Official Transcript of Proceedings

NUCLEAR REGULATORY COMMISSION

Title: Advisory Committee on Reactor Safeguards
Fukushima Subcommittee

Docket Number: N/A

Location: Rockville, Maryland

Date: Tuesday, August 18, 2015

Work Order No.: NRC-1830 Pages 1-219

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NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

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JOINT MEETING OF THE FUKUSHIMA AND RELIABILITY AND

PROBABILISTIC RISK ASSESSMENT SUBCOMMITTEES

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TUESDAY

AUGUST 18, 2015

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ROCKVILLE, MARYLAND

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

COMMITTEE MEMBERS:

STEPHEN P. SCHULTZ, Chairman

DENNIS C. BLEY, Member-at-Large

CHARLES H. BROWN, JR. Member

MICHAEL L. CORRADINI, Member

DANA A. POWERS, Member

JOY REMPE, Member

GORDON R. SKILLMAN, Member

DESIGNATED FEDERAL OFFICIALS:

WEIDONG WANG

JOHN LAI

NRC STAFF PRESENT:

JONATHAN BARR

SUD BASU

THERON BROWN

HOSSEIN ESMAILI

ERIC OESTERLE

BILL RECKLEY

MARTY STUTZKE

RANDOLPH SULLIVAN

ALSO PRESENT:

RANDY BUNT, Southern Company

JEFF GABOR, Erin Engineering

STEVEN KRAFT, NEI

DOUGLAS TRUE, Erin Engineering

RICHARD WACHOWIAK, EPRI

T A B L E O F C O N T E N T S

P R O C E E D I N G S

1:07 p.m.

CHAIR SCHULTZ: On the record. Good afternoon. This meeting will now come to order. This is a joint meeting of the Fukushima and the Reliability and PRA Subcommittees, two standing subcommittees of the Advisory Committee on Reactor Safeguards.

I'm Steven Schultz, the Chairman of the Fukushima Subcommittee. ACRS Members in attendance today are Michael Corradini, Dick Skillman, Dana Powers, John Stetkar, Dennis Bley, Ron Ballinger and Joy Rempe. Weidong Wang and John Lai of the ACRS staff are the Designated Federal Officials for this meeting.

In this meeting, the Subcommittee will continue our review of Regulatory Basis Document for Containment, Protection and Release Reduction for Mark 1 and Mark 2 Boiling Water Reactors. The Subcommittee has held a review of the detailed technical analysis work and evaluations performed by the staff supporting this document at our July 7th meeting.

We also heard presentations from industry representatives regarding their development and analysis of severe accident management approaches for these facilities and discussed these findings. We discussed filtering strategies and severe accident management issues. And we also received comments from members of the public.

Today we intend to explore further details regarding some of the technical topics that were presented at that meeting. The Subcommittees will gather information, analyze relevant issues and facts and formulate proposed positions and actions as appropriate for deliberation by the full Committee.

This entire meeting is open to public attendance. The meeting is being conducted in accordance with the provisions of the Federal Advisory Committee Act. Rules for the participation in the meeting have been published in the Federal Register as part of the notice for this meeting.

A transcript for the meeting is being kept and will be made available as stated in the Federal Register notice. Therefore, we request that participants in the meeting use the microphones located throughout the meeting room when addressing the

Subcommittees. When recognized, first identify yourself and speak with sufficient clarity and volume so that you may be readily heard.

We have received a written comment and we have not received requests for a time to make oral statements from members of the public regarding today's meeting. The written comment we have received was transmitted by email by Paul Gunter of Beyond Nuclear. The Committee has received that email and has it available and will be part of our record for this meeting.

There will be individuals on the bridge line today who are listening on today's proceedings. To effectively coordinate their participation in the meeting, we'll be placing the incoming bridge line on mute so that those individuals may listen in. At the appropriate time later in the meeting, we will provide the opportunity for public comments from both the bridge line and from members of the public in attendance in the meeting room.

I remind us all to turn off your cell phones or communication devices so that there is no interruption during the meeting.

At this point, I'd like to turn the meeting

over to Eric Oesterle of the staff. He's going to make introductory remarks and introduce the presenters from the staff this afternoon. Thank you.

MR. OSTERLE: Thank you, Mr. Chairman, Members of the Subcommittees. My name is Eric Osterle. I'm the Team Lead for the Fukushima Lessons Learned Rulemaking Team. And thank you for inviting us back today.

Today with us we have members of the staff. Bill Reckley will provide a background and discussion. Hossein Esmaili from our research staff will provide discussion on accident modeling. Jonathan Barr will provide a discussion on consequence analysis. And Marty Stutzke will provide a discussion on risk assessment.

We thank the ACRS for inviting us back today. We last were here presenting the information paper submitted to the Commission under SECY-15-0085. And that was submitted in June, June 18 of this year. It was subsequently turned into a notation vote paper by the Commission. And the staff is still awaiting final direction from the Commission on that paper via an SRM. And we're here today to provide additional discussion on specific areas of interest that the

ACRScommunicated to us during the July 7th meeting. Thank you.

CHAIR SCHULTZ: And just to elaborate briefly on that for those that weren't in attendance at that meeting we had a lot of discussion regarding issues such as filter efficiency, filter effectiveness and we wanted to have further discussion on that topic specifically. We also had discussions about the presentation of issues related to the evaluation that has been done. We're dealing with very low likelihood events.

And we evaluate those in a particular fashion and then perform our evaluation and do the numerical evaluation. And sometimes in presentation of those results we can cause some element of confusion. And we wanted to be sure that we were being very clear in identifying what the conclusions of the analysis are and what conclusions then we draw as a result of the evaluations that we have performed which is we know from the presentation by the staff are very detailed. So those are a couple of the things that we brought to the floor.

The other thing that we discussed at the last meeting and we were hoping to have discussion from the staff as well as from the industry was the process of protecting the core in the event of a severe accident with regard to water addition and water management. At the time we had that presentation in July, the information that was being provided was very timely, but very new for us. And we talked about the assumptions that had been made in terms of water addition and water management. And we wanted to think further about the effectiveness of those features and understand better the assumptions that the staff had made in evaluating those and the assumptions that the industry has made in setting forward that process.

That's a summary of those types of issues which we left at the last meeting for further discussion here by the staff and by the industry. First we'll start with the staff. And after the staff's presentation, we'll have a break and the industry presentation will ensue afterwards on the agenda. Thank you.

Welcome, Bill.

MR. RECKLEY: One of the issues that we've had in this particular area is the relationship between

the orders, the rulemaking and how these activities fit together. So I thought I was spend just a few minutes going through the background and some of the history and how this has evolved over time.

Much of this is background and trying to put things in context. Hopefully, it won't take very long.

Obviously, it started with the accident at Fukushima which involved a beyond design basis external event, an earthquake and tsunami, which resulted in an extended loss of electrical power, reliance on the steam systems, RCIC or HPCI, which lasted for Units 2 and 3 a couple days. Unit 1, the older isolation condenser unit failed earlier. The loss of coolant leading to core damage and challenges to containment.

Overall, the agency, the NRC, has looked at various lessons learned from that accident and we've taken a number of actions related to evaluating, reassessing external hazards, looking at plant's capabilities to deal with losses of power, separation from the ultimate heat sink, some changes in the area of emergency planning, spent fuel pool instrumentation and what we're going to talk about largely today the venting for Mark 1 and Mark 2 containments.

But one of the things to try to keep in mind is that as we move forward and evaluate any particular possible regulatory action it's not in the context of all of these other things that we've already done. And so that sometimes get lost in the conversation as we focus in on a particular thing, for example, an engineered filter. It does need to be evaluated in the context of the mitigating strategies or the mitigating strategies for beyond design basis events, rulemaking and the other improvements shown on the graphic.

The first thing in regards specifically to Mark 1 and 2 containments was that like all plants they received Order EA-12-049 to develop Mitigating Strategies for beyond design basis external events. For Mark 1 and 2 containments, that for most plants involves dealing again with the steam driven systems, RCIC, and also having portal pumps that would be available should that system later on lose power from the batteries or the steam source.

Another thing that was done for Mark 1 and 2 containments was that Order EA-12-050 was issued in March of 2012 requiring a reliable hardened vent. So this was an enhancement to the actions that were taken in the late '80s or the early '90s in which Mark 1

containments had developed a venting capability. In light of Fukushima it was looked at and identified that it could be improved. And so Order EA-12-050 required licensees to take another look and to improve the vents systems that were put in place in regard to Generic Letter 89-16.

At the same time we issued the orders in March of 2012, the question arose of if you're going to vent and these accident scenarios have a potential to go into severe accident space should there be a vent. And that was in the context of -- A filter, I'm sorry. And that was in the context of filters being placed in venting systems in some other countries. And the issue had been previously raised within the United States back in the mid '80s.

So that question arose and the Commission directed us to prepare a paper which was SECY-12-0157. And the staff prepared a paper identifying four options, (1) to do nothing more beyond Order EA-12-050 and then as it identified on the slide three additional options. Option (2) was to make the vents severe accident capable. Option (3) was to order licensees to put in an engineered filter. And Option (4) was to do a performance-based rulemaking and further assess

the potential regulatory requirements for either a filter or filtering strategy.

Within the paper, the staff acknowledged that of equal importance to venting was water addition for core debris cooling. But we deferred any recommendations in that area. We made some assumptions that licensees would make efforts to add water, the SAMGs. The Severe Accident Management Guidelines call it. There are some provisions in 50.54(hh). FLEX would have some capabilities. And the staff stated in the paper that that should be further evaluated and maybe taken up in a future rule.

MEMBER STETKAR: Bill.

MR. RECKLEY: Yes.

MEMBER STETKAR: I want to make sure I understand this. You said FLEX will have some capabilities. It's my understanding for BWR with Mark 1 and Mark 2 FLEX will not have capability for water addition to prevent core damage because the analyses assume that RCIC is available. And FLEX is specifically for prevention of core damage.

MR. RECKLEY: For prevention of core damage.

MEMBER STETKAR: Right. So equipment that may be available may be available to provide water addition after core damage begins. If you want to call that equipment FLEX that's fine.

But my understanding of the industry guidance for FLEX is you don't have to have a water addition capability available until about eight hours after an event occurs. I may be wrong about that. But if I am, I want to make sure that I understand it.

MR. RECKLEY: FLEX calls for a continuous ability to cool the core using a combination of installed systems such as RCIC in the case of a boiler supplemented with portable equipment to either inject into the system or to support continued RCIC operation.

MEMBER STETKAR: And FLEX assumes that RCIC remains running for at least eight hours before you need additional water or cooling capability to make sure that RCIC does not lose suction, suppression pool heat removal essentially.

MR. RECKLEY: That's going to be plant specific, but it's going to be some number --

MEMBER STETKAR: It's not starting at T zero.

MR. RECKLEY: Right.

MEMBER STETKAR: Okay.

MR. RECKLEY: And the venting of the suppression pool supports that continued operation through maintenance of the temperature and the suppression pool.

MEMBER STETKAR: My point is when you start talking about water addition in terms of FLEX you have to be very, very careful because FLEX water addition -- FLEX is designed to prevent core damage and the water addition that we're talking about has nothing to do with preventing core damage.

And if it does, the staff and the industry needs to think a little bit about the way the guidance is written.

MR. RECKLEY: I don't think the lines break as cleanly as that. But we'll get into it in a little more discussion.

MEMBER STETKAR: Okay. I'll let you go.

MR. RECKLEY: A criticism of SECY-12-0157 however was that our assumptions on water addition and our focus on venting for overpressure protection in the case of a severe accident paid too little attention to water addition. And actually some tabletop exercises at plants showed that once you started to venture into

the severe accident space water addition became harder because access to places where FLEX equipment or 50.54(hh) equipment was located would become problematic.

And so again a criticism was if you break the containment failure mechanisms into three major parts, melting of the liner, overpressurization and a combination of pressure and temperature causing either lifting of the head or failure of other penetrations, the SECY paper focused on one of those. In so doing, it didn't give a very broad look at improving the performance of containments and put that off into a future rulemaking.

That same thing is reflected in this slide. This slide I borrowed from 2013. We used it in a public meeting right after. So the criticism was that when EPRI and the BWR Owners' Group did its work, it was looking at all the failure modes and thereby really bringing in the importance of water addition for severe accident. The staff's paper was looking at overpressure and filtering of that vent path.

The Commission assessed the comments from the industry and others and directed us in the SRM related to this paper to revise Order EA-12-050 to make

it severe accident capable and to evaluate core debris cooling and other containment integrity issues in a rulemaking which became now called the containment protection and release reduction rulemaking.The revision to Order EA-12-050 became Order EA-13-109. It maintained the requirements of EA-12-050 to support heat removal and prevent containment overpressurization before a severe accident and also brought in requirements for venting the containment during a severe accident. And it was broken into two phases, Phase 1 being venting from the wetwell and Phase 2 requiring either a severe accident capable vent from the drywell or a strategy that makes it unlikely that the licensee would need to vent from the drywell. And even in 2013 that was basically being talked about as a water management strategy where you would control the amount of water you're adding and thereby control the level in the wetwell and prevent it from causing a loss of the vent either by filling up to the vent or causing a loss of instrumentation by going outside the range.

Another important aspect of water addition that kind of evolved as we were doing the rulemaking and the order implementation at the same time was the need to define specifications for the vent systems.

And so for the wetwell vent, that was relatively straightforward given the water in the suppression pool and the assumption of saturated conditions. A number of 350 degrees was chosen. And the staff approved that that was a good temperature for the equipment associated with the wetwell vent.

When it came to the drywell vent and the look at phase 2 of the order, it became apparent through the analytical work again that was being done to support both the order and the rulemaking that water addition was important in establishing the conditions under which a vent might operate. And so with the assumed water addition, the temperatures in the drywell stayed below about 500 degrees Fahrenheit supporting the industry's proposed specification temperature of 545 degrees for the drywell vent equipment. In the absence of water, the temperatures are going to get much higher and that raised questions of how would you establish a specification for the drywell vent.

Again, I'm going back and forth. But this is the way this evolved because we were doing the order implementation and the rulemaking assessments at the same time. The same people were largely involved on both the staff and the industry sides. So there was

a lot of interplay. That was by design because we always saw the rulemaking and the order coming together at the end.

Within the order implementation, the industry's approach is to incorporate external water addition capabilities as part of either maintaining the temperature in the drywell to a reasonable value such that you can assign design specifications or as part of water management where you would prevent overfilling of the wetwell. And if you're going to do that, then you need to have the capability to control the water addition. So it has to be located in a place where you can do that control during a severe accident condition.

No matter which way the industry was proposing to do it water addition became part of the strategy for Order EA-13-109. And the NRC endorsed that. And we briefed the ACRS on several occasions on that development.

Again as that work was being done it was recognized that the water addition has the other benefits of cooling the core debris and preventing the melt-through of the liner should the core go ex-vessel and also controlling the temperature such that the combination of temperature and pressure doesn't cause

a lifting of the drywell head or major failure of other penetrations. The water management strategy and the continued venting through the wetwell has the additional advantage that the wetwell does reduce the release from what would otherwise be since it's acting sort of as a filter.

This just gives the status, the Phase 1, of the order which is the wetwell vent. Licensees have submitted their integrated plans. The staff has issued Interim Staff Evaluations.

Phase 2, the guidance was just issued and we are now working with the industry on the development of the template for the overall integrated plans which will be submitted by the end of the year.

As I've alluded to during the discussion since the order and the rulemaking were being done at the same time, they interweave. I thought I'd try to say what the relationship to the CPRR rulemaking is.

Alternative 1 as it's identified under the rulemaking paper is to do no rulemaking. And we leave Order EA-13-109 in place that was issued primarily for overpressure protection.

The licensees have proposed an approach for Phase 2 and have stated their intended plans to

proceed to have severe accident water addition be part of their implementation of the order. And that has the collateral benefit of core debris cooling should it go ex-vessel and end up in the bottom of the drywell.

Alternative 2 is to codify that order and thereby the core debris cooling remains a collateral benefit. It's there, but it's not a stated purpose of the rule under Alternative 2.

Under Alternative 3 --

MEMBER BLEY: Codify that just means have the rulemakings.

MR. RECKLEY: Yes.

MEMBER CORRADINI: Can you repeat Alternative 2 again please?

MR. RECKLEY: Alternative 2 would take the order. One easy way to think of it is just take the order language and put it in 10 CFR.

MEMBER CORRADINI: Okay.

MEMBER STETKAR: But not explicitly address water addition.

MR. RECKLEY: Not explicitly address and actually the order has language that the venting system is for overpressure protection.

MEMBER STETKAR: Right. Which could be

in principle achieved without water addition. In principle.

MR. RECKLEY: In principle And that was the purpose of Alternative 3 which was to close that loop that Dr. Stetkar brings up and say the regulatory requirement is to address the major failure modes including liner melt-through. So water addition would not be a way to comply. It would be a requirement in and of itself.

MEMBER STETKAR: The way.

MR. RECKLEY: The way, yes.

MEMBER CORRADINI: Going back between one and two, from a technical standpoint, there is no difference.

MR. RECKLEY: Actually from a technical standpoint when we've given this briefing, we say there's no difference between one, two and three as the way it's being implemented.

MEMBER CORRADINI: And why do you say that?

MR. RECKLEY: Because licensees have told us they're going to do severe accident water addition in order to comply with the Order 13-109 and they're going to control the water level in the wetwell.

MEMBER CORRADINI: And therefore you will check what they do to make sure.

MR. RECKLEY: Well, we'll check what they do to make sure it serves the function of the order and then collateral benefit is the core debris cooling should it go ex-vessel and does it protect from a liner melt-through. But that is not the focus of the order. And so we couldn't --

MEMBER STETKAR: Let me see if I can make sure that I understand it because I'm a knucklehead. Under Alternative 1 or Alternative 2, a licensee could come in and weld a cap on the end of their water addition line and still satisfy the requirements of Alternative 1 and Alternative 2. Is that correct?

MR. RECKLEY: You mean, why -- I don't follow the question.

MEMBER STETKAR: Okay. I'm the licensee. Today I say I'm going to do this.

MR. RECKLEY: Okay.

MEMBER STETKAR: And as part of what I'm going to do is I'm going to have a water addition line and that's got a chunk of piping inside the containment with some valves in it and it's got an extension outside the containment that I can hook up something to and pump

water in through that piping. That's good. I can get water in.

Two years from now, I take that piece of piping that extends outside the containment and I weld a cap on the end of it. And in fact I make it a super good weld so that I can never put any water in there. Do I still comply with Alternative 1 or 2?

MR. RECKLEY: Only if you develop an alternative keeping in mind that the licensee added that as a strategy for not needing a drywell vent.

MEMBER STETKAR: Okay.

MR. RECKLEY: So if they were to develop an alternative that didn't need water addition in theory they could do what you're saying assuming they otherwise complied with either having a drywell vent or having another strategy that they didn't need a drywell vent.

MEMBER STETKAR: They'd have to prove it.

MEMBER BLEY: They would have to prove it.

MR. RECKLEY: And they would have to prove it.

CHAIR SCHULTZ: Otherwise they are no longer compliant with the order.

MR. RECKLEY: Right.

CHAIR SCHULTZ: They could not proceed to operate.

MEMBER STETKAR: Okay. That's what I wanted to understand. Okay. Thank you.

MR. RECKLEY: So we built those into the containment protection functions and then the release reduction, Alternative 4, talks about either an engineered filter or a filtering strategy to further reduce the release assuming you've prevented an uncontrolled release through these other failure mechanisms and you're going to continue and vent as part of the accident management.

So we've really gone over this largely. The difference between Alternatives 1, 2 and 3 ends up being regulatory footprint question. From our interactions with industry, we don't think there's a difference between what's being proposed physically at the plants.

MEMBER STETKAR: Bill, are you going to -- I'm trying to look ahead here and I think you are going to talk about the differences between 3 and 4 from a technical perspective later.

MEMBER STETKAR: And actually I was going to go do that at the end after we go through the

technical discussions.

MEMBER STETKAR: Okay. I see the figure that I wanted to refer to. I just wanted to make sure we were. Thank you.

MR. RECKLEY: Okay. And then again we've also talked about the second bullet on this slide. Licensees will be doing water addition as part of the implementation. The implementation of that and the maintenance of that is subject to NRC review and inspections going forward.

Before turning it over to the technical experts, I'll make just a couple observations. And this has been true of many of the topics we've come before the ACRS to discuss. That is that the technical analysis as it's included in the reg-basis document again has to be looked at in the context that we were doing that to support a regulatory decision. So we're kind of looking at that from a backfit perspective.

The assumptions, the sensitivity studies, that we make, the degree of rigor that we put into the analysis, where we stop because we reached or had enough to reach a regulatory decision, all of those things are related to the fact that this is a regulatory analysis and not necessarily a scientific study where we would

model everything to the best of our ability and take as long as we wanted and all of that.

As Dr. Schultz has already mentioned, there is a particular challenge when you go into severe accident space. And this is really one of the few cases where the agency has ventured in to try to regulate severe accident areas.

You're dealing with low frequency but high consequence events and overall it ends up being a low estimated risk to public health and safety. But it nevertheless is a challenge to communicate when you're talking as we do in this paper, as we did in the expedited transfer paper, as you do in almost any severe accident paper.

When you look at the consequence part and there's a large amount of radioactive material released, it's hard to communicate that that's balanced by the fact that it's a very low frequency or low probability event. So in the aggregate, the risk is low and it's from a regulatory perspective acceptable.

Another issue in this assessment that Marty will get into in large part is that as you look at alternatives it's very hard to separate things out 100 percent because they start to interact with each

other. The example in this particular case is the filters.

As you look at the filters, if you assume problems with the water addition such that you raise your probability of melting through the liner, the benefits of the filter go down along with that. So you have to look again in total in how the things are interacting.

The filter is good for one and Jonathan will have a slide on this. It's good for a set of scenarios where another set of scenarios the filter is not going to be beneficial because of limitations or failures of other equipment. With that I'll turn it over to -

CHAIR SCHULTZ: Bill, you presented it well in terms of the combination of the technical analysis and the communication challenges. That is to say that you stated that the technical analysis had its purpose. It was not related to developing the first class engineering evaluation of filters versus non filters and so forth. But there were assumptions made.

And then rightfully you also did sensitivity studies which included some conservatism, some ranges of assumptions that were also incorporated.

So those two features feed into the communication challenges.

MR. RECKLEY: Yes, they can.

CHAIR SCHULTZ: That we are faced with here.

MR. RECKLEY: Right. And by the way, I don't want to detract from or make it sound like I am detracting from the work. The work that the industry did and the work that the staff did I think is still probably some of the best analytical work that's been done in severe accident space for a while.

CHAIR SCHULTZ: And I'm not suggesting that it isn't as well. I'm glad you said that. I hope my comment wasn't intended that way. It just seems that we've augmented the communication challenges because of the way we need to do the work.

MR. RECKLEY: Yes. And that's been the case and other things we've brought before the Committee as well.

CHAIR SCHULTZ: We look at things in piece-parts.

MR. RECKLEY: Right.

CHAIR SCHULTZ: And yet the results sit out there as if they're if you will real. And so that

makes it a difficult communication challenge. Thank you.

MR. ESMAILI: Okay. Good afternoon. I only have four slides because I presented most of this stuff back in July. And I just want to focus on what were some of the questions that were not discussed in the past meeting.

Just a little background. We did use the SOARCA Mark 1 model. We converted it to MELCOR 2.1. For the Mark 2 scoping calculation, the model was mostly consistent with what we had for the Mark 1.

And there were some questions regarding the modeling of the lower head. I think Dr. Rempe was interested in that. And at the previous ACRS meeting I just want to make clear that for CPRR and our assumption and this was consistent with what the industry assumption is is that we are post core damage water injection. I think we were talking about that.

This happens at the time of lower head failure, whenever that would be. So this is beyond certainties of how you can predict lower head failure. And the other thing, we just discussed this. Overall conclusions are not going to be sensitive to the timing of the lower head failure.

But I just put in some more information here. I think I spoke to it, you know, bits and pieces. But as far as the lower head is concerned as far as how the failure occurs, we only model heat transfer from the outer surface of the lower head to the cavity atmosphere by a constant heat transfer coefficient. We do not explicitly model the external structure. These are all the external guide tubes or model radiation heat transfer from them which can become important at relatively elevated temperatures.

I did some sensitivity calculations where I varied that heat transfer coefficient. I just wanted to see how it affects by as much as an order of magnitude. And what happened was that the heat timing of the lower head can be changed by maybe an hour or so. It does not affect the type of release, you know, the cesium, iodine release.

And in the SOARCA certainty analysis, they also examined sensitivity to the creep parameters and also the penetration drain line failures. What they found was that by varying -- Actually, it was a relatively broad range for creep parameters that what they found is that the lower head failure is within 20 minutes. And so they did not even pursue that further

as part of the uncertainty analysis.

This is not -- I mean this is very understandable because everything is happening and it's driven by what is happening inside of us. And the heat is coming from there.

So I hope I answered these questions in terms of the lower head failure. If you have any more questions, I can -- But we tried to resolve some of the issues with sensitivity calculations and to see whether our results are sensitive or not.

MEMBER REMPE: Okay. So the reason I asked the questions after the meeting was that during the discussions I believe the Chairman said, "You're pretty sure the vessel is going to fail."

And I believe you responded back, "Yeah, eventually it's going to happen."

And the reason I asked "Did you do some sensitivity studies" is because I had guessed that you probably didn't consider the guide tubes and you didn't change the heat transfer coefficient because the code is set up that way.

When you said you did sensitivity studies, did you bound what would happen if you increased the area to consider that guide tube? I mean that's

something. You can play with the numbers a bit and encompass the range and conditions. So how big was your sensitivity study? Did you include the additional area and the increase in heat transfer associated with the increase in temperature? Do you think you've got the range covered of conditions?

MR. ESMAILI: Well, this was a sensitivity calculation. So as I said I only varied the heat transfer coefficient. The area of the lower head we are not considering. We do not model the external surfaces.

At some point, if you decrease the heat transfer coefficient you are reaching a stage where the vessel is insulated.

MEMBER REMPE: Right.

MR. ESMAILI: And some of the vessels are insulated. Some are not. And if you decrease the heat transfer coefficient, it does not change the timing of the lower head that much. If you increase it, you have some heat transfer of course.

And even when I change the heat transfer coefficient -- for example, the default was about 10 watts per meter squared K -- I changed it to about 100. At some point, the things do not change that much. So

even in order of magnitude difference, it only changes by an hour or so. I did not try to actually model the external guide tubes, etc.

CHAIR SCHULTZ: I know you didn't. But again what I'm trying to say is -- and I don't know what the numbers are -- if I increase the area to consider that additional surface area, basically Q equals H times A times delta T, right?

MR. ESMAILI: Yes.

MEMBER REMPE: In some simplified fashion. So basically if you know that the area increases, if you consider that heat transfer surface area, is it going to be like an order of magnitude for that in addition to the order of magnitude? So have you bounded things?

I mean you can play with the numbers to get a confident feeling you've covered all the conditions.

MR. ESMAILI: No, I didn't. I did not and the reason is because not the entire surface of all externals is exposed to the debris that is seen inside the vessel. So it may act like a thing where it just conducts some heat through this and that's why I said that radiation heat transfer can be.

So you really have to heat up those

external structures. But before you even get there -- this was my thinking -- your vessel water is going to get pretty hot before it start conducting heat to them.

No, I did not do bounding calculations. But this factor of an hour or so is not going to affect. You know I can change. And then the other thing is that we had different scenarios where the timing of lower head would be substantially different.

MEMBER REMPE: I understand that bounding is bounding.

MR. ESMAILI: Yes.

MEMBER REMPE: But again if you don't want to spend the money to improve the models, if you could have some confidence and say "Yeah, I think I've covered the conditions" that's just what I was asking about.

MR. ESMAILI: I didn't do it. It was a sensitivity calculation.

MEMBER REMPE: I know it costs money and there's limited time and all that.

MR. ESMAILI: That's right.

MEMBER REMPE: But I just wanted to bring that up in the questions raised.

MR. ESMAILI: Even if you consider an order of magnitude it just not translates into an order

of magnitude difference. It's just things change relatively slowly.

MEMBER REMPE: Okay.

CHAIR SCHULTZ: So just to -- I think I'm hearing what you're saying. You're saying you did a sensitivity study. You did substantial variation. And yet the conclusions of the analysis, the engineering conclusions of the analysis, were not changing dramatically.

MR. ESMAILI: Not changing dramatically.

CHAIR SCHULTZ: And the decisions associated with implementing those engineering conclusions didn't change at all.

MR. ESMAILI: No, it didn't change. They were all conclusions. It didn't change the releases. You know there's an hour or difference in terms of timing of the lower head failure which is not going to affect considering its long transient.

CHAIR SCHULTZ: Thank you.

MR. ESMAILI: Okay. So this is something that we did not discuss in the previous meeting. It was a backup. It is in the SECY. So it's just important that part of MELCOR calculation predicts that the radioactive releases start immediately following

the containment venting.

And this is characterized by a sudden release as you can see by the red line. It just keeps going up. So it's a sudden release at the time of venting.

This is well before vessel breach and start of water injection. Because of the amount of hydrogen we produce, the heating and everything, you really need to vent at the PCPL well before that happens.

What the implication is is that when you actually start injecting water at the time of the lower head failure, these are the differences between the red and blue. The difference is that the red are the ones that we inject water. The blue is that we don't inject water. So as you can see it's that as soon as you start injecting water you stabilize the releases. You don't get any further releases, the blue lines. In cases without water addition, the releases continue going up.

The implication is that you are going to get that release at the time of venting. But just at the bottom I'm showing you the type of the release that's going out at that time. When you first start containment venting, this is a very short time. This is about an hour after core damage or gap release.

So the particles that are right now in the wetwell atmosphere they're dominated by very, very small particles. Most of the particles have been scrubbed through the suppression pool. And so it's in the range of 0.2, 0.3 microns that are going out. And we think that the further scrubbing of this aerosols would be minimal because they survive the pool and they come out with this distribution.

CHAIR SCHULTZ: Hossein, what's the assumptions in the modeling that drives this result? You've got on the lower right-hand chart here the number of lines that are at least described here running from 22 microns to 0.15 microns. And yet you've only got it looks like the 0.15 micron is the only one, if you will, that survives.

MR. ESMAILI: Yes, that's the only that survives coming out of the pool because most of the super micron sized particles are being captured by the pool. Those are the easiest ones to capture by the scrubbing suppression pool itself.

MEMBER POWERS: There are three basic processes that capture particles in the suppression pool. One is just gravitational settling. The big ones drop down. The gases within a bubble circulate

and sometimes they circulate so fast that the larger particles can't stay in the stream lines and so they intercept the wall. That again takes up middle-sized particles.

The particles also diffuse to the walls and the smaller the particle the more rapid it diffuses. So what you get is a particle sized dependent removal that has a minimum.

And that minimum is at this typically 0.1 to 0.3 micron size. It depends a little on geometry and things like that. And the minimum is substantial. It's orders of magnitude difference in small changes around that size. So the distribution not only gets attenuated. It gets narrowed around this maximum penetration size.

That's why his lines. You notice that he has 0.15 and then the 0.29 is way the hell down there. That's because the efficiency with which the 0.29 is trapped which is probably an order of magnitude or one and a half orders of magnitude greater than the 0.15 size.

CHAIR SCHULTZ: Are those sizes input to the model? Or are they in fact outputs?

MEMBER POWERS: What they do is they --

CHAIR SCHULTZ: I mean greater than or less than.

MEMBER POWERS: They define bins of sizes and they will inject into some fraction of those bins. And then you get particle growth and whatnot. And it very quickly starts populating all the bins. And it depends on how many bins they define. But this is not an untypical number here. Where he's plotted each one of the bins, there may be one that's smaller and there may be one that's a bit bigger than what he plotted here.

CHAIR SCHULTZ: Okay.

MEMBER POWERS: But this is called the sectional method of solving the aerosol problem. It's in fact a method that the NRC pioneered because of the peculiar nature of NRC type aerosol problems. It has become the standard of all aerosol physics which is based on this sectional method.

MEMBER CORRADINI: It's the equivalent of energy proofs for neutrons.

MEMBER POWERS: Yes, and the migration between that is all done physically. I mean it's based on physical models of aerosol growth and deposition and things like that.

CHAIR SCHULTZ: Right. Understood.

MEMBER POWERS: Yes, this is a key concept. And just about any engineering system has these three attenuation mechanisms operating and they depend on sizes. Diffusion always exists. Gravitation always exists. Gravitation affects the big ones. Diffusion affects the little ones.

So there is some size that's not too diffusive and not too gravitational that gets through nearly all engineering safety systems. We can design systems where those aren't operative. But they're much harder to design. So you always have a minimum. And consequently the aerosol size you put through the first filter, the distribution you put through the first filter, is not the distribution you have for a second filter.

CHAIR SCHULTZ: That's helpful. Thank you very much.

MR. ESMAILI: The other thing that we did not -- This was another thing that we were going to discuss about the effectiveness of the external filters. I think this is one of the interests. And I just want to say that we assumed that these filters are operational throughout the transient. They do not degrade. They are always there. In our analysis, we

assume that.

Of course, when everything else has failed, there's a probability that these filters are not going to be there to work. We did not try to quantify that, but that is a fact.

The decontamination factor, what the external filter. So you saw what was happening and the things that are coming out. We are dealing with very, very small sized particles. The decontamination factor can be affected by the filter design and particle size distribution through the vented paths, to where you put the filters.

Our approach here in CPRR was consistently with the previous work, SECY-12-0157, in that we parametrically varied the decontamination factor. And we applied to all particles sizes. We know that the decontamination factor is dependent on the particle size.

But as you can see from the previous one, it's really dominated by the small sized particles. So you can decontaminate everything above 0.15. But if you cannot scrub that one, that is where your source term is going to be.

There was no mechanistic model in terms of

treatment. This is also consistent with 12-0157. We chose a DF (decontamination factor) of 10, 100, and 1,000. One of the reasons was that it provided a broader range of DF because when Jon wanted to do his MACCS calculation he could go back to more source term. And I just put in some numbers there were assumed in 12-0157. They went 2, 10, 100.

We also went to 1,000. And part of the reason was that back in 2014 we did write to some of these vendors asking them about how these filters behave. And the response was that they said that DF is really, really high even for small sized particles.

MEMBER CORRADINI: With data?

MR. ESMAILI: No, there was an ML number. I don't have the data. And I say that in the last bullet is that we did not look independently at this data by NRC because that is not what we have been doing.

And because our overall conclusions are not going to be affected with what we chose.

MEMBER CORRADINI: Okay. But if I say it back to you, you're saying that given the fact that it wasn't part of the original scope, you didn't look at the fidelity of their numbers.

MR. ESMAILI: We didn't, yeah.

MEMBER CORRADINI: Rather you did a parametric on various DFs.

MR. ESMAILI: That's right.

MEMBER CORRADINI: Okay.

MR. ESMAILI: And then the fact that we stop at -- They cite you know 10,000, 100,000, etc. It's in those documents. You just chose a higher DF of about 1,000 because we have been schooled enough to say that we believe that you can't even measure anything than about 1,000.

But the important thing is that we did not do an independent assessment. We do change it parametrically. And all conclusions are not sensitive to DF as Marty is going to show you later on. It's that whether you choose a DF of 10, 100 or 1,000 you're going to get the same answer.

And this is because of what Bill was saying is that this water addition is not going to be all this successful. You're going to have containment failure. The effectiveness of the filter goes away if you have containment failure. Next slide.

This was also -- I think, all the members, you perfectly understand this. But I'm just giving you some examples of what happens in terms of if all the

releases go through the vented path where you would put a filter. Then you can reduce. But the fact is that if there's containment either due to upper head failure or liner melt-through, then external filter becomes less effective.

I'm just showing you some of the examples from some of the MELCOR runs that we have done. This is Run 1. Run 1 is an example of status quo. There's no water addition.

And here it leads to the containment failure but because we do that containment venting before water addition and at the time of core damage. Here in this case about 80 percent of the cesium at least goes through the vent path. The others cannot.

Here if I put a filter with a DF of 10 you can see that the releases are reduced from about two percent to about one-half percent. But increasing that DF is not going to do anything because you have another portion of the release that does not go through vented path.

And we found that 70 percent or 80 percent that we are talking about here if you look at other MELCOR runs that had no water addition, that's about on the average of about 50/50. So if you average all

of them, 50 percent without water, 50 percent goes through the vented and 50 percent goes through other sources.

Case 3 is a case of a main steamline creep rupture. This is one of the worst because there's not much you can do. But this is one of the unlikely scenarios also.

And here most of the release are going through the containment failure modes, whether it's upper head, because at the time that the hot leg fails most of the releases are bypassing the suppression pool. So you only get about 11-12 percent of the cesium that goes through the vent. Most of it goes through the drywell upper head.

And here it doesn't matter whether you put a filter because it doesn't do anything. Most of the releases are here.

The only way that the releases are or can be reduced is if external water addition is successful. And this one is a big if. And Marty is going to show you that this is not always the case. Some of the cases water addition is successful. Some of them it's not. And here is the only place that if you prevent containment failure then the results become sensitive

to what type of DF you assign on the filter.

These are all what I was going to talk about for presentations. And as I said, Marty is going to tell why that is.

MEMBER CORRADINI: So can I cut to the last one because you had me, then you lost me and then at the end you had me again? If I look at the last row with the various DFs, those still aren't size dependent. So that if I were to talk through this mechanistically the way Dana explained it to us, I probably can't achieve 10, 100 or 1,000 because I've already scrubbed out all the big ones.

MR. ESMAILI: That's right.

MEMBER CORRADINI: Okay. So do I have it correct?

MEMBER STETKAR: But his former slide said they assumed --

MR. ESMAILI: Yes, assumed.

MEMBER STETKAR: -- that it would scrub out even the bazillionth of a micron particle.

MEMBER CORRADINI: I understand. But what I'm trying to say is if I go down the what if path technically, if I go down the path that I can successfully add water and keep things at the

appropriately below conditions of pressure and temperature and I put things through the wetwell, what would come out when I had to vent to hold pressure and temperature would be of a size that I can't physically get a DF that I'm assuming.

MR. ESMAILI: That's what the vendors --

MEMBER CORRADINI: Have I missed anything?

MR. ESMAILI: I think you've got it right because that's what the vendors are saying that they can scrub.

MEMBER CORRADINI: Forget about the vendors.

MR. ESMAILI: Understand.

MEMBER CORRADINI: I'm trying to --

MR. ESMAILI: But here we assume that you can achieve a DF of 1,000.

MEMBER STETKAR: Regardless.

MR. ESMAILI: Even with those small sized particles. This is an assumption and how good is this assumption is that we have to look at the filter. But it does not make any difference because once you put it into the PRA space that goes away. And so going back to Bill's point is that --

MEMBER STETKAR: But wait. PRA and uncertainties in PRA aside --

MEMBER CORRADINI: I just want to get to the -

MEMBER STETKAR: -- if an engineer can't actually design a filter that will take out the particles you're assuming that it takes out, then isn't this a bit misleading to say that you get these very, very large reductions? I mean if they can't really do it.

MR. ESMAILI: They say they can. But we have not --

MEMBER POWERS: Make it very clear that if somebody said you must design a filter system that has a DF for all particles of at least 1,000 yes, it can be done. It is difficult to do. It's even harder to prove that you've done it. That is one of the real challenges.

MEMBER STETKAR: Has anybody done it anywhere?

MEMBER POWERS: Yes, I mean the laboratory. You can always build a filter that gives you a DF of infinity. It's called a wall. But in real systems, I mean in a big engineering system, it becomes

progressively much more difficult to do it and it really becomes formidably difficult to prove that you've done it.

MEMBER CORRADINI: But I mean, I guess, Dana, the way you're answering the question is hypothetical. But if I was designing a clean room, I'd buy it. But if I'm designing what is in essence --

MEMBER STETKAR: Something to be put on the roof of building someplace.

MEMBER CORRADINI: Right.

MEMBER POWERS: It just gets very, very difficult. And it becomes even more difficult to maintain it.

MEMBER STETKAR: Yes.

MEMBER POWERS: On day one it produces a DF of 1,000. Operated for 20 years and now need it. Probably not going to get your DF.

I mean remember that DF is kind of a misleading number. It takes very, very little leakage through unfiltered pathways to undo a DF of 1,000. It takes a huge unfiltered path to undo a DF of 10. And it's just the reciprocal nature of DF as a number.

CHAIR SCHULTZ: Yes.

MEMBER POWERS: If you look at things in

terms of what fraction of a mass gets released the difference between a DF of 100 and 200 is the difference between one percent and half a percent. I mean it's an insignificant amount of difference.

CHAIR SCHULTZ: That's right. And we modeled that carefully when we tried to evaluate control room habitability and filters and that type of thing.

MEMBER POWERS: Right. Unfiltered end leakage and filters is exactly the same problem. It's formidably difficult.

CHAIR SCHULTZ: Yes. You mentioned what's been demonstrated, Dana. And what we're asking here -- I think what Mike's question is -- is you say you have a DF for your filter and you can take out small particles. But if something else has taken out the material that is the small particle and then what is left goes through your filter, how much do you remove then? And that question, has that been answered? The sequential filtration.

MEMBER POWERS: The experimental reviews of these things, you tend to do them any time you do an experiment because you lose particles along the flow path way through deposition. Your big ones go away.

Your little ones go away because they diffuse to the walls and deposit. And what you get experimentally in any aerosol experiment you do, any of them, is you get a distribution that's heaped around some size. It depends on the geometry of your arrangement.

So the answer is do we know these things work. Yeah. Painful experience teaches us that it's hard to generate an aerosol and then have that aerosol show up at whatever you're testing.

MEMBER BALLINGER: But what we're saying here is essentially the reverse. During an accident, the large particles disappear. We're left with the small fraction. The small fraction -- I'm talking about the stuff that goes through the vent, the filter. The small fraction is not likely to be captured by the filter no matter what.

And that leaves the 50 percent or some approximate number that bypasses everything altogether. And that has a completely different particle size distribution than the stuff that eventually finds its way to the vent.

MEMBER POWERS: Exactly true. And what's really subtle about this is it's the very, very small

particles are easy to remove. They remove themselves by diffusion. The very, very big particles are easy to remove. They remove themselves by gravity.

It's in the intermediate range that just it's obnoxious. And it's why this room is filled with particles. I'm mean they're like ten to the seventh per cubic meter in this room. You can't see them because they're smaller than the wave length of a light. So they don't scatter and things like that. And they just defy removal.

MEMBER STETKAR: Okay. Now help me out because I don't understand any of this stuff. So we've bubbled this stuff through a pot full of water and out comes this distribution of the things that you say can't be removed by that pot full of water.

MEMBER CORRADINI: Easily.

MEMBER STETKAR: Easily.

MEMBER POWERS: They're always removed.

MEMBER STETKAR: In principle, I could put a concrete wall in there, but I didn't. I put a pot full of water in.

MEMBER POWERS: I could take that.

MEMBER STETKAR: Now I put that distribution of that stuff into a pipe that goes out

the stack and I put some engineered filter that I can actually build and install in a nuclear power plant. Is that engineered filter going to be very effective?

MEMBER POWERS: It will have some effect.

MEMBER STETKAR: Okay.

MEMBER POWERS: You will get some DF. You always get some DF. Will you get the same DF that you measured in the laboratory with that filter when you put a large particle size distribution? No, not even close.

MEMBER STETKAR: That's it. Okay.

MEMBER POWERS: Not even close. And I wish I had a plot because the difference in removal efficiency for particles of a maximum penetration size and one micron is an order of magnitude at least. Often two or three orders of magnitude.

MEMBER STETKAR: And I think that's what we're trying to understand because we're trying to understand the effectiveness, the incremental effectiveness, of that second filter given the fact that it's with this distribution of things that can't be easily removed by the first one.

MEMBER POWERS: It will always have an effect. There will be a DF from any -- There will be

a DF in the pipe itself.

MEMBER STETKAR: Yes.

MEMBER POWERS: There will be a DF from the filter. Is it a very big DF? Is it enough to make a difference? Depends on what you want to do. Is it enough to make a difference compared to this unfiltered out leakage they had? No, that's his point.

MEMBER STETKAR: Yes, but that's different. Suppose --

MEMBER POWERS: That is the --

MEMBER STETKAR: -- that is the pot of water.

MEMBER POWERS: But that's a crucial point here. In designing an engineering filtering system, you have to account for the unfiltered out leakage. And you can build a hugely expensive and wonderful filter system. You get no increment from it because of the unfiltered out leakage.

And there's always some. And in the Mark 1 it's actually a half of percent per day or something like that per design. By the time you've had a severe accident it's probably a good deal bigger than that.

MEMBER BALLINGER: So when a vendor quotes a DF, that's a useless statement unless that's followed

by for the following particle size distribution. And that particle size distribution for our purposes must be the particle size distribution after all of this stuff has filtered itself out and everything.

MEMBER POWERS: Well -- What's useful is if he comes in and says, "I have a DF for this particle size range. And I've got one for this range and this range." If he says, "Overall, I've got a DF of 10,000" if I'd run bowling balls through it --

(Laughter)

-- it will take out big chunks. Okay. It's just meaningless. But if he gives it to you by size class, then your next question is "Okay. How did you do the experiment?"

MEMBER BLEY: Is it just size?

MEMBER POWERS: Size is really the only thing that counts.

MEMBER BLEY: It's the only thing that counts.

MEMBER POWERS: Shape makes a difference, but it's in the nuances.

MEMBER BLEY: Charge, that's not a big deal.

MEMBER BALLINGER: If you could put an electrostatic precipitator on this thing.

MEMBER POWERS: Charge is really interesting because in principle the charge is bipolar. That is there are many pluses. There are minuses. It turns out not to be quite true because the mobility of ions in the atmosphere is different. The positive ones are immobile. The negative ones are fairly mobile.

And so kind of one micron, two micron particles actually develop kind of a negative charge on them and it can affect things. It does not typically affect these very small particles because they get discharged.

The charging of the atmosphere is coming from the radiation. And so it's bipolar. There's as many positive charges as there are negative charges. The little ones can't hold a charge very long. So they kind of average out to zero. It's called a Boltzmann charge distribution on them.

The bigger ones can, but the bigger ones are easier to remove by other mechanisms.

MR. ESMAILI: And we don't model that.

CHAIR SCHULTZ: So essentially by the time it gets out of our pipe, it doesn't make much

difference.

MEMBER POWERS: Yes. There have been some efforts. Battelle Institute tried to set up a code to model it. And there are lots of cat fighting over these things as there are for any academic issue. The answer came back as it's going to affect the bigger particles, the one micron and bigger particles more than anything else. But those particles get affected by everything else. How much am I going to kill myself to get a two percent effect?

Where it really gets interesting is actually in the piping system in the reactor where the charge concentration is on the order of ten to the twelfth per cubic centimeter which is almost getting close to plasma up there. Then it gets really interesting which means almost impossible to model.

CHAIR SCHULTZ: Other questions for Hossein?

(No verbal response)

Let's go forward, Jon.

MR. BARR: I am Jon Barr from the Accident Analysis Branch in Research. And I presented about 10 or 15 slides offsite consequence analysis model approach conclusions at the last ACRS meeting. I

didn't get any questions or specific issues related to that part. So I thought I just give one slide to just summarize the modeling approach and the high level conclusions. And if there are any questions we can discuss and then move on.

For the modeling approach, I developed a site-specific Mark 1 MACCS model for Peach Bottom and a site-specific Mark 2 for Limerick. Limerick has the highest population within 50 miles of all the Mark 1s and 2s. And Peach Bottom is the third highest.

For the Peach Bottom model, we used SECY-12-0157 and previously in SOARCA. And I updated it wherever there were new data sources available, things like population, economic data, other models, etc. And a similar approach was done for Limerick.

MEMBER POWERS: Are you going to tell us -- I mean particularly I think Limerick has fairly recent evacuation time estimates, doesn't it?

MR. BARR: Yes, all of the plants were required to update them based on the release of the decennial census. And both of them, both of the evacuation time estimates, came in 2014 or late 2013. And that data was used to inform the evacuation models within MACCS.

MEMBER POWERS: And in the case of Limerick, recollection is that there's a substantial transient population that is kind of hard to evacuate.

MR. BARR: There is a transient population. I think that is modeled in the evacuation time estimate.

MEMBER POWERS: But it's slow, I mean.

MR. BARR: Given that it's a higher population site, it is slower than most others. But it's actually not that much longer. I think the Limerick evacuation time estimate for a given weather and time condition was only about three hours longer for the 10 mile EPZ partly based on having a larger road network available.

MEMBER STETKAR: Jonathan, I think we asked this at the Subcommittee. But I just don't have any notes on it. Did you bias your results at all because the risk assessment says that basically the most likely way to have this extended loss of AC power is some severe external event like a really bad day storm or really bad day seismic event if you just take your distribution of evacuation time estimates that apply for a sunny day event and distribution of possible weathers and things like that.

MR. BARR: That's a great question. It's something that was thought about in the development of this. I worked with Randy Sullivan, an EP expert in NSIR, and we discussed this. And we looked at a few other factors that sort of helped us make the assumptions of what to do there.

So one thing is the typical release times coming out of MELCOR showing that in many cases there would be 10 to 20 hours before there would be a release offsite. And also there were sensitivities done in SOARCA and also again in this project here to look at a one hour delay for everyone to evacuate.

Another important thing that was done back in the SOARCA process was that Randy Sullivan and I believe some others on the SOARCA project traveled around Peach Bottom and did an evaluation of some sort of the road and bridge infrastructure there and the rock surface type and things like that. They came to the conclusion that there are not likely to be any major infrastructure bridges or something that would significantly impact the ability to evacuate.

MEMBER STETKAR: Well, I hate to be the devil's advocate here. But not every boiling water reactor is sited at the Peach Bottom site.

MR. BARR: Right.

MEMBER STETKAR: Nor are they cited at Limerick. So the question was making general conclusions for the whole population of BWRs. Did you try to do anything?

MR. BARR: General approach is to use the Peach Bottom ETE data and part of the thought thinking was that this is a higher population site.

MEMBER STETKAR: Yeah, but if it's a higher population site and everybody is guaranteed to get away as quickly as possible under the worst possible circumstances, that may not necessarily apply to the medium density site that everything falls down in an earthquake. Okay. Thanks.

MR. SULLIVAN: Yes, I suppose. Randy Sullivan here. You've asked us the earthquake question several times and we have been pondering it. I don't know. Maybe it's an idea for further study.

But when you add this -- There was a sensitivity analysis done, was there not, where evacuation was kind of delays for several hours as I recall?

MR. BARR: Right, for one specific source term, the fastest one that was released it was really

7.3 hours. There were significant delays of three hours and delays of six hours considered as well as a total no evacuation, no relocation situation. And so in that case, the actual exposures coming from that early phase increased obviously. But it wasn't so significant to make us want to reconsider that I think for all of the other source terms as well.

MR. SULLIVAN: We didn't, we NSIR didn't particularly care for the no evacuation sensitivity analysis as you might imagine since it negates 30 years of emergency preparedness. Although we do agree that there could be delays and things could be more difficult, we think people will be moving.

But we're still pondering the earthquake question and how do we model that. And I'm not sure I have clear path of applied research. But once again, it wraps around the quantitative health objection and does that change when a severe earthquake changes the fatality rate in the environment. And that's as far as we've gotten with that kind of conundrum.

MEMBER STETKAR: That's a really thorny issue.

MR. SULLIVAN: Thank you.

(Laughter)

MR. BARR: Okay. Thanks, Randy. And back to the modeling approach, there were a lot of different source term -- a lot of different MACCS runs done for different source term bins coming from MELCOR analysis. And then there were various sensitivity calculations looking at a bunch of different areas of the model.

One was looking at different population distributions for other sites, land use and economic data. I mentioned one hour evacuation delay. Another thing was increasing the size of the fraction of the people that would not evacuate for whatever reason.

In the intermediate phase, I varied the size from no immediate phase to a full year there. And then also in the long term phase, I varied the habitability criterion which effectively determines what level of exposure is considered acceptable and then what would require interdiction relocation.

MEMBER POWERS: We have some data on the fraction of population that will refuse to evacuate from particularly natural hazards. Do we have any equivalent data for what you'd call technical hazards?

MR. SULLIVAN: Randy again. We don't have good data on the percentage of the population that

refuses to evacuate. We studied something like 250 evacuations. I know you've heard this from me before.

MEMBER POWERS: I use it in my class.

(Laughter)

MR. SULLIVAN: Yes. But the people who are doing the evacuation are busy saving those who want to be saved rather than counting the people who won't cooperate. I guess at the risk of being boring I'll remind you that certain officials have asked those who go to hurricane parties to please put their social security number in indelible ink on their arm.

(Laughter.)

And I've had several local officials tell me "We just don't take time. We do all the warning we can. And then we help those who want to be helped."

So no. I don't have good data for those who refuse. We historically have used half a percent. And I think you did sensitivity analyses to bump that up.

MR. BARR: Up to five percent.

MR. SULLIVAN: All right.

MR. BARR: And that shows no results.

MEMBER POWERS: I'm just thinking of the debate that says that there are people that will go to

hurricane parties. The question is are there --

PARTICIPANT: They may not go to it.

MEMBER POWERS: -- people who go to nuclear accident parties?

(Laughter)

PARTICIPANT: Seriously.

MEMBER POWERS: And I worry that we may overestimate the refusal to evacuate because I think people will -- There is at least a school of thought that says that people are more willing to evacuate on technological hazards, things like chlorine leaks and aircraft impacts, than they are for hurricanes. And it's basically familiarity that they've been through hurricanes before, nothing happened to them last time, and ergo nothing either will happen.

Whereas, you dump a railcar full of chlorine, they don't know squat about that. And they say, "Didn't sound like a good idea. I'm going to get away from it." That may be somewhat equivalent to their response to a nuclear accident.

MR. SULLIVAN: Dr. Powers, on the flip side, I'm a regulator. There is no regulation I can write that will change these people's minds. And so I've often argued that we shouldn't even considered it.

I don't win that argument.

I mean what regulation can I write? How can I fix this problem? What can licensees do?

MEMBER POWERS: It just makes me very happy that I don't have your job.

(Laughter)

MR. BARR: So I will continue with some of the high level results from the MACCS calculations. First of all, for the early fatality risks, there was zero for all of the MACCS runs including all of the sensitivities. And that has to do with essentially the size of the source terms and the delays and the assumption that the evacuation will be pretty much successful.

The individual latent cancer fatality risk when frequency-weighted is well below the QHOs as we have shown in various slides. I think Marty will get to those.

And then also the individual latent cancer fatality risk is driven by the long-term phase exposures because again -- and we did already talk about this -- the assumption with delayed releases. There may be time for people to evacuate.

And then in the long-term phase the health risk is strongly affected by this habitability criterion. Any exposures over the level will cause people to be relocated and land to be interdicted and then will trigger economic losses and land contamination. That's my one slide summary.

MEMBER POWERS: A pretty good summary.

CHAIR SCHULTZ: Any other questions for Jonathan?

(No verbal response)

Thank you.

MR. STUTZKE: Hi, I'm Marty Stutzke from the Division of Risk Analysis in the Office of Research. And I want to summarize some of the results from the PRA and give you a little insight as to how they were calculated.

I guess it's okay if I preface my remarks as we intend to write a NUREG that explains this analysis, not just the PRA but the MELCOR and the MACCS in its full-blown glory as well as a chapter or chapters that would be a knowledge management capture thing to talk about the history of containment venting from the beginning. From the middle '60s I think is as far back as we've been able to trace it to try to preserve it.

It may be relevant I guess for Bill and maybe not for Jon if they're talking about an early buyouts now.

(Laughter)

It might be nice to preserve some of the history.

MEMBER STETKAR: Marty, if you're going to do that, what's the schedule for that? I mean, has it got a lot of good things to record what you've done? There are some pitfalls in some of the things that you did.

MR. STUTZKE: Yeah.

MEMBER STETKAR: That also ought to be identified.

MR. STUTZKE: I believe the current schedule is to the end of the year. Get the graphic out.

MEMBER STETKAR: Oh quickly. Are we going to get a chance to see that?

MR. STUTZKE: But I'm critical path. So that probably will change.

(Laughter)

MEMBER BLEY: Did you just ask a question?

MEMBER STETKAR: Yes, I did. Are we going to get a chance to see that?

MR. STUTZKE: I don't think that's been decided. I'm looking at Dr. Basu.

MEMBER STETKAR: I think we'd like a chance because as I said it's not just documenting what was done. It's some of the implications that might carry forth into the future of this is the way it shall be done.

MEMBER BLEY: And there were at least some things we've commented on.

MR. STUTZKE: I appreciate that.

MEMBER BLEY: I can make sure. Codified is the way to do things perhaps.

MEMBER STETKAR: So we ought to think about that. If it is indeed targeted toward the end of this year it's --

DR BASU: Sud Basu from the Office of Research. I was about to say yes in a definite way to your question. I'm also reminded that the Commission has not deliberated on the issue. So we will defer until we see the SRM. We will have a report.

MEMBER STETKAR: Yes. But, Sud, that shouldn't affect this NUREG that describes the

technical analysis that was done that Marty's talking about.

DR BASU: Yes. I think Marty mentioned NUREG and at the time that we discussed this amongst ourselves, it was to be a NUREG. I'm not sure what the SRM is going to -- It may be an internal report and that's what we're unsure of.

MEMBER STETKAR: Okay.

DR BASU: But at any rate I mean the internal report I see no reason why we couldn't share this with the ACRS. Does that answer your question, John?

MEMBER STETKAR: Yes.

DR BASU: Thank you.

MR. STUTZKE: The reason for saying that is my excuse for not presenting in great detail all the event trees and then assumptions like that. I want to try to focus on the results.

But this slide here shows the basic way the risk calculation is done. We have probabilistic models for ELAP frequencies at all the sites that include the seismic hazards, etc.

It runs through a core damage event tree which looks at the mitigating strategies from FLEX

implementation probabilities, produces the results which are grouped into two plant damage states that input to a set of accident progression event trees. That calculates the frequencies of various types of release categories. Then having those frequencies we have a representative MELCOR case which then pulls up a representative MACCS bin that determines the conditional consequence.

In that case, my arithmetic is very simple. I simply multiply the frequency times the consequence which gives me the risk of that bin. And you add them up to the total.

A great deal of the effort is in the construction of these event trees. And funny enough it's in the core damage event trees because I had to model FLEX. The idea of not treating the issue piecemeal but you try to look at the impact of the other regulatory things. For example, there's 139 unique plant damage states going into the accident progression event tree.

MEMBER CORRADINI: But when you're modeling FLEX, you're modeling it as its ability to prevent core damage, not to respond to after core damage for this. That's treated in a different manner. Am

I understanding it correctly?

MR. STUTZKE: Well, the way that it's actually done is the plant damage states keep track of equipment status. So it will know. It assumes the FLEX pump that is being used prior to core damage is the same piece of hardware that would be used post core damage.

MEMBER CORRADINI: So it didn't work to stop it, but it's still may be available to do something after the fact.

MR. STUTZKE: Right. Well, for example, it knows if the FLEX pump has failed mechanically. There is no further credit taken for that pump in the analysis.

MEMBER CORRADINI: But if it failed to start in an appropriate time, it still might be able to be turned back on.

MR. STUTZKE: Correct.

MEMBER CORRADINI: Okay.

MEMBER STETKAR: And I think you also told us just to make sure I've got it, Marty, that when you turned on FLEX if you will that my notes from July said that you did not include credit for FLEX to prevent core damage if RCIC failed earlier than four hours.

MR. STUTZKE: That is correct.

MEMBER STETKAR: So that complete loss of DC at time zero or RCIC fails to start FLEX didn't help you there. It could later for post core damage.

MR. STUTZKE: That's correct.

MEMBER STETKAR: But it could help you if RCIC failed during operation, a running failure.

MR. STUTZKE: That is correct.

MEMBER STETKAR: Okay. So there was a little bit of discrimination of how much you could get from FLEX to prevent core damage.

MEMBER CORRADINI: Okay. But you could say it another way. So I remember it is there is a dead span which you just simply can't get it into operation from zero to X time.

MEMBER STETKAR: From zero to four.

MEMBER CORRADINI: Yes.

MEMBER STETKAR: Four is the assumed mode.

MEMBER CORRADINI: X is four in this case.

MEMBER STETKAR: Right.

MR. STUTZKE: And I would also be remiss if I didn't point out that FLEX is more than a pump. It is a whole set of strategies that includes for example DC power and the core damage event tree

understands that. For example, it will look at a seismic failure of DC switchgear. And if it has failed, it takes no credit for the portable generator because there's nothing to connect it to. So all of those dependencies hopefully are modeled to some extent like this.

The main purpose of the slide here is to say there are some 20 sub-alternatives that were looked at in the regulatory analysis. And they have a history. They evolved as the project evolved. It seemed like every time I had a meeting some new alternatives were there.

It refers to a specific set of strategies. For example, we'll talk about post accident or severe accident water addition. And the question is is it to the reactor vessel or to the drywell.

And so that's a specific strategy. That doesn't mean that in that strategy water addition is guaranteed to operate or to fail. What it means is at least it's possible and the model sorts out probabilistic whether it actually works or not.

That's the reason why you have all of these different release categories. The nomenclature is cryptic to you. But, for example, if I look at the

first release category here it ends in IVR. That means in-vessel retention. That tells me the pump worked. The operators got it working. The next one, liner melt-through, LMT, indicates it didn't work like this. So all the possibilities are there.

By the way, these frequencies sum up to about 98 to 99 percent of the total core damage frequency in most cases.

MEMBER STETKAR: Total core damage frequency from seismic induced failures.

MR. STUTZKE: Right.

MEMBER STETKAR: Okay.

MR. STUTZKE: I didn't just arbitrarily whack it. I tried to add them up. It's surprisingly concentrated, but it's probably because the release categories could be further broken out. Next slide.

This is an example of the types of engineering results here that the original purpose behind the viewgraph was to show you first of all the different cases and the differences between injecting to the reactor vessel versus the drywell. It's not obvious.

So again across the horizontal axis, you have all the various regulatory sub-alternatives and

their rather cryptic notation as to what they mean. These are sorted into RPV injection versus drywell injection like this.

And what the graph shows you is that roughly 60 percent of the cases where we have RPV injection, it actually works on the core debris retained within the reactor vessel. So 40 percent of the time it goes ex-vessel and also into liner melt-through. When the pumps fail the pumps fail. As opposed to drywell injection, there's no chance that it would ever be retained inside the vessel.

MEMBER CORRADINI: I don't -- I guess there's a logic that I don't get. So I understand the green. Why is there no yellow in the first five? Because of equipment unavailability?

MR. STUTZKE: It's the combination of equipment unavailability and the operator reliability. When this turned out, I actually expected to see some yellow in the first five.

MEMBER CORRADINI: And you didn't.

MR. STUTZKE: And there are none.

MEMBER CORRADINI: And that's because the operators don't have the ability -- It's not there to do or it's a combination. It's not there to do and they

don't do it right.

MR. STUTZKE: It's the latter. In other words, sometimes the equipment fails and sometimes the operator fails.

MEMBER CORRADINI: So where do they put the water if the equipment is there?

MR. STUTZKE: Well, what it says is that they're unsuccessful in putting the water anywhere.

MEMBER CORRADINI: Ah. Even though the equipment is ready.

MR. STUTZKE: They'd be able to do it, right.

MEMBER CORRADINI: And this is just due to human factors failures.

MR. STUTZKE: That sort of thing. The other purpose behind the graph is a little more explanatory.

MEMBER CORRADINI: I'm sorry. I'm still bothered by there's no yellow. Does that mean that there is yellow and it's too teeny tiny to see?

MR. STUTZKE: It's teeny tiny.

MEMBER CORRADINI: Okay.

MR. STUTZKE: It's actually there.

MEMBER CORRADINI: Okay.

MR. STUTZKE: But I've looked at it multiple times trying to make certain that I didn't have a mistake, just a flat out mistake and it seems to be there.

So the other purpose is when you look at the first couple of bars you see this 60 percent/40 percent. Do not confuse that with the high level conservative estimate that said 60 percent of the time FLEX is assuming to work. The number coincidentally is the same, 60 percent. In the high level conservative estimates, 60 percent is the reliability of the FLEX hardware. That seems to confuse some.

Contributions to risk on the next slide. This is something in an effort to try to explain the results we're seeing. What I did was to --

MEMBER CORRADINI: Can you go back? I'm sorry that I'm not -- What is it about the drywell injection that makes that more successful from the human factors standard? Why wouldn't I expect a bunch of teeny tiny yellows there?

MR. STUTZKE: Well, what it says is in drywell injection there is no chance of it being retained in vessel. You're going to get a vessel breach.

MEMBER CORRADINI: So, in other words, in the first six which is red and green, I could be trying to put it, but I'm putting it in the wrong place or I just failed to put it. In the ones that are yellow and red, it's more of a clear path to success by operator action.

I'm still struggling with the lack of yellow on the left and the big yellow on the right. It just seems counterintuitive to me.

MR. STUTZKE: What it says here is that your intention is to put it into the reactor vessel and that's how the equipment is lined up. They're either going to do it or they're not going to do it at all which means it's either retained in vessel or it goes to the liner.

In other words, the event tree model actually considers you didn't get it hooked up in time. You didn't get water injection going in time to prevent vessel breach. But what if we give it one last push and we get it lined up in time to prevent liner melt-through.

MEMBER CORRADINI: Okay.

MR. STUTZKE: And the difference is once you get from vessel breach to liner melt-through it's

only 20 to 30 minutes. And so it's very little extra credit. But I did try to account for it.

Okay. Slide 23 is an effort to show the risk contributors in an effort to explain some of these other tables or the charts that we'll show later on. The black line is simply total individual latent cancer fatality risk.

The horizontal axis is showing various regulatory sub-alternatives. And I've tried to indicate those in the table below. One says there's no water addition capability. Just perhaps unrealistic. And there's no filter on here. So it's 100 percent of the time the containment will fail because of the liner melt-through like this.

And then you can look at the various contributors. So the blue line on it is containment venting was successful, but liner melt-through occurred because water addition failed. It's kind of the base case.

And then so forth and so on. There is a case where overpressurization fails and later you've got a liner melt-through. Nothing worked at all like this.

As you introduce water addition capability, going to this sub-alternative 3a, you see a rather dramatic shift in the risk. At least on this graph you do.

MEMBER STETKAR: I'm sorry. It looks dramatic if you just look at colored lines on a piece of paper. It's the difference between a little less than three times ten to the minus nine and a little more than one times ten to the minus nine on things that have factors of maybe a hundred uncertainty about them.

MR. STUTZKE: Understand.

MEMBER STETKAR: So to me that's not all that dramatic. It's about the same number.

MR. STUTZKE: Yeah, and we'll show that later on where all the answers are basically the same.

MEMBER STETKAR: The only reason I mention that is in many cases in the regulatory basis document there are statement made dramatic decrease, substantial reduction, based on things that if I stand in the back of the room and can see a blue line plummeting on a picture it looks like a big difference. It's really quantitatively no difference at all especially once you consider the uncertainties in these things.

MR. STUTZKE: Absolutely.

MEMBER STETKAR: Okay.

MR. STUTZKE: But it does indicate that when you have water addition capability you can now have a chance of preventing the liner melt-through. So it's risk contribution goes down. The other ones come up accordingly, so forth. And then when you add in the filters you get some benefit that way as well.

But as John rightly points out, if you look the next slide on 24, again this is rolling up -- this is nothing but a plot of the black lines for all of the different regulatory sub-alternatives. And I have tried to label the chart to indicate exactly what those sub-alternatives are because quite frankly I can't remember the numbers at the bottom of the page myself.

MEMBER CORRADINI: So this is the red and green and yellow. It's the colorful chart two or three ago, but exactly what each of them are.

MR. STUTZKE: Rolled up.

MEMBER CORRADINI: Got it.

MR. STUTZKE: Yes. For example, if I look at Alternative 3a, the third one over, that tells me we're going to consider severe accident water addition capability. The venting strategy will be to open and

leave open the vent. The injection's going into the reactor pressure vessel. And the first thing that we'll try is to vent the wetwell prior to the drywell.

So we have various alternatives. And what it shows you is that without any water addition the risk is higher. Once we begin to credit water addition, you see a drop in the curve like this. The cross hack ones are cases where engineered filters have been installed in there. So you can see there is some reduction in the risk because of the presence of the engineered filter. But again the filter doesn't -- Not all releases go through the vent line and hence not all releases are filterable. Hence, the risk is not reduced down to zero like this.

There are cases on the right-hand side of the chart where early in the project we were considering drywell first venting capability. The issue there was maybe we just want to passive rupture disk onto the vent. When it reaches the pressure it blows. So no operator action is there. And these have been retained in there.

On slide 25 is our comparison to the safety goal. Let me try to explain this again. What you see on the horizontal action are the various regulatory

sub-alternatives. The box and whisker charts are the results of a Monte Carlo analysis to propagate the uncertainty through the analysis. That includes the uncertainty in the seismic hazard curves, the uncertainty in the fragilities, all the equipment failures, the operator failures and the uncertainty in an approximate way of the conditional consequence that was informed by the SOARCA uncertainty work.

MEMBER CORRADINI: So this is what John would love to see where it all looks the same.

MEMBER STETKAR: This is the one that I understand. This tells me how much. For example, if I compare the alternatives two, three, four, how much does each buy me in terms of risk if you will? And I can quickly see that alternative four versus alternative three because I don't care about all of the fine structure and all of the alphabet soup. On a mean value basis, it gets me less than a factor of two in terms of consequences within a range of about a factor of -- I don't know -- 50 or so uncertainty.

MEMBER CORRADINI: Yes, but I'm sorry. Maybe you understand this one. But the way he explained it, is alternative one, two and three the regulatory alternatives? Or are these different

alternatives?

MR. STUTZKE: These are the SECY paper alternatives.

MEMBER STETKAR: These are the SECY paper.

MEMBER CORRADINI: But in the response -- I'm going to put Bill on the spot -- at the very beginning a good two hours ago, you said one, two and three are the same.

MEMBER STETKAR: No, no.

MEMBER CORRADINI: Wait a minute. I beg to differ. He corrected us when we said what's the difference between one, two and three and he said for all intents and purposes on a technical basis they're the same. So why don't I see the same result?

MEMBER STETKAR: On here, one and two don't have water addition. Is that correct, Marty?

MEMBER CORRADINI: Okay.

MR. STUTZKE: That is correct.

MEMBER STETKAR: So on here one and two are the same. But three is different.

MEMBER BLEY: But the one and two we saw earlier included water addition.

MEMBER CORRADINI: Right. That's what I was trying to.

MEMBER STETKAR: When Bill was speaking, one, two and three all included water addition. It was just a matter of whether the police or how the police enforced it.

MR. STUTZKE: Now, to some extent, what you're seeing is the evolution of the analysis as it went along. When we got the original SRM back from the Commission, it said assume you have severe accident vent capability and then build off of that.

MEMBER CORRADINI: Okay.

MR. STUTZKE: And at that time, it didn't occur to us you needed water addition to make that practical.

CHAIR SCHULTZ: To even get started.

MEMBER CORRADINI: Okay. But I mean if I -- All right. So these one, two and three are not the one, two and three that you explained to us at the beginning. That's what I'm trying to get at.

MR. RECKLEY: This would be important to us.

MEMBER CORRADINI: That's all I want to make sure.

MR. STUTZKE: Now, the other thing that may not have been as clear is when we started the work

the focus was on estimating the risk of these various sub-alternatives for input into a cost benefit study. Okay. It wasn't until after we had done a great deal of this work that we came back and looked at this high level conservative estimate. And the high level conservative estimate was an effort to try to see how -- I won't say how bad it could be but to ignore or to deal with the issues of the uncertainties which are very large and complicated to model like this, primarily the operator behavior and things like that.

So the high level conservative estimate, remember I calculated ELAP frequencies for the fleet of BWR Mark 1s and Mark 2s. We just picked the highest one across the fleet. We gave it a 60 percent credit, not to be confused with the 60 percent chance of liner melt-through, but a 60 percent credit that FLEX would actually do its job and prevent core damage.

We then went and asked Jon "What's the highest conditional consequence you can generate for me credibly?" We multiplied them together and you get this number 7E minus eight like that. So that's kind of an upper bound on it. This high level conservative estimate gives no credit at all for any CPR strategies. It says once the core is damaged it's going to release

and it's in the release that the most conservative have been and the worst consequence have been like that.

CHAIR SCHULTZ: And, Jon, in that case, the consequence evaluation was like that which was done for the spent fuel pool evaluation. Or is there some -- I mean, in general, was there another step taken for this evaluation as compared to the spent fuel pool study?

MR. BARR: I don't recall the details of that similar kind of calculation in the spent fuel pool study. But essentially it was looking at the highest source term and then looking at the different sensitivities, the five or six that I had mentioned before and looking at all those and seeing which one had the largest.

CHAIR SCHULTZ: So therefore, in general, similar.

MR. BARR: I think it was a similar style.

CHAIR SCHULTZ: That's what I was looking for. So we're on the same page.

MR. BARR: Yes.

CHAIR SCHULTZ: Thank you.

MEMBER STETKAR: And, Marty, if you took absolutely no credit. Forget -- There were questions

about the 60 percent reliability of FLEX or the 40 percent failure probability of FLEX. You took no credit for FLEX. That seven times ten to minus eight would go up to be about a little less than two times ten to minus seven.

MR. STUTZKE: Yes. The original high level estimate took no credit for FLEX whatsoever.

MEMBER STETKAR: I mean you get two and a half, a factor of two and a half, increase.

MR. STUTZKE: Right.

MEMBER STETKAR: It wouldn't affect the consequence. Thanks.

MR. STUTZKE: You still end up well below the QHO. Further questions on the risk evaluation.

(No verbal response)

If not, I guess Bill will wrap up for us.

MR. RECKLEY: We've talked about much of this. There was some discussion about explaining the difference between the more recent assessment and this assessment in 2012 as we documented in 12-0157. I think you've heard most of this.

Basically, the analysis went in more detail. They did more explicit modeling of plant and its features including FLEX and severe accident water

addition.

We did focus more on the quantitative health objectives. I know from one of the questions we get is why from a staff viewpoint. The agency might not have moved much, but the staff recommended engineered filters. And now we basically are saying they're not justified as a regulatory action.

I think it is important every once and awhile to go back in mindset to 2011 and 2012 from the staff's viewpoint. This was before the Commission weighed in on SECY 12-0110 which was the economic consequence paper.

Although the agency's policies never officially changed, I think it's fair to say the agency was questioning whether we should consider changes. As time has gone on, it's become much more clear that the established processes that were under including the backfit are basically the same as they were.

That allowed us to do a more quantitative analysis and rely on that quantitative analysis. The work that was done by Hossein and Jon and Marty reduced the qualitative factors because a lot more was actually modeled and quantified.

When we looked at the qualitative factors as we addressed them in SECY 12-0157 and looked at them anew, basically our conclusion was that alternative 3 actually captured most of those qualitative factors including the discussions, the defense in depth and so forth. That's not to say the filters in some cases didn't have benefits. But overall we thought alternative 3 based on the quantitative analysis and the qualitative factors was the best fit. And that's what is recommended in this CPRR reg basis document.

This kind of goes to -- and the colors don't come out great, I apologize -- some of the questions that have gone through. What we tried to do was look at the regulatory alternatives we were looking at and the failure mechanisms and whether from a regulatory perspective they were actually addressed by what would be in place after.

So no core damage, in that condition, overpressure was taken care of by actually all of the alternatives because that is the FLEX portion and the adequate protection part of Order EA-13-0109.

When you get into the core damage conditions, again 13-0109 which is alternative 1 captures the overpressure protection. And we've

talked about it, it gets a little harder than when you talk about over temperature and liner melt-through. The order didn't specifically require it, but the way the industry is responding does. So it's not required, but by choice of the way it's being addressed it covers it.

The filter to further reduce the release is not addressed by alternatives one, two or three. It's not until you get to alternative four where you get the extra benefit of an engineered filter. Again, if you've prevented -- I shouldn't say prevented -- if you've reduced the chances of an uncontrolled containment failure, an uncontrolled release, then you would get the most benefit from an engineered filter.

MEMBER CORRADINI: Maybe I should ask the question. So the little brown ones would say not required, but it's going to be part of the implementation. Does it mean it will be part of the SAMG? It will be part of what is considered in SAMG training for the operators if they implement FLEX.

MR. RECKLEY: We're working out the template now and the industry can say. But basically what we've been told is and then order requires to be a process or a procedure that where it will end up is

the SAMG. And we'll look at least at this part of the SAMGs because it will be a way that they are complying with the order.

MEMBER CORRADINI: Okay. Thank you.

MR. RECKLEY: In conclusion then, the CPRR laid out as alternative three as our path forward. That would capture not only the overpressure protection, but the other failure modes. It was justified within the paper. Basically as we can argue it's cost beneficial because there's no cost. It's a sunk cost because the licensees are already doing it as part of compliance with the order.

We explained our plan to discontinue looking further at engineered filters or engineering strategies, alternative four. That was sent up to the Commission as an information paper with a plan to release it for public comment. As you're aware, it's SECY-15-085. The Commission turned it into a voting paper and we're awaiting direction from the Commission on how to proceed with this.

CHAIR SCHULTZ: Other questions for the staff?

(No verbal response)

Hearing none, I'd like to declare a break

until 3:25 p.m. Off the record.

(Whereupon, the above-entitled matter went off the record at 3:09 p.m. and resumed at 3:27 p.m.)

CHAIRMAN SCHULTZ: We're back on the record and ready for the industry's presentation. I'll call on Steven Kraft to begin.

MR. KRAFT: Yes, thank you, Mr. Chairman. For the record we thought we were done with tuition payments. My daughter starts graduate school September and I just noticed my wife paid the next tuition. So, no, I am not retiring any time soon. Thank you very much.

(Laughter)

MR. KRAFT: I'd like that on the record, please. We'll mail that home. All right. Okay.

(Laughter)

MR. KRAFT: Actually mail it to my daughter. And we've been trying to get some grant money here. And, okay. Enough of my problems. Let's stop with that.

MEMBER POWERS: If you were looking for money from us, you are looking at a very well.

(Laughter)

MR. KRAFT: Well, Dana, I will tell you, you were joking with Randy, as the only guy who works. Randy is the only guy who pays the rate for everyone in this room.

(Laughter)

MR. KRAFT: So I always keep that in mind. It's a very close subject.

So thanks again for inviting us back to this additional discussion on CPRR rulemaking. I am joined -- you know my colleagues Jeff Gabor, Rick Wachowiak, Doug True and Randy Bunt. Phil Amway, who would normally be here, had other commitments and was unfortunately unable to join us.

Before I proceed into our prepared remarks, I want to just go back for a minute to that penultimate slide that Bill Reckley had. This was the multiple box affair, okay, that a lot of you asked questions about. And I just want to point out that sometimes the NRC process doesn't always reflect what's happening at the plants, and no more so than in this case, because there is an artificiality that I think might put his fingers on that there are things we're doing at the plant as a result of the order that are not reflected in the so-called analysis and rulemaking

in a cost-benefit base because it's already being done. And it gets sort of a zero cost-benefit associated with it, or a -- and this business about what's an alternative 1, alternative 2, alternative 3.

And so the way you were asking the question about, okay, is severe accident water addition in or not has really to do with the way the alternatives are defined in the analysis. And what Bill was referring to as the collateral effect of the water addition is in fact the sum total, very important thing we're doing at the plant. Of course as we described to you a couple times, we had the a-ha moment back in November of 2012 when we were doing a table top pilot at Nine Mile Point trying to figure out how we were going to proceed with the rulemaking analysis. And as we said in previous meetings, injecting water to prevent core damage or control damage core is nothing new. It's the basis of every safety system we have.

But having to do it, as I said once before, under ELAP conditions reliably perhaps in the face of a loss of a ultimate heat sink is really the essence of this, of the order. And so, we are putting in -- so my point is is that while analytically certain things are accounted for or not accounted for, the fact of the

matter is the reality at the plants we're doing certain things, and we'll talk about that as it was one of the questions that we were asked.

But I just want to say that sometimes it leads to a lot of confusion on a lot of people's parts as to how these processes are going, but I am the first to say that I support and value the NRC process because I think it protects everybody, and more importantly it protects the general public the most because it makes everyone focus and do what is the most important for safety. That is the essence of the way these analyses are being done.

So let me go on to the questions we were asked, and we generally greatly appreciate the specific questions that were posed because it's helpful to focus the conversation.

Where we stand with severe accident water addition and with regard to severe accident water management as an adjunct post-core damage venting or was -- we'll talk to that in the technical presentation. There was a questionnaire. What are the cost estimates for both severe accident water addition and management? Some questions about effectiveness of external containment filter performance, which you all had a

very healthy conversation about that when the NRC staff was up here. And vessel modeling and predictions for us for the MAAP codes. So we'll turn these questions.

At the last meeting, Steve, you asked me, okay, is the industry committed to SAWA? And the answer is -- I got a twofold answer for you now. At large the industry is. I've been in enough senior executive meetings to know that there is a very, very strong commitment including SAWA at the affected plants. As I told you last time, individual commitments will be observed in the Overall Integrated Plans and that we have an industry goal to make sure that people will adopt SAWM. But again, in the order of things SAWA is the most important. Then you go from there.

And then we will talk about in a few minutes this Consistency Assist Program, but I think Randy wants to comment on the use of this technology.

MR. BUNT: Yes, what we did is with the BWR Owners' Group we went out and surveyed our members in the U.S., and everyone commented back that they are planning to use severe accident water addition and severe accident water management. Now of course their individual commitments will come with their OIPs, so

the Owners' Group can't commit to that. But right now based on our survey that's what everybody's doing right now for their conceptual phase. That's as strong as we can get right now before their commitment.

MR. KRAFT: Yes, thank you for that, Randy. Randy will be more than happy to answer more questions about that survey. It's not something that I think will be documented and sent in as a letter to NRC, but it is an indication as to where things are going.

The Consistency Assist Program was an idea we had in conversations with the chief nuclear officers. The chief nuclear officers were concerned about two things: One is that assuring that we're actually doing SAWA at all the affected units. And secondly is doing it in a way where we don't turn it into something it shouldn't be. We have a tendency in the industry to engineer things one way, and it's not necessarily always appropriate when you're in the beyond design basis phase.

So we thought that our guidance in NEI 13-02 was complicated enough, and particularly with the way SAWM is intended to work and based upon the analysis that EPRI and Erin Engineering has done. So we pulled

together a team from the BWR Owners' Group and NEI, meaning me, and we are reviewing all of the individual utility plant plans. At the strategic level how are you planning to do things? And at the end of the year this year we'll have an internal industry workshop and we will look at everybody's P&IDs and figure out are you actually doing what we'd like? And also I have a commitment to the CNOs to make sure that you're not turning it into something it's not intended to be. So I will continue to go on with that. We've had several of those sessions. We're up and running on that program. We'd mentioned it once before. I just wanted to assure you that we are serious about it; it's going forward.

Cost estimates. We provided a Level 1 estimate to NRC staff on May 31st, 2014 by letter. I attempted to re-transmit that letter this morning to Weidong, but apparently his computer blew up every time I sent it in, so I don't want to do that again. But it is in ADAMS I'm sure. So we could probably find it in a way that will not damage systems. I don't know why it's doing this. It's just a PDF.

But in that estimate severe accident water addition alone, which is piping connections, pipe runs,

controls, you see the range here, that's the difference -- that range is the differences, the contingency factor that's in the Level 1 estimate. By the way, a Level 1 estimate is what is traditionally used in our industry for decision making. It is not the estimate that you would then base a design on, but it is enough detail with enough contingency in it to where say you present different options to whoever the decision maker has to be, depending upon size of the expenditure, and they would have enough information to prepare different options, which we thought was the right level for the analysis that was being done at NRC because it is a comparison of options analysis. That's where we did it.

I will point out individual plant costs may vary. For example, one fleet that we've already looked at in the Consistency Assist Program is telling us that it even can vary within the fleet. One unit can do it for much less because they've already got existing piping. They did a FLEX connection, that it's already protected from the high radiation that you would get with the core melt. Others did not. I mean, so it will vary.

With regard to SAWM, water management, we did not estimate that specifically. Every time we go through a major procedure change, guidance change, the units tell us it's about $100,000 to change all the paperwork and do all the additional training. That's where that comes from. We do not expect hardware changes, but we cannot preclude it in limited cases. There may be a plant or two or three who needs to say move the level tap on the torus to gain more space, for example. And that will come all that cheaply, but you can't then come up with a general estimate for that, because not everybody's doing that. In fact, I would say the vast majority will not have to do that. So that's what we've already done.

CHAIRMAN SCHULTZ: This is good, Steve. The information that you're showing here was available to us and to the staff, but what the Committee wanted to understand is since a lot has gone on since May 2014 if things changed much. And what you're saying is from the Level 1 perspective this range is still appropriate.

MR. KRAFT: It is. And the reason it still applies is first of all i it applies for two reasons: One is the analysis that NRC is doing, NRC

staff is doing is still a comparative analysis among -- and what ever other cost estimate they're using in other areas; and I think Fred's here, he can talk about it, are no different in its level. If I'm saying -- so it's not like -- even if I had absolute after construction costs to show you, I wouldn't compare it anyway, because I don't have that for the other. I'd have to have the same information.

Going on --

MR. BUNT: Steve, one thing on that previous slide that -- you're talking about things that have changed since May of 2014 -- is this change to the procedures to do water management has been approved by the BWR Committee, Procedures Committee, and it is out there for plants to be able to implement at any time going forward as a strategy change.

MR. KRAFT: Right, that is good. In fact, it happened since the last discussion. Thank you, Randy.

And then the big discussion that was going on with the staff, external filter performance; and I think this is the top bullet here, is sort of the essence of the conversation you were having with the staff and among yourselves, just be considered in the context of

overall risk. So, obviously sources of data that we're aware of, the vendor information -- Bill Reckley referenced letters that the vendors -- I've not -- there were three letters, I believe. I saw only the response for one and it was information out of -- I don't know what you want to call it, a brochure? It was no more detailed than that. I mean, it told you what they designed it to. It did not -- you -- Mike asked about data. There was no data. It was just here's what we are saying the system could do.

There were presentations and meetings made by vendors to the NRC staff. Perhaps there's more information available. Some of that information is proprietary so wouldn't come to the meetings because there's vendor proprietary information.

I think everyone's aware that there was testing back in the 1990s in the ACE Program. There was a report published by EPRI back then, but it was in 1992. If we were do the testing today, probably test the same things. But they're probably approved testing methods, so I'm just generally speaking because it's so long ago. But the important point here that there's no consensus standards for filter performance.

So if I was going to say let's spec out a filter and test it, what would I do? What would I pick? So that becomes an issue. And there was a -- there actually is a -- I think there's a society for everything in this country, and there is on that is -- it's been around for about 35 years and it's called the Nuclear Air Cleaning Conference, or something like that. And they basically work on the kind of filters that you normally think about in the plants.

MEMBER POWERS: It's been around for almost 40 years.

MR. KRAFT: Forty-four years. In fact, I think a former NRC staffer is the project director for --

CHAIRMAN SCHULTZ: Not focusing on these types of filters?

MR. KRAFT: Only lightly. And I did go to one of their conferences and give a -- just have a discussion about it. And the papers from that discussion, which are publicly available, shows the vendor data. I mean, I take no credit for it. I'm just telling you that information is out there and it's available. But the important point is there's nothing to compare it to. And part of the vendor information

is whatever testing the vendors did, whatever that information is. And there was a discussion with, I want to say AREVA Canada NRC staff held where there was some testing done, but it was really showing testing of metal solid -- metal filters versus water filters. Of course metal filters melt in the face of the decay heat.

So the early work that was done by EPRI; I say industry, but done by EPRI -- I should emphasize EPRI does do their work funded by the industry, but they do their work independently and very fiercely defend that independence -- was showing that external filters did not provide much benefit in the context of overall risk. Having learned that, we said, well, there wasn't a lot to be gained by spending resources to explore further.

So in the analysis in those scenarios where a filter helps in terms of reduction of releases and you assume no degradation it is of course a conservative analysis relative to the benefit of the filter, not necessarily relative to the engineering of the filter. But then we did assume; and Jeff can talk about this in more detail, aerosol loading effects, although it is not any kind of sort of slow degradation of the

filter, it's that when you hit -- the filter's on until you hit that level, then the filter's off, which is not the way the filter performs. And there are of course other -- the degradation mechanism. But that is the extent to which we did it. And I'm sure Jeff and Doug and Rick could talk to that in greater detail.

So those are my introductory remarks and I'm prepared to turn it over to my colleagues.

MR. GABOR: So I'm Jeff Gabor with Erin Engineering. I drew the short stick here, but I'm sure my colleagues will chime in when --

MEMBER CORRADINI: Are those your consultants?

PARTICIPANT: I did it last time.

MR. GABOR: Yes, the --

MEMBER CORRADINI: Are those who you have a lifeline to if you --

MR. GABOR: Yes. Yes, if I need a lifeline.

PARTICIPANT: Yes, his boss is the client.

MEMBER STETKAR: If you're in the same room with Doug, you by definition draw the short stick.

MR. GABOR: Yes, good point.

(Laughter)

MR. GABOR: So we took the comments that Dr. Schultz sent to us and tried to address them individually. The one you see that's not -- there were four. There was one relative to the cost of the SAWA implementation that Steve already addressed, so we're not really talking about that. So we're looking at the water addition and water management. We're going to talk a little bit about the effectiveness of the filter. And then finally the comment that was made about the lower head modeling and the heat losses.

As far as water addition, I just copied in the text from the questions that we received. I think when we went back and looked at the draft reg basis, we got a bit confused ourselves. And I think some of the words, especially on page 32 -- we think they can be misleading. The venting after core damage has occurred has been in the Severe Accident Guidelines for a long time. Early '90s, mid-'90s. It's always been a strategy. It's not anything that's come out of the CPRR work, early ventings there.

And the way it's in there is once you establish that you need to transfer -- and I think you've heard this from various presentations -- once you uncover the core and you transfer out of the EOPs

and into the Severe Accident Guidelines -- when you do that, there are -- in most of the plants the way they've designed them, there are some various paths that you'll put yourself in, the operators will put themselves in.

And when you enter the SAGs, the first thing that you see in there is that they're told to vent to control pressure below what's called a pressure suppression, or PSP limit. That PSP limit is there to provide margin for blowdown. It's meant to keep the containment pressure at a point where if you had a re-pressurization of the RPV or if you had vessel breach that caused a lot of steam generation and all that steam ended up in the pool, that the containment would survive that impact. So the PSP, I kind of -- I put down here PSP kind of provides margin to more the ultimate limit, which is the primary containment pressure limit, which is the point that obviously we would want to have vented the containment.

And that upon entering the SAG, this PSP, which is typically a lower pressure than -- it is a lower pressure than the PSPL -- that would be the first focus. And then as I think correctly stated in other parts of the -- I think the draft reg basis is that once you've determined that vessel breach has occurred you no

longer have to provide that margin because you've already blown down the vessel and you failed the vessel. So now you basically are told to vent to control pressure below the PSPL. And again, like I said, that strategy, that logic has existed for a long time. And I think we discuss it a lot in the CPRR. They discuss it in the draft reg basis, but that really has been around.

MEMBER CORRADINI: Since you brought it up; so it's your fault, what are you looking for as an instrumentation indicator that tells you you've crossed that boundary?

MR. GABOR: The vessel breach?

MEMBER CORRADINI: Yes.

MR. GABOR: Well, typically in the Technical Support Guidelines, which is a support piece to the Severe Accident Guideline, there are decision trees in there that look at a combination of things like rapid depress of the RPV. Rapid increase in pressure in containment, increases in temperatures might be -- some of the plants may have temperature indicators in the lower plenum that they could look at. Could be indications in SRV tailpipes. Anything that tells you that you just saw an event that, like I say, may have

rapidly depressurized the vessel, may have rapidly increased the containment pressure.

MEMBER CORRADINI: So the Technical Support Guidelines would say if i get this indication, go over here and see if I've got a consistent indication of this compared with a consistent indication of that so that I get some sort of portrait of two or three or four things that are consistently showing essentially inventory coming out of the primary system?

MR. GABOR: Yes.

MEMBER REMPE: Are there new ones that are the FLEX Support Guidelines that you're referring to rather than -- are you just talking --

MR. GABOR: No, I meant Technical Support Guideline, TSG. FLEX Support are totally different. They're in place to help the operators implement and control the FLEX equipment itself.

What I'm talking about is once you're in the Severe Accident Guidelines -- so I know I've got core damage. Then at that point I enter the Severe Accident Guidelines and there are these Supplemental Technical Support Guidelines that the TSC staff would be using to make decisions. And in there is this logic tree or decision tree that says how do I assess if the

vessel's been breached or not? And as Mike pointed out, there's a logic train that they would follow to determine.

We all appreciate that that was difficult at Fukushima to actually nail that down for a lot of different reasons. The RPV may have already been depressurized. The way in which the vessel breached that we've talked about here may have been somewhat benign such that they didn't see the large increase in pressure. Other things might have been that they had already breached the containment. So any rapid increase might not have been as visible because there was already -- a drywell head had already lifted. So there's reasons why it may have been harder at Fukushima. But that decision tree does exist.

MEMBER REMPE: So in these Technical Support Guidelines that are depending on instrumentation, it acknowledged that some of the instrumentation might be out of its EQ --

(Simultaneous speaking)

MR. GABOR: They do acknowledge that. They also, to provide -- the ones I'm familiar with -- because the plants implement these individually. The ones I'm familiar with would give

them multiple ways to get indications, multiple ways to read a pressure in containment, multiple ways to read a temperature in containment, not just one -- not counting on -- relying on one instrument. So they provide that, assuming that power was --

(Simultaneous speaking)

MEMBER REMPE: And are they relying on trending a lot of times of that instrumentation and is there any technical basis experimental data to provide confidence in that trending?

MR. BUNT: There is the trending there and there is -- they have -- the BWR Owners' Group has done some workshops on that and they have enhanced that information based on some of the post-Fukushima events and curves associated with that, the signatures out of that. So that's an evolving process, but it is a process to look at the trending, look at the values, don't take any one instrumentation reading or value as the gospel going forward, that there needs to be a group of information that leads you there, and preferably at least two, if not three, to get you there. And that's what the training of the staff for the support center as well as why this guidance and the decision trees are established and intended for. And there's

been a lot of information done to utilize some of the -- all three of the units at Fukushima to look at what are those signatures? What could you have derived from these type signatures knowing that certain instruments were off-scale, certain instruments were only trending values, some were giving false indications? How would you interpret that and how would you use a backup instrument or an alternate way to get there?

MEMBER REMPE: And I think that's important, but I just wonder how much data there are in that area. And then sometimes from my own experiences thermocouples don't always de-calibrate the same way.

MR. BUNT: Right.

MEMBER REMPE: And so I am just kind of wondering how confident we are in their behavior, I mean beyond their EQ.

MR. BUNT: Right, and I think that's why trending is more valuable than absolute numbers --

MEMBER REMPE: Sometimes --

MR. BUNT: -- in most of these decisions. But I understand.

MEMBER REMPE: -- again we see thermocouples go up and down --

MR. BUNT: Right.

MEMBER REMPE: -- and they're both at the same temperature based on the furnace. And so I just am wondering about that.

MR. WACHOWIAK: And like Jeff said, in the flow chart for this there are -- it's not just one way of doing it. I think there's several options -- or not options, there are several things that you check to corroborate that the decision you made was correct. And this has been in there for so long, actually so long that I've actually used those procedures in a plant where I worked, and it's been quite a while since I've been at a plant.

MEMBER REMPE: Yes.

MR. WACHOWIAK: So, they've been around for quite awhile.

MEMBER REMPE: Yes, okay.

MR. WACHOWIAK: And they're evolving.

MR. GABOR: What I tried to do, this was a slide that we actually presented to the staff quite awhile ago, and we tried to break this -- it kind of summarizes what I just had in words, but it looks at

venting prior to core damage, which is in the EPGs, Emergency Procedure Guidelines, or EOPs, which is the plant-specific implementation of those guidelines.

In the green box prior to core damage, as we've stated and you've heard, venting will be performed in order to maintain operation for a system like RCIC that is perhaps taking suction out of the suppression pool. There may be some concern about high pool temperatures. If I vent the containment early, I actually have a process where I can maintain that suppression pool temperature. Also, in the EOPs or in the prior-to-core-damage phase I would be also venting to maintain this pressure suppression function. That's that PSP limit.

Now we move into the Severe Accident Guideline after we've determined that there's some core damage going on. If I had previously initiated a vent for the reasons that I stated there, the procedures are pretty clear that I would isolate that open vent upon entry into the Severe Accident Guidelines. But if I do get into the Severe Accident Guidelines and again I find myself approaching this PSP limit, I would vent containment. And then again as we just discussed, once vessel breach has been determined, that switches to

venting at PCPL.

MEMBER CORRADINI: Just from a numbers standpoint what's the difference between PCPL and PSP?

MR. GABOR: About half.

(Simultaneous speaking)

MEMBER CORRADINI: -- or two?

MR. GABOR: Yes, roughly 30 and 60 pounds gauge, roughly.

MR. WACHOWIAK: For Mark I and II.

MR. GABOR: For Mark I and II.

The next discussion was on the two kind of sub-bullets that were asked by Dr. Schultz on the effectiveness of filter performance. And there was a lot of discussion by the staff that we generally were in agreement with. Our process, the EPRI kind of independent look at this in the EPRI analysis, we assumed whenever a filter was operating, it was operating perfectly with a DF of 1,000 while it was functioning. Now, that's not for cases where, as you discussed with the staff earlier, that the filter could be bypassed for some reason. That would be due to an over-pressure failure or the vent didn't open, we had liner melt-through.

And as Steve pointed out earlier, one element of our analysis was if you recall we had strategies that had a so-called small filter or small capacity filter and a large capacity filter. The DFs for those two were the same, but what small to us meant -- and we communicated this multiple times with the staff. In our analysis small meant that it had a lower capacity for thermal loading and mechanical loading, or aerosol loading.

So what we actually did see in some of our strategies where the drywell would be vented first or for various reasons the drywell was the primary vent path, we could actually overload that small capacity filter pretty quickly. When that happened in our MAAP analysis, we would just degrade it, as Steve said, a step change down to a DF of 1 so it is no longer affected. But other than that, I think what the discussion that you had with the staff was fairly similar to what we have done.

When we look at DF -- and you saw in a lot of our results that we presented we would talk about a system DF. We'd talk about the DF for the entire containment, RCS and containment system and we would quote numbers like 500 or 1,000, which are typical for

the type of releases that we see from these events. But as was discussed earlier with the staff, you have to look at this integrated risk assessment in order to understand the benefits of an external filter.

And we show our integrated results, much like the ones that Marty Stutzke presented for the staff showed that we had many order of magnitude margin to the safety goal. And in fact, if we had considered any additional degradation of the filter, as we talked about other bypass mechanisms, degradation, the filters aren't as good at different sizes of aerosols -- if we had built that in, it would only decrease the change in the maximum averted cost risk and it ultimately would make the filter less beneficial, cost-beneficial. So we just didn't determine -- we judged that that additional analysis just wasn't warranted.

Our industry analysis. As I said, we looked at the risk spectrum, as the staff did. Differences in our approaches, difference in our quantification, but basically following the same type of risk assessment. And where you can pull out some isolated cases, as Dr. Schultz pointed out in the comment on table 420 from the new SECY, you can

see -- for specific cases you can see some benefit and you can see source term reduction and you can see reductions in some of the consequences. But when you build this into an integrated risk profile, the added benefit of the external filter is really -- is not seen as significant compared to the benefit that we see by just doing the severe accident water addition.

And then lastly the modeling and the predictions of vessel failure using MELCOR and MAAP. There was a good discussion on that topic. I'm not sure we add a lot of new thinking to that. We understand there are uncertainties associated with the heat losses off of the RPG during the core degradation phase.

We did build into our evaluation the EPRI analysis, as the staff did. We put in the potential in our accident progression tree that if I could depressurize the vessel and if I could get a low pressure injection system operating in time prior to vessel breach, there would be some likelihood, some success that I could prevent vessel breach. I think Doug said it was 50 percent if all the other elements stacked up, meaning pressure, low and water.

So we decided just to look at the sensitivity. What if none of those cases went to

success? So independent of having a FLEX pump operating or de-pressuring the vessel, if all of the cases where debris dropped in the lower head we assume they went directly to vessel breach. And we put this in our summary report that you received. We saw very insignificant impact in the latent cancer fatality risk from that.

And then additionally work that EPRI has been doing with the MAAP enhancement project indicates that this phenomenon may actually acknowledge that it could delay RPV breach or RPV failure, but in most cases where you accumulated a significant amount of debris in the lower head, it wouldn't be sufficient to actually prevent vessel breach.

And, Rick?

MR. WACHOWIAK: Yes, and we're actually putting this radiation network of fins in the model MAAP. It will be out in the next version. But we've done some testing with it and like we said it may change the timing some, but it's not going to be a mechanism for saving the lower head if there's no water.

MEMBER REMPE: So just out of curiosity, because that's what I was trying to get to earlier and I never got the warm feeling is what the current model

is predicting versus if you did the more detailed. And it sounds like you are getting ready --

MR. WACHOWIAK: Yes.

MEMBER REMPE: -- to do the more detailed. And are you in the middle range? Are you at the high end or the low end?

MR. WACHOWIAK: What we see in the MAAP model is the vessel failure modes that we have in are a creep rupture of the lower head. We also look at a failure of the penetration welds for these guide tubes. And then we also look at other -- attack of the vessel melting, things like that. And so it's kind of a horse race for which failure mechanism wins out. And what we tend to see is the penetration weld failures as the primary mechanism for failing the lower head. So even though we've included the cooling available from these fins, if you will, on the bottom of the vessel, all that really delays is the creep rupture failure of the vessel and not the failure of the welds or the penetrations going through the vessel. So the penetration failure wins the horse race a little more often.

MEMBER REMPE: And in MELCOR they don't do the penetration failure, so they would --

MR. WACHOWIAK: They might see something different.

MEMBER REMPE: -- presumably see -- more different, but --

MR. WACHOWIAK: What we find that in vessel retention is more controlled by is the ability to get water between the crust of the core debris and the vessel wall, and that's limited by being able to release the steam from the water ingression vaporizing in there. And so it's steam flow-limited. And what we find is that once you've got a significant amount of debris in the lower head, then -- let's say more than half way full of the hemisphere, there's just no way to get enough water down in there to prevent the vessel breach.

MEMBER REMPE: So if a miracle happens and they get into those reactors at Daiichi and see that some of the vessels have not failed, we're going to be doing a lot of changes in our current assumptions or --

MR. WACHOWIAK: Well, let's take, first off, one of them where we think that it may not be a vessel breach might be Unit 2.

MEMBER REMPE: Yes.

MR. WACHOWIAK: We also think that not so much core material got down into the lower head. So that may be consistent with what we're seeing here. So if you've got a small puddle down there, then enough water can get around and quench the thing before it fails the head. But if we get in there and see that the whole lower head is filled with water and the thing didn't fail, we'll be doing some more noodling.

(Laughter)

MEMBER REMPE: Okay. Thank you.

MR. GABOR: So my last slide is that we weren't planning to go through this, our results --

CHAIRMAN SCHULTZ: Is your green light on?

MR. GABOR: It's not on. Sorry. My last slide states that we presented this material on July 7th to the Committee and we're happy to answer any additional questions, but we weren't planning to go through it. And the slides are there.

MR. KRAFT: That concludes our presentation.

MEMBER SKILLMAN: Steve, I'd like to ask you this: The concept of adding water ultimately to prevent vessel failure, but also to virtually demonstrate that a filter really isn't that beneficial

is a complex concept. The public sees a filter as a catalytic converter that's going to fix this issue. What actions are under way to form a message that in layman's terms would provide a thinking member of the public who has at least somewhat of an open mind to understand this complex topic?

MR. KRAFT: Well, Dick, we -- and I can provide it to you if you wish or direct you to the URL on one of our web sites. We did do -- when we first got into this analysis we did what we call an infographic. And your point about it takes a member of the public who is actually interested and wants to sit with it, I think you are right if you're implying that there's no really good three-second sound bite that explains this, typical of many of the issues we deal with. So that material is available. Every time there is information from NRC, from our European colleagues who are doing things differently, we use the information we have. That's a good piece of it, a variety of communication pieces, blogs, things like that that we direct people to read.

And again, where people are interested and they want to learn and they have an open mind, as you say, I think that we've had successes in terms of -- the

only barometer I could really tell you is that talking to the media and seeing what they write, and is what they write accurately reflecting what we're saying in terms of the reporter understanding it. But beyond that, other than the occasional story about the -- was it last year or early -- last year about the Convention on Nuclear Safety amendment that was being promoted by certain European countries that would lead to a greater consideration of this technology, there's not been a lot at all.

And reflective of that, sometimes it's; not always, as a barometer is what's Congress saying? And I'm not sure -- when we've been invited as an industry; not me personally, to appear on the Hill and talk about things Fukushima or talk about nuclear things, this is not a question that's getting asked. So at this point we're prepared to answer the questions, but we are not mounting a campaign to explain it, because we're not sure we have to at this point. We think this is at the moment kind of within the community of people in this building, in this industry, in the NGOs that understand it, and that's where it's being discussed.

That's the only way I can answer the question at this point. We are prepared certainly, but I have spoken with the people in NEI who handle those things and there just doesn't appear to be a need to go any further at this point. There might be. I'll make that point. And if there's a decision from the Commission on the rulemaking, whatever that happens to be, I think there might be some more interest, and we'll have to deal with it. But when we talk about messaging to the public on nuclear, it is the higher level that really mean the most. Clean air, energy. And it's those things that seem to matter the most. These other questions are important, but they're not getting that kind of notice.

MEMBER SKILLMAN: Thank you.

MEMBER POWERS: Jeff, let me ask you a question. You outlined a couple of strategies there: adding water, preventing vessel breach, having vessel breach but still in the end what you end up with, if you're entirely successful, is a lot of radioactive material in your suppression pool. And that radioactive material is not staying there, and how can it be released out of the suppression pool? Well, you can get iodine gas flowing out of there. If the

suppression pool is bubbling, boiling or gases are going through it, you're getting droplets coming off, what do you about that? Or what do you think about that? Your population presumably, your civilian population is presumably evacuated by this time. But what do you think about that? You're getting a release because there's no filter beyond your suppression pool, so you're getting a release and you're going to get a significant release for the next 30 days. Now what?

MR. GABOR: I guess I'll start and ask for some others to chime in. I think with the suppression pool issue we may be able to put ourselves in a position where we're not boiling long-term. I mean, if we can reestablish RHR, if we can --

MEMBER POWERS: You're always going to have gas going --

(Simultaneous speaking)

MR. GABOR: You are, but if we can -- the kind of direct looking at your pool boiling concern and the entrainment of water droplets and things like that, I think that can be pretty significantly reduced by again our strategies of recovering, getting pool cooling back on. Once we have established that, then we can close the vent. Now, we still may have other

leakage paths, smaller, but at least we can reduce. I think it is the strategy. And Randy should comment. I mean, it is our strategy to recover this, and we have a goal in seven days to be able to recover, to close the vent, to move into a phase where we're removing decay heat from the suppression pool.

MEMBER POWERS: How do you know that you can close that vent?

MR. GABOR: That we'll be able to close it?

MEMBER POWERS: Yes.

MR. BUNT: Is that from a functioning of the vent standpoint or because of the --

MEMBER POWERS: No, no.

MR. BUNT: -- conditions of the plant?

MEMBER POWERS: The condition of the plant. I mean, if he closes it, it's going to pressurize back up on you and there's some point where you don't want to go beyond that pressure.

MR. BUNT: But the thought here is that you've had a significant amount of time, which seven days would be a significant amount of time in severe accident land, to come up with alternatives. You've got multiple ways for water additions, for other applications, for putting other components on it or

doing things. And that's what the seven days is intended to be utilized for. And there's some analysis that's been done that you could go out to greater than 30 days on some of these and you would still be functioning. And then you would be potentially cycling that vent to accommodate for other release factors that may be what you would want to do.

MEMBER POWERS: Yes, well, what I'm asking him about is you've got this long release --

MR. BUNT: Correct.

MEMBER POWERS: -- low, most of your population, save for the Randy Sullivan's half percent of obstinate souls, is evacuated, but you've still got radioactive material coming out the stack. Now, maybe it's episodic because you're having to bend things. And what do you think about -- I mean, I'm just asking what would you think about that. So I don't know that we have the ability to quantify that release. It's not going to be huge. I mean, we can probably take it from whatever release they got in the last few days after the accident at Fukushima. That's probably a good estimate. It's non-trivial. So what do you think about that?

MR. WACHOWIAK: So what we see in the analysis that we've done, that only goes out 100 or so hours; 140 or 50 maybe are the longest ones, the longest cases that we've run, is that the release from them in the model has tailed off by then and we're not getting a significant amount of additional release even if we leave the vent open.

Now, that doesn't account for some of the things like you're saying, re-evolution of iodine from the pools under these long-term things, but I would agree with Randy that I think that more is the recovery phase of this. And that's when you'd be getting portable equipment in to help deal with water that you have and maybe some of the air cleanup that you need to do, things like that.

I don't see how a permanently installed equipment is a good solution for that particular phase of the scenario. You've got some time to address those smaller releases. But they're there. I mean --

MR. BUNT: And the study also shows that you also have the capability to keep the vent closed for a long -- as you get further out you have the time period to keep the valve closed longer and time the right timing for the release based on all other factors

necessary.

MEMBER POWERS: But I guess as you're taking --

(Simultaneous speaking)

MR. BUNT: Because of your pressure -- because you can drop the pressure down lower when you do vents.

MEMBER POWERS: I mean, suppose you think about things like hydrogen generation from radiolytic or corrosion processes and things like that that are going to go on in this longer term. Can you keep the vent closed then?

MR. TRUE: I think what Randy's saying is you can cycle it, not that you can close it permanently, but it's not going to be open all of the time either. Because as you get out in time decay heat has dropped, your pressure is going to drop, you can close it off, allow pressure to build.

MR. WACHOWIAK: But I still don't see us sitting there with no suppression pool cooling for 30 days.

MR. TRUE: For forever, right.

MR. WACHOWIAK: That's going to -- maybe it's not going to come back in the first --

MEMBER POWERS: Most of the processes I'm talking about --

MR. WACHOWIAK: -- three days after an earthquake, but --

MEMBER POWERS: -- are kind of temperature-independent. We talked about boiling and Jeff says, okay, we're going to take care of that. But now I'm talking about the non --

MR. WACHOWIAK: Yes, but the re-pressurization of the containment from radiolytic interactions in the pool -- if we started out with the containment all the way down at atmosphere and used radiolytic gas generation to pump it back up to 60 pounds, that's a --

MEMBER POWERS: That's going to take --

MR. WACHOWIAK: forever sort of --

MEMBER POWERS: -- longer than my life time. But you will get into a flammability condition, especially in the head space over the suppression pool pretty easily.

MR. WACHOWIAK: You can get into that. And that's probably most likely why additional venting might be going on. But once again, there are other things that can happen as time goes on. Your

vent -- your purge system may come back into play. You could add nitrogen into the containment, not that that will help with the radiolytic that much, but --

MEMBER POWERS: No, you'd be surprised how much it would help.

MR. WACHOWIAK: -- at last it could help you establish some sort of a more continuous thing. And that equipment then is filtered by standby gas treatment. So as things come back in to play later on and later on in the scenario, you have some of those things. But I think still that for the long term when the plant gets into the recovery mode, they're going to go out and they're going to hire companies that will bring in portable equipment that can deal with things like the additional release of iodine from the pool and cleanup of the water in the pool, things like that. I don't see it just sitting that way static for months.

MR. GABOR: Well, I also think that our strategies -- I mean, and some of these strategies that exist now, they've been around. You mention combustible gas control. And there's an entire section in the Severe Accident Guideline that addresses combustible gas control, both oxygen and hydrogen. Now, we don't normally expect the oxygen, of course,

but in your scenario long term you would start to see it. And to the point if you had the capability of measuring it; it might be from taking samples or doing something, there are procedures in there, as Rick pointed out, to vent and purge that would address that.

And the other thing I was just going to mention is that we're taking a lot of steps to prevent additional leak paths out of containment. One thing that's significant in my mind, significant between what happened at Fukushima and what could happen if you followed our Severe Accident Guidelines is when do you vent containment? We're venting at PCPL, which is essentially design pressure. If you look at some of the early charts that came out of Fukushima where they identified what they called an AM vent pressure, accident management vent pressure, it was two times that pressure. And we know that from the work that Sandia has done that drywell head leakage and things like that could start to be significant at those kinds of pressures. So we're minimizing the potential for that leakage out of containment as well.

MEMBER SKILLMAN: Jeff, let me ask you this: I appreciate your off-the-cuff answer, but none of those things that you mentioned are easy to do after

an accident. Dana raised the prospect of effervescent gas, radiolytic decomposition that results in hydrogen and oxygen, results in a combustible environment. I can tell you firsthand when you're responding to an accident and you're seven or eight days into it and you don't have access to equipment that you thought you might have access to, then unless you've drilled on the types of activities that you're mentioning, you're likely not going to be successful in accomplishing what you intend.

I've spent years in these plants and you don't sit there on watch anticipating your plant crumbling under your feet and anticipating having to get into gas control. And when it finally smacks you between the eyes, you realize you have enough hydrogen to blow the top off of one of your buildings. And you basically say what am I going to do now?

And so I appreciate what you said, but unless there is a well thought out approach to respond to that eventuality, the operating team is going to get stung, much the way they did at Fukushima, much they way they did at TMI-2. What happens is the plant creeps up on you and then you're in a situation where you find yourself not prepared.

So unless there has been an incremental preparation for the type of eventuality that you point to, I, as one of this Subcommittee, would say it's not going to happen. You're going to be sitting there in the exact Muhammed Ali rope-a-dope situation and you're going to get socked. It's going to get you.

MR. GABOR: I guess let me -- I won't intervene too much, but I want Randy to pick this up from an operational standpoint. I'd just add one experience that I had during the Fukushima event, and this was weeks, this was weeks into the event. And I wasn't the only one that came to this conclusion, but the symptom-based procedures or guidelines that the BWR Owners' Group had developed, the Severe Accident Guidelines, we determined they were -- the guidance provided in there still applied weeks into the event, and it's because it's pretty simple common sense kind of guidance.

And it's issues like we talked about, monitor oxygen and hydrogen. Watch out for that potential for combustion and take actions to vent and purge containment to prevent that. It's is the core covered? Is the debris covered? And they're pretty simple actions, but they are drilled, they are tested

on the Severe Accident Guidelines. And those symptom -- again, my experience was weeks into the events, actually on the INPO phone calls twice a day, weeks into the event we kept looking back at the BWROG Severe Accident Guidelines and what they were telling us to do still applied. Yes, there were some additional things that we could come up with, but the basic recommendations of the SAGs still applied weeks into the event.

MEMBER SKILLMAN: I agree with that as long as you have access to the equipment upon which you are depending and as long as you have the intelligence, meaning instrumentation, to guide you to what actions you need to take. But in two major accidents we didn't have access to the equipment and we didn't have the instrumentation, and those two are Fukushima and TMI. And so we need to make sure that we have access to the equipment and to the instrumentation.

MR. BUNT: I'm not sure our post-evaluation of Fukushima said we didn't have access to some of the information that would have told you some information. If they had been following the Severe Accident Guidelines, they were identified. That's what I understand Jeff is saying. That's what several

people have looked at. And we've also improved those guidelines since that time to give more indication. And we're also doing workshops, and there are more workshops planned coming up, that go over how to utilize the various information and look at your technical support staff and how to utilize those and leverage those based it.

So, while I understand there are difficulties, there are things -- the way we would apply those Severe Accident Guidelines in the U.S. and the training and our background of those were not applicable, 100 applicable to what was done in Fukushima.

MEMBER SKILLMAN: Randy, as you say that, what radiation levels do your activities anticipate?

MR. BUNT: I wouldn't be able to say that right now.

MEMBER SKILLMAN: Bingo. I will tell you when you're finding yourself in a 2,000 r field, 3,000 r field, 5,000 r field, all bets are off. What I'm trying to communicate here is there needs to be a sense of extraordinary caution. I don't disagree with the thermal hydraulics. I don't disagree with the approach that you are laying out, and I agree that the

Severe Accident Management Guidelines will take you in the direction that you should be going, but the one topic that we don't talk about very much is what happens when you've got that much core destruction, you've got that many isotopes loose and what the radiation levels look at -- look like? And if you go back to Fukushima, you'll find operators were stopped in their tracks because of the radiation levels. We ought be talking about that.

MR. WACHOWIAK: They were stopped because of radiation levels and also because a building next to them blew up. So those types of things --

MEMBER SKILLMAN: Bingo. Loss of equipment and radiation levels. And that's all I'm saying. I'm not trying to be a doomsday guy here, but I'm saying there's a lot more to this than being pretty slick and saying this option will work. Well, that option will be successful if -- and there are a lot of ifs that need to be proven available.

MR. WACHOWIAK: So aside from this particular or this specific work, we still have our Fukushima technical evaluation project going on at EPRI. We're looking at things like this. Is there a way to predict from our models what the local radiation

levels are going to be? You know, not some of the worst case things like people do, but can we reconstruct Fukushima with the models that we've done, including some of the on-site and off-site radiation conditions? We're finding that sometimes we can; sometimes we can't. And we're identifying places where we can improve our ability to do that. But it's based on the information that's coming in from Fukushima. And we'll probably still be revising that analysis for years as we get into these.

One of the outcomes of that project is supposed to be to inform the procedures being developed by the owners' groups. So we do have some things that we've been looking at for hydrogen transport in the reactor buildings. And sometime in the next year or so when we're done with that analysis, we'll probably be making more recommendations to address things like keeping your building in a non -- maybe not non-flammable, but non-explosive state. But that's being done under this project as we're understanding how the hydrogen and oxygen and things like that are transported from the pool through the leaks, through the building. What kind of things can you do to make sure?

So, there's more things going on than just this one particular rulemaking, and the objective is to inform future operations generations to not be caught blind, to say if you're in this, you're going to have to consider hydrogen. There's going to be hydrogen around. More hydrogen than you've ever seen in your life is going to be in this plant; not that you can see hydrogen, but there's going to be more there than you would have ever expected and you have to deal with it and the procedures are going to have to -- or the guidelines are going to have to give them that tickle that says you got to worry about that.

We're looking at the radiation stuff. That's a tough one. It's hard to get the codes to predict good radiation fields. And we're looking at some things. It's going to be limited, but the guidance will have to say be prepared for 5,000 r field in some of these areas. That's just the way that these things evolve. As we find more in these projects, we get the things wrapped into the procedures.

MR. GABOR: I mean, to that end I just wanted to comment that it's not -- I mean, we've got two places. I know that in the -- whatever the appendix is in NEI 13-02 we do have a pretty extensive radiation,

local radiation assessment in there primarily for the purpose of venting containment. What's going to be in that pipe? What's the local doses going to be near that hot pipe? Realizing that it's going to be hot. It's going to be a high rad area. That's discussed in great detail in the NEI guidance.

In addition to that, the owners' group has a Core Damage Assessment Guide that lays out at different portions of the event what the expected radiation levels would be in containment and provides a lot of insight to the plant operators on what they might expect at different phases of a core damage event. And the numbers that they quote in there are numbers way larger than the ones you're quoting. They do expect unbelievable radiation levels inside containment and they'll have to deal with that.

MEMBER SKILLMAN: Thank you.

CHAIRMAN SCHULTZ: Rick, I presume the international EPRI members are very interested in the activities that are associated with Fukushima. Are they also participating in this effort in any way, or reviewing what EPRI is doing?

MR. WACHOWIAK: They've been reviewing what we've doing. In terms of helping with the effort,

we did do another report where we used the Spanish plant Cofrentes and we did an evaluation of strategies for minimizing releases with their plant. They're a little bit different configuration. Their FLEX equipment is much larger than what we've done here. They're doing to do some additional things. But it was for their configurations. They participated. They did the calculations. So we do have some participation there.

PARTICIPANT: (Off microphone).

MR. WACHOWIAK: Yes, well, that's mostly Fukushima stuff, but we're participating in the BASF effort. And then actually the same day as the meeting, the next ACRS Committee meeting, we just got informed of, I have a meeting with the -- used to be called SARNET. Now it's called something else that escapes me right now.

MEMBER CORRADINI: NUGENIA?

MR. WACHOWIAK: NUGENIA. And to see what sort of collaboration we can do on severe accident research. So there's quite a bit of -- now, I always put in my presentations with those guys that if they're acceptance criteria is different than what we were looking at here, the latent cancer failures and things

like that, they could get to a different result. So, they have to take that in the context of what their regulatory structure is. So we do get the question how come you guys didn't come up with filters and we did?

MR. BUNT: And from the BWR Owners' Group there's significant industry -- I mean, from the international committee interested in what we're doing and how we're going forward with that from both Europe and from Asia.

CHAIRMAN SCHULTZ: Other questions from members of the Committee? Dana?

MEMBER POWERS: Well, if we've got a little time, I'd just ask Rich, do we understand why the hydrogen exploded in Unit 3?

MR. WACHOWIAK: In Unit 3?

MEMBER POWERS: Dead cold plant, release into the reactor building, and we didn't get just a deflagration, we actually got a detonation there. Unit 1 I don't --

(Simultaneous speaking)

MR. WACHOWIAK: Well, Unit 3 is where the hydrogen came from. It didn't come from 4.

MR. GABOR: But a dead cold building is not Unit 3.

MR. WACHOWIAK: Yes, it was a somewhat hot building, but the release there seemed to be lower in the building than what we saw in Unit 1. Unit 1 everything was up on the top floor and not much of the building was involved in that explosion. It appears that; and I just say appears that because we're still looking into this, but it appears that the release into the building 3 reactor building was low enough that the fourth floor, not just the fifth floor was --

(Simultaneous speaking)

MEMBER POWERS: Well, see the trouble I have with that particular event is that I know how hard it is to initiate a detonation. And I don't have any obvious mechanism to initiate a detonation.

MEMBER CORRADINI: The trigger or just the roll-up to a detonation?

MEMBER POWERS: The direct initiation of a detonation is almost impossible in these plants. The only way I can get it is to get a deflagration transitioning to a detonation. But I got a dead cold plant. I mean, I don't have TMI's pilot valve moving and things like that. And I just struggle to find out why we initiated a detonation in the plant. And I just wondered if you had any insights.

MR. WACHOWIAK: We hadn't gotten to that part of why it detonated yet. We've been looking at what are the conditions necessary to see the building damage that we saw. And --

MEMBER POWERS: The question that I have had posed to me and I'm perfectly willing to put the monkey on your back is if one goes into 3 and wants to address that question of why did it detonate, what kind of information should you be looking for inside that plant to help you answer that question?

MR. WACHOWIAK: (No audible response)

MEMBER POWERS: You don't have to give me an answer right now --

MR. WACHOWIAK: Yes, I don't have --

MEMBER POWERS: -- but I would appreciate if you thought about it.

MR. WACHOWIAK: Yes.

MR. GABOR: We know the document that recommendation should go in though.

MR. WACHOWIAK: Yes, I told you, Randy, stop paying him.

MR. GABOR: Okay.

(Laughter)

MEMBER POWERS: I know that, I mean, for instance at TMI we know almost everything about that deflagration because we could see the signatures on the wall and on supply wood and things like that. We know the velocity of the deflagration wave and things like that because we looked. For this one -- and it was happenstance. I mean, we were dumb as stones about severe accidents at TMI. Now we know a lot. Can we give them some advice on the things to look for lest they be lost forever because of the drive to clean things up?

MR. WACHOWIAK: That particular question would fall --

(Laughter)

MR. WACHOWIAK: The Department of --

MEMBER POWERS: Nice try, Rick, but --

(Simultaneous speaking)

MR. WACHOWIAK: The Department of Energy has put together a committee that is trying to put together such a document that says here are some things we'd like you to look at before all the evidence goes away. And so that effort is being undertaken. There's all sorts of different people working on it.

MEMBER POWERS: You just explained to me about all this work that EPRI is doing. Is that insight and the very talented people I know that you have working on it, including yourself, feeding into this DOE document that question? I mean, I have a personal interest in this, because had you asked me prior to Fukushima is it possible to get a detonation in a reactor building of a Mark I BWR, I would have given you 5,000 reasons on why it was absolutely physically impossible to do, that the best you could see was what you saw at Unit 1. And so, obviously I am dumb as a stone, still. In fact, I'm perfectly willing to admit. And I'm trying to get you to rescue me.

(Laughter)

MR. WACHOWIAK: Again, right now the phase of the project that we're in with the technical evaluation is looking at the hydrogen generation and transport in the reactor building, or hydrogen release into the reactor building. So we're in the middle of it.

MEMBER POWERS: So you're going to rescue me of eventually?

MR. WACHOWIAK: Eventually. Maybe sometime --

MEMBER POWERS: Meanwhile, I drown.

MR. WACHOWIAK: -- in the second quarter of next year.

MEMBER POWERS: Second quarter of next year? I drown until then. I suffer horrible inflictions of -- Joy sneers at me and says --

MR. WACHOWIAK: But in terms of --

MEMBER CORRADINI: I think the final point is as you should.

(Laughter)

MR. WACHOWIAK: But that phase is ongoing right now. And we're also trying to incorporate some uncertainty analysis into it as well.

MEMBER POWERS: But I hope you don't forget about it, because --

MR. WACHOWIAK: No, no. It's important.

MEMBER POWERS: -- I mean, this is the one thing I can guarantee you about every severe accident that I've participated in is that we always learn something that we never knew, and this will be no exception.

MR. WACHOWIAK: Right.

MEMBER POWERS: I mean, we didn't even know to put it in the models. It's not that we didn't

know exactly how to model it. We didn't even know that it should go into the models.

CHAIRMAN SCHULTZ: Other questions from the Committee at this time for the industry?

(No audible response)

CHAIRMAN SCHULTZ: Hospital none, I'd like to turn to public comments. Weidong, if you can open the phone, that would be helpful. In the meanwhile while that is --

MR. BROWN: The bridge is open.

CHAIRMAN SCHULTZ: The bridge is open. Can we first look to members of the public in the meeting room? Is there anyone here who would like to make a comment?

(No audible response)

CHAIRMAN SCHULTZ: Seeing none coming to the microphone, the bridge line should be open. Could someone please out there say hello to just verify that it is open for us? Anyone on the line willing to say hello to us, please?

MR. JACKSON: Yes, Dave Jackson, Entergy. Hello. The line's open.

CHAIRMAN SCHULTZ: Thank you. Would anyone like to make a comment? If so, please state your

name.

(No audible response)

CHAIRMAN SCHULTZ: Anyone like to make a comment for the benefit of the Committee?

(No audible response)

CHAIRMAN SCHULTZ: Hearing none, we're going to close the bridge line. And I'll turn now for comments from members of the -- I also closed my microphone.

(Laughter)

CHAIRMAN SCHULTZ: I turn now then to comments from members of the Committee. We'll go around the table. And, John, did you want to say a few words about next steps?

MEMBER STETKAR: Yes, I think that as we usually do in the Subcommittee meetings, especially on topics like this, one of the things that we should consider is will the Subcommittee recommend to the Full Committee whether the ACRS should write a letter on this topic? And I think as we go around the table in our summary comments or remarks I'd certainly like to hear what other members have ideas on regarding that topic.

I personally think that we should try to address a couple of technical issues, that come to my

mind anyway, quickly. One is we've heard an awful lot, and we've not written on this topic before, about the importance of water addition to the whole process.

And the second; and I'm a little more unsure on this topic, is the incremental effectiveness of an engineered filter given the strategy of water addition. So when I think about whether we should write a letter, I would focus on as technical issues that the ACRS could weigh in on given what we've heard up through and including today's Subcommittee meeting, the discussions that we've had. And so, I guess I'm weighing in in sort of favor of writing a letter in that direction.

The only other thing I'd like to say is I'd like to thank everybody. I think this was a very worthwhile meeting. The staff and folks sitting in front of us now. I think it was very useful, at least for me anyway. I learned a bunch of things that -- or at least clarified things that helped me an awful lot.

CHAIRMAN SCHULTZ: Dana?

MEMBER POWERS: Well, John raises a good point that both the staff and the industry team here raised some very crucial points in their discussion that I think deserve to be highlighted. I think some

phenomenological points were raised, for instance, in Hossein's presentation about the unfiltered out-leakage as a limitation on the decontamination you can hope to achieve. The water addition effectiveness is of course a good point.

But I think the equally important are all the steps that the industry is taking to assure that their operational staff; and by that I include your technical support committees, are aware of what things they should be looking at. I thought Jeff's point about the Severe Accident Guidelines being applicable well after an accident is over is something that I think deserves some prominence in the public discussion of these accidents. And if a letter from us will facilitate that, then I think we should think about drafting one.

CHAIRMAN SCHULTZ: Thank you, Dana. Dick?

MEMBER SKILLMAN: Thank you, Steve. I wanted to thank staff and the industry for very good use of time and good presentations. Thank you to industry and thank you to the staff.

I concur with writing a letter for the reasons that both John and Dana have outlined. To me

the blue chip, the real important message is the potential for bypass has the capacity to degrade significantly any real benefit that an engineered filter would provide. And I'm quite confident that that subtlety will not be appreciated unless somehow we get that described very clearly. But again, thank you.

CHAIRMAN SCHULTZ: Okay. Mike?

MEMBER CORRADINI: I do think we should write a letter. I guess I would dwell more on the first point, which is the importance of water addition within the context of what it brings and actually covers a whole range of bases.

The other thing I think that we mentioned last meeting; we didn't bring it up here, but I didn't know where it fit. But I think we had brought up to the industry and to the staff the need for drywell sprays as a mechanism for water addition, not just essentially addition into the pedestal/lower drywell region because it may actually benefit -- I'm sorry?

MEMBER STETKAR: On Mark IIs in particular.

MEMBER CORRADINI: In Mark II in particular is what Dana brought up, but I think what

we emphasized at least in our discussions at the end. I seem to remember that. But I guess if we're going to have a letter, I would prefer the letter focus on that.

On the second point of John's, I don't think we have enough information other than what-if calculations. What if it's 10, what if it's 100, what if it's 1,000, and there's very little variability? If that's what John's after relative to describing I can have a large range in decontamination factors, essentially unverifiable, but still I don't have much of an effect, then fine. But I think the main point of the letter about water addition to me is probably more important.

CHAIRMAN SCHULTZ: Thank you. Dennis?

MEMBER BLEY: Yes, I agree that we should write a letter and agree with all my colleagues on this one. And I'd take it even back a couple of years. I mean, the thinking on this and the positions of staff and industry have evolved a long way from when we first heard this and people have learned a lot more. And I just think we need to come in on the technical basis and support the things they've done. I not only appreciate today. I appreciate the whole string of

meetings.

And I have to say on this and on FLEX the way the industry has come together and standardized what they're going after has struck me as a very important evolution for us. I mean, it's come a long way.

CHAIRMAN SCHULTZ: Thank you. Ron?

MEMBER BALLINGER: I also agree that we should write a letter. I think I've seen that we've come a long way and in some cases almost recommended stuff which subsequently we would have never done if we'd not proceeded here.

And the water addition issue serves to tamp everything down so that the filter part -- even though the filter itself is of limited usefulness because of the bypass issue, the water addition, I don't -- maybe I'm not using the words "tamp down" properly, but cuts down on everything and makes the argument that because the filter doesn't provide that much of a benefit and that the amount of release is being affected by the water addition as well is a very good story that has to be told.

CHAIRMAN SCHULTZ: Thank you. Joy?

MEMBER REMPE: Okay. Well, I agree we should write a letter. I agree for the reasons that John stated. I tend to think it would be beneficial to mention the effectiveness of the filters and that issue and not just bypass it totally, because I think it's something that's a nuance that might add some clarity to it.

The other thing that I didn't hear anyone else mention that I think might be worthwhile acknowledging is what we heard from industry today, that it is a continuing process, as we learned, and more what happened at the accidents over there, and that that's just the reality of the beast. And I think that might be worth emphasizing, too. Thanks.

CHAIRMAN SCHULTZ: Thank you. Well, I will first say that I also favor writing a letter for all of the reasons that were mentioned by other members of the Committee. Most importantly to me is that even over the last few meetings after the issuance of the documentation we have learned a lot. A lot of discussion has been brought to the table and it has led to a much better understanding of the overall technical area as well as the overall focus that one might bring to this discussion. And if we could, as Dana had

indicated, document that in one place, I think that would be a worthwhile effort by the Committee.

Having said that, that would mean in terms of our process that at the Full Committee meeting in September we will need to have a presentation to the Full Committee by the staff and by industry. We would like to arrange that with both the staff and industry. I feel given that the discussions that we have had over the last two meetings: today and then in July, we have a fairly full appreciation for what has been done and what has already been brought to the table. So a reasonably short discussion associated with each of the presentations would be suitable for the Full Committee meeting, even though there are a few members that are absent today.

As I mentioned in the opening comments, we had comments by a member of the public by email, and part of that comment was a request to participate in the Full Committee meeting. And that's not the only request that we have received from members of the public to participate in the Full Committee meetings. So we are also planning to incorporate in the Full Committee meeting discussions, a time slot for presentation of comments from members of the public.

So, we plan to hold that on September 9th. Wednesday afternoon. And we'll be sure to make that information available.

MEMBER STETKAR: Yes, our agenda will be issued --

CHAIRMAN SCHULTZ: In a few days.

MEMBER STETKAR: -- in a Federal Register notice in the next couple of days or so.

CHAIRMAN SCHULTZ: Yes.

MEMBER STETKAR: But we will be holding that session Wednesday afternoon, September 9th.

CHAIRMAN SCHULTZ: We'll proceed along those lines.

And lastly, I would also like to thank the staff and the industry. I think the entire Committee as well as the staff and the industry have benefitted from the discussions this afternoon and we shall therefore move forward with a much better understanding of the issues and solutions that we have in front of us. Thank you.

(Whereupon, the above-entitled matter went off the record at 4:54 p.m.)

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Protecting People and the Environment

ACRS Subcommittee Meeting: Containment Protection and Release Reduction (CPRR) Rulemaking

August 18, 2015

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- NRC Staff Presenters
  - Eric Oesterle, NRR
  - Bill Reckley, NRR
  - Hossein Esmaili, RES
  - Jon Barr, RES
  - Marty Stutzke, RES

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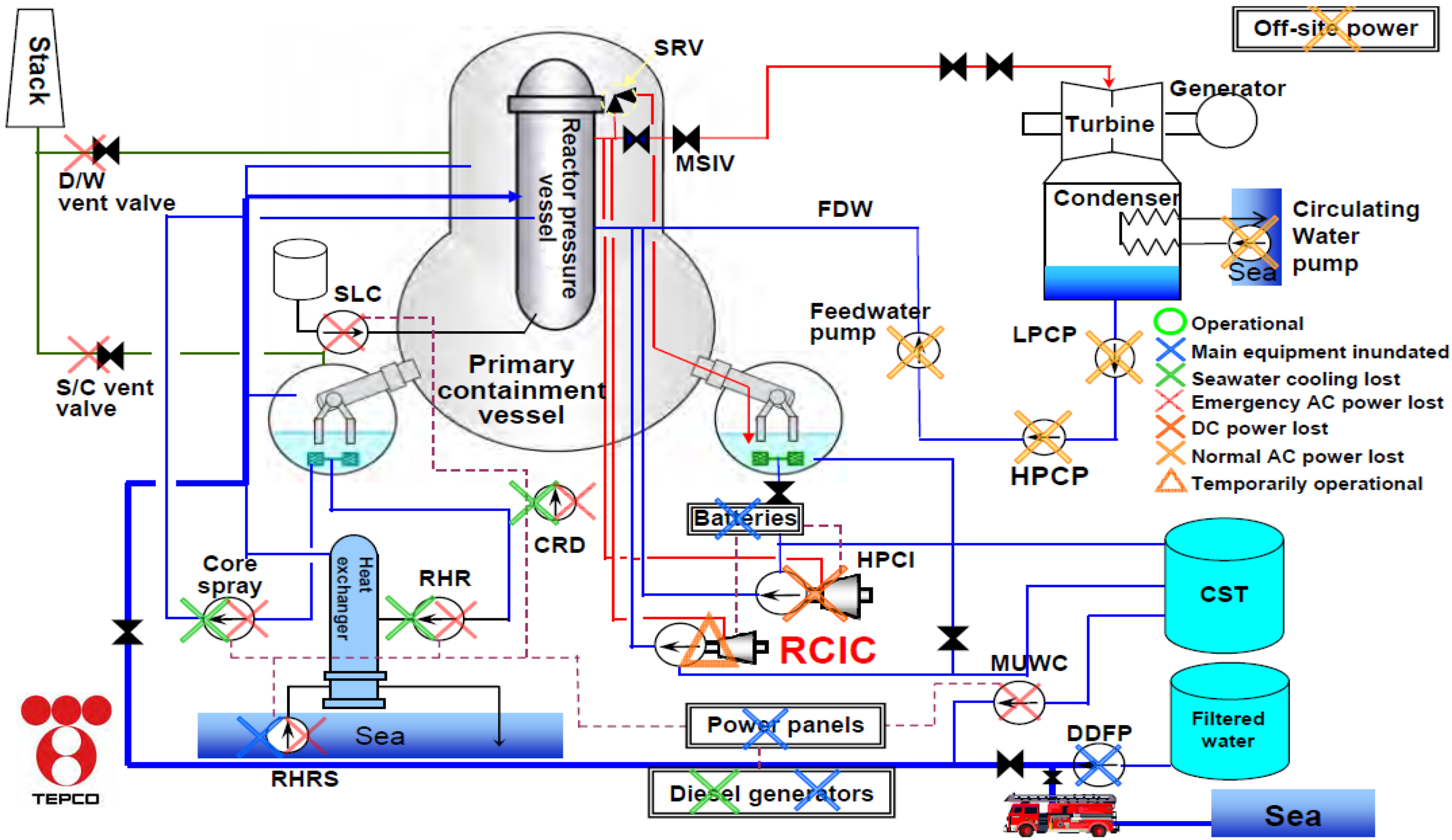
Background

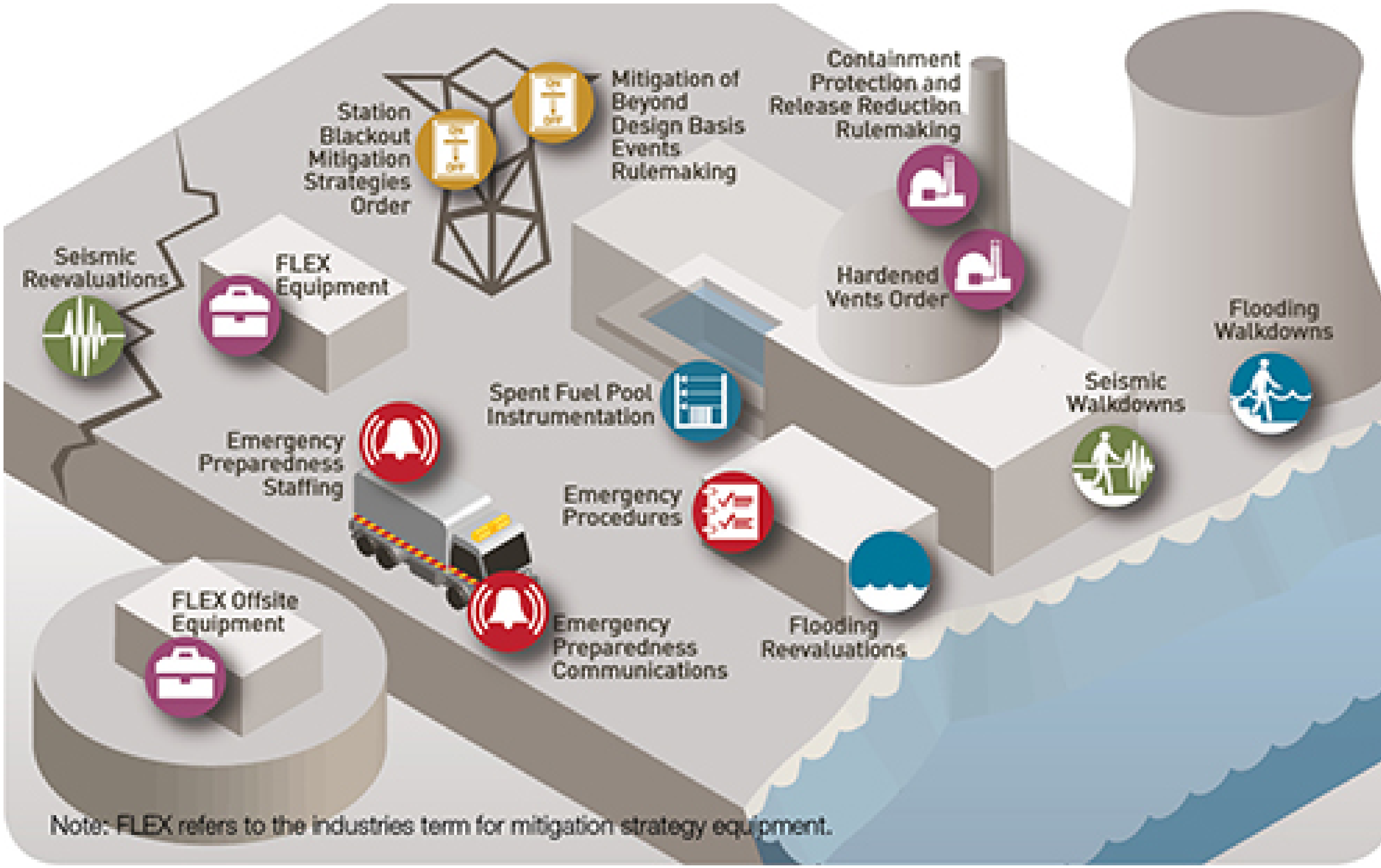
Fukushima – Tsunami & Extended Loss of Electrical Power



Fukushima Daiichi Unit 2

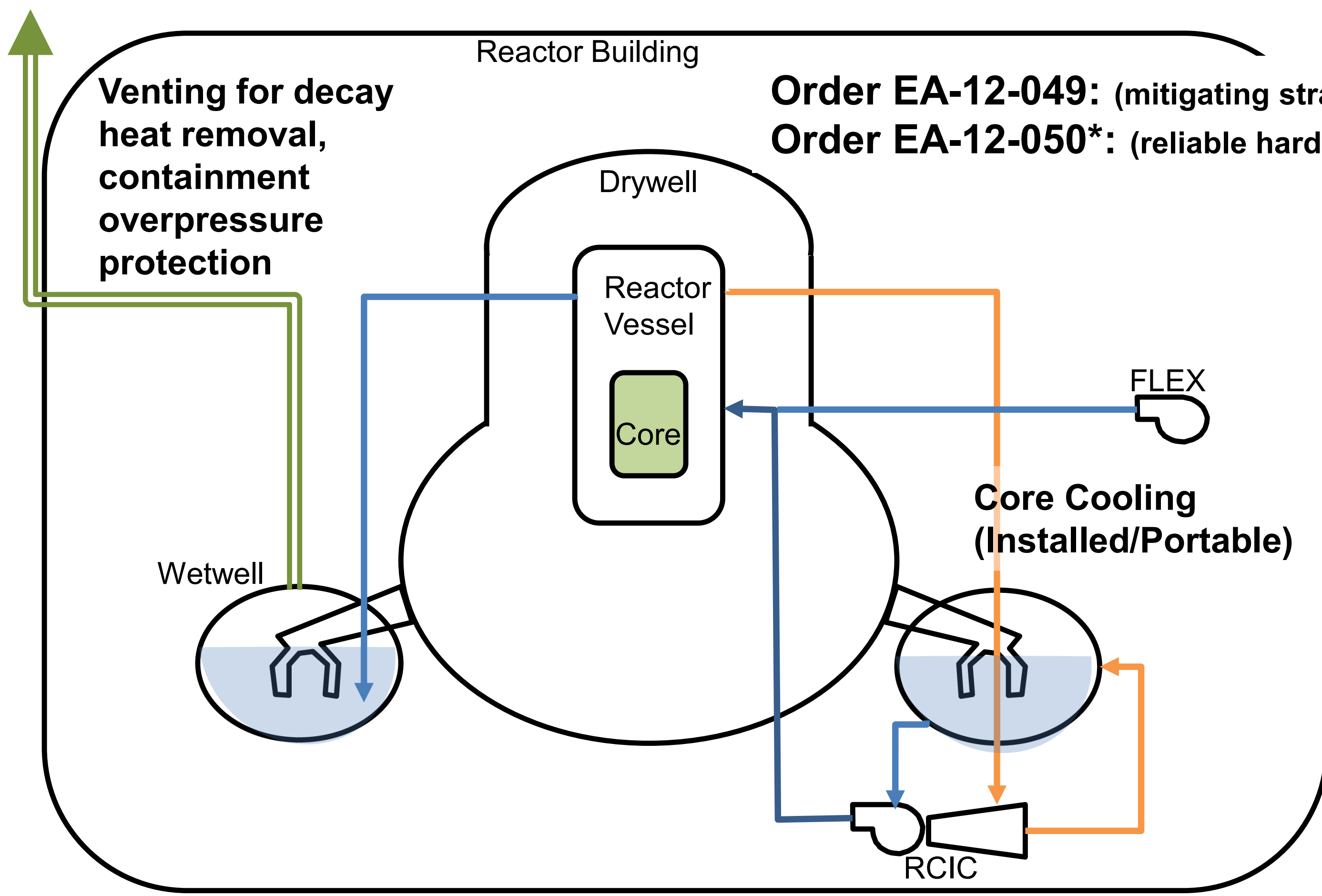
Background

NRC Activities to Address Fukushima Lessons Learned



Background

March 2012 Orders – Mark I/II Containments

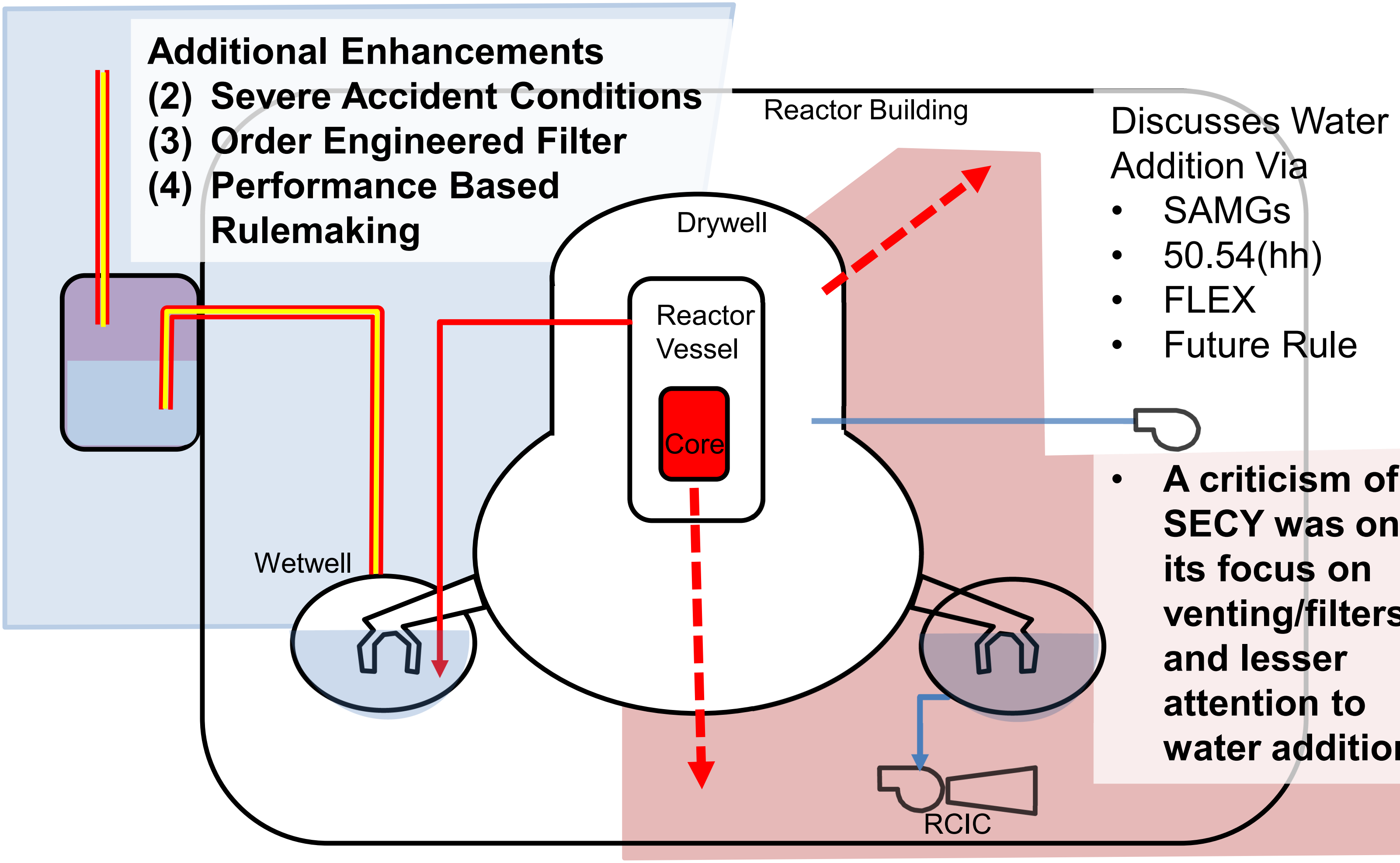


* Adequate Protection Portion of Order EA-13-109

Background

SECY-12-0157 – Response to Question on Possible Addition of Engineered Filter

Additional Enhancements
(2) Severe Accident Conditions
(3) Order Engineered Filter
(4) Performance Based Rulemaking



Discusses Water Addition Via

- SAMGs
- 50.54(hh)
- FLEX
- Future Rule

- **A criticism of SECY was on its focus on venting/filters and lesser attention to water addition**

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Background

SECY-12-0157 Focus on Venting & Filters

Mechanism	Consideration
Containment bypass	Low frequency
Liner melt through	Drywell flooding
Overtemperature	Venting, sprays
Overpressure	Venting

SECY focus (Overpressure – Venting)

EPRI - BWROG focus (Drywell flooding; Venting, sprays; Venting)

Note: SECY-12-0157 mentions possible future rulemaking to go beyond 10 CFR 50.54(hh) for severe accident water addition

Note: Post-SECY-12-0157 the NRC maintained purpose of order (EA-13-109) as decay heat removal and overpressure protection and addresses other failure modes in the related rulemaking

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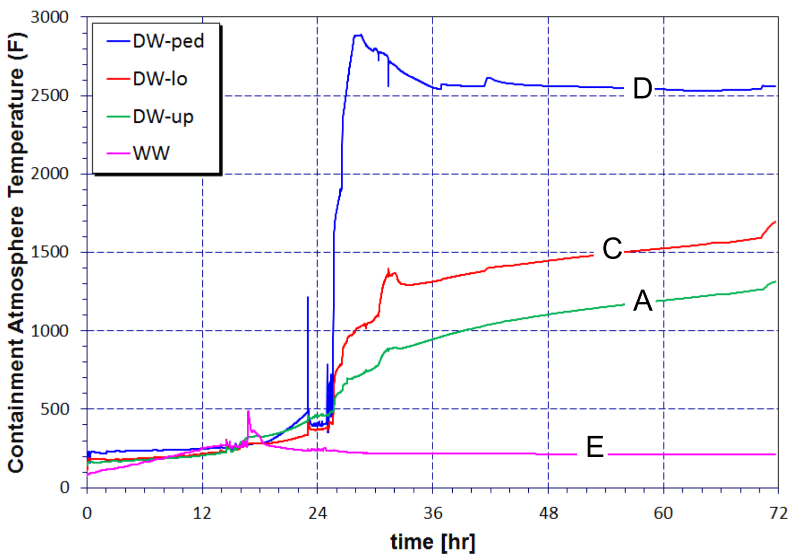
Background
Post SECY-12-0157 Activities

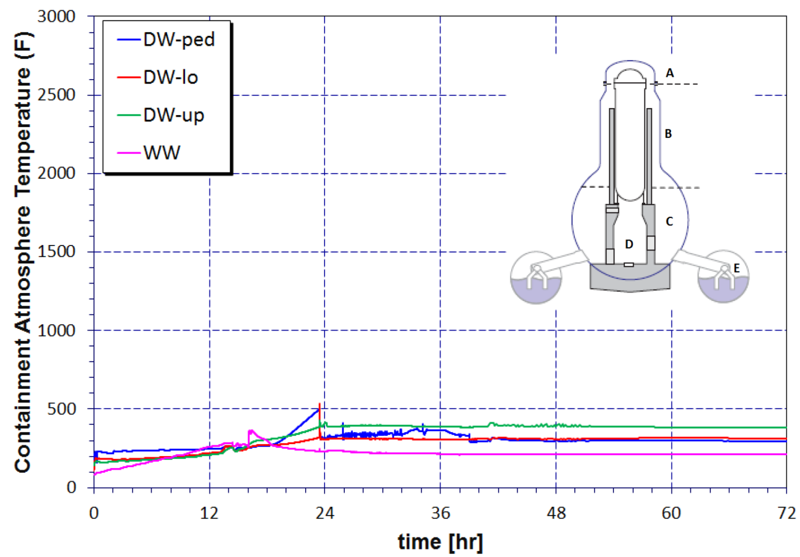
- Order EA-13-109 requires severe accident capabilities for vents from Mark I/II containments
  - Phase 1 addressed required venting capabilities from the wetwell
  - Phase 2 requires either a severe accident capable drywell vent or a strategy that makes it unlikely that a licensee would need to vent from drywell (e.g., maintain water level below wetwell vent)
- Evaluate potential rulemaking to address other issues on containment integrity and core debris cooling

Order EA-13-109

- Impact of external water addition on drywell temperatures (establishing vent specifications)



No Water



Water Addition

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Order EA-13-109

- The industry's projected approach to complying with Phase 2 of Order EA-13-109 is to develop a "reliable containment venting strategy."
  - Incorporates external water capability during a severe accident (severe accident water addition or SAWA)
  - The NRC has endorsed in interim staff guidance JLD-ISG-2015-01
- Additional benefits for providing external water include:
  - Reduces the likelihood of containment failure from over-pressure, over-temperature, or liner melt-through.
  - Venting from the containment through the wetwell reduces the release of radioactive materials because the water in the suppression pool scrubs or filters the release.

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Order EA-13-109

- Phase 1 (severe accident capable wetwell vent) shall be completed no later than:
  - Startup from the 2nd outage that begins after June 2014, or
  - June 30, 2018, whichever comes first.
  - Phase 1 integrated plans submitted by June 30, 2014: **COMPLETE & Interim Staff Evaluations Issued.**
- Phase 2 (severe accident capable drywell vent or an alternative reliable containment venting strategy) shall be completed no later than:
  - Startup from the first 1st outage that begins after June 30, 2017, or
  - June 30, 2019, whichever comes first.
  - Phase 2 integrated plans are due December 31, 2015: **On schedule (developing template)**.

Order EA-13-109

Relationship to CPRR Rulemaking

Containment Protection

- Alternative 1 (no rulemaking)
  - Order EA-13-109 for overpressure protection
  - SAWA/SAWM for Phase 2
    - Establishes design conditions & supports wetwell level control
    - Collateral Benefit of Core Debris Cooling
- Alternative 2 (codify order)
  - Core Debris Cooling remains collateral benefit
- Alternative 3 (codify order plus require SAWA)
  - Rule for protection against major failure modes

Release Reduction

- Alternative 4 (engineered filter/filtering strategy)

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Order EA-13-109

Relationship to CPRR Rulemaking

- Difference between Alternatives 1, 2, and 3
  - What is the most appropriate "regulatory footprint" for protection against various failure modes?
  - General agreement on the benefits of external water addition
- Guidance for compliance with Order EA-13-109 includes severe accident water addition
  - All licensees expected to include SAWA as part of compliance with order
  - Implementation and maintenance of capabilities subject to review and inspection

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CPRR Rulemaking
Evaluation of Alternatives

- Technical Analyses
  - Assumptions and Sensitivity Evaluations Support Regulatory Decision (Backfit)
- Communication Challenges
  - Consideration of Severe Accidents (Low Frequency-High Consequence Events with low estimated risks to public health and safety)
  - Evaluation of alternatives considers factors such as the performance of other response capabilities

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RES ANALYSIS IN SUPPORT OF CPRR RULEMAKING

Office of Nuclear Regulatory Research

August 18, 2015

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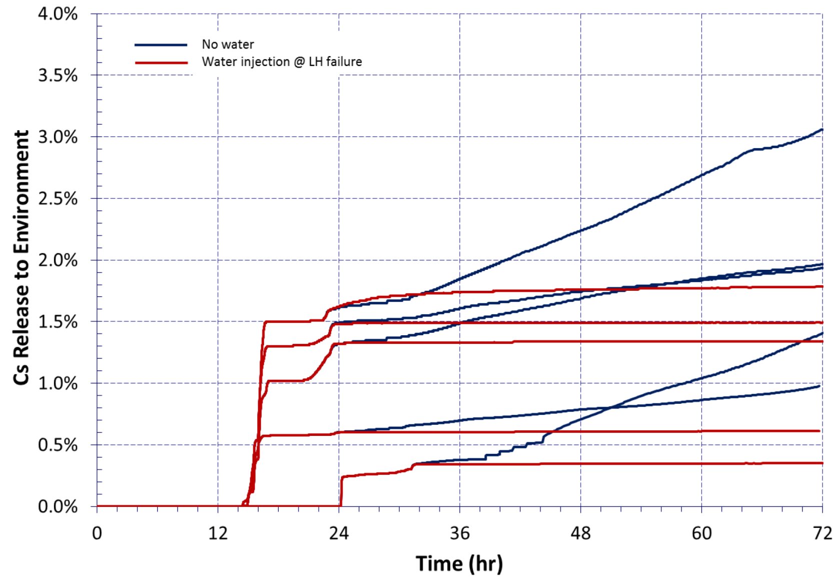
MELCOR Model Overview

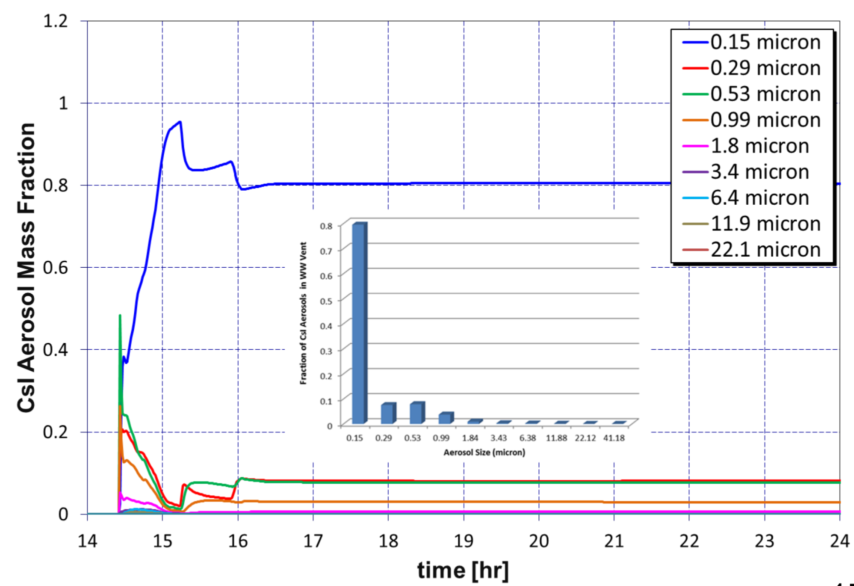
- SOARCA Mark I model converted to MELCOR 2.1
  - Mark II model consistent with Mark I
- 500 gpm injection into RPV or Drywell at **vessel breach**
- Lower head failure model for CPRR
  - Consistent with SOARCA (NUREG/CR-7110 Vol 1)
  - One-dimensional model of stress-strain distribution in the lower head
    - SOARCA uncertainty analysis examined sensitivities to penetration failure and creep rupture parameters (impact not significant)
  - Effect of external structures (e.g., guide tubes) not considered
    - Radiation heat transfer is dependent on the geometry and can become important at elevated temperatures
  - Heat transfer from the outer surface of the lower head to the cavity atmosphere is modeled by a constant heat transfer coefficient

Cs Release Fraction to Environment



Water addition at lower head failure has the benefit of mitigating further release, but does not affect the release at the time of venting

Particle size distribution dominated by very small aerosols at the time of venting.



External Filter Effectiveness

- Assumed operational without degradation
- Decontamination factor is affected by the filter design and particle size distribution
  - DF is modeled parametrically and applied to all particle sizes for the vent pathway (dominated by small size particles)
  - No mechanistic treatment
  - CPRR assumed a DF of 10, 100, 1000
    - Provide a broader range of DFs for binning purposes
    - SECY 12-0157 assumed a range of DF (2, 10, 100 for wetwell venting)
  - Vendors provided information on their design in response to NRC request (ML14261A045)
    - AREVA (ML14329A148, November 18, 2014) reported DF > 10,000 even for small size particles
    - OECD/NEA/CSNI Status Report on Filtered Containment Venting NEA/CSNI/R(2014)7
  - No independent assessment by NRC since overall conclusions not sensitive to the choice of DF

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Potential External Filter Effectiveness for Three Examples Cases

CPRR Alternatives	MELCOR Mark I Case and External Filter DF	Percent of Source Term Released Through Vented Pathway		Total Source Term Released to Environment		MACCS Source Term Bin	Description of External Filter Effectiveness
		Cesium	Iodine	Cesium	Iodine		
Status Quo (No External Water Addition) resulting in drywell liner melt-through	1	78.2%	85.5%	1.93%	22.70%	12	External filter has a notable effect on reducing environmental release for DF=10 but smaller incremental benefit for higher DF
	1DF10			0.57%	5.24%	7	
	1DF100			0.44%	3.49%	7	
	1DF1000			0.42%	3.32%	7	
Status Quo (No External Water Addition) resulting in main steam line creep rupture	3	11.5%	21.6%	9.88%	30.20%	17	External filter has an insignificant effect on reducing environmental release
	3DF10			8.85%	24.32%	17	
	3DF100			8.75%	23.74%	17	
	3DF1000			8.74%	23.68%	17	
External Water Addition Successful	10	100.0%	100.0%	0.72%	8.04%	7	External filter reduces environmental release
	10DF10			0.07%	0.80%	5	
	10DF100			0.007%	0.08%	3	
	10DF1000			0.0007%	0.008%	1	

* Among the many MELCOR cases resulting in DW LMT, on average about half the cesium is released through a vent pathway and half escapes through other non-vented pathways.

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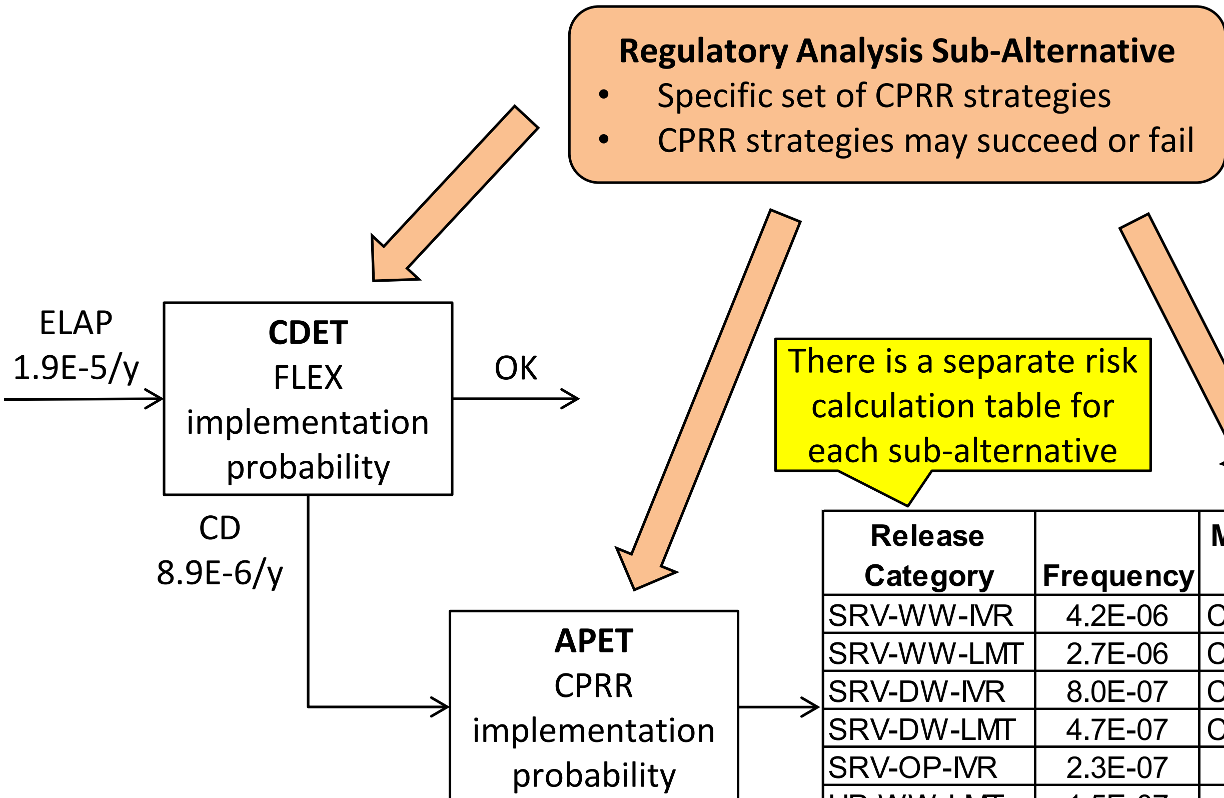
MACCS Overview

- Developed site-specific MACCS models
  - Reference Mark I site: Peach Bottom
  - Reference Mark II site: Limerick
  - Used updated population, economic, land use, evacuation data, etc…
- Sensitivity calculations to explore site-to-site variability
  - Population, land use, and economic data
  - Evacuation delay
  - Nonevacuating cohort size
  - Intermediate phase duration
  - Long-term phase habitability criterion
- Zero early fatality risk for all MACCS runs
- Individual latent cancer fatality risk well below QHO when frequency-weighted
- Individual latent cancer fatality risk driven by long-term phase exposures
  - Delayed releases (~10-20 hrs) calculated with MELCOR combined with up-to-date ETE data support assumption that 10-mile EPZ population has time to evacuate before plume exposure

Example Risk Calculation



Example: Sub-Alternative 4Bi(1)

Release Category	Frequency	MELCOR Case	MACCS Bin	Conditional Consequence	ILCFR
SRV-WW-IVR	4.2E-06	C108DF10	123	7.4E-05	3.1E-10
SRV-WW-LMT	2.7E-06	C104DF10	110	2.5E-04	6.7E-10
SRV-DW-IVR	8.0E-07	C108DF10	123	7.4E-05	5.9E-11
SRV-DW-LMT	4.7E-07	C104DF10	110	2.5E-04	1.2E-10
SRV-OP-IVR	2.3E-07	C108	122	1.3E-04	2.9E-11
HP-WW-LMT	1.5E-07	2DF10	10	4.1E-04	6.1E-11
SRV-OP-LMT	9.9E-08	C104DF10	110	2.5E-04	2.5E-11

Total ILCFR for Sub-Alternative 4Bi(1) = 1.3E-09

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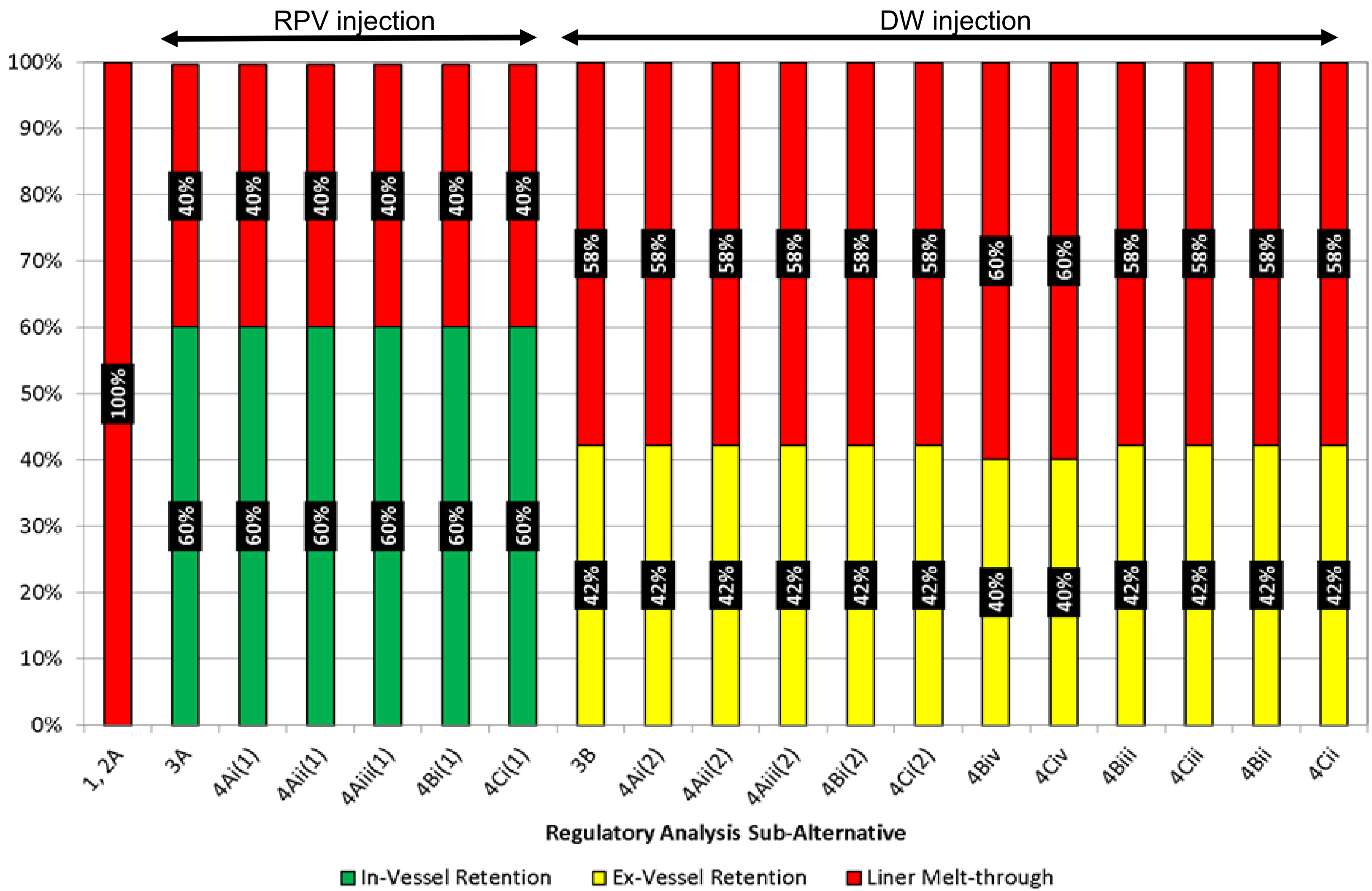
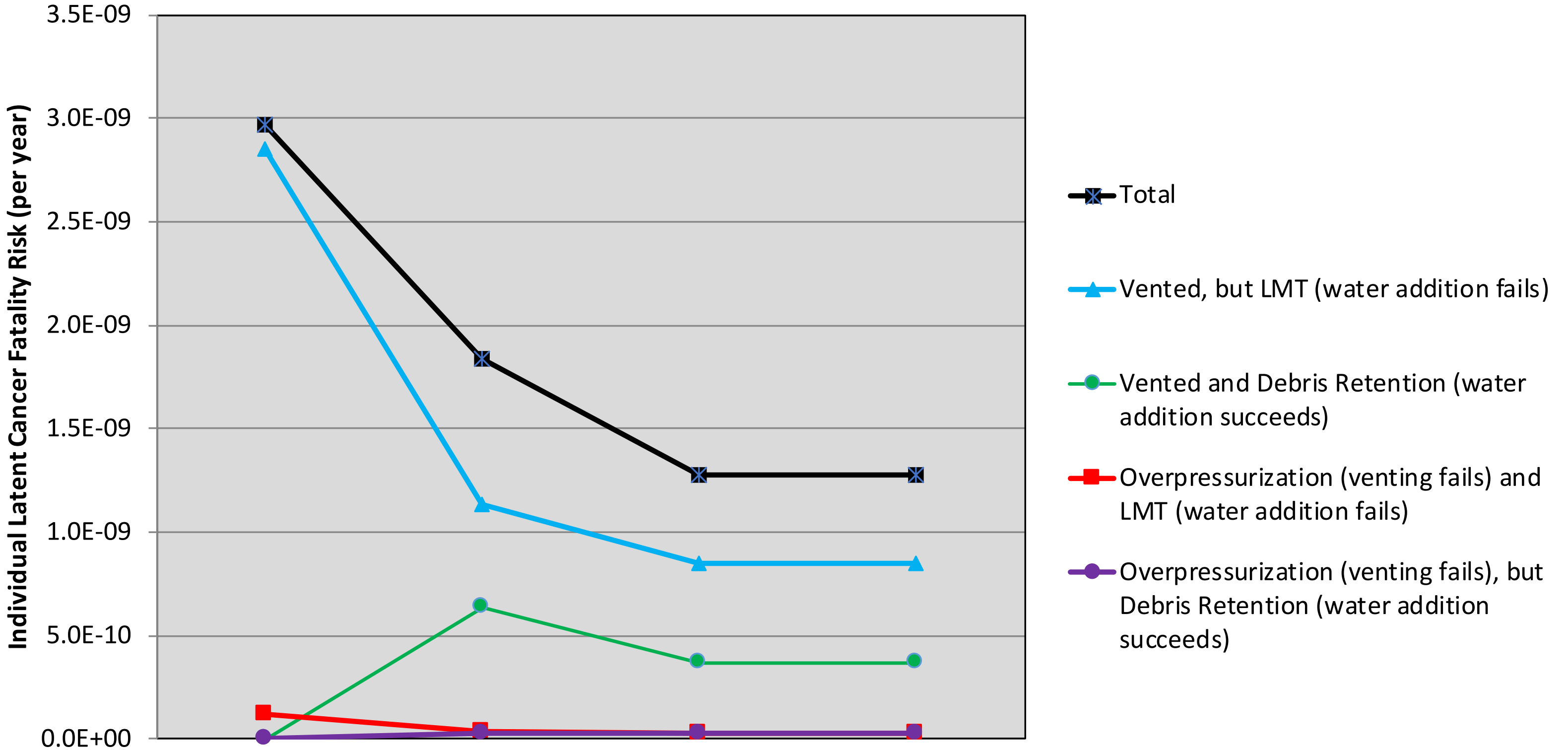
Comparison of Ability to Retain Core Debris



Contributions to Risk



Sub-Alternative	1	3A	4Bi(1)	4Ci(1)
water addition capability	no	yes	yes	yes
filter	no	no	DF=10	DF=1000
CCFP	100%	42%	42%	42%

CCFP = conditional containment failure probability (overpressurization and/or LMT)
LMT = liner melt-through

For each sub-alternative:

- Injection pathway: RPV
- Water strategy: severe accident water addition (SAWA)
- Vent priority: wetwell first
- Vent control: manual
- Vent strategy: open-and-leave-open

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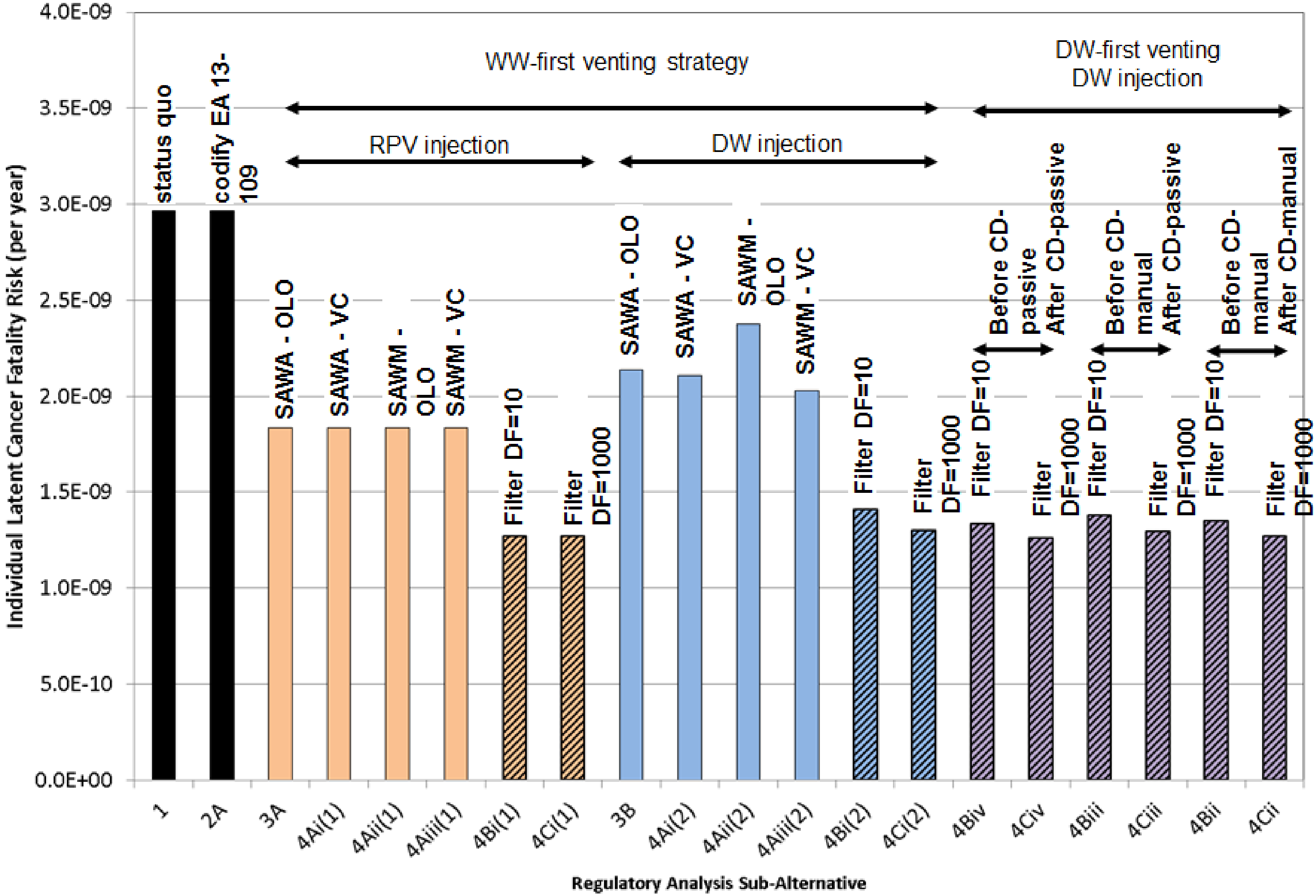
Comparison of Alternatives using Individual Latent Cancer Fatality Risk (0-10 miles)



Comparison to NRC Safety Goal

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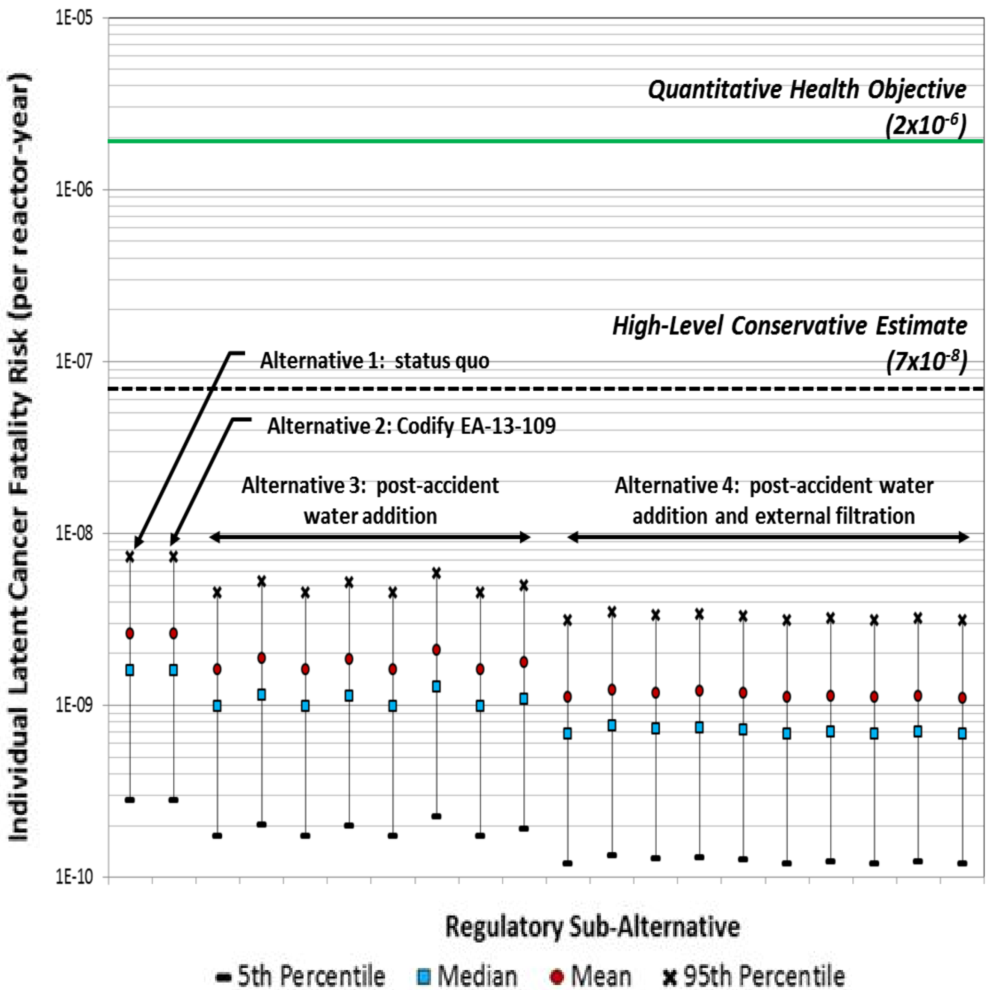
- Frequency-weighted individual LCF risk is orders of magnitude below the NRC Safety Goal QHO
- High-level conservative estimate using highest ELAP frequency and highest conditional LCF risk about 30 times below QHO
- Risk reduction from regulatory alternatives are within uncertainty bounds



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Comparison to SECY-12-0157

- More Detailed Analyses and Quantification
  - Core damage frequency.
  - Additional sensitivity analyses.
  - Explicit modeling of additional external water injection.
    - In SECY-12-0157, the cases did not consider new mitigation measures involving water addition, beyond existing water addition capabilities associated with the loss of large areas and FLEX.
    - The importance of this water capability was recognized but a new requirement was not proposed in the Order and was considered a feature to evaluate in the CPRR rulemaking.
  - Consideration of other Fukushima activities.
  - Focus on comparison to quantitative health objectives.
- Updated Discussion of Qualitative Factors
  - Other Fukushima-related safety enhancements.
  - Recent Commission decisions.
  - Alternative 3 address majority of factors with only small additional risk benefits provided by engineered filters.

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CPRR Alternatives Summary

Reactor Conditions	Containment Failure Mode	Alternative 1 (No Action)	Alternative 2 (Rulemaking EA-13-109)	Alternative 3 (Rulemaking EA-13-109 with SAWA)	Alternative 4 (Release Reduction)
No Core Damage	Over-Pressure	Required	Required	Required	Required
Core Damage (Severe Accident)	Over-Pressure	Required	Required	Required	Required
	Over-Temperature	Not Required	Not Required	Required	Required
	Liner Melt Through	Not Required	Not Required	Required	Required
	Release via Controlled Venting	Not Required	Not Required	Not Required	Required

While not required, external water addition is expected to implemented as part of over-pressure protection and provides collateral benefits of additional containment protection for over-temperature and liner melt-through.

CPRR Conclusions

- The staff's Commission paper included the preliminary conclusions, path forward, and a draft regulatory basis document.
  - Proceed with the CPRR rulemaking to place requirements of EA-13-109 within regulations
  - Also require severe accident water addition for core debris cooling (other containment failure modes)
  - Discontinue other aspects of the CPRR rulemaking (i.e., engineered filters).
- Awaiting Commission direction

Containment Protection and Release Reduction Rulemaking Regulatory Evaluation

ACRS Fukushima Subcommittee

August 18, 2015

BWR OWNERS' GROUP

NUCLEAR ENERGY INSTITUTE

Questions Posed

- Where does the industry stand:
  - Severe Accident Water Addition
  - Post-core damage venting
- Cost estimates for Severe Accident Water Addition and Severe Accident Water Management
- Effectiveness of external containment filter performance
- Reactor Vessel modeling and predictions
  - MAAP

Severe Accident Water Addition

- The industry at-large is committed to Severe Accident Water Addition (SAWA) at plants affected by Order EA-13-109
- Individual commitments in Overall Integrated Plans due end 2015
- It is a goal that all affected units adopt Severe Accident Water Management (SAWM)
- Consistency assist program established

SAWA/M Cost Estimates

- Provided Level 1 estimate to NRC staff on May 31, 2014.
  - Stand-alone SAWA estimate ~ $2.5 – 3.7M
  - Individual plant costs may vary
- SAWM not estimated
  - Expect largely procedures and training ~ $100K
  - Do not expect hardware changes, but can’t preclude in limited cases

External Filter Performance

- Must be considered in the context of overall risk
- Sources of data
  - Vendor information
  - Containment Filtration Systems Tests of the Advanced Containment Experiments (ACE) Project (1992)
- No consensus standards for filter performance
- Early industry work showed that external filters did not provide much benefit; did not explore filter performance further
  - Conservative analysis
  - Assumed aerosol loading effects on filter performance

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Industry Technical Evaluations Supporting CPRR

Rick Wachowiak (EPRI): EPRI Project Manager

Jeff Gabor (ERIN): Investigator

Doug True (ERIN): Investigator

Advisory Committee on Reactor Safeguards

August 18, 2015

Further Discussion Requested by ACRS

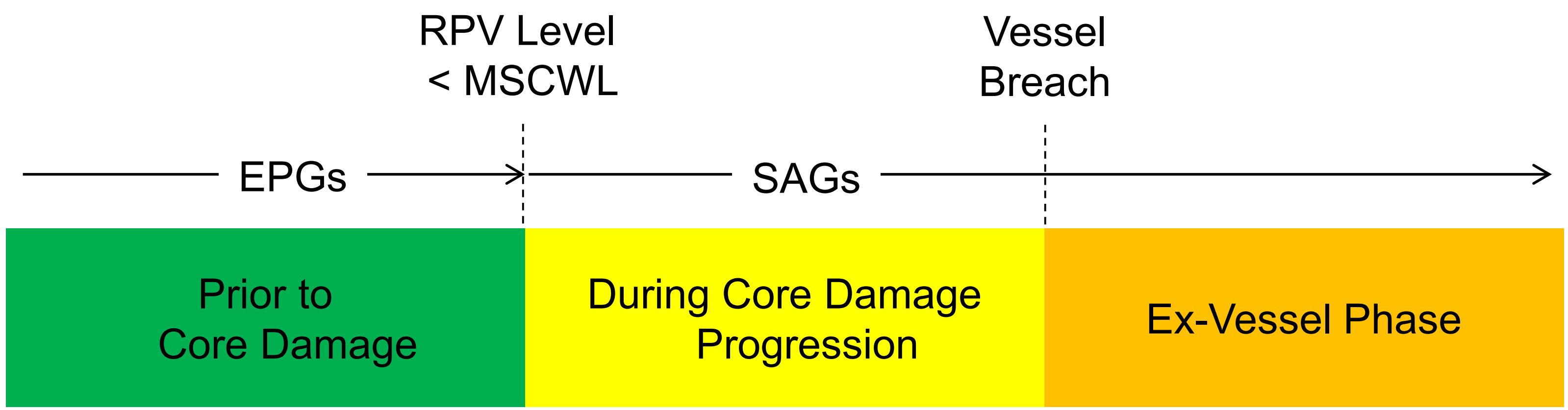
- Based on presentations during July 7, 2015 Subcommittee meeting – 3 general topics
  1. Water addition and water management
  2. Effectiveness of filter performance
  3. Modeling and predictions of vessel failure using MELCOR and MAAP

Water addition and water management

The Draft Regulatory Basis states that (p.7) the industry's approach to complying with the Phase 2 Order EA-13-109 is to incorporate the addition of water during a severe accident to support venting and help prevent the over pressurization of BWR Mark I and II containments". In addition, the DRG states (p.32) that "It (the BWROG) also is ***considering venting*** *(emphasis added) after core damage …" Where does the industry and the staff stand with respect to commitments at this time on these issues? And/or what is anticipated to be in place?*

- Industry Response
  - Statement on p.32 can be misleading
  - Venting after core damage currently exists in the Severe Accident Guidelines (SAG)
    - Upon entering SAG – vent to control pressure below Pressure Suppression Pressure (PSP) to provide margin to Primary Containment Pressure Limit (PCPL)
    - If core debris has breached the RPV – vent to control pressure below PCPL

Applicable EPG/SAG Venting Controls



- Maintain low SP temp for RCIC Operation
- Maintain Pressure Suppression Function (<PSP)

- Initially isolate open vent upon SAG entry
- Maintain Pressure Suppression Function (< PSP)

- Maintain Containment Integrity (<PCPL)

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Effectiveness of filter performance

1. *The DRB analysis approach and presentation tends to leave an impression that filtration capabilities can be substantial…There is no discussion of filtration phenomena that can degrade filter performance, such as by-pass (at the point of filtration), knock-through, saturation, or decomposition in irradiation fields…*
2. *…However, the table also depicts that SAWA/SAWM is 100% effective in maintaining the venting pathway. Accordingly, the assumed DF values show dramatic reductions that might easily be attributed as a clear demonstration of the value of selecting Alternative 4 (as labeled).*

- Industry Response
  1. EPRI analysis (3002003301) assumed a filter DF of 1000 when the external filter was functioning (i.e. not bypassed, not overloaded by aerosol mass, etc.).
     - Integrated risk results clearly indicated orders of magnitude margin to safety goal
     - Degradation of filter would only decrease the change in maximum averted cost risk (ΔMACR), making a filter less cost beneficial
     - Additional analysis not warranted.
  2. Industry analysis has always looked at entire risk spectrum
     - Where selected scenarios may show significant impact from external filters (Table 4-20 SECY-15-0085), integrated risk analysis by both industry and NRC show insignificant benefit beyond that obtained by SAWA

Modeling and Predictions of Vessel Failure using MELCOR and MAAP

What is the significance of radiation heat transfer losses from the 185+ CR Guide Tubes (in addition to the 55+ instrumentation tubes and drain line that extend beyond the lower head of the reactor vessel)?

- Industry Response
  - Uncertainties exist relative to recovery of a degraded core within the RPV once water addition is established.
  - EPRI analysis (3002003301) considered potential to retain core material within the RPV and avoid vessel breach as part of the Accident Progression Event Tree (APET) structure
    - Given low pressure and successful water addition prior to vessel breach, a probability was assigned for in-vessel retention (IVR)
    - Sensitivity analysis performed assuming NO potential for IVR
    - Results indicate insignificant impact on Latent Cancer Fatality (LCF) risk
  - Current EPRI work indicates that this phenomenon may delay RPV failure, but will not prevent it.

Results for
Mark I Containments
(July 7, 2015 ACRS Subcommittee Meeting)

CPRR Rulemaking

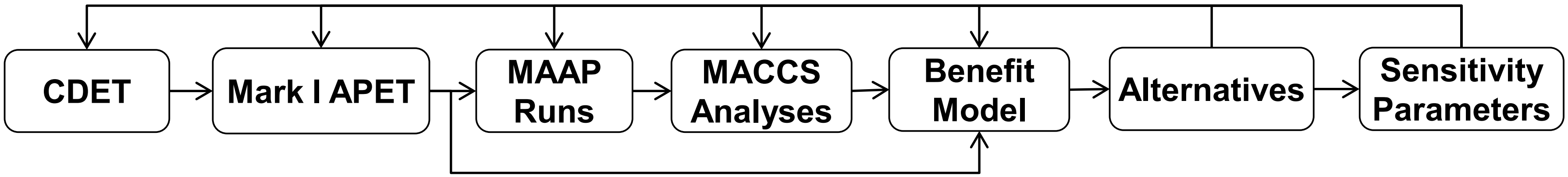
- Evaluation of the residual benefits of filtering strategies should be made in the context of an effective accident management capability and focused on the dominant accident scenarios
- Industry has always viewed the CPRR Rulemaking in the context of accident management
  - Response to postulated severe accidents like the accidents at Fukushima requires operator action
- Accident management involves:
  - Cooling core debris
  - Managing decay heat
  - Mitigating releases

Objectives of EPRI Evaluation

- Understand the role FLEX plays in ELAP mitigation
- Understand dominant severe accident scenarios
- Develop clear, manageable analysis of filtering strategy alternatives
- Support open dialog with NRC staff on assumptions, technical issues, dominant scenarios, and insights
- Inform the implementation of EA 13-109 (to the extent feasible)
- Providing insights to BWROG on EPG/SAGs
- Support industry decision-makers on the cost-benefit considerations

Technical Basis for Severe Accident Mitigating Strategies: Volume 1. EPRI, Palo Alto, CA: 2015. 3002003301.

EPRI Analysis Framework



- CDET → 13 core damage scenarios
- APET → 39 release scenarios (per CDET sequence)
- Total = 507 release scenarios
- Specific MAAP & WinMACCS runs for each 507
- All done 24 times to address the alternatives

Alternatives Analyzed

- Severe Accident Wetwell Vent
  - Phase 1 of EA-13-109
- Severe Accident Drywell Vent
  - Phase 2 Option 1 of EA-13-109
- Severe Accident Water Addition – SAWA
  - Phase 2 Option 2 of EA-13-109
  - RPV addition
  - Drywell addition
- Severe Accident Water Management
  - Phase 2 Option 2 of EA-13-109
  - Preservation of WW vent path
- Vent Cycling
- External filters

Considerations in Assessing Alternatives

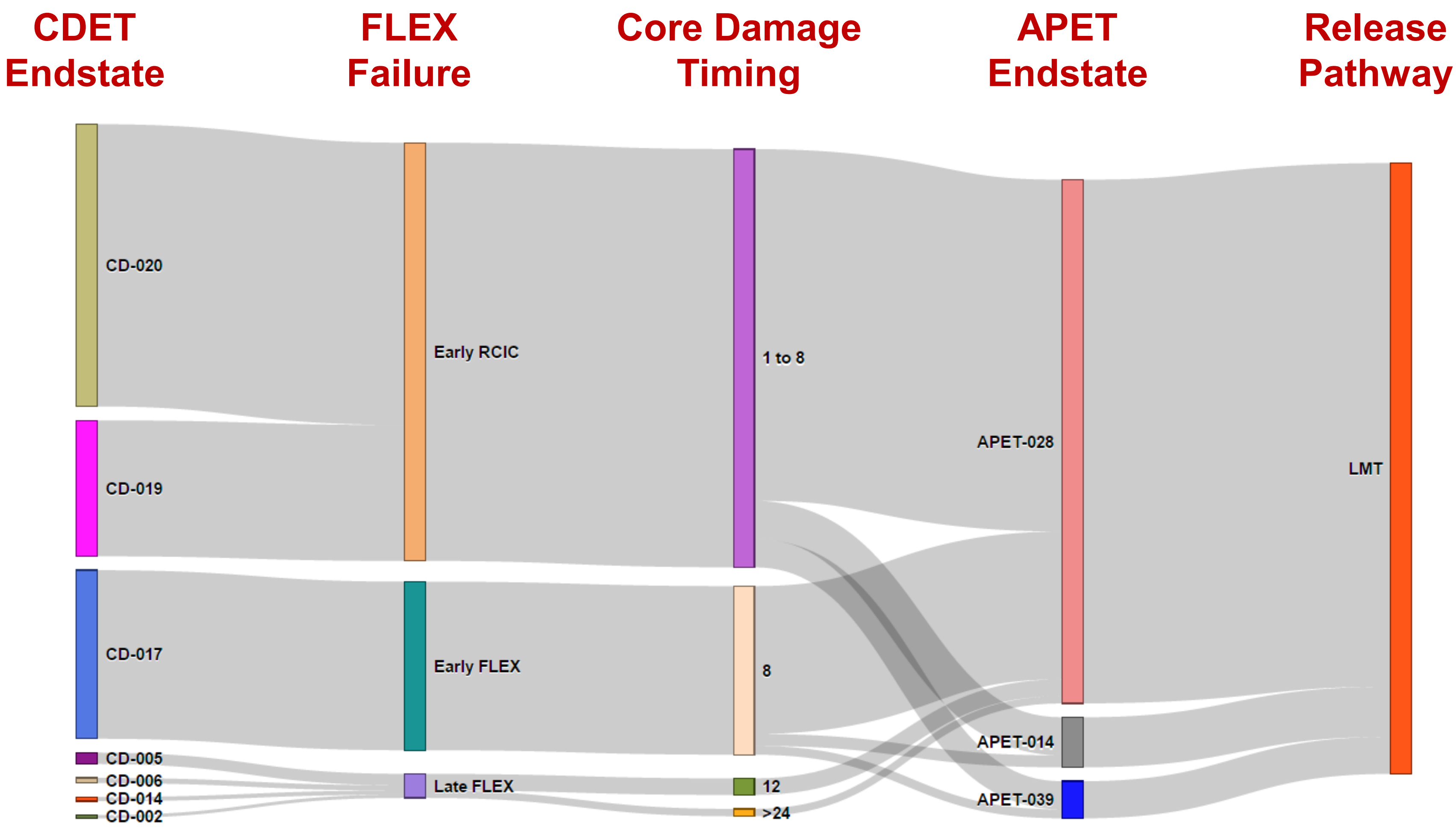
Risk Metrics

- Core Damage Frequency (CDF)
- Conditional Containment Failure Probability (CCFP)
- Latent Cancer Fatality (LCF) Risk
- Financial Consequence Risk

Other Considerations

- Defense-in-depth
- Containment temperature control
- Reliance on human actions
- Instrumentation requirements
- Release reduction
- Hydrogen control

Baseline Results Visualization



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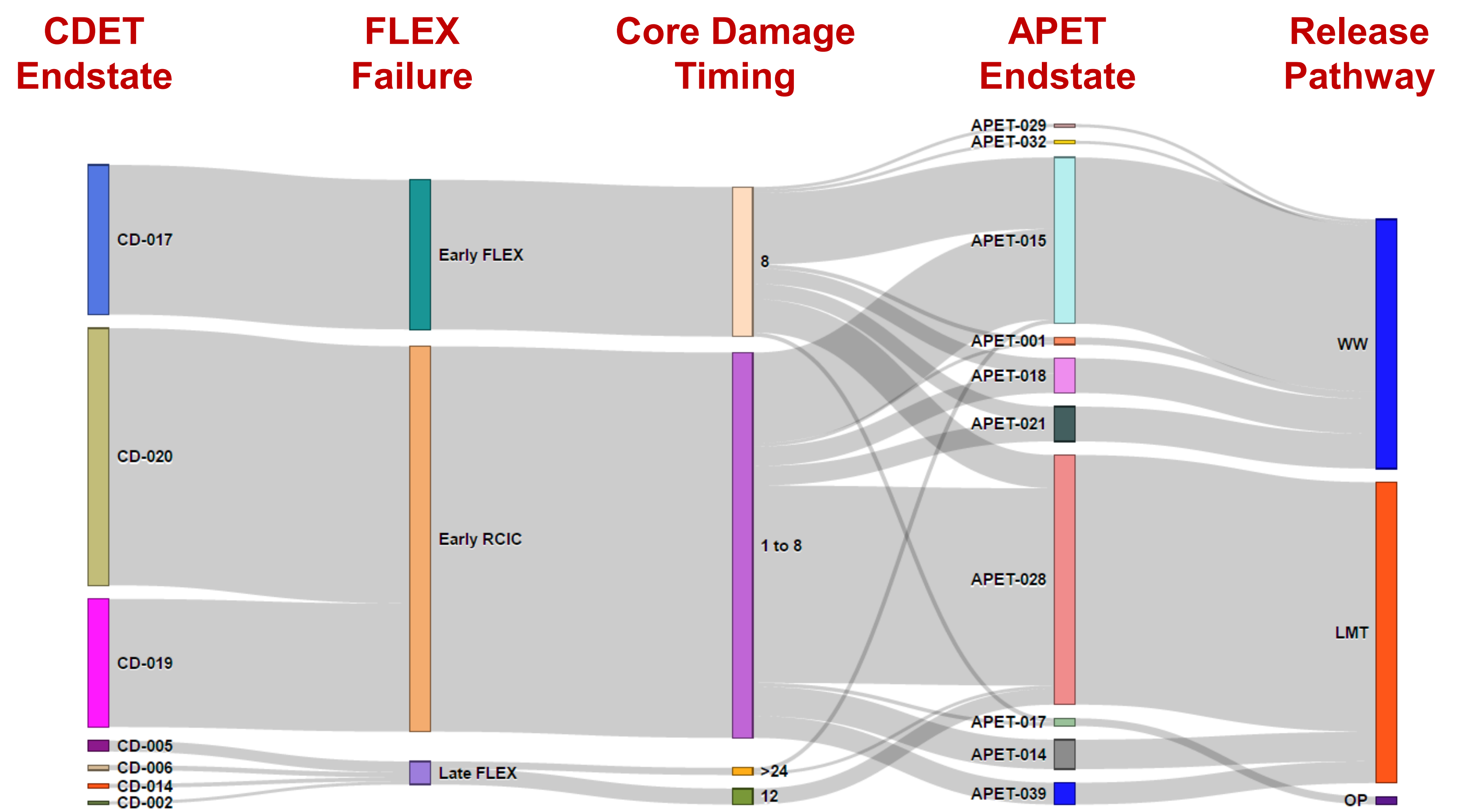
Cases with Water Addition Results Visualization



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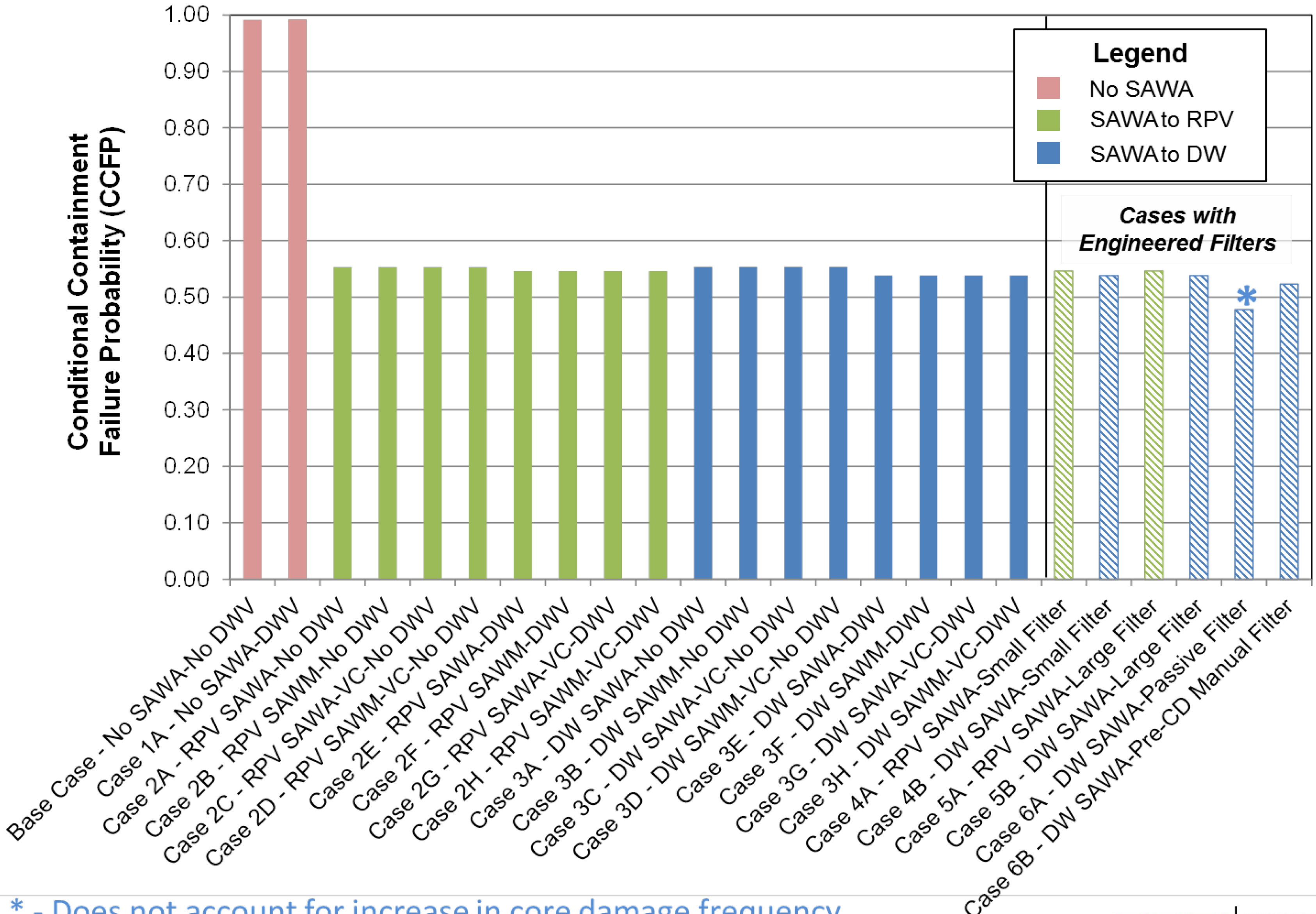
High-level Results for Mark I Containments

Conditional Containment Failure Probability



* - Does not account for increase in core damage frequency

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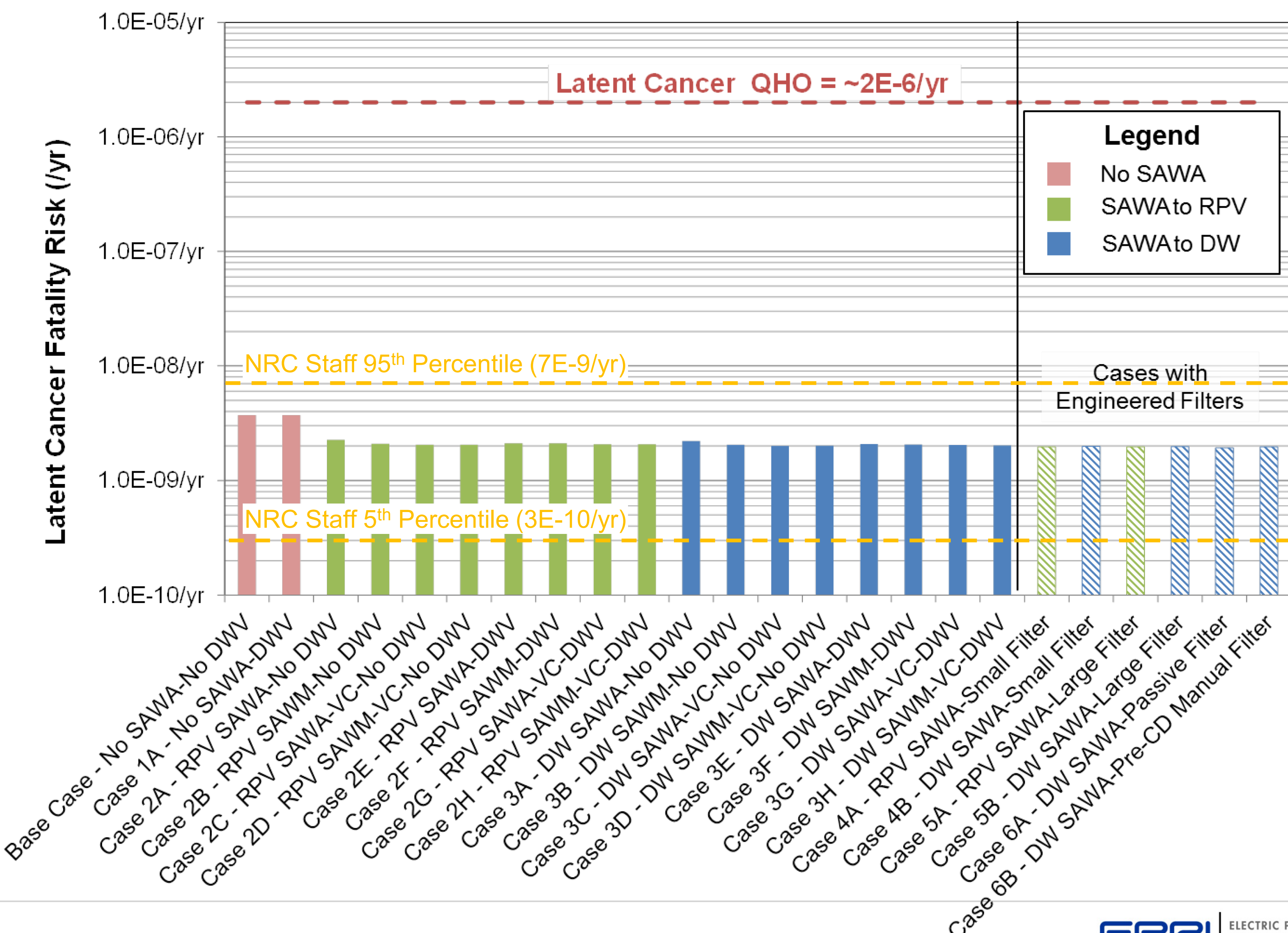
Latent Cancer Fatality Risk



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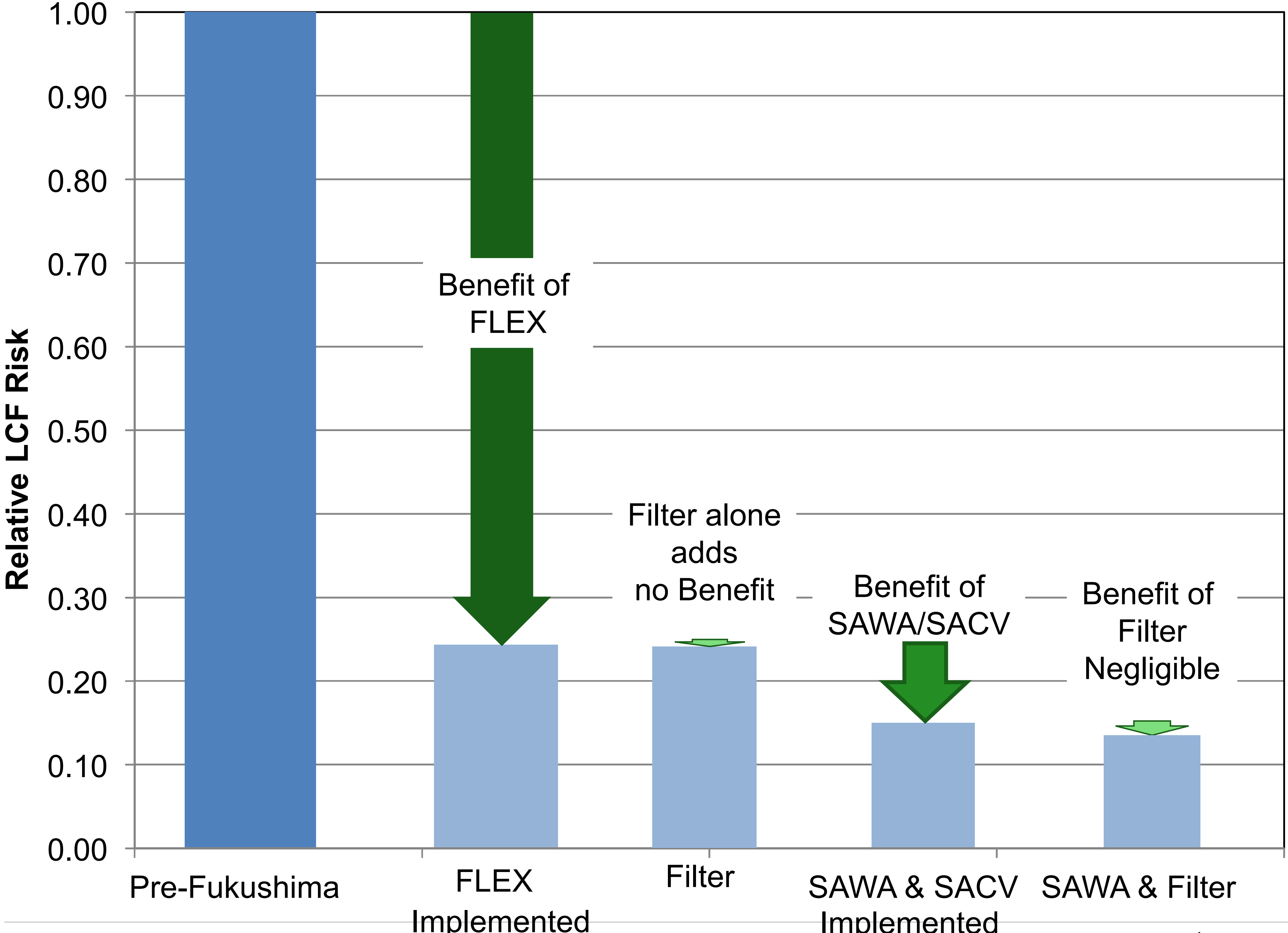
Latent Cancer Fatality Benefits



Insights

- Essential role of the operators
- Importance of water addition
- Incremental benefit of engineered filters
- Totally passive vent shown to increase CDF
- Sensitivity cases confirmed that the margins identified in the base results are not challenged by uncertainties

Conclusions

- Adoption of severe accident water addition strategies provides the greatest overall safety benefit, both in terms of protecting containment and reducing releases
- Manual actions would be required to manage the severe accident for all strategies
- Other alternatives, including installation of engineered filters, provide negligible additional benefit to public health and safety

Together…Shaping the Future of Electricity

Wang, Weidong

From: Paul Gunter <paul@beyondnuclear.org>
Sent: Tuesday, August 18, 2015 6:50 AM
To: Wang, Weidong
Cc: Hackett, Edwin; Freedhoff/ Michal; Lochbaum/David; Lampert/Mary.; M. V. Ramana; Von Hippel / Frank

Subject: [External_Sender] August 18, 2015 ACRS subcommittee meeting on Mark I & II CPRR

To the ACRS Subcommittee,

I regret that I am unable to attend the August 18, 2015 ACRS subcommittee meeting that regards the Containment Protection and Release Reduction (CPRR) rulemaking. Beyond Nuclear remains deeply concerned about the NRC staff recommendation to disallow public and independent expert comment on the public safety benefit of external, engineered, high-capacity radiation filters on all GE BWR Mark I and II pressure suppression containment systems in the rulemaking.

I request that the subcommittee please include my comments in the subcommittee's deliberations and meeting transcript as it considers the draft ACRS to the Commission on the CPRR rulemaking.

I am providing the link to AREVA's August 17, 2015 press release announcing the delivery of an external, engineered, high-capacity radiation filtrated containment vent system for installation on the Hamaoka nuclear power plant in Japan.

http://www.areva.com/EN/news-10583/nuclear-safety-delivery-of-venting-systems-in-japan.html

The fact that the global nuclear industry is proceeding with its 14th installation of filtered containment systems on boiling water reactors and pressurized water reactors in post-Fukushima Japan while the NRC staff proposes to deny public independent expert comment in its rulemaking on the matter is alarming on several points.

First, the AREVA announcement provides additional evidence of the current and timely availability of the state-of-the-art technology for more functional reliability to long-standing controversial Mark I and Mark II containment systems that remain vulnerable to catastrophic failure under severe accident conditions here in the United States.

Second, the announcement demonstrates that state-of-the-art public safety technology is being required and afforded in a timely manner under Japan's post-Fukushima regulatory regime while being denied even further consideration for the U.S. public safety.

Third, the current NRC staff recommendation to truncate the U.S. public's due process in the matter by excluding evidence of technological demonstration and regulatory oversight from deliberations in its rulemaking process is an apparent an effort to financially shield U.S. Mark I and II operators from an independent cost-benefit analysis.

The NRC staff has yet to explain why it proposes to deny formal public expert comments from any further deliberation in the CPRR rulemaking process. We believe the agency at least owes the public an explanation.

I further request the opportunity to raise these concerns and others at the ACRS full committee meeting in follow-up to the subcommittee's draft letter to the Commission on this matter presently scheduled in September 2015.

Thank you,

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