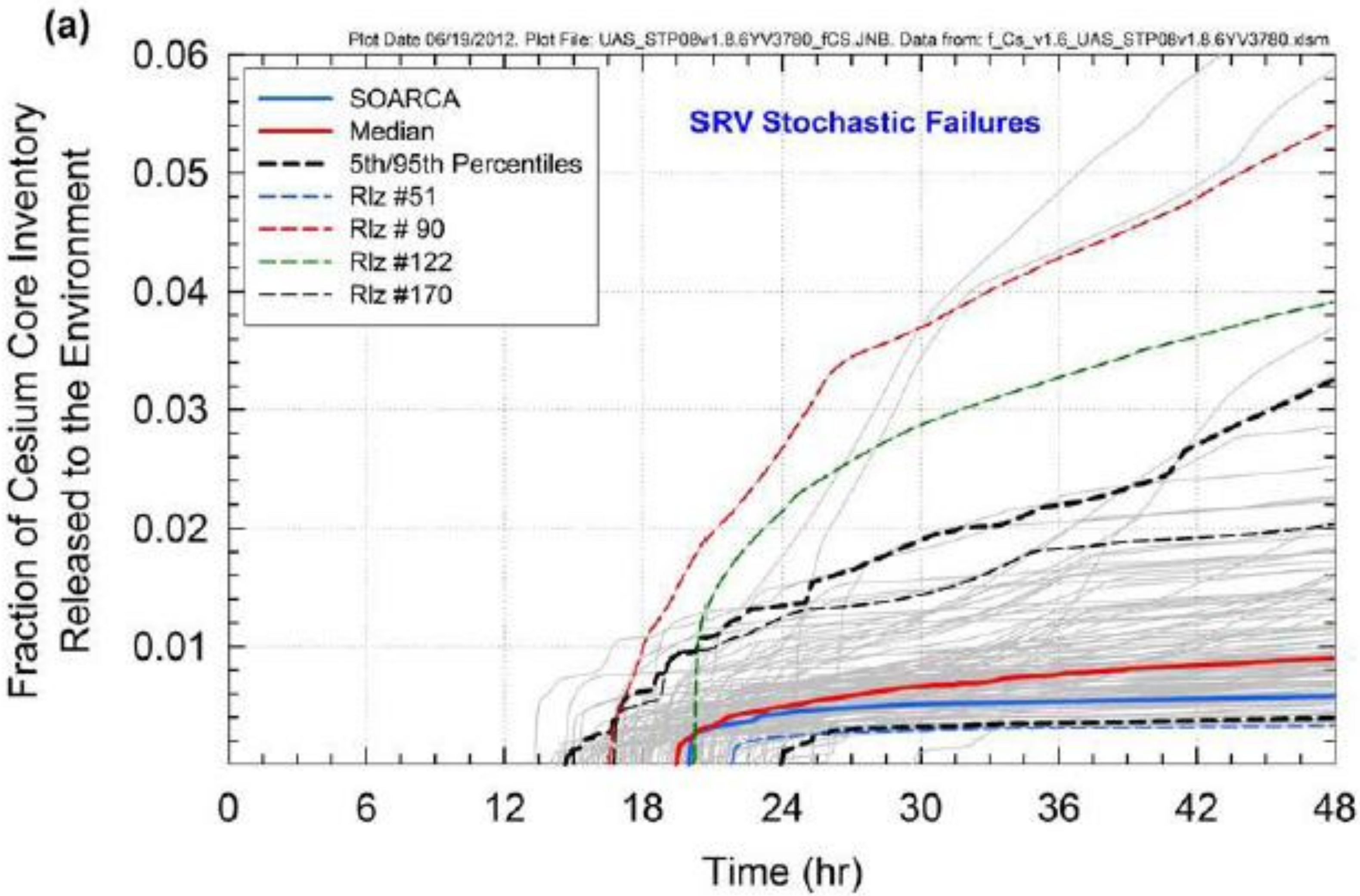
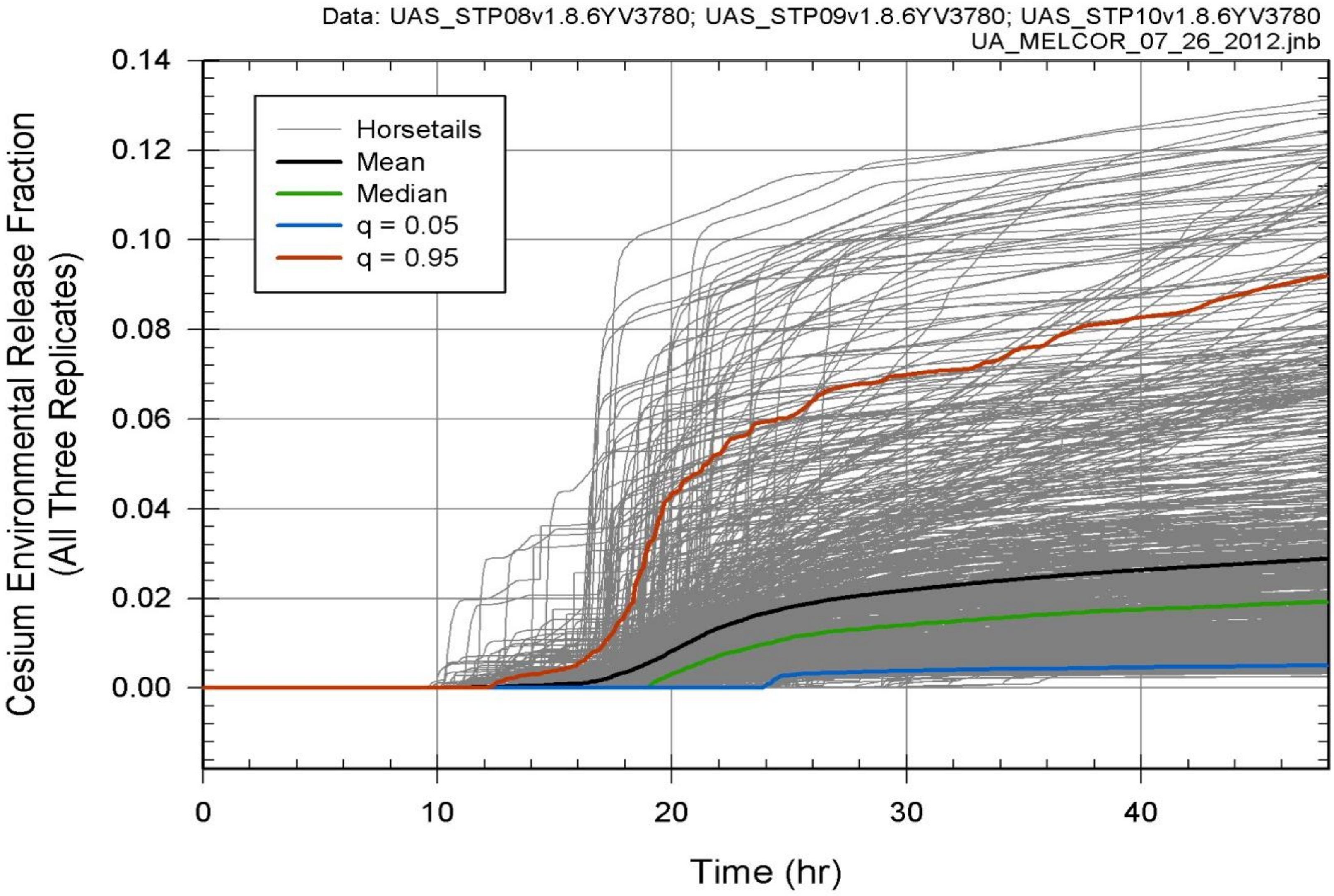
Distribution of Results

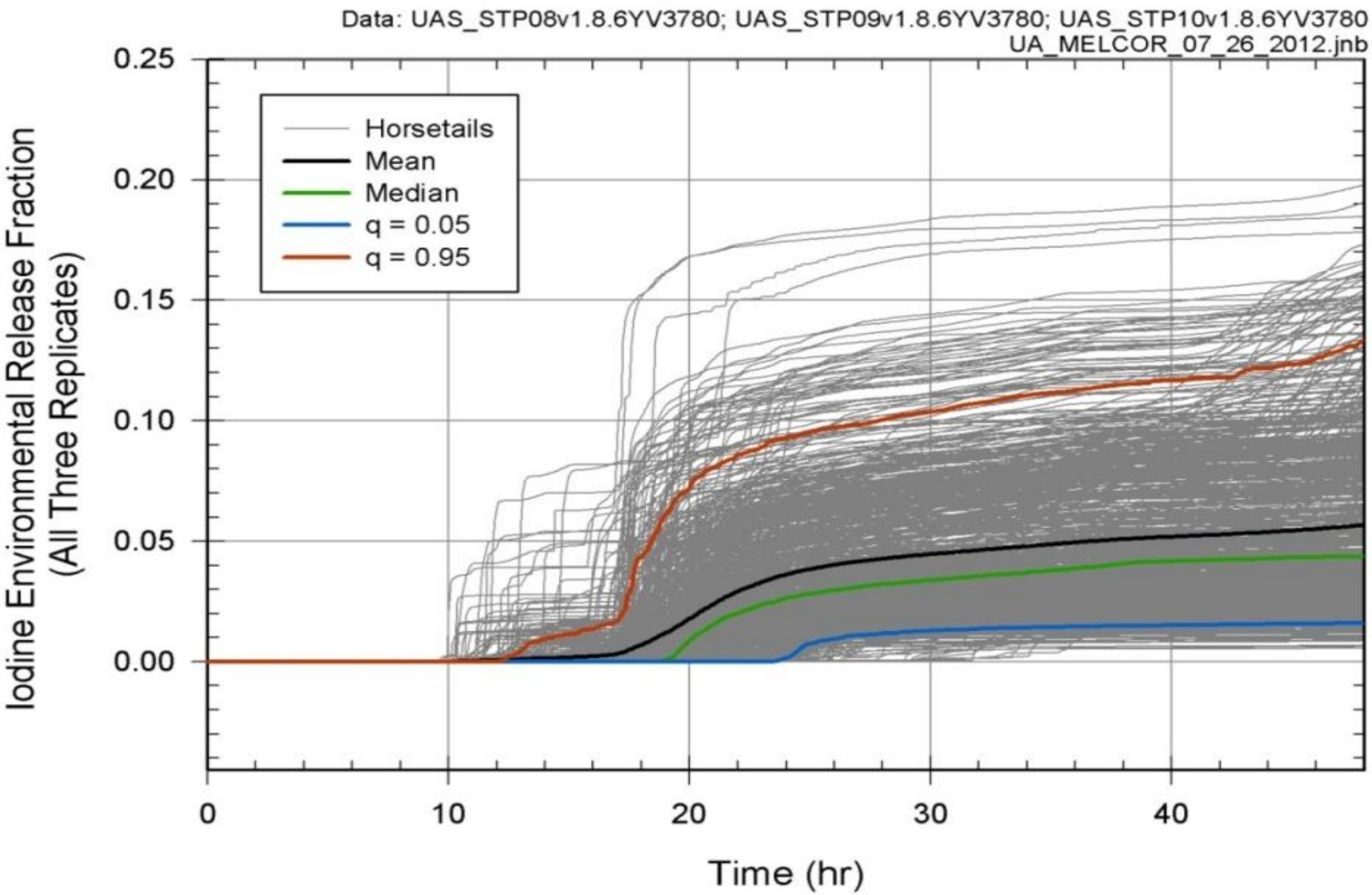
SRV Stochastic Failures from Replicate 1 and Single Realizations chosen for analysis



Fraction of the cesium core inventory released to the environment for combined (865) results for the PB Unmitigated LTSBO



Fraction of the iodine core inventory released to the environment for combined (865) results for the PB Unmitigated LTSBO



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Conditional mean, individual latent cancer fatality (LCF) risk (per event) for combined results (865) with LNT model

	0-10 miles	0-20 miles	0-30 miles	0-40 miles	0-50 miles
5th percentile	3.1×10^{-5}	4.9×10^{-5}	3.4×10^{-5}	2.2×10^{-5}	1.9×10^{-5}
Median	1.3×10^{-4}	1.9×10^{-4}	1.3×10^{-4}	8.7×10^{-5}	7.1×10^{-5}
Mean	1.7×10^{-4}	2.8×10^{-4}	2.0×10^{-4}	1.3×10^{-4}	1.0×10^{-4}
95th percentile	4.2×10^{-4}	7.7×10^{-4}	5.3×10^{-4}	3.4×10^{-4}	2.7×10^{-4}
SOARCA UA Base Case	9.0×10^{-5}	8.3×10^{-5}	5.8×10^{-5}	3.7×10^{-5}	3.0×10^{-5}

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Conditional mean, individual prompt-fatality risk (per event) for combined results (865)

	0 - 1.3 miles	0 - 2.5 miles	0 - 5 miles	0 - 10 miles
Median and 75th percentile	0.0	0.0	0.0	0.0
Mean	4.5×10^{-7}	8.9×10^{-8}	1.4×10^{-8}	4.8×10^{-9}
95th percentile	1.9×10^{-6}	3.5×10^{-8}	0.0	0.0

Most Influential Uncertain Input Parameters and Associated Phenomena

Most Influential Parameters for Source Term Magnitude

- The expected number of SRV cycles before failing to reclose (i.e., remain in the fully open position) (SRVLAM)
- The chemical form of cesium (i.e., the amount of cesium as CsOH vs. Cs_2MoO_4) (CHEMFORM)
- The size of the breach in the drywell liner resulting from core debris contacting and melting through the liner (FL904A)
- The fractional open area of an SRV after it has failed to reseat because of overheating (SRVOAFRAC)
- The time-at-temperature criterion specified for loss of "intact" fuel rod geometry (FFC – fuel failure criterion)
- The temperature at which oxidized cladding mechanically fails (SC1131_2)
- Whether railroad doors open, and fraction open (RRDOOR, RRIDFRAC)

Regression analyses of fraction of cesium released over 48 hours

	Rank Regression			Quadratic			Recursive Partitioning			MARS		
Final R^2 -- Variance explained	0.61			0.64			0.90			0.66		
Input name	R^2 inc.	R^2 cont.	SRRC	S_i	T_i	p-val	S_i	T_i	p-val	S_i	T_i	p-val
SRVLAM	0.50	0.50	-0.72	0.39	0.64	0.00	0.43	0.70	0.00	0.57	0.68	0.00
FL904A	0.53	0.03	0.19	0.01	0.04	0.12	0.06	0.02	0.44	0.00	0.03	0.10
FFC	0.55	0.02	0.19	0.04	0.05	0.31	0.02	0.10	0.00	0.01	0.08	0.00
RRDOOR	0.58	0.03	0.33	0.02	0.10	0.00	0.02	0.03	0.19	---	---	---
SRVOAFRAC	0.59	0.02	-0.13	0.07	0.19	0.00	0.11	0.33	0.00	0.12	0.27	0.00
CHEMFORM	0.60	0.01	0.09	0.00	0.08	0.38	0.01	0.18	0.00	0.02	0.00	0.87
SC1131_2	0.60	0.01	-0.07	0.02	0.01	0.63	0.00	0.07	0.00	0.00	0.04	0.01

Most Influential Parameters for Individual LCF Risk

- MACCS2 dry deposition velocity (VDEPOS)
- MELCOR SRV stochastic failure probability (SRVLAM)
- MELCOR fuel failure criterion (FFC)
- MELCOR drywell liner melt-through open area flow path (FL904A)
- MACCS2 residual cancer risk factor (CFRISK–Residual)
- MACCS2 residual dose and dose-rate effectiveness factor (DDREFA–Residual)

Most Influential Parameters for Individual Prompt Fatality Risk within 2 mile Circular Area

- MACCS2 wet deposition parameter (CWASH1)
- MELCOR SRV stochastic failure probability (SRVLAM)
- MELCOR SRV open area fraction (SRVOAFRAC)
- MELCOR DC station battery duration (BATTDUR)
- MACCS2 early health effects threshold and beta (shape) factor for red bone marrow (EFFTHR-Red Marrow and EFFACB-Red Marrow)
- MACCS2 linear, crosswind dispersion coefficient (CYSIGA)

Aleatory (weather) Uncertainty Sensitivity Studies

- Comparison of results using SOARCA sampling, versus using all available weather data in the year
  - Miniscule difference
- Comparison of effect of aleatory uncertainty versus epistemic uncertainty
  - Epistemic uncertainty seems to bound the uncertainty stemming from weather, for the LNT model

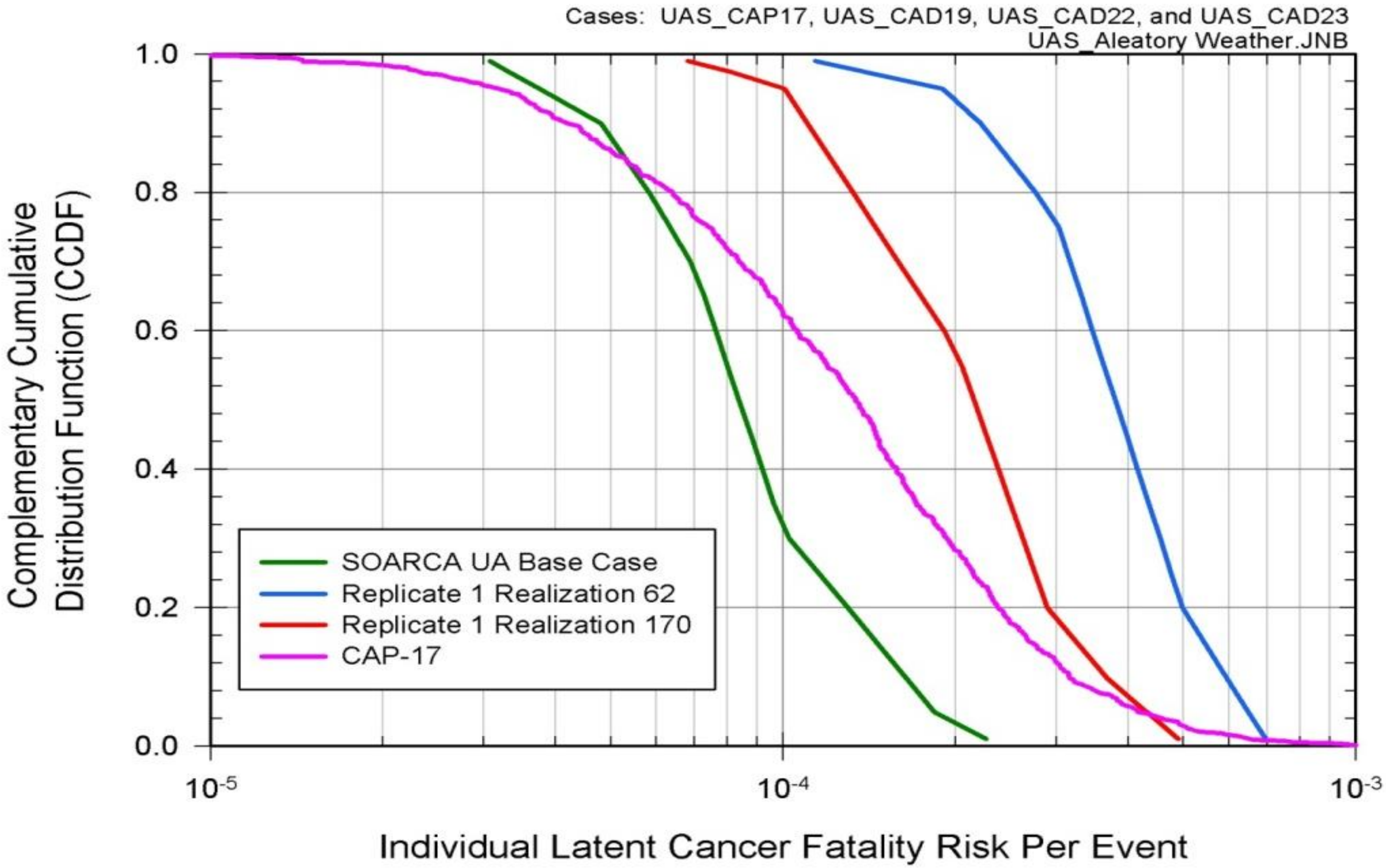
Weather sampling comparison of the conditional, mean, individual LCF risk (per event) using the LNT dose-response model

Distance	SOARCA UA Base Case	All Weather Trials	Difference (%)
10	9.0×10^{-5}	8.9×10^{-5}	0.8%
20	8.3×10^{-5}	8.1×10^{-5}	2.4%
30	5.8×10^{-5}	5.7×10^{-5}	1.7%
40	3.7×10^{-5}	3.7×10^{-5}	1.1%
50	3.0×10^{-5}	3.0×10^{-5}	1.3%

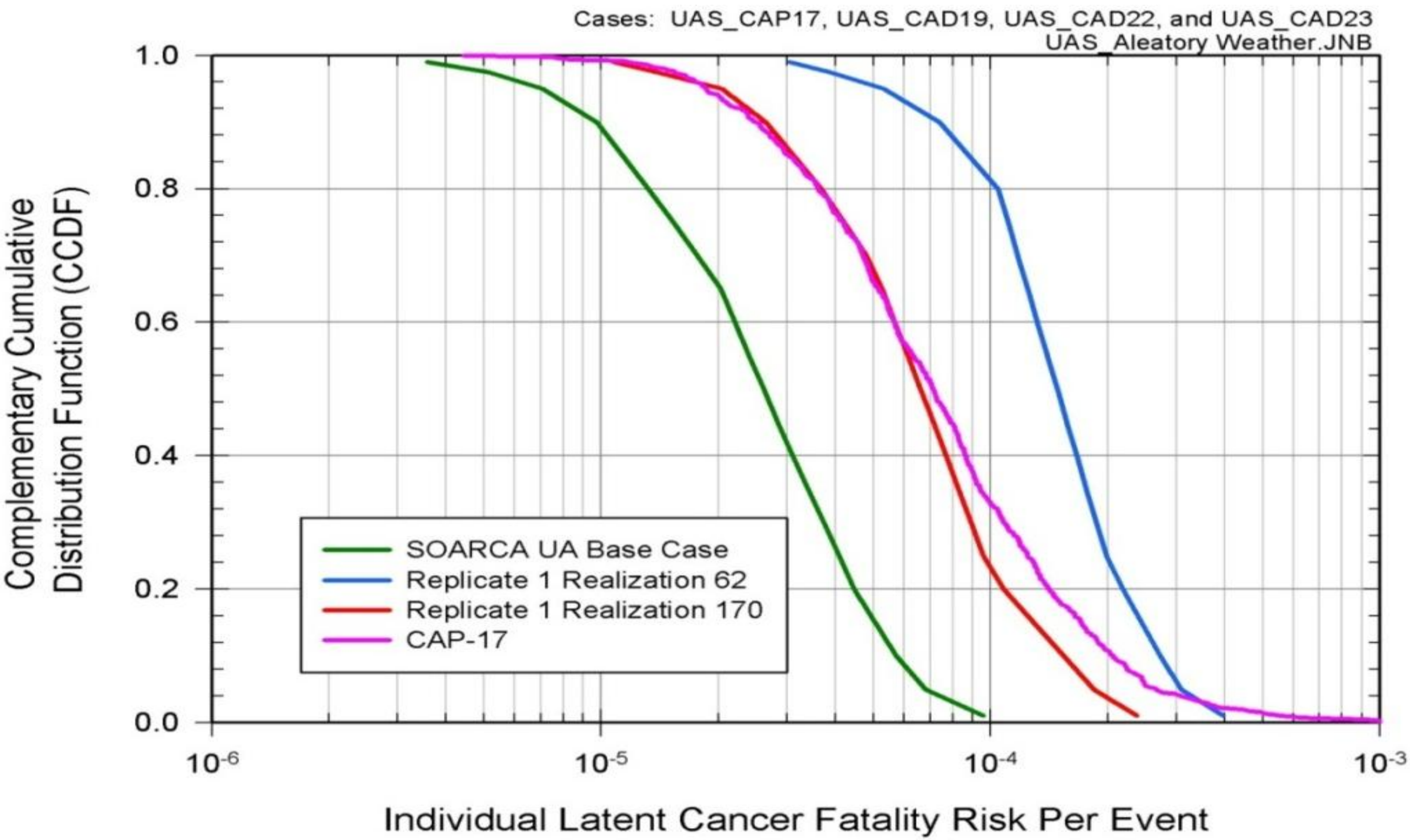
Brief source term description for the single realizations selected from Replicate 1 (STP08) MELCOR Analyses for the aleatory weather uncertainty analyses

Scenario	Integral Release Fractions by Chemical Group									Atmospheric Release Timing	
	Xe	Cs	Ba	I	Te	Ru	Mo	Ce	La	Start (hr)	End (hr)
SOARCA UA Base Case	0.981	0.005	0.010	0.025	0.019	0	0	0	0	19.9	48
RLZ062	0.995	0.055	0.014	0.104	0.089	0	0.012	0	0	13.6	48
RLZ170	0.985	0.020	0.022	0.031	0.027	0	0	0.001	0	16.6	48

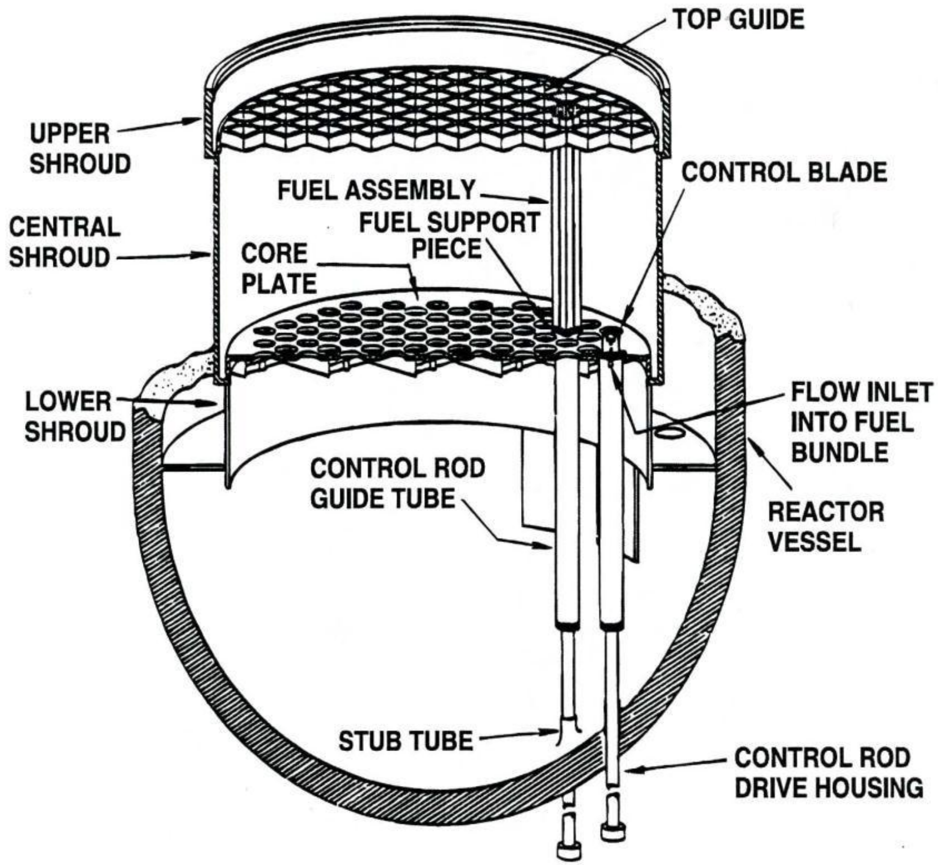
CCDF of conditional, mean, individual LCF risk (per event) within the 10-mile circular area for aleatory weather uncertainty and the MACCS2 CAP17 (epistemic uncertainty) analysis



CCDF of conditional, mean, individual LCF risk (per event) within the 50-mile circular area for aleatory weather uncertainty and the MACCS2 CAP17 (epistemic uncertainty) analysis



Separate Sensitivity Analysis for Lower-Head Penetration Failures



Lower-Head Penetration Failure Sensitivity

- Past work considered only “gross creep failure” of RPV lower head
- Sensitivity considers penetration failures
  - 2 to 38 instrument tubes
  - Average of 13.5 tubes
- Sampled additional variables:
  - Heat transfer coefficient between penetrations and core debris
  - Failure temperature

Lower-Head Penetration Failure Sensitivity (2)

- Penetration failures generally occurred 3 hours before the gross lower head failure
- Relatively insensitive to variations in the sampled input parameters
- Relocation of core debris to the reactor cavity through penetrations generally began within 6 minutes of the first penetration failure once appreciable molten material resided near the penetration
- The penetrations did not ablate significantly

Lower-Head Penetration Failure Sensitivity (3)

- Influence on relative cesium release to the environment is potentially large
  - Fractional releases of cesium to the environment ranged 0.006 – 0.07, with a mean of 0.04
- Important to note that the penetration modeling available in MELCOR does not calculate the plugging of an open penetration by freezing melt
  - If this phenomenon were accounted for, penetration failures might be immaterial in that the associated openings readily reclose
  - Such plugging was observed to have occurred in the Three Mile Island accident

Separate Sensitivity Analysis for Habitability Criterion and Dose-Threshold Response Models

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Percentage change in conditional mean, individual LCF risk per event for the LNT dose-response model from variations in habitability criterion

Radius (mi)	SOARCA UA Base Case Individual LCF Risk 0.5 rem/yr	0.1 rem/yr	2 rem/yr
10	9.0×10^{-5}	-59%	75%
20	8.3×10^{-5}	-30%	34%
30	5.8×10^{-5}	-27%	28%
40	3.7×10^{-5}	-25%	23%
50	3.0×10^{-5}	-25%	21%

LNT habitability criterion sensitivity insights

- Majority of the LCF risk contribution within the EPZ resulted from the long-term phase for all habitability scenarios
  - The higher the habitability criterion, the higher the LCF risk as a result of long-term dose within the EPZ
- Majority of the LCF risk for the 0.1 rem/yr habitability criterion results from the emergency phase
- Most of the risk corresponds to the long-term phase for other choices of habitability criterion

Percentage change in conditional mean, individual LCF risk (per event) for USBGR dose-threshold (620 mrem/yr) model from variations in habitability criterion

Radius (mi)	SOARCA UA Base Case Individual LCF Risk 0.5 rem/yr	0.1 rem/yr	2 rem/yr
10	8.9×10^{-7}	-8.6%	2,600%
20	2.6×10^{-5}	-23%	49%
30	1.6×10^{-5}	-30%	50%
40	7.7×10^{-6}	-37%	57%
50	5.2×10^{-6}	-39%	66%

Dose threshold models habitability criterion sensitivity insights

- Most of the doses received during the long-term phase are below the dose threshold limit and are not counted toward health effects; most of the risks are from doses received during the first year.
- LCF risks within the EPZ are orders of magnitude lower when the habitability criterion is below the dose-threshold level

Other Content in UA Report

- Separate sensitivity analyses for operator action timing (manual depressurization)
- Hydrogen generation insights
- Fukushima comparison
- Stability analysis for results, statistical convergence
- Probabilistic analysis methodology
- MELCOR version changes since best-estimate analysis was complete, and their effects
- Peer review & ACRS comment resolution

Next Steps

- Address office comments – July 2013
- ANS PSA Conference presentation and papers – September 2013
- Send final NUREG/CR-7155 report for publication – Fall 2013
- NRC research seminar – Fall 2013

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Questions and Comments

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BACK-UP SLIDES

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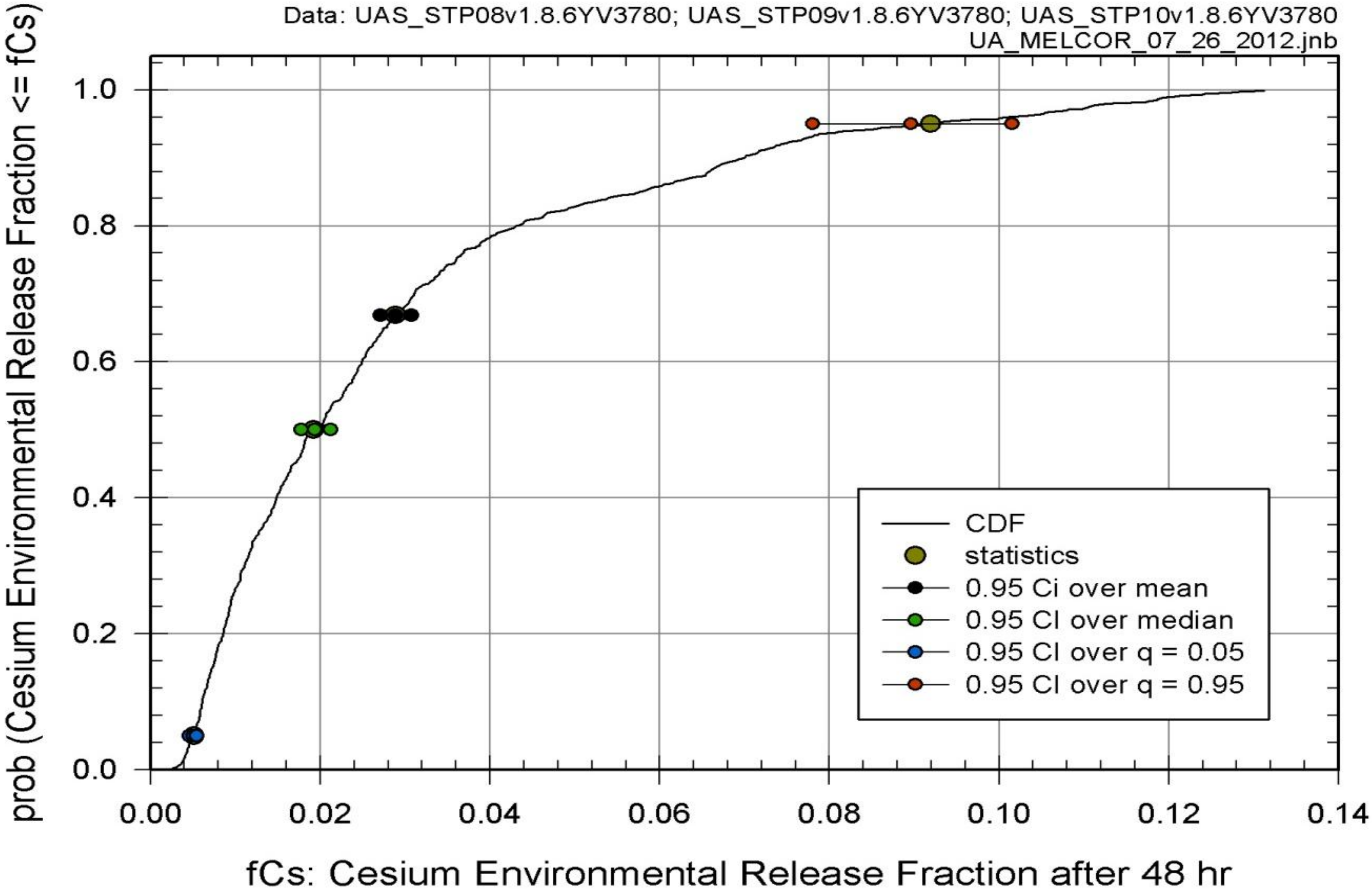
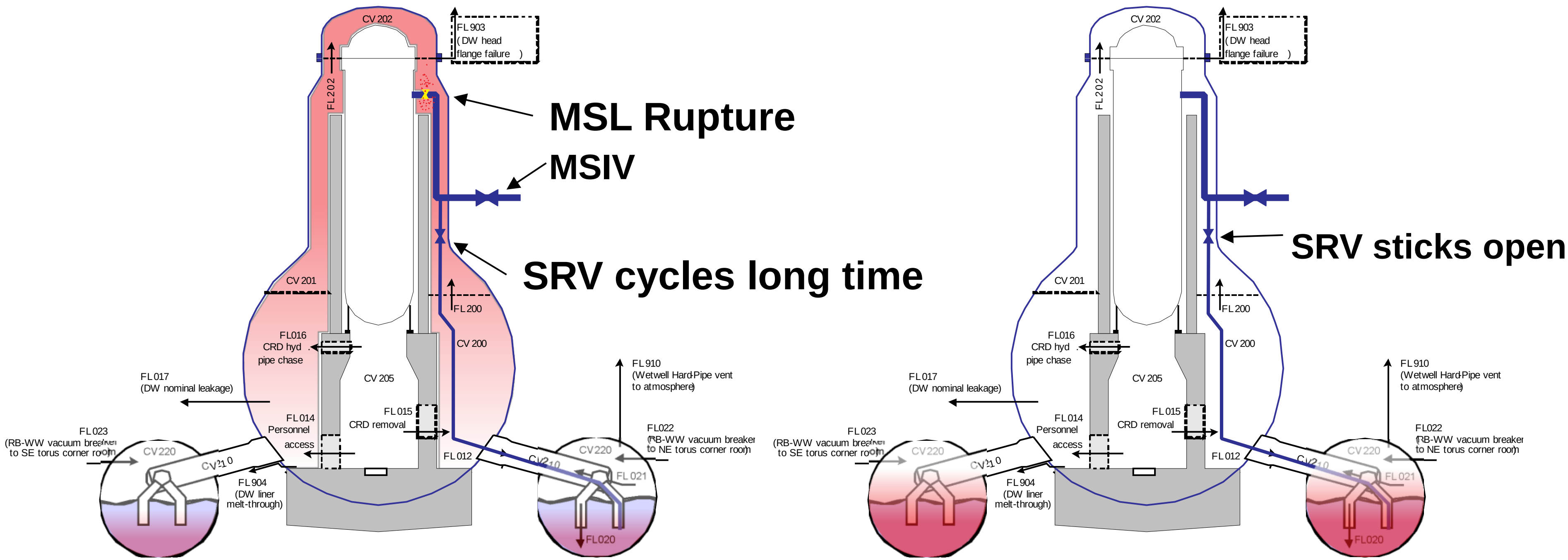
Cumulative distribution function of fraction of cesium core inventory released to the environment after 48 hours based on all combined (i.e., 865) results, with 95% confidence interval over statistical measures



SRV Seizure Versus MSL Rupture



Main Steam Line Rupture vents
Fission products to drywell

Release to environment via head
Flange failure or drywell liner melt through

SRV Seizure vents fission products
Into wetwell

Wetwell scrubbing prevents release
To the environment

Goals of the Uncertainty Analysis

- Develop insight into overall sensitivity of SOARCA results to uncertainty in inputs
- Identify most influential input parameters for releases and consequences
- Demonstrate uncertainty analysis methodology

Approach

- Focus is on epistemic (state-of-knowledge) uncertainty in input parameter values
  - Model uncertainty addressed to the extent that some parameters represent or capture alternate model effects; or in separate sensitivity analyses
  - Aleatory (random) uncertainty due to weather is handled in the same way as the SOARCA study
- Peach Bottom, unmitigated, long-term station blackout scenario chosen
- Scenario definition not changed after Fukushima
  - A separate qualitative discussion planned for an appendix
- Looking at uncertainty in key model inputs
  - MELCOR parameters
  - MACCS2 parameters

Approach (continued)

- Key uncertain input parameters were identified
- Uncertainty in these parameters propagated in two steps using Monte Carlo and Latin Hypercube (LHS) sampling:
  - A set of source terms generated using MELCOR model
  - A distribution of consequence results generated using MACCS2 model
- Epistemic sample sets of 300 generated to complete a corresponding number of individual code runs (Monte Carlo “realizations”) to evaluate the influence of the uncertainty on the estimated outcome

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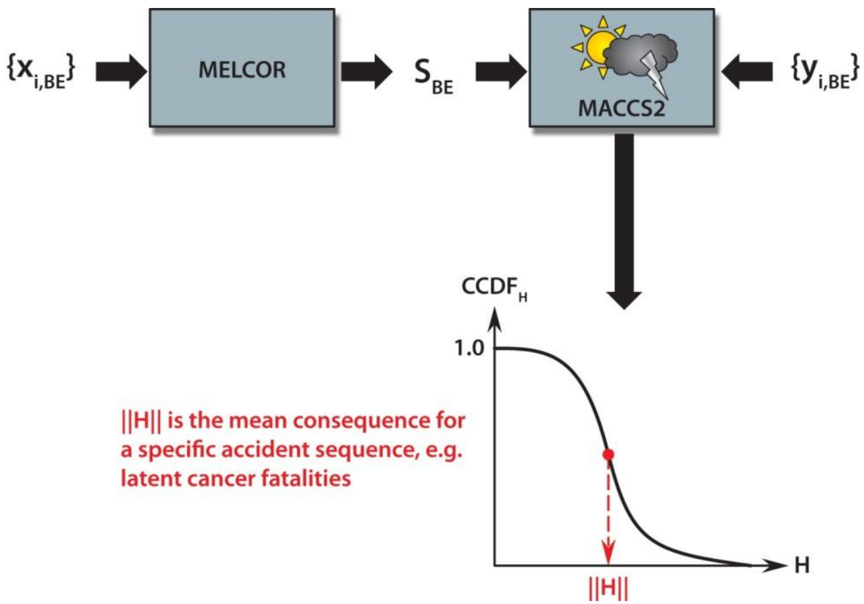
Approach (continued)

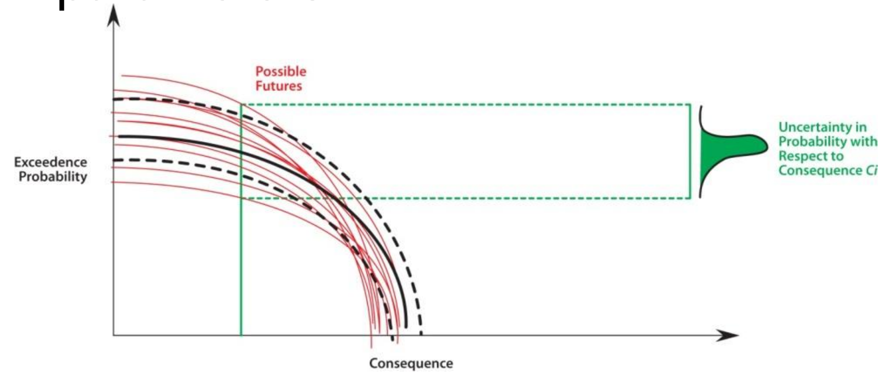
- Results reported will include:
  - Analysis of source term releases including Cesium and Iodine release over time
  - Latent cancer fatality risk, with three dose threshold models
  - Description of most influential uncertain parameters in study
- Tools used to analyze results include statistical regression-based methods as well as scatter plots and phenomenological investigation of individual realizations of interest
- Guidance solicited from SOARCA peer reviewers on the uncertainty analysis plan documenting the approach, chosen parameters and distributions; feedback from Advisory Committee on Reactor Safeguards

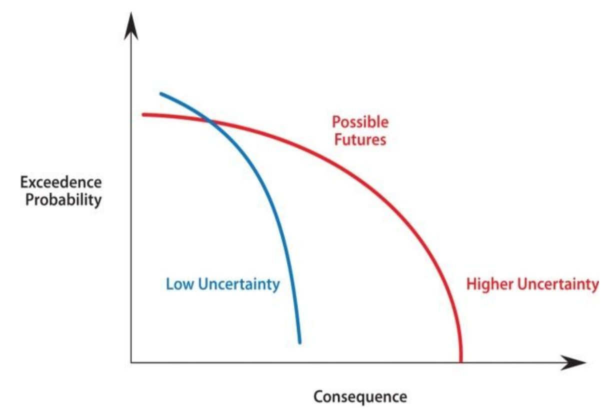
SOARCA Uncertainty Analysis

Best estimate calculations include weather variability in the consequences



Probabilistic UA includes both the weather variability and the uncertainty in the epistemic input parameters





Core Team Members

- MELCOR and severe accident progression: Randy Gauntt, Kyle Ross, Doug Osborn, Don Kalinich, Mike Young, Jeff Cardoni, Andrew Goldmann (SNL); Mark Leonard (dycoda); Ed Fuller (NRC)
- MACCS2, consequence analysis and emergency response: Nate Bixler, Joe Jones, Doug Osborn (SNL)
- UA methodology: Patrick Mattie, Cedric Sallaberry, Jon Helton (SNL); Tina Ghosh (NRC)
- Consultants for MACCS2 latent health effects modeling: Keith Eckerman (ORNL); Tony Huffert (NRC)

Process for Choosing Parameters and Distributions

- Core team of staff from SNL and NRC with expertise in probability and statistics, uncertainty analysis, and MELCOR and MACCS2 modeling for SOARCA
- Subject matter experts (SMEs) provided support in reviews of data and parameters
- Approach is based on a formalized PIRT (phenomena identification, and ranking table) process.
- Focus on confirming that the parameter representations appropriately reflect key sources of uncertainty, are reasonable, and have a defensible technical basis
- Attempt to obtain contribution from uncertainty across the spectrum of phenomena operative in the analyses, through a balanced depth and breadth of coverage

MELCOR Uncertain Parameters

Sequence Issues

- Battery duration
- SRV stochastic failure rate, thermal seizure criteria, and open area fraction

In-Vessel Accident Progression

- Main steam line (MSL) creep rupture open area fraction
- Zircaloy melt breakout temperature
- Molten clad drainage rate
- Fuel failure criterion
- Debris radial relocation time constants

Ex-vessel Accident Progression

- Debris lateral relocation time constants

Containment & building behavior

- Drywell liner failure flow area
- Drywell head flange leakage parameters
- Hydrogen ignition criteria (where flammable)
- Railroad doors open fraction

Fission Product release, transport, and deposition

- Cesium and Iodine chemical forms
- Aerosol deposition parameters

MACCS2 Uncertain Parameters

Atmospheric Transport and Deposition

- Wet deposition model linear coefficient
- Dry deposition velocities
- Dispersion parameters

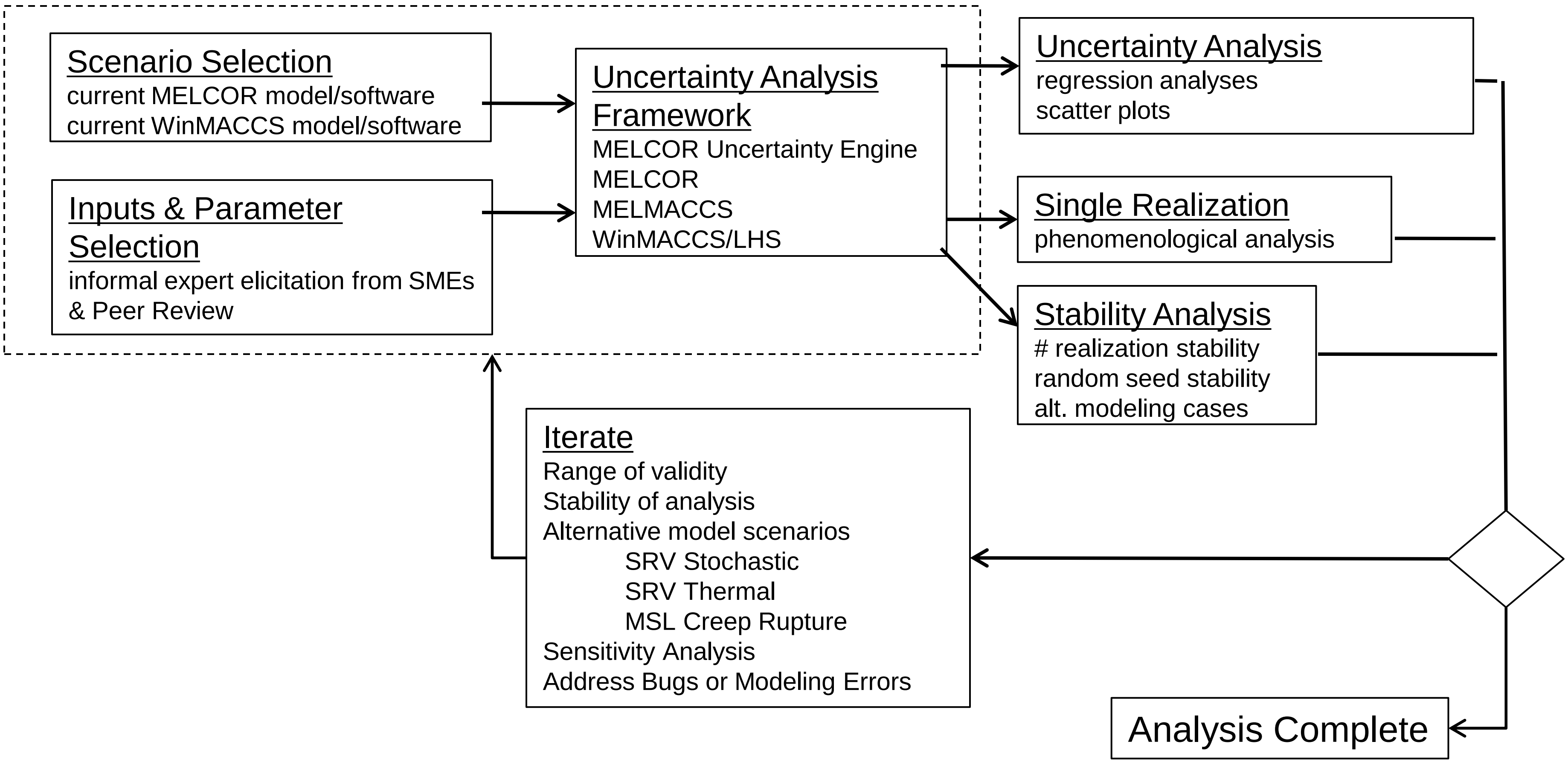
Emergency planning and response

- Shielding factors
- Hotspot and normal relocation
- Evacuation delay and speed

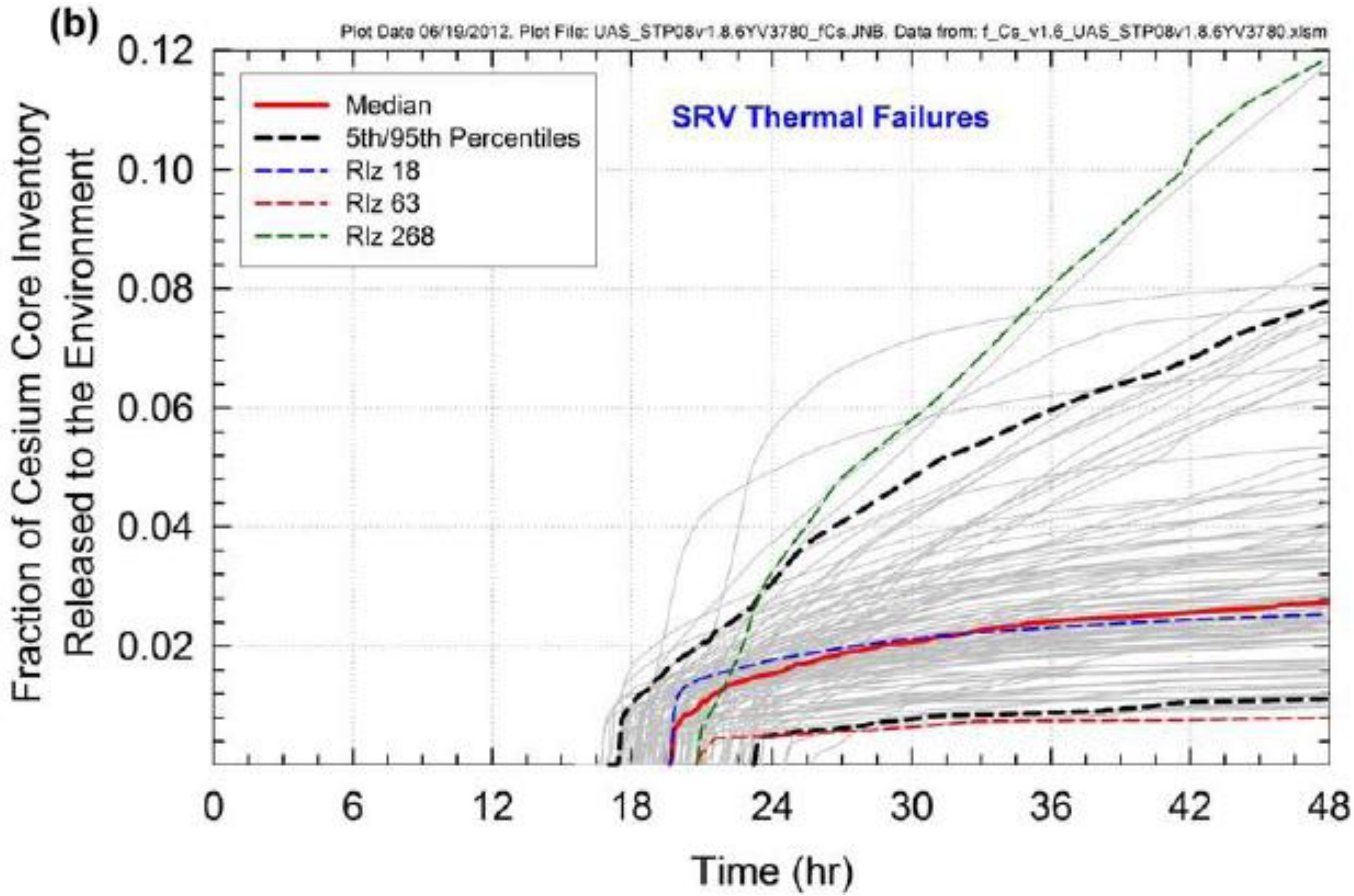
Health Effects

- Early health effects
- Latent health effects
  - Groundshine dose coefficients
  - Dose and dose rate effectiveness factors
  - Inhalation dose coefficients
  - Cancer mortality risk coefficients

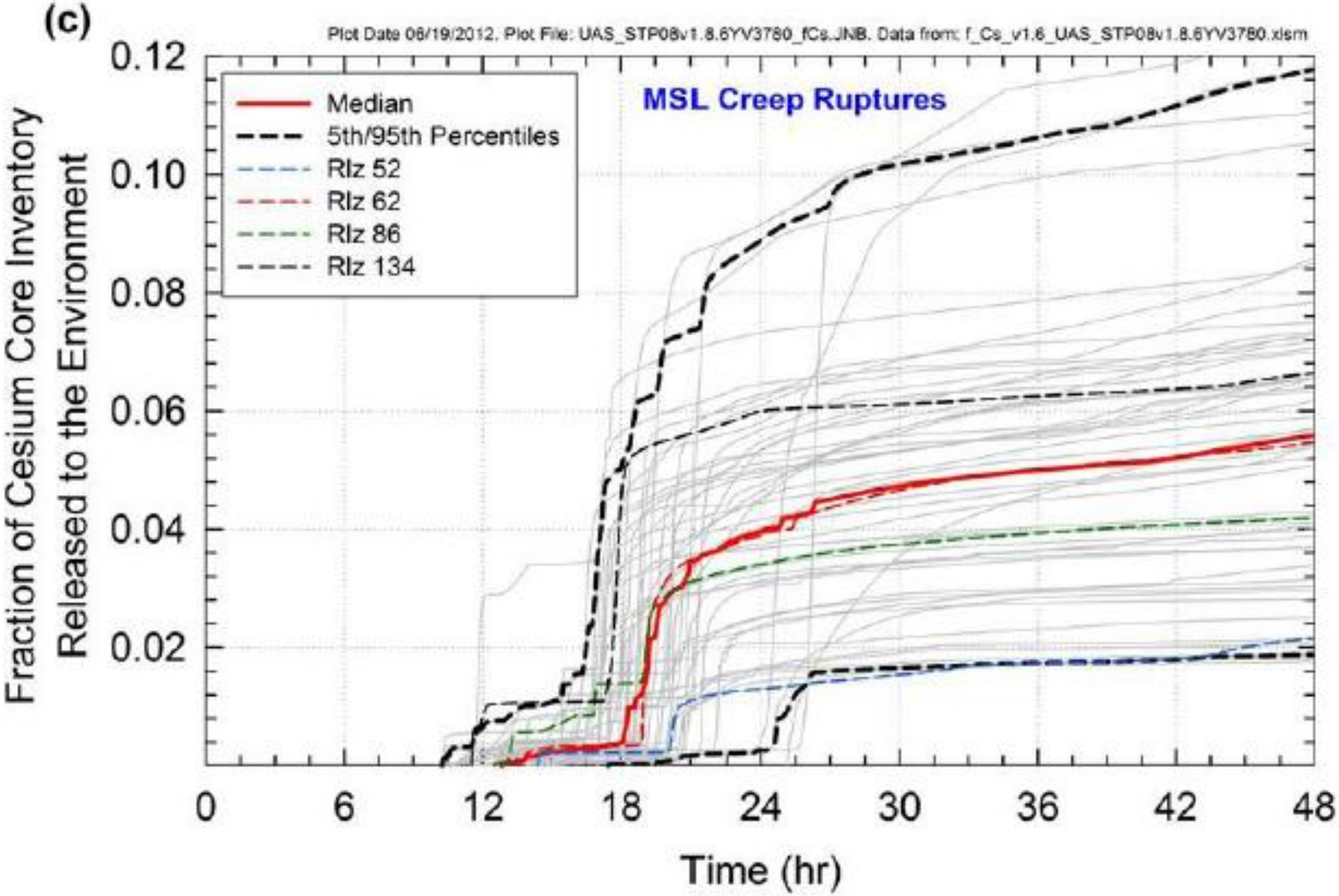
Probabilistic Uncertainty analysis is an iterative process



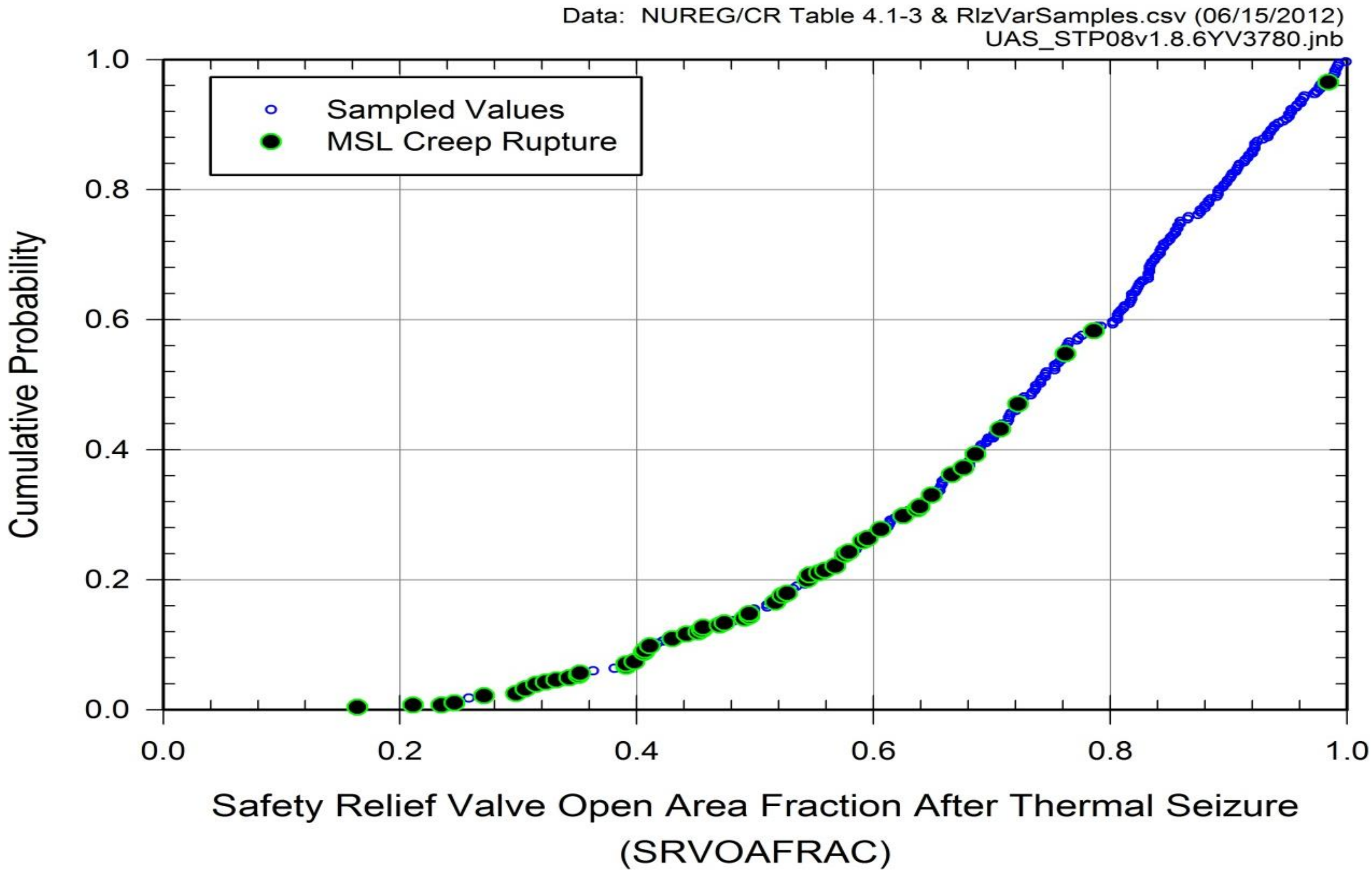
SRV Thermal Failures without MSL rupture from Replicate 1 and Single Realizations chosen for analysis



SRV Thermal Failures with MSL creep rupture from Replicate 1 and Single Realizations chosen for analysis



Cumulative distribution function of SRVOAFRAC with samples where MSL creep rupture indicated for Replicate 1



Mean, individual prompt-fatality risk per event regression of the MACCS2 Uncertainty Analysis for the 2-mile circular area

	Rank Regression			Quadratic			Recursive Partitioning			MARS		
Final R^2	0.24			0.62			0.63			0.58		
Input	R^2 inc.	R^2 cont.	SRRC	S_i	T_i	p-val	S_i	T_i	p-val	S_i	T_i	p-val
CWASH1	0.03	0.03	0.08	0.29	0.76	0	0.15	0.60	0	0.04	0.78	0
SRVLAM	0.07	0.04	-0.10	0.01	0.41	0	0	0.10	0.35	0.01	0.28	0.07
SRVOAFRAC	0.10	0.03	-0.09	0.01	0	1	0.06	0.53	0	0.06	0	1
BATTDUR	0.10	0	-0.03	0	0.13	0.09	0	0.05	0.32	---	---	---
EFFTHR Red Marrow	0.15	0.05	-0.12	0	0.18	0.13	0.01	0.52	0	0.02	0.47	0
EFFACB Red Marrow	0.16	0.01	0.04	---	---	---	---	---	---	0.01	0	1
CYSIGA	0.18	0.02	0.07	0	0.40	0	---	---	---	0.04	0.48	0
DLTEVA Cohort 5	0.19	0.01	-0.07	0.02	0	1	0.07	0.15	0.17	0	0	1
GSHFAC Normal	0.21	0.02	0.06	---	---	---	---	---	---	0.01	0.12	0.27

Mean, individual LCF Risk per event regression of MACCS2 Uncertainty Analysis using LNT model for the 50-mile circular area

	Rank Regression			Quadratic			Recursive Partitioning			MARS		
Final R^2	0.52			0.57			0.71			0.54		
Input	R^2 inc.	R^2 cont.	SRRC	S_i	T_i	p-val	S_i	T_i	p-val	S_i	T_i	p-val
VDEPOS	0.18	0.18	-0.43	0.09	0.18	0	0.16	0.46	0	0.19	0.39	0
SRVLAM	0.25	0.07	0.26	0.12	0.31	0	0.05	0.29	0	0.05	0.16	0.06
DDREFA Residual	0.30	0.05	0.24	0.05	0.09	0.07	---	---	---	0.09	0.09	0.29
Fuel failure criterion	0.45	0.03	0.16	---	---	---	0	0.05	0.07	0	0.01	0.38
FL904A	0.48	0.02	-0.14	0.04	0.08	0	0.05	0.28	0	0.02	0	1
BATTDUR	---	---	---	0.03	0.02	0.46	---	---	---	0	0.01	0.34
CFRISK Residual	---	---	---	0	0.04	0.33	0	0.12	0	0.02	0.01	0.37
GSHFAC Normal	0.34	0.04	0.18	---	---	---	0	0.03	0.45	0.06	0.05	0.14
CFRISK Lung	0.37	0.03	0.19	0.01	0.12	0.01	0.04	0.22	0	0.03	0.07	0.28
DDREFA Lung	0.40	0.03	0.26	0	0.13	0	---	---	---	0.02	0.11	0
GSHFAC Evacuation	0.43	0.03	0.16	0.06	0.15	0	0.01	0.23	0	0.04	0.08	0

Percentage change in mean, individual LCF risk per event for the HPS dose-response model from variations in habitability criterion

Radius (mi)	SOARCA UA Base Case Individual LCF Risk 0.5 rem/yr	0.1 rem/yr	2 rem/yr
10	5.6×10^{-7}	-5.7%	45%
20	4.4×10^{-6}	-12%	40%
30	1.7×10^{-6}	-13%	42%
40	7.1×10^{-7}	-13%	42%
50	4.5×10^{-7}	-13%	42%

Low-Level Radioactive Waste Disposal (10 CFR Part 61) Preliminary Version

Andrew Carrera

Division of Intergovernmental Liaison and Rulemaking

Office of Federal and State Materials and Environmental Management Programs

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606th Advisory Committee on Reactor Safeguards
July 10, 2013

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Purpose of the rule:

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- Specify site-specific technical analyses requirements
- Permit development of criteria for waste disposal based on the results of these analyses
- Better align the requirements with current health and safety standards

Proposed Amendments: Site-Specific Analyses

- Performance assessment — Add requirements to demonstrate protection of the general population within the 10,000-year compliance period (§ 61.41(a)) and to minimize releases of radioactivity to the extend reasonably achievable at any time during the post-10,000-year period (§ 61.41(b))

- Intruder assessment — Add requirements to demonstrate protection of inadvertent intruders within the 10,000-year compliance period and a stated dose limit (§ 61.42(a)) and to minimize exposures to any inadvertent intruder to the extend reasonably achievable at any time during the post-10,000-year period (§ 61.42(b))

Proposed Amendments: Site-Specific Analyses

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- Long-term analyses — Add requirement to demonstrate how the disposal system limits the potential radiological impacts from long-lived waste during the post-10,000-year performance period (§ 61.13 (e))

- Update analyses — Add requirement for updated analyses at facility closure (§ 61.28)

Proposed Amendments: Waste Acceptance

- Waste acceptance — Add requirements to develop waste acceptance criteria, establish waste characterization methods, and develop waste certification program (§ 61.58)

Proposed Amendments: Other Supporting Changes

- Definitions and Concepts— Add new definitions (§ 61.2 and § 20.1003) and new concepts (§ 61.7)
- Allow the use of up-to-date ICRP dose methodology
- Revise Appendix G to 10 CFR Part 20

10 CFR Part 61:
Preliminary Proposed Rule Language

Preliminary Proposed Rule Language: Technical Analyses

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- § 61.41 Protection of the general population from releases of radioactivity (revised requirement):

(a) Concentrations of radioactive material that may be released to the general environment in ground water, surface water, air, soil, plants, or animals must not result in an annual dose exceeding an equivalent of 0.25 milliSievert (25 millirems) to any member of the public within the compliance period. Reasonable effort should be made to maintain releases of radioactivity in effluents to the general environment as low as is reasonably achievable during the compliance period. Compliance with this paragraph must be demonstrated through analyses that meet the requirements specified in § 61.13(a).

Preliminary Proposed Rule Language: Technical Analyses

- Performance assessment (§ 61.13(a)):

  (1) Identifies the features, events, and processes (FEPs)

  (2) Examines the effects of these FEPs on the performance of the disposal system

  (3) Estimates the annual dose to any member of the public considering uncertainties, caused by all significant FEPs

Preliminary Proposed Rule Language: Technical Analyses

- § 61.13 Technical analyses (revised requirements):

(a) A performance assessment that demonstrates that there is reasonable assurance that the exposure to humans from the release of radioactivity will meet the performance objective set forth in § 61.41(a). A performance assessment shall:

(1) Consider features, events, and processes that might affect demonstrating compliance with § 61.41(a). The features, events, and processes considered must represent a range of phenomena with both beneficial and adverse effects on performance, and must consider the specific technical information required in §§ 61.12(a) through (i). A technical basis for either inclusion or exclusion of specific features, events, and processes must be provided. Specific features, events, and processes must be evaluated in detail if their omission would significantly affect meeting the performance objective specified in § 61.41(a).

(2) Consider the likelihood of disruptive or other unlikely features, events, or processes for comparison with the limits set forth in § 61.41(a).

Preliminary Proposed Rule Language: Technical Analyses

- § 61.13 Technical analyses (revised requirements):

(a)***

(3) Provide a technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes (e.g., of the engineered barriers, waste form, site characteristics) and interactions between the disposal facility and site characteristics that might affect the facility's ability to meet the performance objective in § 61.41(a).

(4) Provide a technical basis for models used in the performance assessment such as comparisons made with outputs of detailed process-level models or empirical observations (e.g., laboratory testing, field investigations, and natural analogs).

(5) Evaluate pathways including air, soil, groundwater, surface water, plant uptake, and exhumation by burrowing animals.

Preliminary Proposed Rule Language: Technical Analyses

- § 61.13 Technical analyses (revised requirements):

(a)***

(6) Account for uncertainties and variabilities in the projected behavior of the disposal system (e.g., disposal facility, natural system, and environment).

(7) Consider alternative conceptual models of features and processes that are consistent with available data and current scientific understanding, and evaluate the effects that alternative conceptual models have on the understanding of the performance of the disposal facility.

(8) Identify and differentiate between the roles performed by the natural disposal site characteristics and design features of the disposal facility in limiting releases of radioactivity to the general population.

Preliminary Proposed Rule Language: Technical Analyses

- § 61.41 Protection of the general population from releases of radioactivity (new requirement):

(b) Effort shall be made to minimize releases of radioactivity from a disposal facility to the general environment to the extent reasonably achievable at any time during the performance period. Compliance with this paragraph must be demonstrated through analyses that meet the requirements specified in § 61.13(e).

Preliminary Proposed Rule Language: Technical Analyses

- Long-term analyses (§61.13(e)):

  (1) Applies to disposal site with certain long-lived waste

  (2) Minimize exposures to the extent reasonably achievable metric

  (3) Analyze potential radiological impacts from long-lived waste during the post-10,000-year performance period

Preliminary Proposed Rule Language: Technical Analyses

- § 61.13 Technical analyses (new requirement):

(e) Analyses that assess how the disposal site limits the potential long-term radiological impacts, consistent with available data and current scientific understanding. The analyses shall be required for disposal sites with waste that contains radionuclides with average concentrations exceeding the values listed in table A of this paragraph, or if necessitated by site-specific conditions. For wastes containing mixtures of radionuclides found in table A, the total concentration shall be determined by the sum of fractions rule described in paragraph 61.55(a)(7). The analyses must identify and describe the features of the design and site characteristics that will demonstrate that the performance objectives set forth in §§ 61.41(b) and 61.42(b) will be met.

Preliminary Proposed Rule Language: Technical Analyses

Table A - Average Concentrations of Long-lived Radionuclides Requiring Performance Period Analyses

Radionuclide	Concentration (Ci/m^3)[1]
C-14	0.8
C-14 in activated metal	8
Ni-59 in activated metal	22
Nb-94 in activated metal	0.02
Tc-99	0.3
I-129	0.008
Long-lived alpha-emitting nuclides[2]	10[3]
Pu-241	350[3]
Cm-242	2,000[3]

[1] Values derived from § 61.55 Class A limits.

[2] Includes alpha-emitting transuranic nuclides as well as other long-lived alpha-emitting nuclides.

[3] Units are nanocuries per gram.

Preliminary Proposed Rule Language: Technical Analyses

- § 61.42 Protection of inadvertent intruders (revised requirement):

(a) Design, operation, and closure of the land disposal facility must ensure protection of any inadvertent intruder into the disposal site who occupies the site or contacts the waste at any time after active institutional controls over the disposal site are removed. The annual dose must not exceed 5 milliSieverts (500 millirems) to any inadvertent intruder within the compliance period. Compliance with this paragraph must be demonstrated through analyses that meet the requirements specified in § 61.13(b).

Preliminary Proposed Rule Language: Technical Analyses

- Intruder assessment (§ 61.13(b)):

  (1) Assumes that an inadvertent intruder occupies the site after institutional controls are ineffective and engages in activities that might unknowingly expose the inadvertent intruder to radiation from the waste.

  (2) Examines the capabilities of intruder barriers.

  (3) Estimates the potential annual dose by considering associated uncertainties.

  (4) Dose criterion set for intruder (500 mrem/yr).

Preliminary Proposed Rule Language: Technical Analyses

- § 61.13 Technical analyses (revised requirements):

(b) Inadvertent intruder analyses that demonstrate there is reasonable assurance that:

(1) the waste acceptance criteria developed in accordance with § 61.58 will be met,

(2) adequate barriers to inadvertent intrusion will be provided, and

Preliminary Proposed Rule Language: Technical Analyses

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- § 61.13 Technical analyses (revised requirements):

(b)***

(3) any inadvertent intruder will not be exposed to doses that exceed the limits set forth in § 61.42(a) as part of the intruder assessment. An intruder assessment shall:

(i)Assume that an inadvertent intruder occupies the disposal site at any time during the compliance period after the period of institutional controls ends, and engages in normal activities including agriculture, dwelling construction, resource exploration or exploitation (e.g., well drilling), or other reasonably foreseeable pursuits that unknowingly expose the intruder to radiation from the waste.

(ii) Identify adequate barriers to inadvertent intrusion that inhibit contact with the waste or limit exposure to radiation from the waste, and provide a basis for the time period over which barriers are effective.

(iii) Account for uncertainties and variabilities.

Preliminary Proposed Rule Language: Technical Analyses

- § 61.42 Protection of inadvertent intruders (revised requirements):

(b) Effort shall be made to minimize exposures to any inadvertent intruder to the extent reasonably achievable at any time during the performance period. Compliance with this paragraph must be demonstrated through analyses that meet the requirements specified in § 61.13(e).

Preliminary Proposed Rule Language: Technical Analyses

- § 61.13 Technical analyses (revised introductory language):

The specific technical information must also include the following analyses needed to demonstrate that the performance objectives of subpart C of this part will be met. Licensees with licenses for land disposal facilities in effect on the effective date of this subpart must submit these analyses at the next license renewal or within 5 years of the effective date of this subpart, whichever comes first.

Preliminary Proposed Rule Language: Waste acceptance

- Waste acceptance (§ 61.58):

(1) develop waste acceptance criteria

(2) establish waste characterization methods

(3) develop waste certification program

Preliminary Proposed Rule Language: Waste Acceptance

- § 61.58 Waste acceptance (new requirements):

(a) Waste acceptance criteria. Each applicant shall provide, for approval by the Commission, criteria for the acceptance of waste for disposal that provide reasonable assurance of compliance with the performance objectives of subpart C of this part. Waste acceptance criteria shall specify, at a minimum, the following:

(1) Allowable activities and concentrations of specific radionuclides. Allowable activities and concentrations shall be developed from the technical analyses required by either § 61.13 for any land disposal facility or the waste classification requirements set forth in § 61.55 for a near-surface disposal facility.

Preliminary Proposed Rule Language: Waste Acceptance

- § 61.58 Waste acceptance (new requirements):

(a) * * *

(2) Acceptable wasteform characteristics and container specifications. The characteristics and specifications shall meet the minimum requirements for waste characteristics set forth in § 61.56(a) for all waste, and the requirements in § 61.56(b) for waste that requires stability to demonstrate compliance with the performance objectives of subpart C of this part.

(3) Restrictions or prohibitions on waste, materials, or containers that might affect the facility's ability to meet the performance objectives in subpart C of this part.

Preliminary Proposed Rule Language: Waste Acceptance

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- § 61.58 Waste acceptance (new requirements):

(b) Waste characterization. Each applicant shall provide, for Commission approval, acceptable methods for characterizing the waste for acceptance. The methods shall identify the characterization parameters and acceptable uncertainty in the characterization data. The following information, at a minimum, shall be required to characterize waste:

(1) Physical and chemical characteristics;

(2) Volume, including the waste and any stabilization or absorbent media;

(3) Weight of the container and contents;

(4) Identities, activities, and concentrations;

(5) Characterization date;

(6) Generating source; and

(7) Any other information needed to characterize the waste to demonstrate that the waste acceptance criteria set forth in § 61.58(a) are met.

Preliminary Proposed Rule Language: Waste Acceptance

- § 61.58 Waste acceptance (new requirements):

(c) Waste certification. Each applicant shall provide, for Commission approval, a program to certify that waste meets the acceptance criteria prior to shipment to the disposal facility. The certification program shall:

(1) Designate authority to certify and receive waste for disposal at the disposal facility.

(2) Provide procedures for certifying that waste meets the waste acceptance criteria.

(3) Specify documentation required for waste acceptance including waste characterization, shipment (including the requirements set forth in appendix G of 10 CFR part 20), and certification.

(4) Identify records, reports, tests, and inspections that are necessary to comply with the requirements in § 61.80.

(5) Provide approaches for managing waste that has been certified as meeting the waste acceptance criteria in a manner that maintains its certification status.

Preliminary Proposed Rule Language: Waste Acceptance

- § 61.58 Waste acceptance (new requirements):

(d) Licensees with licenses for land disposal facilities in effect on the effective date of this subpart shall comply with the requirements of paragraphs (a), (b), and (c) of this section at the next license renewal or within 5 years of the effective date of this subpart, whichever comes first.

(e) For license applicants, the waste acceptance criteria will be incorporated into the facility license. For licensees with licenses for land disposal facilities in effect on the effective date of this subpart, upon Commission approval and if otherwise consistent with applicable State and Federal law, the NRC will issue an amendment to the license incorporating the waste acceptance criteria into the existing license.

Preliminary Proposed Rule Language: Waste Acceptance

- § 61.58 Waste acceptance (new requirements):

  (f) Each licensee shall annually review the content and implementation of the waste acceptance criteria, waste characterization methods, and certification program

  (g) Applications for modification of approved waste acceptance criteria must be filed in accordance with § 61.20

  (h) In determining whether waste acceptance criteria will be approved, the Commission will apply the criteria set forth in § 61.23

Preliminary Proposed Rule Language: Other Changes

- Definitions(§ 61.2)
- Concepts(§ 61.7)
- “Requirements for Transfers of Low-Level Radioactive Waste Intended for Disposal at Licensed Land Disposal Facilities and Manifests” Appendix G to 10 CFR Part 20
- “Uniform Low-Level Radioactive Waste Manifest” NRC Forms 540 and 541

Preliminary Proposed Rule Language: Other Changes

- § 61.2 Definitions (new definition):

Long-lived waste means waste containing radionuclides (1) where more than 10 percent of the initial activity of a radionuclide remains after 10,000 years (e.g., long-lived parent), (2) where the peak activity from progeny occurs after 10,000 years (e.g., long-lived parent – short-lived progeny), or (3) where more than 10 percent of the peak activity of a radionuclide (including progeny) within 10,000 years remains after 10,000 years (e.g., short-lived parent – long-lived progeny).

Preliminary Proposed Rule Language: Other Changes

- § 61.2 Definitions (new definition):

Compliance period is the time during which compliance with the performance objectives specified in §§ 61.41, 61.42, and 61.44 must be demonstrated. This period ends 10,000 years after closure of the disposal facility.

Performance period is the timeframe established considering waste and site characteristics to evaluate the performance of the site after the compliance period

Preliminary Proposed Rule Language: Other Changes

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- § 61.2 Definitions (new definition):

Waste means those low-level radioactive wastes containing source, special nuclear, or byproduct material that are acceptable for disposal in a land disposal facility. For the purposes of this definition, low-level radioactive waste means radioactive waste not classified as high-level radioactive waste, transuranic waste, spent nuclear fuel, or byproduct material as defined in paragraphs (2), (3), and (4) of the definition of Byproduct material set forth in this section. Consistent with the National Defense Authorization Act for Fiscal Year 2013, low-level radioactive waste also includes radioactive material that, notwithstanding Section 2 of the Nuclear Waste Policy Act of 1982, results from the production of medical isotopes that have been permanently removed from a reactor or subcritical assembly, for which there is no further use, and the disposal of which can meet the requirements of this part.

Preliminary Proposed Rule Language: Other Changes

- § 61.7 Concepts (new concept):

(e) ***

(2) Institutional control of access to the site is required for up to 100 years. This permits the disposal of Class A and B waste without special provisions for intrusion protection, since these wastes contain types and quantities of radioisotopes that generally will decay during the 100-year period and will present an acceptable hazard to the intruder. However, waste that is Class A under 61.55(a)(6) may not decay to acceptable levels in 100 years. For waste classified under 61.55(a)(6), safety is provided by limiting the quantities and concentrations of the material consistent with the disposal site design. Safe disposal of waste classified under 61.55(a)(6) is demonstrated by the technical analyses and compliance with the performance objectives. The government landowner administering the active institutional control program has flexibility in controlling site access, which may include allowing productive uses of the land provided the integrity and long-term performance of the site are not affected.

Preliminary Proposed Rule Language: Other Changes

- § 61.7 Concepts (new concept):

(f) ***

(3) During the period when the final site closure and stabilization activities are being carried out, the licensee is in a disposal site closure phase. Following that, for a period of five years, the licensee must remain at the disposal site for a period of postclosure observation and maintenance to assure that the disposal site is stable and ready for institutional control. The period of postclosure observation and maintenance is used to ensure that the final site closure and stabilization activities have not resulted in unintended instability at the disposal site. The Commission may approve shorter or require longer periods if conditions warrant. At the end of this period, the licensee applies for a license transfer to the disposal site owner.

Preliminary Proposed Rule Language: Other Changes

- § 61.7 Concepts (new concept):

(g) Implementation of dose methodology. The dose methodology used to demonstrate compliance with the performance objectives of this part shall be consistent with the dose methodology specified in the standards for radiation protection set forth in part 20 of this chapter. After the effective date of these regulations, applicants and licensees may use updated factors incorporated by the Environmental Protection Agency into federal radiation protection guidance or may use the most current scientific models and methodologies (e.g., those accepted by the International Commission on Radiological Protection) appropriate for site-specific circumstances to calculate the dose. The weighting factors used in the calculation of the dose must be consistent with the methodology used to perform the calculation.

Preliminary Proposed Rule Language: Other Changes

- Appendix G to Part 20 -- Requirements for Transfers of Low-Level Radioactive Waste Intended for Disposal at Licensed Land Disposal Facilities and Manifests (revised requirements):

II. * * *

An authorized representative of the waste generator, processor, or collector shall certify by signing and dating the shipment manifest that the transported materials meet the waste acceptance criteria for disposal; are properly classified, described, packaged, marked, and labeled; and are in proper condition for transportation according to the applicable regulations of the Department of Transportation and the Commission. A collector who signs the certification is certifying that nothing has been done to the collected waste that would invalidate the waste generator's certification.

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Preliminary Proposed Rule Language: Other Changes

- Appendix G to Part 20 -- Requirements for Transfers of Low-Level Radioactive Waste Intended for Disposal at Licensed Land Disposal Facilities and Manifests (revised requirements):

III. * * *

A. * * *

1. Prepare all wastes according to the land disposal facility's criteria for waste acceptance developed in accordance with § 61.58 of this chapter;

2. Label each disposal container (or transport package if potential radiation hazards preclude labeling of the individual disposal container) of waste in accordance with § 61.57 of this chapter;

3. Conduct a quality assurance program to assure compliance with the land disposal facility's criteria for waste acceptance that has been developed in accordance with § 61.58 of this chapter (the program must include management evaluation of audits);

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Preliminary Proposed Rule Language: Other Changes

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- Appendix G to Part 20 -- Requirements for Transfers of Low-Level Radioactive Waste Intended for Disposal at Licensed Land Disposal Facilities and Manifests (revised requirements):

III. * * *

C. * * *

3. Prepare all wastes according to the land disposal facility's criteria for waste acceptance developed in accordance with § 61.58 of this chapter;

4. Label each package of waste in accordance with § 61.57 of this chapter;

5. Conduct a quality assurance program to assure compliance with the land disposal facility's criteria for waste acceptance that has been developed in accordance with § 61.58 of this chapter (the program shall include management evaluation of audits);

Preliminary Proposed Rule Language: Other Changes

- Uniform Low-Level Radioactive Waste Manifest (revised forms):

  NRC Form 540 — Revised certification statement

  NRC Form 541 — Revised to allow licensees to indicate the use of WAC

Next Steps …

U.S.NRC
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- **If Commission approves of rulemaking package …**
  - Publish in *Federal Register* later in calendar year (Fall/Winter 2013)
  - Conduct public meetings in FY2014 (locations and dates yet to be determined)
  - Deliver final rulemaking package to Commission in late calendar year 2014

Low-Level Radioactive Waste Disposal (10 CFR Part 61)

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606th Advisory Committee on Reactor Safeguards
July 10, 2013

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

Why are we here today:

- Provide update of Part 61 Low-Level Radioactive Waste Disposal rulemaking

- ACRS briefings
  - ❖ Subcommittee (December 2009, June 2011, August 2011, April 2013, and June 2013)
  - ❖ Full Committee (March 2010, July 2011, and September 2011)

- Preliminary “Low-Level Radioactive Waste Disposal (10 CFR Part 61)” Federal Register notice

Commission Directions:

- SRM-SECY-08-0147 and SRM-SECY-10-0043

  Require site-specific analysis for disposal of large quantities of DU, specify criteria needed for analysis, develop supporting guidance, and incorporate blending issue into the existing rulemaking for DU.

- SRM-COMWDM-11-0002/COMGEA-11-0002

  1. Allowing licensees the flexibility to use ICRP dose methodology;
  2. A two tiered approach that establishes a compliance period that covers the reasonably foreseeable future and a longer period of performance that is not a priori;
  3. Flexibility for disposal facilities to establish site-specific waste acceptance criteria based on the results of the site's performance assessment and intruder assessment;
  4. A compatibility category…that ensures alignment between the States and Federal government on safety fundamentals, while providing the States with the flexibility to determine how to implement these safety requirements.

Today's topics and presenters:

Topic	Presenter
Preliminary Proposed Rule: *Low-level Radioactive Waste Disposal (10 CFR Part 61)*	Andrew Carrera, DILR