

Official Transcript of Proceedings
NUCLEAR REGULATORY COMMISSION

Title: Advisory Committee on Reactor Safeguards
 Reliability and PRA Subcommittee

Docket Number: (n/a)

Location: Rockville, Maryland

Date: Wednesday, March 5, 2014

Work Order No.: NRC-625

Pages 1-121

NEAL R. GROSS AND CO., INC.
Court Reporters and Transcribers
1323 Rhode Island Avenue, N.W.
Washington, D.C. 20005
(202) 234-4433

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

+ + + + +

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

+ + + + +

RELIABILITY AND PRA SUBCOMMITTEE

+ + + + +

WEDNESDAY, MARCH 5, 2014

+ + + + +

ROCKVILLE, MARYLAND

The Subcommittee met at the Nuclear
Regulatory Commission, Two White Flint North, Room T2B1,
11545 Rockville Pike, at 8:30 a.m., John W. Stetkar,
Chairman, presiding.

COMMITTEE MEMBERS:

JOHN W. STETKAR, Subcommittee Chairman

RONALD G. BALLINGER, Member

DENNIS C. BLEY, Member

MICHAEL L. CORRADINI, Member

HAROLD B. RAY, Member

JOY REMPE, Member

MICHAEL T. RYAN, Member

STEPHEN P. SCHULTZ, Member

ACRS CONSULTANT:

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23

WILLIAM SHACK

DESIGNATED FEDERAL OFFICIAL:

JOHN LAI

ALSO PRESENT:

EDWIN M. HACKETT, Executive Director, ACRS

THOMAS BOYCE, RES

ARTHUR CUNANAN, RES

JOHN KAUFFMAN, RES

MARTY STALLONE*

MARTIN STUTZKE, RES

BRIAN THOMAS, RES

*Present via telephone

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

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24

PAGE

1. Opening remarks

 Chairman Stetkar.....4

2. Generic Issues Program Overview

 John Kauffman.....6

3. Notional Analysis Approach

 Martin Stutzke.....27

4. Member Discussion.....91

5. Adjourn.....97

P R O C E E D I N G S

(8:30 a.m.)

1
2
3 CHAIRMAN STETKAR: The meeting will now
4 come to order. This is a meeting of the Reliability and
5 PRA Subcommittee. I'm John Stetkar, Chairman of the
6 Subcommittee meeting.

7 ACRS members in attendance are Ron
8 Ballinger, Harold Ray, Steve Schultz, Dennis Bley, Mike
9 Ryan, Joy Rempe, and Mike Corradini. We're joined also
10 by our consultant Dr. Bill Shack. John Lai of the ACRS
11 staff is the designated federal official for this
12 meeting.

13 The Subcommittee will hear a brief
14 presentation of the Generic Issues program. We'll also
15 discuss the scoping estimates of the multi-unit site
16 risks analysis. There will be a phone bridge line. To
17 preclude interruption of the meeting the phone will be
18 placed in a listen in mode during the presentation and
19 committee discussion.

20 We have received no written comments or
21 requests for time to make oral statements from members
22 of the public, regarding today's meeting. The
23 subcommittee will gather information and analyze
24 relevant issues and facts, and formulate proposed
25 positions and actions as appropriate for deliberation

NEAL R. GROSSCOURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 by the full committee.

2 The rules for participation in today's
3 meeting have been announced as part of the notice for
4 this meeting, previously published in the Federal
5 Register. A transcript of this meeting is being kept,
6 and will be made available as stated in the Federal
7 Register notice.

8 Therefore, we request that participants in
9 this meeting use the microphones located throughout the
10 meeting room when addressing the Subcommittee. The
11 participants should first identify themselves, and
12 speak with sufficient clarity and volume, so that they
13 may be readily heard. We'll now proceed. And I call
14 upon Tom Boyce of the NRC staff. Do you have any opening
15 comments?

16 MR. BOYCE: Well, good morning, I guess.
17 We work in the Generic Issues branch, and we think we
18 do a great job. And we are happy, actually, to have had
19 the opportunity to have an article published inside NRC
20 on this particular topic, where we screened out the
21 multi-unit risk.

22 And as a result of that article we came to
23 light, we got noticed. And I think we really welcome
24 the opportunity to be able to tell you about what we
25 do.

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 CHAIRMAN STETKAR: Thank you for that. I
2 don't know who's going to take the lead. John?

3 MR. KAUFFMAN: Good morning. My name is
4 John Kauffman. I'm the program lead for the Generic
5 Issues Program. To my left is Marty Stutzke, who is
6 going to be briefing on the notational analysis that
7 he developed. And over on the far left is Arthur
8 Cunanan, who's a Generic Issues staff member.

9 As Tom already mentioned, this issue has
10 received some attention from outside, in an inside NRC
11 article. And also the Union of Concerned Scientists has
12 been critical of our screening out of this issue, based
13 on the Fukushima event.

14 The staff initiated this issue. It was
15 proposed by the SOARCA staff in research. And it became
16 a proposed Generic Issue in 2008. At that point in time
17 what did we know? We realized that there are no legal
18 requirements for single unit PRAs. We realized that
19 there were no multi-unit PRAs. So it would be very
20 difficult to get information on this issue based on that.

21 We also had the understanding, or the
22 thought that this topic is mostly driven by external
23 events that could affect both units. And we had a
24 Generic Issue underway on Generic Issue 199 on seismic.
25 And soon thereafter we had an Issue that became, on

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 flooding that became GI-204.

2 And we also knew that it would be a major
3 effort to develop multi-unit PRAs. And it didn't seem
4 like there was justification to push the industry that
5 way. And it wasn't even clear that there was, could be
6 justified to spend this type of resources in research
7 to develop that.

8 So this was a topic that the Generic Issues
9 program staff initially felt would require longer term
10 research to be understood. And one of our criteria is,
11 topics that aren't really understood, and that will need
12 longer term research, should not become Generic Issues.
13 They should become research projects, or perhaps not
14 pursued at all.

15 Anyway, the research management in place
16 at the time decided to exercise the program to develop
17 agency wide consensus on what to do with this issue.
18 So this issue was accepted and it went to screening.

19 The screening panel was made up of three
20 members. Sunil Weerakkody was the panel Chair, Don
21 Budde from New Reactors was a member, and Marty Stutzke
22 was also a member. And as the issue progressed the
23 screening panel came back. And they also recommended
24 that it not be a GI.

25 But research management kept pressing us

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 about, is there something we can do? Is there some sort
2 of a bounding analysis that we can do to show that the
3 risk is low, and that this isn't a topic that needs to
4 be pursued quickly? And so, we continued to work as a
5 panel and engage.

6 Then real life intervened. Fukushima
7 happened. And much of the staff was redirected in
8 responding to that. In fact, I went to JLD for about
9 eight or nine months. This issue sat in limbo for a
10 little while.

11 But remember, as I talked about, it would
12 be a major effort and take time to develop the multi-unit
13 PRAs. So it was a case of, I don't think the delay was
14 harmful. Next slide, please.

15 As a very brief overview, we're moving to
16 a three stage Generic Issue Program. I briefed the full
17 committee about three years ago. And at that point
18 there was a five stage program. Since then there's been
19 a tiger team to improve the program.

20 And it's been decided that the
21 identification and acceptance review stages could be
22 eliminated. And the second stage in the current
23 program, which is the technical assessment and
24 regulatory assessment, which we're going to call
25 assessment, could be combined.

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 And then typically when we have figured out
2 what agency action needs to be taken with an issue, then
3 it gets sent to the program office for implementation.
4 And that was considered to occur outside of the program
5 in the past.

6 With this revision that we're currently
7 doing that stage will now be within the program. And,
8 of course, the issue can exit when it fails the criteria,
9 or it goes through additional research. Or this last
10 flow, if it isn't really corrected. If it goes to
11 another office for implementation, then it's still in
12 the program. Next slide, please.

13 The program's criteria are basically set
14 up that whatever we're dealing with can pass backfit.
15 So the first criteria is it must pass, it must effect
16 public health and safety. Virtually everything does
17 that. So that has some embedded risk criteria in it.
18 And basically, if we can show that the risk of something
19 falls below ten to the minus fifth, then it would screen
20 out.

21 Second criteria is that issues have to be
22 generic. And we try not to be duplicative with other
23 programs. So the third criteria is it's not readily
24 addressable through established or existing programs.

25 And the fifth criteria, can have its risk

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 or safety significance adequately determined. That
2 gets to what I mentioned before, that if something needs
3 a lot of work to understand it, perhaps it's appropriate
4 for that work to be done.

5 But until we understand it, it's not
6 something that we can justify taking action at the plan.
7 And we want our issues to be defined and discrete. And
8 ultimately, we want issues that will result in action
9 by licensees.

10 An example there, and we go back to TMI.
11 There was a Generic Issues that headquarters staff be
12 consolidated in one building. Now that is not something
13 that would effect licensees. So in today's program we
14 would not take that as a GI. Because it's really, other
15 than where licensees would send things, it's really not
16 something in the licensees' purview. Next slide.

17 The crux of this issue is that multi-unit
18 core damage sequences may challenge the ability of the
19 plant operating personnel. They may require resources
20 beyond those available for single units. And there's
21 a potential for increase in offsite consequences.

22 And the third bullet kind of sums this up.
23 To really understand what that means, and how important
24 those issues are it would require quantification through
25 development of a PRA.

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 And just as some background, there are 32
2 sites with two operating reactors. And there are three
3 sites with three operating reactors. And in addition,
4 there are some sites that are near to each other, like
5 Nine Mile and FitzPatrick, and Salem and Hope Creek.
6 Next slide.

7 As we talked about, the first script here
8 in the program is a risk component. And the reason we're
9 here today is that second bullet. Marty developed a
10 highly simplified notational analysis. And this
11 analysis, he'll get into it in gory detail.

12 But this analysis suggests that the
13 currently operating plants meet the NRC safety goal
14 policy for single units. And therefore, it appears that
15 the risk of this topic is low. And it's a major
16 justification for why there's time to perhaps pursue
17 multi-units done on PRAs, and that interim regulatory
18 actions are not needed.

19 The thinking of this issue also failed the
20 fifth criteria. And the idea there is, we did use a
21 highly simplified analysis to develop a belief, or a
22 basis, that we don't think this is highly risk
23 significant.

24 However, until you actually do a full blown
25 Level 3 PRA for a number of sites, you won't absolutely

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 know that. And that activity would take a long time.
2 And so this potential issue also failed on the idea that
3 it would require longer term research to fully look at
4 and evaluate. Next slide.

5 So the bottom line is, going forward, in
6 addition to Marty's analysis, we note that the near term
7 task force from Fukushima has reduced multi-unit risk
8 with some of their 2.1, 2.3 seismic and flooding
9 walkdowns and evaluations, the actions for the flex
10 equipment, looking at emergency staffing, and those sort
11 of things.

12 And research staff is also continuing to
13 pursue insights into multi-unit risk via the Level 3
14 PRA project. And staff is expecting to have results
15 from that in 2017. And, as with all Generic Issues, if
16 that project results in insights that suggest reopening
17 this issue, then that issue can be reopened at that time.

18 So that is the result of the screening. If
19 there are any questions we'll be glad to take them. If
20 not, Marty's ready to talk about his notational
21 analysis.

22 MEMBER CORRADINI: Can I ask about the last
23 bullet, staff is continuing? So when you do this for
24 the Level 3 project, are you going to include all four
25 units, or just the two current units?

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 MR. STUTZKE: Just the two current units

2 MEMBER CORRADINI: The logic being, since
3 there's going to be four there anyway?

4 MR. STUTZKE: No, the logic being, let's
5 analyze what we have the detailed designs for, and
6 adjusting risk assessment for.

7 CHAIRMAN STETKAR: Let me ask, John,
8 something about process. ACRS typically is involved in
9 issues that are raised to the level of a Generic Issue.
10 We typically follow those and have briefings, if not
11 more formal interactions.

12 Why is the ACRS not routinely involved in
13 issues like this, and supporting analyses and decisions
14 that are made to not pursue something as a Generic Issue?

15 MR. KAUFFMAN: The reason we're having this
16 meeting is literally, we discovered it through, you
17 know, a news item. And, okay, well I guess the short
18 answer is the process isn't really set up for that.

19 And one thing to remember is, we get all
20 sorts of things submitted to us. They can be more
21 worried about nuclear safety. And so our process is set
22 up so that some things we can dispose of, we don't spend
23 a lot of time on, and can dispose of fairly quickly.

24 For the issues that do become GIs, we put
25 out probably an internal reports on those issues, that

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 are updated every quarter. And we also put out a
2 periodic report on the status of proposed issues. That
3 comes out about twice a year, once or twice a year.

4 So I guess part of it is we think it is set
5 up for NRC staff and others to be aware, and weigh in
6 on the issue if they want. Certainly it is something
7 we can look forward.

8 As I said, we are redoing our management
9 directive and our process. And it's out for comment.
10 So certainly that is something you can comment on. And
11 something we can take back and include on our MD rewrite
12 and update.

13 CHAIRMAN STETKAR: I look at this as
14 somewhat, from our perspective, from the committee's
15 perspective, as something that's somewhat analogous to
16 updating regulatory guides, for example. Different
17 issues, but in terms of process.

18 We essentially receive information from
19 the staff whenever a regulatory guide is updated. We
20 look at the merits of the substance of the proposed
21 update. And at that point we make a decision about
22 whether or not we want to pursue it further, or we think
23 it's primarily an administrative, you know, update, or
24 something like that.

25 But at least we're given the opportunity.

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 There's a formal communication that informs us that
2 there's activity afoot, if you will. And gives us the
3 opportunity if we decide to weigh in or investigate it
4 a little bit more deeply.

5 Essentially, it doesn't require the ACRS
6 to cull through tons of information that's produced by
7 the NRC staff every year, in terms of what's happening.
8 And some of these issues could conceivably be more
9 weighty than, for example, an administrative update to
10 some regulatory guide.

11 So we may want to think about a more formal
12 method of communication, to alert us when you do reach
13 a decision about something. Certainly when something
14 is raised to the importance of being a Generic Issue,
15 we're informed of that. But, all right, these decisions
16 that fly below the radar is, at least from our radar
17 anyway.

18 MR. KAUFFMAN: Right. And we just had a
19 realignment of the program. The program got moved from
20 Research DRA to Research Division of Engineering. And
21 Tom Boyce just happens to own the Reg Guide branch and
22 updates. So I think it's a perfect opportunity for us
23 to think about how to re-engage, or engage differently.

24 MR. BOYCE: Yes. If I could draw a parallel
25 to the Reg Guide process? We give the opportunity to

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 review draft guides. But it's a question of maturity.
2 We develop initial staff positions to the point where
3 we want to issue a revision and a draft guide, or new
4 guidance and a draft guide.

5 And so really we need to bring an issue to
6 an issue to a state of maturity before it's worthwhile
7 talking about. And in this case we are in the screening
8 process. So we had a panel that met, brought it to a
9 state of maturity. And we issued a memorandum from the
10 panel saying, here's our finding.

11 So at least in this one example, you're
12 getting the information in an analogous manner when it's
13 mature enough that we have an opportunity to weigh in.
14 In this case we said, we don't want to take a position.

15 But we do, the next stage of the process
16 is pass screening into assessment. And then during the
17 assessment this might be a good opportunity for you to
18 weigh in and review it. I would suggest we -- These memos
19 are publicly available. And have your ACRS staff take
20 a look at the ones we've recently issued.

21 And then maybe we can decide whether or not
22 you'd like to review the types of issues we look at.
23 But I would suggest after the panel meets and does the
24 screening analysis, is the right level of maturity for
25 that opportunity.

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 MEMBER BLEY: That would make sense.
2 John, I'd like to take you back to your Slides 3 and
3 4, and ask a couple of questions. Because I haven't been
4 following this all the way.

5 You said that the new revised three stage
6 program here dropped off the first two steps, which were
7 kind of the same as, described how things actually get
8 to you, right?

9 MR. KAUFFMAN: Right.

10 MEMBER BLEY: Can you describe that process
11 that's now a part of your program, to me? How do things
12 get to you?

13 MR. KAUFFMAN: Things can be sent us, any
14 member of the public can propose a Generic Issue. And
15 also NRC staff members, as members of the public and
16 as NRC staff, can propose issues. Although we do
17 encourage NRC staff members to work through their chain
18 of command.

19 And each office also has a contact, a person
20 that's familiar with the Generic Issues program, that
21 we ask them to work through. But they can be submitted
22 via email, it can be submitted via memo.

23 MEMBER BLEY: Okay. But they come
24 actually as effectively a letter saying, I propose this
25 as a Generic Issue?

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 MR. KAUFFMAN: Yes.

2 MEMBER BLEY: So all of those go into this
3 process that's on the chart here? Anything that shows
4 up on your desk as a proposed Generic Issue?

5 MR. KAUFFMAN: Well, as I said, if it's
6 something that is kind of frivolous like, I'm worried
7 about nuclear safety, we work with the submitter and
8 try to focus their concern on something that we can work
9 with.

10 And it's a little bit of an art form as to
11 when we might combine issues, and when we might separate
12 issues. But, yes. The idea is that it's a very open
13 program. And we document the results so people can see
14 what has become of the issue.

15 MEMBER BLEY: There's a little informal
16 front end where you work things out. But if whoever
17 submitted the idea still wants it, it then comes into
18 this program.

19 MR. KAUFFMAN: Right. It comes in. And a
20 big part of working with them there is, we know the
21 criteria, we know the type of things that will cause
22 it to fail. And so we work with them to try and develop
23 wording or justification, such that it doesn't fail.

24 We also do a review for duplication.
25 Throughout the history of the program there's been about

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 850 issues. And if somebody re-proposes an old issue
2 we will try and identify that, and see if anything has
3 changed that would justify re-opening or a different
4 conclusion.

5 To answer your question, the new version
6 of the management directive will talk about the
7 criteria, identifying and submitting issues. We're
8 just not calling that a stage. And what we called
9 acceptance review in the past, which was at a low level,
10 the branch chief could say, it clearly doesn't meet the
11 criteria, we're not going to accept it.

12 There is still going to be a provision in
13 the screening that if it clearly doesn't meet the
14 criteria that it can be closed out at that point. In
15 many ways this three stage process is -- People were
16 confused by the five stages. So this is being helpful.

17 I would say a major change that isn't on
18 this slide is, the current program, when something
19 passes screening and gets to communications plan, it
20 gets to public meeting, and it gets designated as a
21 Generic Issue.

22 The new program, it will not become a GI
23 until the assessment is completed, and the agency is
24 deciding to take action. So in the future, GIs will not
25 be a thing where the agency might be taking action. They

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 will be things where the agency has decided.

2 MEMBER BLEY: Already moves through
3 assessment, and is implemented as a GI. Can we go to
4 the next slide? Some of these, and I haven't ever
5 followed your process. Some of these seem a little
6 sticky to me.

7 I mean, Item 1, it must effect public health
8 and safety. And you said that is the core damage risk
9 of ten to the minus fifth per year or higher, I think
10 is what you said.

11 MR. KAUFFMAN: Right.

12 MEMBER BLEY: But in Item 5 somehow you've
13 already decided the risk up in 1. And then we come to
14 5, that you must be able to adequately determine the
15 risk. But you're actually using that in 1. So they seem
16 a little confused.

17 MR. KAUFFMAN: Well, I think one way to look
18 at this is, the criteria -- As an issue works through
19 the process we learn more about it. And I think, and
20 at any point it's determined that it's failed these
21 criteria, then the program can decide that it's not a
22 Generic Issue, and then stop dealing with it.

23 So the first one, at least initially, is
24 the topic must kind of have the potential to be a big
25 safety issue and deal. And later on in 5, once we

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 determine its significance, if at that point we think
2 it can't pass backfit, then we don't really have a
3 choice. Our hands are tied, and we have to move on.

4 So 5 in a different wording might be, is
5 this something we understand? Or is this going to take
6 long term research? Because as you're probably aware,
7 one of the historical, or one of the criticisms for a
8 long time of the program has been that it's not timely
9 in handling issues.

10 MEMBER BLEY: Some of the, for long term
11 research issues, yes.

12 MR. KAUFFMAN: Yes. And so one way we've
13 tried to address that is, if the thing is, you know,
14 Brian Sheron has told me on many occasions, if something
15 is a bonafide safety issue we want to work it, we want
16 to deal with it, and move on.

17 But things, you know, true safety issues
18 shouldn't take 20 years to work on. So part of that
19 solution is, if it's going to take longer term research,
20 we're just not going to call it a GI.

21 MEMBER BLEY: Okay. Well, my last
22 question on the structure of how you do things. Well,
23 my second to last question is, something comes in, it
24 goes through your screening and assessment, and you
25 decide it should not be a Generic Issue. What mechanism

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 defines that? Is there memo to file or, you know, what
2 is the resolution?

3 MR. KAUFFMAN: Actually, the way the
4 process is set up is, all of the effected office
5 directors are on concurrence for that panel memorandum.
6 And Brian Sheron, as the executive sponsor of the
7 program, he has to agree and endorse on that
8 recommendation.

9 MEMBER BLEY: It's an executive memorandum
10 essentially from research?

11 MR. KAUFFMAN: Right. With concurrence by
12 the other offices.

13 MEMBER BLEY: By the other offices, okay.
14 So there's a formal record of it?

15 MR. KAUFFMAN: Right.

16 MEMBER BLEY: And my last question is, the
17 new way it's being rearranged. I think you said it's
18 in a management directive that's still in draft. Is
19 that right?

20 MR. KAUFFMAN: There's a management
21 directive on the books. There's Management Directive
22 6.4. And we are revising that management directive and
23 the associated research office instruction, Tech 002,
24 that gives the detailed guidance on the program.

25 And as you're aware there's a, probably

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 aware, there's a fairly involved process to revise a
2 management directive. It has to go, it has to be
3 prepared. It has to go out to the offices, IG, EDO, ACRS,
4 for comment.

5 And then we get the comments back, resolve
6 the comments. And so the three step process I described
7 is not the process on the books. But it's the process
8 we're moving to.

9 MEMBER BLEY: Okay. That helps me.

10 MEMBER SCHULTZ: Does it envision then that
11 the memo report is going to incorporate both the
12 screening and assessment results? You mentioned that,
13 it sounded as if there was present a couple of different
14 streams of reporting assessment, and then screening
15 memos. You said the screening memos might come out
16 twice a year.

17 MR. KAUFFMAN: Well, at each stage --

18 MEMBER SCHULTZ: What do you envision with
19 these --

20 MR. KAUFFMAN: -- there will be a memo that
21 documents completion of that stage. Currently we put
22 out quarterly reports on the status of all active Generic
23 Issues. And we put out a report about once a year on
24 the status of proposed issues.

25 MEMBER SCHULTZ: Once a year.

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 MR. KAUFFMAN: And those are available on
2 the internal website, and also on the public website.
3 We can easily enough give people those links, or show
4 them where they are.

5 MEMBER SCHULTZ: Go back one slide. The
6 proposed issue report is focused on screening? And you
7 also have the exit approach associated with assessment.

8 I'm trying to understand, if we were to look
9 for what comes out of the program, into the bottom box,
10 through that exit path, is that going to be in the future
11 one report? Or is it going to be something different?

12 MR. KAUFFMAN: What we will have is, we will
13 have one report on the proposed issues, until they
14 complete assessment. Although there will be a memo that
15 comes out documenting the completion of screening.

16 MEMBER SCHULTZ: Separately?

17 MR. KAUFFMAN: Yes.

18 MEMBER SCHULTZ: Okay.

19 MR. KAUFFMAN: And of course, any pre GI
20 report would have a link to that screening memo, and
21 give the results of the screening in summary form.

22 MR. BOYCE: Maybe this would clarify it. I
23 think you have a copy of the results of the screening
24 memo for this particular issue. It's dated December
25 2nd. So what you're seeing is, at least where that first

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 arrow comes down from the screening block, you're seeing
2 the document, the staff documentation.

3 It's about a 20 page memo. And what it does
4 is assess the project against the criteria. That's the
5 first stage. And then it lets us seemingly add a
6 different result when we accepted it into the program
7 for further analysis.

8 We further developed the safety
9 significance, and established more of the technical
10 basis in the assessment process. And then developed
11 potential options for regulatory implementation.

12 So the next report that you would see, which
13 is the second arrow in the middle of that screen, coming
14 down from assessment, would be a documentation of all
15 that additional type of information, after the -- What
16 I said before is, if you want to take a look at these
17 type of memos, December 2nd, that's the right
18 opportunity.

19 CHAIRMAN STETKAR: Yes, okay.

20 MR. BOYCE: Because we've made at least an
21 initial call --

22 CHAIRMAN STETKAR: Yes. Because as this
23 one, if they don't pass the screen they don't carry
24 forward.

25 MR. BOYCE: Well, they don't carry forward

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 in our program. The reason you might still want to
2 review it is in case you thought the staff ought to pursue
3 further research or --

4 CHAIRMAN STETKAR: Exactly, exactly.
5 That's right.

6 MR. BOYCE: So the decision would be
7 broader than just the Generic Issues program. It would
8 be an agency level type decision that you'd be advising
9 on.

10 MEMBER BLEY: But I think I agree that
11 before it hits this point it's too amorphous for us.

12 CHAIRMAN STETKAR: Oh, yes. That's
13 absolutely true. That's right.

14 MEMBER BLEY: Thank you.

15 MR. KAUFFMAN: Any other questions, so we
16 can move on to Marty Stutzke's presentation?

17 MR. STUTZKE: Let's go for it. So I'm Marty
18 Stutzke, the, well I'll give you the formal title, Senior
19 Technical Advisor for Probabilistic Risk Assessment
20 Technologies in the Division of Risk Assessment, Office
21 of Nuclear Regulatory Research. And it's my, I guess
22 whenever John --

23 CHAIRMAN STETKAR: So, okay, we can just
24 call you Marty, right?

25 MR. STUTZKE: Yes. You can just call me

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 Marty. Whenever John gets these hard problems I find
2 him sitting in my office, which is how I was introduced
3 to this multi-unit Pre-Generic Issue.

4 As John had mentioned, the origin of the
5 concern came out during the SOARCA sequence selection.
6 It was actually identified by Rick Sherry. I'm certain
7 most of you know Rick. And he was looking at sequences
8 at a few of the plants. And the staff's PRA, not the
9 staff's, but the licensees' PRA staff said, you know,
10 this is a multi-unit accident. And he goes, huh, how
11 about that.

12 So a long debate ensued within the SOARCA
13 project about, maybe they should just analyze the effect
14 of the multi-unit, by tricks such as doubling the source
15 term, or something like that. Ultimately they decided
16 not to pursue that. And hence, the motivation not to
17 lose the concept to enter it into the Generic Issues
18 program.

19 This has been, as John had noted, some time
20 in evolving. Certainly I need to thank Rick, in
21 addition, for raising the problem. Thank Brian Sheron
22 for demanding that it be answered to an appropriate
23 level.

24 Many discussions with my former Deputy
25 Division Director, Doug Coe, on the idea of a notional

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 model. And some discussions with Nathan Siu and Steve
2 Lowers, my fellow SOSers, who did all the mathematics
3 review for me.

4 I'll point out, this notional model is being
5 presented at the PSAM Conference in Honolulu this
6 summer. So, Honolulu sounds good right about now. Like
7 that. So, flipping through briefly. I'll try to give
8 you a little background here.

9 We'll talk about sequence delineation in
10 a multi-unit environment. I don't know. All good
11 presentations require some math. And so you've got mine
12 for probably the next five years, and some example
13 estimates like that. So, what the frontispiece, you
14 know, the quote from Box and Draper about all models
15 being wrong, but sometimes they're useful. Bear that
16 in mind here, like that.

17 I should also point out, one of the other
18 things that I do in life is that I'm the task leader
19 for the multi-unit part of the Site Level 3 project that
20 the Office of Research is doing. So I've been thinking
21 about this from a broad viewpoint of how we can modify
22 existing event tree, fault tree methodology to treat
23 multi-unit risk, in addition to this notional model that
24 came up.

25 Okay, Slide 11. We'd talked before about

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 how many sites are actually multi-unit. And this is my
2 list. Like that, we'll point out, you know, there are
3 always the odd duck situations, you know, adjacent
4 sites, like Salem, Hook Creek, and Nine Mile Point and
5 FitzPatrick that are physically together, but they're
6 actually separate units.

7 You'll see why that's important. The
8 physical proximity is important for things like external
9 events. So one would expect a seismic event would not
10 just effect Hope Creek, but Salem would also feel it,
11 things like that.

12 At the same time, if we're worried about
13 multi-unit risk that is due to shared systems, you know,
14 a lot of plants have interconnections like this. Then
15 within Salem 1 and 2, one would expect that type of
16 effect. But perhaps not between the Salem units and
17 Hope Creek Point. Okay. And of course, excluding the
18 new units being built at Summer and Vogtle. And
19 exploiting the units at San Onofre. Okay.

20 So Slide 12. Let's be clear, when I talk
21 about site risk, I'm talking about the accidents that
22 effect one or more sources on the site. The typical PRA
23 looks at one radiological source, for example, the
24 reactor core, Surry Unit 1, or Surry Unit 2, et cetera,
25 et cetera. And that's normally what we do inside a PRA.

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 And so we fixate on one source.

2 The issue here is, we could have multiple
3 combinations of radiological sources being impacted,
4 as happened at Fukushima. So looking at the types of
5 radiological hazards on the site, we have the fuel inside
6 the reactor, spent fuel that's stored in the pools, or
7 dry cask.

8 And so in principle we would like to be able
9 to address all combinations of that type of things with
10 the -- That's exactly what we're doing in the Site Level
11 3 project. Or at least that's our intention.

12 And it is not just considering when the
13 reactor is operating, but during various shutdown and
14 low power states of operation. So Unit 1 could be
15 operating, Unit 2 could be in refueling, and some sort
16 of accident occur. And we will try to pick up all of
17 the sorts of things like that.

18 As you can imagine, it becomes an enormous
19 bookkeeping problem to try to keep track of that. Other
20 people have suggested various approaches, you know.
21 One I'll call the naive approach. They say, well, I know
22 the single unit risks, I'll just multiply it by the
23 number of units and I'm done, right? Well, I wish it
24 were that easy, like that.

25 So the idea of a notional model comes out,

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 as John had mentioned before, you know. When we do a
2 Generic Issue assessment the general guidance is, pick
3 a representative plant. Well, it's hard to pick a
4 representative plant when you're talking about
5 multi-unit risk. The external hazards are different.
6 The seismic hazard varies from site to site. The units
7 differ in the amount of their interconnections, you
8 know.

9 An example of a highly interconnected
10 system is at Browns Ferry, where a lot of systems are
11 shared. At the Site Level 3 project we picked Vogtle.
12 And the committee's previously heard why we ended up
13 with that. In my perhaps sarcastic view of the world,
14 Vogtle got picked because they were the ones that raised
15 their hand, like that.

16 But we're finding at Vogtle is that it does
17 not share many systems from unit to unit that are
18 important to safety. So just to pick a single unit, and
19 to, or a single site, and to be able to do a detailed
20 Site Level 3 PRA, gives us insights about that site,
21 gives us insights about methodology. But it's hard to
22 extrapolate the results, and make a broad claim that
23 no site has an issue like this.

24 That being the case, when I was first
25 approached to do this, you know, I said, fine, you know,

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 give me X million dollars and I'll be back in 20 years,
2 and we'll have the answer.

3 MEMBER CORRADINI: You really did that,
4 huh?

5 MR. STUTZKE: Not acceptable. Well my
6 first attempt was --

7 MEMBER CORRADINI: What are you, some sort
8 of researcher or something?

9 MR. STUTZKE: Yes, well, what can I say,
10 like that. So the idea is, can we do something with the
11 results of the single unit PRA to scale it up, or to
12 otherwise estimate total site risk? That's the premise
13 here.

14 So simple view of a Level 3 PRA, and this
15 is highly simplified, is we have some initiators that
16 come in, and we do a plant response, the so called Level
17 1 analysis that decides whether core damage has occurred
18 or not. We will then, if core damage occurs, go into
19 the containment response, the Level 2 portion of the
20 analysis.

21 And basically you get three types of
22 results, you know, where everything's okay. You might
23 have a core damage, but there's no release. Or you have
24 a core damage and subsequent release. And so, to
25 estimate the risk after all of this high powered math,

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 event tree, fault tree logic, the mean risk turns out
2 to be the frequency of accidents, sequences times their
3 consequence, and add them all up. Not that simple.

4 Now, thinking about it in a multi-unit
5 environment, we have to realize that any sequence may
6 cause an initiating event in the other units at the site.
7 For example, one could imagine an initiating event that
8 occurs, say at Unit 1, say a LOCA. And Unit 1 behaves
9 as expected. And the effects of that LOCA are
10 mitigated, and there's no core damage.

11 At the same time the other units will see
12 perhaps a consequential loss of offsite power, due to
13 the drop of load when Unit 1 went down. Now they're the
14 ones being challenged. So it's inappropriate simply to
15 focus on extending the core damage sequences for one
16 unit into the other units.

17 You have to worry about these success paths
18 of the event tree, that could also serve as initiating
19 events for the other units, like this. And of course,
20 floating around here is the need to consider the
21 dependency among all the units, the shared systems.
22 Those are the most obvious ones.

23 Common cause failures now cross the units
24 like this. And, you know, perhaps the hobgoblin, as
25 Doug True has called it, is the human actions floating

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 around.

2 As we have mentioned before, you may
3 overwhelm your available resources when the accident
4 occurs. It's one thing to have an accident at 9 o'clock
5 on Monday morning. And it's totally different if it
6 happens at 2 o'clock Sunday morning. But just from
7 numbers of people available, like this.

8 Also, a practical limitation is that when
9 we do these things is, we don't always know individual
10 sequences. We don't have all of the parts of the PRA.
11 We generally get our high level results like this.

12 To remind you, the staff maintains SPAR
13 models, the Standardized Risk Analysis that we use for
14 various regulatory purposes. And the SPAR models
15 normally are internal events at full power.

16 We have some SPAR models that cover external
17 events up to Level 1. There are some proof of concept
18 models that go to Level 2. And there are no Level 3 SPAR
19 models. Instead what we have are older studies, such
20 as NUREG-1150, that quite frankly have been, the details
21 of them, the actual logic models are not as well
22 preserved as one would expect or perhaps hope for.

23 So in thinking about this a lot, let's go
24 to the next slide. If we're going to develop some sort
25 of a notional, or a scoping model, one thing that stands

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 out is there are different types of initiating events
2 with respect to multi-unit risk.

3 So I've labeled them Common Cause
4 Initiators. Something that challenges or trips all of
5 the units at the site, basically at the same time, like
6 a big earthquake. It could be a flood. Generally, some
7 sort of external event. Perhaps a loss of grid
8 transient, something like that.

9 And that's in contrast to what I will call
10 Single Unit Initiators, or SUIs, that says one unit gets
11 challenged. But it propagates over to the other units
12 because of the shared systems, or some sort of spatial
13 interactions, you know, a fire could propagate over,
14 some sorts of common cause failures across the units,
15 and operator actions.

16 An example of a spatial interaction is
17 actually what happened at Chernobyl. When Unit 4
18 happened, the graphite moderator was ejected, and it
19 landed on the roof of Unit 3, and actually set it on
20 fire. Now, it didn't burn through, but it's an example
21 of a sort of phenomenon that I'm looking for.

22 This distinction between the CCIs and the
23 SUIs turned out to be a key realization of mine while
24 I was developing the notional model. It let me then
25 write some pretty tight mathematics that seemed to

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 account for everything like this.

2 CHAIRMAN STETKAR: Marty, before you leave
3 this, something that was nagging at me a bit as I read
4 through this. How do you characterize initiating
5 events that are loss of offsite power, loss of service
6 water, loss of component cooling water?

7 MR. STUTZKE: It depends on the site.
8 That's the problem.

9 CHAIRMAN STETKAR: No. In your math how
10 are they characterized?

11 MR. STUTZKE: Generally, those are going to
12 be Single Unit Initiators.

13 CHAIRMAN STETKAR: And you, well, we'll
14 revisit that question later.

15 MR. STUTZKE: You know, actually, when you
16 look at like the LOOP frequency that's in NUREG/CR-6890,
17 and they actually calculate the probability of
18 consequential LOOPS in other units.

19 And for loss of grid the probability is 0.8,
20 it's not 1. It's not guaranteed to happen. Now, that
21 may be because of the way that they've counted the data.
22 It may be because you have different transmission lines.

23 CHAIRMAN STETKAR: It may be because they
24 only counted things at power, and not during shutdown
25 that effected the shutdown unit, for example. But that

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 wasn't counted.

2 MR. STUTZKE: Right. The sort of thing
3 like that. Okay. So with some nomenclature here we try
4 to keep things reasonably clear like this, the number
5 of units, the frequency of the Common Cause Initiators.
6 These split fractions, the probability of release from
7 k out of n units, are important.

8 The notional model can take a single unit
9 accident sequence, and divide it up by adding split
10 fractions. And then account for the likelihood of
11 multiple are failed by doing that. And each one of those
12 has, you know, consequences.

13 So along the way I found it useful to make
14 the assumptions the units are in fact identical. This
15 allows simple scaling, keeps the math clean. The other
16 key assumption is that the consequence is proportional
17 to the number of units involved, like this.

18 MEMBER BALLINGER: I have a question.

19 MR. STUTZKE: Yes.

20 MEMBER BALLINGER: What do you mean by
21 identical? From a PRA point of view, how much
22 identicalness do you need to be identical?

23 MR. STUTZKE: Well, it lets me say that the
24 core damage frequency, or the release frequency at Unit
25 2 is the same number as it is for Unit 1.

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 CHAIRMAN STETKAR: Let me follow up on
2 that. And I always like to use examples. Because it
3 takes things out of the realm of philosophy. I used to
4 be an operator at Zion Nuclear Power Plant. If you read
5 the Zion Unit 1 FSAR, you would be led to believe that
6 Zion Unit 1 had three diesel generators. If you read
7 the Zion 2 FSAR you would be led to believe that Zion
8 Unit 2 had three diesel generators.

9 In fact, if you went through the plant, Zion
10 had five diesel generators. One diesel generator,
11 depending on a relay race, either fed Unit 1 or it fed
12 Unit 2. Now, those two units, in some sense, were
13 identical, if you will. But their risk is not equal for
14 loss of offsite power. The risk is very different.

15 So what I'd like to know is, did you look
16 at the SPAR models to look at the success criteria for
17 units that, especially units that had shared systems.
18 For example, if you had a SPAR model for Zion, did the
19 model for Unit 1 take credit for three diesel generators?

20 Or for Farley, take credit for four diesel
21 generators? Or for Browns Ferry, take credit for four
22 diesel generators and eight service water pumps, for
23 those single unit events? If they did, your other unit
24 risk is not equal to the first unit risk during those
25 events.

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 MR. STUTZKE: Right.

2 CHAIRMAN STETKAR: And your combinatorics
3 fall apart.

4 MR. STUTZKE: Right. I have looked at some
5 of the SPAR models, not in the context of the notional
6 analysis, but in the context of the Site Level 3, to
7 try to understand.

8 And what you find in them as far as
9 multi-unit aspects is, sometimes they credit recovery
10 from the other unit, like this. And those are almost
11 always set to zero in the model. So it's like a place
12 holder in the model that's not credited whatsoever.

13 CHAIRMAN STETKAR: Okay. But in Zion it
14 wasn't recovery. It was an automatic function. It was
15 a relay race. At Browns Ferry it's not recovery, it's
16 relays. So it's not an operator actively going out and
17 mechanically switching things. It could be that people
18 just said, well it's available to Unit 1, at Zion for
19 example, with the reliability of the diesel.

20 MEMBER REMPE: Well also --

21 CHAIRMAN STETKAR: Instead of .5.

22 MEMBER REMPE: Also, when I was reading
23 your Enclosure 1, like Peach Bottom's internal flood
24 numbers, Units 2 and 3 have quite different numbers.
25 And so I, that's just one example. One could also look

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 at some of the other plants, like Limerick. And so I
2 was puzzled, you know, why, you know, how good is that
3 assumption?

4 And then of course, one thinks about what
5 happened at Daiichi. And of course, the units were
6 different. But sometimes the accidents did progress
7 quite differently. And so I'm not, I mean, I know it
8 simplifies the math. But is that a good assumption?

9 MR. STUTZKE: Well, I think as far as
10 looking at individual units, what I did was pick the
11 biggest one.

12 MEMBER REMPE: You did? Okay.

13 MR. STUTZKE: Picked the biggest risk,
14 tried to bound it. Remember, the idea here is not to
15 compute the risk. It's to show that the risk is below
16 some level where we need to take immediate action. So
17 we're trying to bound the risk like this. And I think
18 that gives us a certain amount of latitude and
19 flexibility in how we approach the problem.

20 MEMBER CORRADINI: So can I go down that
21 path? Just so maybe I'm, maybe this is too simplified.
22 Because I'm trying to find, there was a presentation
23 given by Carl Fleming about this, in another context.
24 I'm not sure if you were in the room. I think --

25 MR. STUTZKE: Yes, I listened to Carl's --

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 MEMBER CORRADINI: Okay. And I can't find
2 it. But in my mind is, in the simplest form, as you had
3 your, the one event tree I understood, which was like
4 two slides ago. Don't go back.

5 It's that, if I have two units, and I have
6 a common initiator, then at most the risk would double.
7 Because I'd have twice as much source term for the same
8 sort of effect. Is that wrong to think that way?

9 MR. STUTZKE: That's how we originally were
10 thinking about it.

11 MEMBER CORRADINI: Okay. But is that
12 bounding?

13 MR. STUTZKE: I don't think that's
14 necessarily bounding.

15 MEMBER CORRADINI: Okay.

16 MEMBER REMPE: Because it could go longer.

17 MR. STUTZKE: It could go longer if you
18 worry about these Single Unit Initiators. So I would
19 have n units there, and each one of the consequences
20 is times n . So that implies an n squared sort of term.

21 MEMBER CORRADINI: I was just thinking a
22 multiplier.

23 MR. STUTZKE: Right. And that's why
24 you'll see, when you get down to this you'll see both
25 the n multiplier and the n squared multiplier pop out

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 of the arithmetic.

2 MEMBER CORRADINI: Okay.

3 MR. STUTZKE: Which justifies your
4 intuition about it.

5 MEMBER CORRADINI: But, so then to my first
6 part of the question, you are familiar with some of the
7 work I've seen by Fleming?

8 MR. STUTZKE: Yes.

9 MEMBER CORRADINI: Okay. Thank you.

10 MR. STUTZKE: Let's look at the Venn
11 diagram on Page 16. This is trying to show how to account
12 for the contributions of the multi-unit risk. So each
13 circle is basically the result that you get from a single
14 unit PRA. It's what we all know and understand, like
15 that.

16 And the notion is that some of those
17 sequences that are described in the single unit PRA,
18 in fact could go on to create multi-unit sequences. So
19 we could get two out of three, you know, specifically
20 one and two, or one and three. We could get all of them
21 coming in there, like that.

22 And the idea behind all of the math is to
23 account for all of these different contributions like
24 that. For example, when we go through the combinatorics
25 we can express the single unit risk from Common Cause

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 Initiators, simply by adding up all the parts within
2 one circle, within one part of the Venn diagram, like
3 that.

4 In contrast, if I want to account for the
5 multi-unit risk, I need to worry about all of the parts
6 across all of the circles of the Venn diagram. That's
7 the second equation there, after applying the assumption
8 and adding them up, and you find the whole.

9 Or the site risk due to Common Cause
10 Initiators, event units, is simply n times the per unit,
11 or the single unit multiplier. That's where the
12 assumption comes in about the units being identical.
13 That's why you're allowed to say it's a factor of n times
14 the single unit.

15 Otherwise you would come up with the sum
16 of Unit 1 risk plus Unit 2 risk, for Common Cause
17 Initiators. That sort of thing, like that. Okay.
18 Single unit initiators are a lot harder.

19 Let's flip to Slide 18. And that's because
20 you need to worry about the fact that some of those
21 sequences in the single unit PRA that were successful,
22 may serve as initiating events for the other units, like
23 that.

24 So I've invented this taxonomy, that's
25 caused no amount of confusion and consternation among

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 the staff. These are my original labels, and I'm
2 sticking with them. So we have the idea of a cascading
3 sequence. That's just supposed --

4 At one time they were Type 1, Type 2 and
5 Type 3. And I could never remember which one was which.
6 So the idea here is a cascading sequence. Okay, I've
7 got core damage in the unit where a Single Unit Initiator
8 occurred, and also in one or more additional units, like
9 that.

10 Propagating sequences are those that are
11 success paths in the original unit. So nothing happened
12 in the unit where the initiator occurred. But core
13 damage and release occurs in other units, other
14 additional units.

15 And then finally I needed a label for the
16 restricted sequence. It says, it occurred in a specific
17 unit, and it stayed there. It never got outside
18 anyplace, like that. So to try to give you a flavor for,
19 let's flip over to 19.

20 It looks very similar to what we saw for
21 the -- Oops. The subscripts are on. That should be SUI
22 subscripts, instead of CCIs. That is, the
23 nomenclature's basically the same, except now I have
24 a new factor in here that says I'm trying to account
25 for the propagating sequences, like this.

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 Let's bounce to Slide 20, which is again
2 the Venn diagram, and see if I can walk you through this
3 thing. Yes, it's a guaranteed to cause eye strain sort
4 of thing. You can draw it actually pretty eloquently,
5 if there's only two units. And when you get three units
6 it wants to become multi-dimensional, and things like
7 that.

8 But here's the idea. If you start in the
9 upper left you have a Single Unit Initiator. And we'll
10 say that it occurs at Unit 1, realizing we could flip
11 the diagram to say it occurs at Unit 2 or 3, or however
12 many you want in there.

13 And the notion is, if you take the down
14 branch to your restricted sequence, so only Unit 1 has
15 core damage and a potential release. And that's the
16 term for it that comes down here.

17 In addition, Unit 1 may go to core damage.
18 And at the same time there may be core damage and release
19 from the other units. And those are the so called
20 cascading sequences, which I've labeled, the purple one,
21 the white one, and the blue one in the diagram like this.

22 The new thought is the propagating
23 sequences. So the success path sequences that come from
24 the Unit 1, now serving as initiating events that can
25 effect the other units. So the yellow part, the, I don't

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 really know what that color is, and kind of the gray
2 one down in the bottom.

3 MEMBER CORRADINI: So the yellow, fleshy
4 and gray?

5 MR. STUTZKE: Right. Those are the
6 propagating sequences.

7 MEMBER CORRADINI: So your point, your big
8 point is, that I guess I missed, is that you can have
9 something happen at Unit 1 and life is successful. But
10 then something goes awry --

11 MR. STUTZKE: In Unit 2, or 2, or 3, or both.
12 Yes. So just trying to be complete, and account for all
13 of the parts later, like that. So using the
14 nomenclature, before you end up with something like
15 Equation 21, where the first part of the right hand side
16 are some contribution from the restrictive and the
17 cascading sequences.

18 The part on the right hand side are the
19 propagating sequences, like this. Again, the
20 assumption of identical units, that's the n multiplier
21 on the right hand side. Otherwise, I would begin to have
22 multiple turns like that.

23 So that's the key to making them the same
24 like this. Pages and pages and pages of algebra later,
25 flipping this thing around, you wind up with an

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 expression that's shown on Slide 22. Nathan says I owe
2 him big time for checking all of this, like this.

3 You end up with the equation at the top,
4 where you see what we have done is, we have n squared
5 now, times a single unit risk from the SUIs, minus a
6 whole bunch of other terms like that.

7 MEMBER CORRADINI: So it's not n squared,
8 but it's not n . It's somewhere in between.

9 MR. STUTZKE: Right.

10 MEMBER CORRADINI: And so, I'm sorry. You
11 told me this once, but can you just repeat it? So one
12 more time. It's n squared because --

13 MR. STUTZKE: I would --

14 MEMBER CORRADINI: it's a cascading
15 effect?

16 MR. STUTZKE: The notion of n squared is,
17 the consequence is now increased, because there's more
18 units involved. And --

19 MEMBER CORRADINI: But it's not additive
20 because why?

21 MR. STUTZKE: Additive in which sense?

22 MEMBER CORRADINI: Well, I'm still back to,
23 my mind was going with your first explanation, which
24 was on slide, don't go back, but on Slide, can't remember
25 which slide it was, Slide 17. I was thinking, what,

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 Slide 17 for everything. So this Single Unit Initiator
2 is right for it. So one more time, then I'll stop.

3 MR. STUTZKE: The slide is for each
4 initiating event that occurred, single unit, let's scale
5 up the consequences by a factor of n. That accounts for
6 the multi-unit force term that could come out. Then I
7 realized I have n of those initiating events across the
8 site.

9 MEMBER CORRADINI: Because it's, okay,
10 we're back to the success of stopping it here does not
11 necessarily propagate, correct?

12 MR. STUTZKE: Right.

13 MEMBER CORRADINI: Okay, sorry. Thank
14 you.

15 MR. STUTZKE: So I end up with this
16 expression. And on the right hand side you realize this
17 is related to the propagating sequences. And the notion
18 is, in order for a sequence to propagate and cause a
19 problem it actually has to trip the other units in there.

20 And so, through this type of argument I
21 think it's appropriate just to throw away the top side
22 and bound it. So I end up with a compact expression of
23 the square of the number of units times the single unit
24 risk, as far as the SUIs.

25 CONSULTANT SHACK: And I had a problem with

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 that, Marty. Because you're not really dealing with the
2 same sequences in each one. You make the argument that
3 there's a sequence probability and a conditional
4 probability, you multiply them. You know, I'm willing
5 to believe that those numbers are probably true.

6 But, you know, in your paper you make it
7 seem as though it's logically, it has to follow that
8 way. And it seems to me that you're not counting the
9 fact that you could have different sequences leading
10 to one versus the other. And therefore, that
11 multiplication, the conditional probability isn't
12 quite kosher.

13 MR. STUTZKE: Right. This isn't an
14 account of individual sequences. This is a count of the
15 total risk. So what it says is, I have a frequency coming
16 out of Unit 1, times a split fraction that says, what
17 is the probability that other units are involved, and
18 this can go all the way to release?

19 And the argument here is the p term in here
20 is, that is the probability given Unit 1 has gone to
21 core damage. The q is given that it did not. Okay? So
22 I believe there needs to be an additional term in here.

23 CONSULTANT SHACK: Right. But those
24 frequencies are so different, that I don't see
25 multiplying by the conditional probability then

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 guarantees you have that relation.

2 MR. STUTZKE: When you look at the end of
3 the PRA, the right hand side, right, the sum of the
4 frequencies has to equal the initiating frequency coming
5 up. You have that --

6 CONSULTANT SHACK: Okay.

7 MR. STUTZKE: -- right here. In other
8 words, all an event tree does is split things out. It's
9 a, you know, a classic probability tree diagram. And
10 all it says is, all the parts have to equal what you
11 put into it. So anyway, I'll press on. And then, I
12 guess in the interest in time as much as anything. Yes.

13 But this is a crucial assumption that lets
14 me bound this thing. Because it says, now I don't need
15 to worry about the fraction that propagates and goes
16 over like that. I can just discard it. And somehow I
17 bounded it.

18 And when I throw it together, as shown on
19 Slide 23, I end up with a rather compact expression for
20 site risk, that says, well, it's less than the number
21 of units times the CCI from single unit. Or, the square
22 of the number of units times the single unit, right.

23 So this actually reproduces to some extent,
24 you know, the naive estimator that would say, well, it's
25 always due to some seismic event like this. And so all

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 I need to do is scale it up by n. And at the other hand
2 it says, well, if I have single units initiators I
3 increase the source term by a factor of n. And I have
4 initiators across the site, okay. And so it works out.

5 Again, it achieves, the goal that we were
6 after was, well, we can estimate this equation from the
7 results of the single unit PRA. It all works out very
8 well. The only thing that needs to be done is the
9 protection results on the Common Cause Initiators and
10 Single Unit Initiators. And generally we have that type
11 of information available.

12 Of course, it's just a number. It's a very
13 little insight as to what's driving the multi-unit risk.
14 I think the best you can do is say, well, it's either
15 common cause works the Single Unit Initiators like this.
16 I have tried to evolve the technique into shutdown, low
17 power, spent fuel.

18 And it's a God awful mess, to be honest with
19 you. You end up with pages and pages of terms that don't
20 want to cancel, or reasonably can be deleted, collapsed,
21 whatever. So it's probably about, I've pushed it about
22 as far as it can be pushed with this type of a notional
23 analysis, like that.

24 So, having done this, let's reflect a little
25 bit on what it all means, before we go looking at some

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 of the numbers, like that. And that is simply, we don't
2 have any guidance on what is acceptable site risk. And
3 I've spent some time trying to drill down into the
4 history of this thing.

5 When the safety goals were originally being
6 formulated in the early '80s, remember they started out
7 in basically 1981. And the safety goal policy statement
8 wasn't published until '86. And there was a lot of, well
9 say spirited discussion.

10 There were some meetings, you know, the
11 notable one at Harpers Ferry. I think there was another
12 one at Palo Alto a while back, like this. But one of
13 the issues that the staff approached the Commission
14 about was, what should we do about multi-unit sites?
15 And the Commission came back and said, let's not worry
16 about that now. We don't want to penalize multi-unit
17 sites.

18 So the idea is, or the implication is that
19 a multi-unit site could conceptually have a higher
20 acceptable site risk than a single unit site. The
21 Commission has been silent on how much higher that tends
22 to be.

23 CONSULTANT SHACK: The Commission has been
24 what?

25 MR. STUTZKE: They've been silent --

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 CONSULTANT SHACK: Oh, okay.

2 MR. STUTZKE: -- on what that is. So what
3 we have now basically are single units safety goals.
4 In addition, there was some work that went on for the
5 so called technology neutral framework that Mary Drouin
6 evolved. And we ask again, at the time it used to be
7 called collective risk or integrated risk.

8 And the question is, how much risk is
9 acceptable for a site when we lay this thing out? And
10 again, what happened in that case was, the Commission
11 told us to open an ANPR, we did, and Advanced Notice
12 of Potential Rulemaking.

13 And we debated the issues like this. They
14 came back after that and said, well, we will defer on
15 this until we get an actual license application in hand
16 for a multi-unit site, like the pebble bed, which hasn't
17 happened. So we have yet to address this thing.

18 Again, the Office of New Reactors had a
19 working group a while back, a couple of months ago, that
20 I participated in. And again, the issue arose in the
21 context of multi-modules. So now you're talking about
22 small modular reactors. And you may have six, eight,
23 ten of them on the site. And now, what to do?

24 The analogy I like to use, you know, is,
25 a PRA will tell you how fast you're going. The

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 Commission's got to tell me the speed limit, okay.
2 That's the policy. And we can debate, you know, about
3 how accurate my measurement of the speed is, the notional
4 things, or the details of the PRA.

5 But the question still remains, how much
6 is too much? I would also hasten to point out, when we
7 talk about safety goals, that they don't define how much
8 is too much. They define how much is safe enough. It's
9 at the lower end. It doesn't say how much risk is
10 unacceptable.

11 Again, that comes into the realm of adequate
12 protection. And there are no numerical guidelines that
13 relate to adequate protection to risk metrics, like
14 this. The best we have are some suggestions. And in
15 our office instructions it's called LIC-504 that say,
16 well, when the CDF begins to get up around ten to the
17 minus three, think about shutting the plant down.

18 But the fact is, so we don't have anything
19 for multi-units. So how to compare any numbers that I
20 would be able to calculate and reach a decision? And
21 all this says is, well, we could compare the site risk
22 numbers that I produced to the per-reactor QHOs. And
23 if we're below that, surely, we're okay, right. If
24 we're not, then don't know what to do.

25 CONSULTANT SHACK: And you're in a gray

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 region.

2 MR. STUTZKE: Right. So I tried to make
3 estimates of site risk for all of the multi-unit sites,
4 by cobbling together the available information. And
5 admittedly, it's pretty cobbled. For example, I told
6 you before, we don't have a lot of external event SPAR
7 models. There's maybe 16 or 17 of them in there, like
8 that.

9 So I took some liberties by fitting it, you
10 know, to the log normal probability plot, and tried to
11 pick a big number, like the 80th percentile. And said,
12 all I need to do to find a flood multiplier is to scale
13 up the internal event CDF by a certain factor. That's
14 the approach that's normally done in SAMA analysis for
15 license renewals.

16 Similarly, I tried looking at NFPA 805
17 submittals to get an idea of where fire frequencies are.
18 There are very few of them there. And again, I evolved
19 some sort of fire multiplier, just to simply scale up
20 the internal events. I had made estimates before from
21 Generic Issue 199 on earthquakes.

22 And then there's new information out on the
23 frequency of tornadoes. These are the tornadoes where
24 the wind speed exceeds the designed site design basis,
25 not necessarily the frequency of tornado induced core

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 damage accidents. So it's pretty conservative I would
2 say, like that.

3 I tried looking at a variety of, you know,
4 frequency information's hard enough to find.
5 Consequence information is almost nonexistent.
6 There's NUREG-1150 that provides us some information
7 like this. We have the benefit of the SOARCA analyses,
8 that's perhaps better.

9 I persuaded one of my colleagues in DSA to
10 do some scoping MACCS2 calculations for me, where
11 basically where we're using the SOARCA input decks, and
12 simply doubled the source term across the board, and
13 re-ran it. And the results indicated, you know, the
14 consequences of doubling the source term are less than
15 twice, sub-linear or sub-additive, like this.

16 The problem with those types of
17 calculations -- And I should point out, shortly after
18 the Fukushima accident happened, Charlie Tinker and I,
19 Charlie being one of the architects of the SOARCA study,
20 got invited to brief the Chairman on multi-unit risk.
21 And Charlie had sent Sandia, at work over the weekend,
22 basically double the source terms.

23 MEMBER CORRADINI: He what? I'm sorry.

24 MR. STUTZKE: Yes, double the source terms
25 and do a bunch of MACCS2 calculations for all of the

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 SOARCA things. And we went up there, and the Chairman
2 was not satisfied with that.

3 Because, in true multi-unit accidents
4 things aren't released simultaneously. One unit will
5 release, and there may be a period of several times.
6 The other is released, and now the wind has changed
7 directions.

8 Meanwhile, at the start of the first release
9 evacuation has already occurred. So maybe the second
10 release doesn't effect anybody. Or, you know, has
11 different effects like this. So the interplay of
12 emergency planning, meteorology, and things like this.

13 So, you know, former Chairman Jaczko was
14 not at all happy with this type of a simple let's double
15 the source term sort of thing. But it does also
16 indicate, you know, certainly as far as the health
17 related metrics, individual latent cancer fatality
18 risk, or whatever, the effect seems to be sub-additive,
19 like this.

20 It gets even more complicated when you begin
21 to use threshold types of models where there's no risk.
22 And suddenly the multi-unit effect goes, wow, like this.
23 So this is based, you know, realizing linear threshold
24 is kind of at the heart of this sort of thing, which
25 just may or may not be appropriate, like this.

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 Looking through all of these things I keep
2 coming up with this conditional probability of latent
3 cancer fatality. It varies between ten to the minus
4 five and ten to the minus three. SOARCA was somewhere
5 in the middle with ten to the minus four. It really
6 depends on whether you're looking at seismic, or
7 whatever.

8 So I said, look, let's just pick minus three
9 across the board. It's probably the best I can do at
10 this point in time. So the next slide shows you my
11 attempt to quantify all of this, the internal event
12 numbers, the flood multipliers.

13 So you can see where I've actually used the
14 SPAR data, where I had an external event model, or NFPA
15 805. Those numbers are good. Otherwise I had to use
16 this multiplier, like this. And anyway, so you come up
17 with some estimate on the site individual latent cancer
18 fatality risk.

19 And you scan down the list. And you see
20 they're all below the two times ten to the minus six
21 that we normally use for the quantitative health
22 objective, like this. Not very much. I mean, if I
23 rounded it, obviously I don't believe, I know this to
24 be, you know, three significant digits.

25 MEMBER CORRADINI: Would I meet -- I know

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 I should know this, but I don't. You're comparing it
2 to what? I'm back on Slide 24, but you don't have to
3 go back. You're comparing it to the individual latent
4 cancer fatality risk? Is that what you're comparing it
5 to?

6 MR. STUTZKE: Right. Just that
7 quantitative health objective, which turns out to be
8 about two times ten to the minus six per year. The
9 rationale here is SOARCA was telling us the individual
10 early fatality risk was vanishingly small. So why
11 compute it at a site level? Didn't seem to be
12 worthwhile.

13 Actually, in regulatory analysis we don't
14 use individual latent cancer fatality risk. We'll use
15 things like population dose risk, person-rem per year,
16 like this. Because that can be modified times the, you
17 know, times the \$2,000 dollars per person rem, or
18 whatever the current number is. I understand it's been
19 increased.

20 Or in regulatory analysis the other thing
21 we use is offsite dollars, offsite economic
22 consequences, like that. But again, there's no safety
23 goal for single units for either one of those metrics.
24 And I needed some yardstick to calibrate it against.
25 So the only one that made sense was the individual latent

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 cancer fatality risk.

2 MEMBER CORRADINI: And, I guess I should,
3 again should note that's what I think. So that involves
4 some assumption about evacuation, since you're --

5 MR. STUTZKE: It's all embedded into this
6 conditional probability of latent cancer fatality
7 number, up on Slide 25.

8 MEMBER CORRADINI: Okay.

9 MR. STUTZKE: That's where that comes from.

10 MEMBER CORRADINI: Okay. Thank you.

11 MR. STUTZKE: So in principle it's in
12 there. But again, it's, I don't know to say that it's
13 double counting, you know, the effect of this sub-linear
14 like this. As I said before, it's possible when the
15 first unit begins to release evacuation starts.

16 And so by the time a second or third unit
17 would release, people have already left. In principle
18 they've left. So that's where we ended up with this.
19 It's, you know, for the purposes of screening or trying
20 to disposition our Generic Issue to reach a conclusion,
21 you know, do we have an immediate safety concern, yes
22 or no? I think the analysis is probably sufficient for
23 that purpose.

24 I've tried to introduce some, I guess as
25 former Chairman Diaz used to call it, realistic

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 conservatism in the analysis, to try to bound what I
2 didn't know. That's not always a good approach in PRA,
3 of adding conservatism. We pride ourselves on being
4 realistic. But that's in the eye of the beholder.

5 MEMBER CORRADINI: I'm sorry, just one more
6 clarification. You guys are going to ask all the hard
7 questions. They're poised, ready. So simple, and back
8 on Slide 22. So what you're computing here, or not 22,
9 23.

10 What you're computing here is the right hand
11 side of the simple equation? So all we know is that
12 assuming you did your estimates, it's less than the right
13 hand side. But the listing of the tabular values is the
14 right hand side?

15 MR. STUTZKE: Yes, correct. So when you
16 look on it, it's broken into the single unit
17 contributions and the common cause contributions. And
18 it does add them up. So it's an effort to, you know,
19 to try to estimate the entire site risk from all types
20 of the initiating events.

21 MEMBER CORRADINI: Okay. Thank you.

22 MEMBER BLEY: Marty, a couple of things.
23 One is, I really like the way you broke the problem apart.
24 It's extraordinarily clever, and really interesting.
25 When we come to actually applying it and get numbers

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 for this table, is where I start getting quite nervous.

2 Number 1, and this gets to what John was
3 saying earlier, the embedded assumption of identical
4 units. I don't know how important that is. And it could
5 be quite important. But Number 2, the way we've done
6 the multipliers and used them makes me extraordinarily
7 uncomfortable. The 80th percentile is picked out of the
8 sky. I mean, there's no basis for that.

9 MR. STUTZKE: It is.

10 MEMBER BLEY: The reasons the multipliers
11 vary very widely, which they do in the plants for which
12 you have PRAs to compare, and the flood multiplier varies
13 over orders of magnitude, and the fire over a really
14 broad range.

15 And then we come back. We take the 80th
16 percentile, and we apply it to all the plants, even the
17 ones that have their own multipliers calculated --

18 MR. STUTZKE: Oh, no. No. That's --

19 MEMBER BLEY: That's what it looks like in
20 the table.

21 MR. STUTZKE: No. If I actually had a
22 value, I used it.

23 MEMBER BLEY: Okay. I thought I saw the
24 other one there. Okay. That helps a little. Because
25 I did see on one of these tables the generic multiplier.

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 But maybe I --

2 MR. STUTZKE: Yes. For example, so we have
3 SPAR external event models for --

4 MEMBER BLEY: Oh, yes, I think you're
5 right.

6 MR. STUTZKE: -- Salem.

7 MEMBER BLEY: Okay.

8 MR. STUTZKE: So I used it if I had it. You
9 know, the question is what to do about the other sites
10 where I don't.

11 MEMBER BLEY: But the 80th percentile
12 doesn't help me very much. The reason the fire risk is
13 wildly different is because designs are quite different.

14 MR. STUTZKE: Understood.

15 MEMBER BLEY: And there's a real basis for
16 that variability. And we're not, we're kind of
17 pretending using the 80th percentile accounts for that
18 variability. And it's so broad. I don't find that
19 comforting.

20 MR. STUTZKE: I would agree.

21 MEMBER BLEY: Now, on the other hand, as a
22 quick look to say, do we have more work going on? And
23 we can really understand this when we do a Level 3 PRA?
24 Maybe that's a reasonable thing. But that's the quite
25 queasy one.

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 MR. STUTZKE: Right. You know, the real
2 problem is, you know, the premise, what this notional
3 approach drives for is to let you use the results of
4 the single unit PRA.

5 But we don't even have single unit PRAs for
6 most of the plants, nor do the licensees. And, you know,
7 trying to be a risk informed regulator, that puts us
8 in quite of a dilemma.

9 CHAIRMAN STETKAR: Marty, I'm --

10 MR. STUTZKE: That's my indirect lobby for
11 a PRA rule.

12 CHAIRMAN STETKAR: Marty, I want to --

13 MR. STUTZKE: It was indirect.

14 CHAIRMAN STETKAR: You want to purse the --

15 MEMBER BLEY: No.

16 CHAIRMAN STETKAR: I want to pick up, you
17 need to help me a little bit. I really, and again, I
18 echo Dennis's, this is kind of a really clever way of
19 trying to get your hands around a difficult problem that
20 you really don't have a lot of information about, despite
21 all the numbers in this table.

22 What I was saying, and I understand exactly
23 what you did with all the Boolean math and the
24 combinatorics, and all that kind of stuff. It's kind
25 of neat.

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 What bothers me though, and perhaps you
2 might help me out is, I'll go back to my earlier questions
3 about, what is a Common Cause Initiating Event versus
4 a Single Unit Initiating Event? And how did you think
5 about those sites that have very integrated shared
6 systems?

7 I think that, my sense is that this works
8 very, very well for sites, and you mentioned in the
9 introduction, so I can echo that. Sites like Vogtle
10 where the two units are, let's call them for practical
11 purposes nominally identical. But they basically don't
12 share anything except for maybe the switch yard.

13 I mentioned sites like, and I can mention,
14 you know, I'll use Zion as a good example. Because it's
15 not as politically charged as perhaps other sites. But
16 Zion shared service water, component cooling water,
17 instrument air, diesel generators, AC power, DC power.
18 It was basically a single two unit site.

19 And it's not clear that this process works
20 very well, unless the left hand column on this Slide
21 26, that internal event CDF, unless that column applied
22 really, really careful success criteria for those shared
23 systems for events that can effect both units, like loss
24 of service water, like loss of offsite power, like loss
25 of component coolant water, maybe loss of instant air,

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 maybe fires in common areas, maybe floods in common
2 areas.

3 We had a common auxiliary building between
4 the two units. We had a common turbine building between
5 the two units. So can you help me a little bit how you
6 thought about that? Because there are a number of, I
7 don't know how many. I'm familiar with some units on
8 this list that do have very closely integrated shared
9 systems.

10 MEMBER CORRADINI: Can I just ask?
11 Because I know what John's asking. But I'm curious. If
12 that's an issue, is there a way to get to a simplified
13 estimate using your technique? Because I'm trying to
14 understand. I understand what you did and how you tried
15 to simplify it down.

16 But here I've got, instead of 1,085
17 megawatts, I've got 2,200 megawatts of stuff, all
18 essentially with shared systems. So isn't that just one
19 bigger plant?

20 MR. STUTZKE: Potentially. I guess it's a
21 bigger plant. For example --

22 MEMBER CORRADINI: With a double PRA.

23 MR. STUTZKE: -- the big plant, the big Zion
24 plant had five diesels. None of these plants have five
25 diesels. So, for example, the single unit numbers for

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 any of these are not a five diesel type number, you know.

2 MEMBER CORRADINI: Understood.

3 MR. STUTZKE: So a five diesel number is
4 something smaller than probably many of these numbers.
5 But something a lot larger than these numbers squared.

6 MEMBER BLEY: The good news is there aren't
7 a lot of plants with that kind of design.

8 MR. STUTZKE: That's right.

9 MEMBER BLEY: There are a few on this list
10 that have even more complex --

11 CHAIRMAN STETKAR: Oh, yes.

12 MEMBER BLEY: -- share in that, yes.

13 CHAIRMAN STETKAR: Sorry.

14 MR. STUTZKE: But I would, I guess there's
15 a couple of things. One is our SPAR models are generally
16 not definitive as to what unit they model. There are
17 some notable occasions, differences. For example,
18 Vogtle is a Unit 1 and Unit 2 model. And we will argue
19 that that is the CDF for both units, like that.

20 There are unique SPAR models for I think
21 plants like Browns Ferry. But not always. I think
22 there's a 1 and 2 model, and then there's Unit 3, like
23 that. So the level of resolution within the SPAR models
24 is not probably fine enough to let you go after one unit.
25 It's really asymmetrical from the other, like that.

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 But the other thing that I would argue is,
2 if you flip back to Slide 23 here, look at what the
3 equation results. The issue is, I have all these
4 contributors to single unit risk. And I'm tasked with
5 deciding, are they common cause or are they single units,
6 all right?

7 And I've got to make a choice. It's one or
8 the other in the equation. If I err on the fact that
9 they're Single Unit Initiators, then that right hand
10 term, that n squared term will drive the answer, like
11 this.

12 On the other hand, if I have systems that
13 are highly shared between them, where I think they're
14 Common Cause Initiatives, it's driven towards the n term
15 in the equation, like this.

16 CHAIRMAN STETKAR: But, Marty, that's not
17 the way the math works. The Common Cause Initiators by
18 definition are only seismic events and high winds. They
19 are not losses of offsite power.

20 MR. STUTZKE: They are --

21 CHAIRMAN STETKAR: They are not the plain
22 vanilla losses of offsite power that happen a lot more
23 frequently than seismic events.

24 MR. STUTZKE: They are the initiator that
25 caused both units to be challenged simultaneously.

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 CHAIRMAN STETKAR: They are not losses of
2 offsite power.

3 MR. STUTZKE: Which are generally not
4 losses of offsite power or LOOPs. So the LOOPs show up
5 in the --

6 CHAIRMAN STETKAR: Single unit.

7 MR. STUTZKE: -- Single Unit Initiators.

8 CHAIRMAN STETKAR: And my whole, you know
9 -- Let me give you an example. The single unit, pick
10 Zion again. The single unit, Zion Unit 1 core damage
11 frequency accounts for loss of offsite power initiating
12 event. And it's an internal event, initiating event.
13 It's not a seismic event.

14 And you need failures of, I'll pick a
15 number, let's call it three diesels. And those diesels
16 could have common cause failures, beta gamma. That
17 gives me three diesels. It's not five diesel failures.
18 Unit 2 doesn't have three diesels for that same loss of
19 offsite power initiating event, it's only got two.

20 But if I get common cause failures of all
21 five, I have no diesels for both units. This notional
22 model doesn't account for things like that. It can't,
23 because the notional, the combinatorics presume that the
24 number for Unit 1 also applies to Unit 2, in terms of
25 the conditional core damage probability, given the loss

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 of offsite power initiating event.

2 CONSULTANT SHACK: But isn't some of that
3 covered in his propagating and cascading probability?

4 CHAIRMAN STETKAR: No, because --

5 CONSULTANT SHACK: So if he comes back to
6 --

7 CHAIRMAN STETKAR: No. He presumed that
8 the cascading is small. And I'm saying that they're
9 completely --

10 CONSULTANT SHACK: No. He didn't say it
11 was small. He just said it was an inequality between
12 the cascading and the propagating.

13 CHAIRMAN STETKAR: And he used that to
14 justify discarding the other --

15 CONSULTANT SHACK: Right.

16 CHAIRMAN STETKAR: -- term in the equation.

17 CONSULTANT SHACK: So it isn't a question
18 of small. It's a question of whether you believe that
19 inequality on 22.

20 CHAIRMAN STETKAR: Well, and that's
21 essentially what I'm -- I don't believe that inequality
22 on 22 for sites that have very highly integrated shared
23 systems. For selected sets of initiating events, like
24 losses of offsite power, losses of cooling water, it
25 challenged the shared.

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 Turbine trip, you know, fine. Reactor
2 trip, you know, those kind of initiating events, yes,
3 I'll buy that inequality for those. And I think it's,
4 the only place that I kept hanging up are those sites
5 that do have those very integrated shared support
6 systems, AC power, DC power, cooling water, and so forth.

7 And some of Dennis's concerns I think also
8 translate into shared spaces, you know, which also tend
9 to be those, the plants that have shared support systems,
10 you know.

11 CONSULTANT SHACK: Probably, yes.

12 CHAIRMAN STETKAR: It's like Zion. The,
13 you know, common turbine building, common auxiliary
14 building, where the conditional core damage probability
15 of a flood in a particular area is not equal between the
16 two units. But then, you know, I mean, that's one of
17 the, you come up with whopping conservatism he's got with
18 the tornado CDF.

19 CONSULTANT SHACK: Yes. But the tornado --

20 CHAIRMAN STETKAR: Almost overwhelms
21 things.

22 CONSULTANT SHACK: Yes. But if you look at
23 the map that is very conservative. But it doesn't effect
24 much of anything at all.

25 CHAIRMAN STETKAR: It's sort of the major

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 contributor to the total CDF in many cases.

2 MEMBER SCHULTZ: In fact it's the, almost
3 anything.

4 CONSULTANT SHACK: Yes, there's a couple
5 that it's not.

6 CHAIRMAN STETKAR: There's a couple that
7 it's not. But, I mean, it really pushes things --

8 MEMBER CORRADINI: But I think, you'll find
9 in the right hand column that in an awful lot of the cases
10 the n squared single unit stuff is driving the number,
11 when you look at the math.

12 CHAIRMAN STETKAR: Sure.

13 MEMBER CORRADINI: It's not a 90 percent 10
14 percent. It tends to be about two-thirds, one-third
15 roughly. So even though the tornadoes are an important
16 contributor, let's say to that one-third, they are not
17 driving the right hand column.

18 The n squared single unit stuff tends to be
19 the more important contributor. But there are
20 exceptions. But it tends to be the more important
21 contributor to the overall conclusion. And especially
22 when you get up to, you know, the three unit sites, it's
23 mostly the single unit stuff.

24 CHAIRMAN STETKAR: That's true.

25 MEMBER CORRADINI: Three unit sites again

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 are?

2 MR. STUTZKE: Browns Ferry, Oconee and Palo
3 Verde.

4 MEMBER CORRADINI: Palo Verde.

5 MR. STUTZKE: Browns Ferry is kind of a
6 three unit site.

7 CHAIRMAN STETKAR: It's sort of a two and
8 a one with some cross ties. I mean, in terms of the
9 concerns that I was raising.

10 MR. STUTZKE: Right.

11 CHAIRMAN STETKAR: It's different.

12 MEMBER SCHULTZ: In the approach taken it
13 turns out to be different.

14 CHAIRMAN STETKAR: Yes. I don't have, you
15 know, unless you have some enlightenment over those?
16 And I also don't know, I mean, I'm familiar, I know Browns
17 Ferry. We've mentioned Browns Ferry. I know at least
18 one other plant on this list that has at least pretty
19 integrated shared electric power. And I'm not familiar
20 with all of the plants. So I don't know if there are
21 others.

22 I think the process does work really well
23 for those sites that don't share systems. And quite
24 honestly, I mean, you know, the reason I asked you about
25 the SPAR success criteria is, if SPAR carefully

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 accounted for that sharing.

2 In other words, in my Zion example, if SPAR
3 only took credit for two and a half diesels, or something
4 like that, or a 50 percent probability that Unit 1 had
5 that shared diesel. If the SPAR models did that you'd
6 be, I'd have a lot more confidence, you know.

7 MEMBER SCHULTZ: Yes, and the --

8 CHAIRMAN STETKAR: But if they took credit
9 for, you know, the full sharing, and on some of the plants
10 it's pretty extensive.

11 MR. STUTZKE: You know, the SPAR models are
12 benchmarked against licensees' PRA models. Not just in
13 terms of the numbers they produce. But, you know, our
14 contractors at Idaho review to see that they're being
15 produced. So, you know, in the case where systems are
16 being heavily shared, you know, what you're suggesting
17 is perhaps we've all missed the boat somehow.

18 CHAIRMAN STETKAR: Well, you know, the only
19 reason I've raised this is I've seen, and this is not
20 in the U.S. I have to, my experience over the last pretty
21 much decade and a half has been overseas.

22 And I've seen many PRAs developed over there
23 using the same standards that we use, that basically say,
24 I'm doing a PRA for a single unit. And they'll take
25 credit for sharing anything they can get their hands on.

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 MR. STUTZKE: Oh, yes.

2 CHAIRMAN STETKAR: Because well, just
3 because they do that. And I don't know how people are
4 doing that, you know, today, in either the site specific
5 models that people have developed over the last nine
6 years or so, or in SPAR models.

7 MEMBER BLEY: Now, I think a lot of the
8 things John's raised, there might be some simple things
9 you could do within the SPAR model to cover this, at least
10 in a bounding way.

11 CHAIRMAN STETKAR: There might be. But you
12 have to think about it pretty carefully. That's the
13 whole notion, is you have to think about it.

14 MEMBER BLEY: But I don't know if there's
15 a good list of which of the plants that --

16 CHAIRMAN STETKAR: I don't know. I mean,
17 you know, I only know anecdotally a couple on this list.

18 MEMBER BLEY: Back in the old ACEP program
19 they kind of laid out what the pieces of all the systems
20 were in the plants that were around at that time.

21 MR. STUTZKE: And it might not be so bad to
22 find, you know, it depends almost on the vintage of the
23 FSAR.

24 CHAIRMAN STETKAR: Yes.

25 MR. STUTZKE: That's said of Vogtle.

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 There's like in Chapter 1 that says, here's everything
2 we have that's shared.

3 CHAIRMAN STETKAR: Yes.

4 MEMBER BLEY: Right.

5 CHAIRMAN STETKAR: Yes.

6 MR. STUTZKE: So I'll have to find it.

7 CHAIRMAN STETKAR: I actually, quite
8 honestly, last night I tried to look up a couple FSARs.
9 And I found one that spelled it out pretty well. I found
10 another that I knew had shared systems, where it was --
11 If I knew what I was looking for I could see how the words
12 might describe what I was looking for.

13 MR. STUTZKE: Exactly.

14 CHAIRMAN STETKAR: But if I wasn't looking
15 for it, the FSAR, it wasn't very clearly leading me in
16 the direction that I needed to be led. I mean, obviously
17 the site, this is not an infinite number of plants. So
18 the site resident inspectors would certainly be
19 cognizant of what the shared systems were.

20 MR. STUTZKE: Yes. Perhaps the regional
21 SRAs could find it.

22 CHAIRMAN STETKAR: You'd hope at least,
23 certainly the resident inspectors would know.

24 MEMBER BLEY: In any case, this does a nice
25 job already of saying, you don't see any giant problems

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 working there. That's very helpful. I don't know that
2 our Level 3 project's going to narrow this issue.
3 Because I think that plant's a nice one.

4 CHAIRMAN STETKAR: That's right. I mean,
5 the Level 3 will give us some insight about the seismic,
6 you know, site level, seismic flooding, those types of
7 things, high winds.

8 MR. STUTZKE: Right.

9 CHAIRMAN STETKAR: And it will give us some
10 insight about multi-unit releases translating out into
11 Level 3 risk. Your, you know, your nominal ten to the
12 minus three scaling factor for the latent cancer risk.
13 But it won't help the left hand side of this.

14 MEMBER BLEY: It will help those other
15 issues, I suspect. You'll look at timing of releases
16 and that sort of thing.

17 MR. STUTZKE: Yes. You'll get insights and
18 operator actions in times like this. Because one, for
19 example, at Vogtle one of the issues that you have here
20 is how does the second unit actually get tripped? It's
21 easy enough if there's some sort of shared system. And
22 at Vogtle that wants to be the switch yard. So I can
23 worry about that.

24 But other, under what other circumstances
25 would the second unit actually get challenged? And what

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 I'm going with in that case is the site emergency
2 response guidelines, which are the high level
3 procedures. This is for the emergency director to come
4 in and decide when he needs to notify state and local
5 authorities, et cetera.

6 And there's a line item in there that says,
7 think about what you want to do if the other unit. Maybe
8 you should think about shutting it down. Or maybe it's
9 not the right time to shut it down. So the assumption,
10 you know, that I'm likely to make in the Site Level 3
11 is, well, upon core damage in one unit, the other unit
12 is going to be shut down, just because I have to reach
13 some decision.

14 Again, I'll point back at Chernobyl. Units
15 1 and 2 continued to operate for a day after Unit 4 had
16 already destroyed itself. And then they got the order,
17 okay, shut it down. Rather remarkable.

18 MEMBER BLEY: Well, I'd also go back to
19 your, you don't have to go to it, Slide 20, your Venn
20 diagram. The way you've broken this out with the
21 cascading sequences and the propagating sequences. I
22 think many people would have not even thought of chasing
23 the propagating sequences without this structure. I
24 think that's --

25 MR. STUTZKE: I was worried that would be

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 the driver. Because the frequency of the propagating
2 sequence is much higher than the core damage coming up.
3 And, in fact, one of the things I debated is, aren't those
4 already included in the other initiating event
5 frequencies when I count them?

6 And I've gone through at least a fair amount
7 of the initiator. You can't find examples of multi-unit
8 trips very often. They just don't happen very often.
9 I guess my favorite one was an incident a while back at
10 Braidwood. You'll love this one.

11 Where, I can't remember which unit tripped.
12 But they had normal turbine trip. And they had a
13 misaligned valve. And they filled up, I think it was
14 the condensate tank or their feed tank. And the water
15 overflowed and spilled on the switch gear, and tripped
16 the second unit.

17 CHAIRMAN STETKAR: That's a good one.

18 MR. STUTZKE: Classic. It's like, oh, I
19 never would have thought to model that. So yes, we have
20 looked. Actually, you may be familiar with the IBM
21 Watson, the contacts come for analytics to find things.
22 We had looked through by, manually all of the multi-unit
23 LERs that we could find.

24 And our approach was very crude, to say
25 look, find me two LERs for the incident of date, which

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 was only 24 hours from each other. And then we'll come
2 down and look and see, like this.

3 Well, we intend to use this software from
4 Watson to see what it can find. And see, well, are there
5 multi-unit implications for some of the sites. Can't
6 find it now. Save us from reading the LERs.

7 MEMBER BLEY: How many of those near time
8 trips did you find?

9 MR. STUTZKE: It was only about 50 or so.

10 MEMBER BLEY: That's more than I --

11 MR. STUTZKE: I mean, and --

12 CHAIRMAN STETKAR: Since day one? Yes, I
13 wouldn't, that's not surprising.

14 MR. STUTZKE: You know, and a majority of
15 them are LOOP related, you know, like the great northeast
16 blackout a couple of years back, you know, ten years ago
17 or so, you can find multiple trips then.

18 CHAIRMAN STETKAR: That just --

19 MR. STUTZKE: You know, I haven't found any
20 where both units went down for like a, you know, a service
21 water, or a CCW. I was looking for that. Or, you know,
22 one unit went down, and we got excited and shut the other
23 unit down as a precaution, or something like that. And
24 I haven't found any of those either.

25 MEMBER SCHULTZ: You know, the insights

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 you're talking about now are very interesting to
2 explore, given what you've done here analytically. You
3 talked at first about the internal peer review, and
4 checking and evaluation of the model, and the concept.
5 And you mentioned also you're taking it to PSAM. Have
6 there been external reviews, peer reviews at this point?

7 MR. STUTZKE: No. The only other people
8 that have seen this work -- Well, I mean, it is publicly
9 available. There's nothing hidden. And, you know, the
10 math is belabored because the old Generic Issues process
11 said, document everything so it's independently
12 reproducible. And I think we've fallen kind of short
13 like that.

14 In January I attended a meeting of the CANDU
15 Owners Group. And they're very interested in what they
16 call whole site risk. They're in the process of
17 re-licensing some plants.

18 And their regulators got, you know, said,
19 you need to worry about site risk for times like that.
20 And I have informally shared this with members of the
21 CANDU Owners Group.

22 MEMBER SCHULTZ: Good.

23 MEMBER RAY: Look at shared heat sink
24 event. I know there have been power reductions.

25 CHAIRMAN STETKAR: Power reductions are

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 pretty common. Especially close to the site.

2 MEMBER RAY: And if they get close to trips

3 --

4 MR. STUTZKE: Salem, in particular.
5 Salem's had a couple. I'm not sure if they actually
6 tripped. But they essentially weren't making any
7 power.

8 MEMBER RAY: I've had to dive in plants to
9 do a unit plan.

10 MR. STUTZKE: It's the analogy, when you do
11 common cause data. And you're looking for examples
12 where two pumps failed, or three valves failed. And the
13 preponderance of the evidence is, something failed.
14 And the other one wasn't feeling so good, okay. It's
15 hard to find clear cut cases where two things failed like
16 we actually model.

17 MEMBER RAY: Well --

18 MR. STUTZKE: So, you know, these power
19 reductions, or things like that -- But I, you know,
20 you've --

21 MEMBER RAY: Seaweed ingress, for example.
22 Happens to both units at the same time typically, when
23 there's an off shore storm.

24 MR. STUTZKE: Right. But yes, we will
25 continue to hunt down the LERs to see. You know, I'd

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 like to find some real examples of the sorts of scenarios
2 that we're modeling here. Or at least precursors to them
3 to get a feel for what's real. Very good.

4 CHAIRMAN STETKAR: Excuse me. Didn't get
5 my coffee in. My voice is going away. Any members have
6 any more questions for the staff?

7 MEMBER BALLINGER: I have a sort of naive
8 question. If you were to relax the assumptions, or do
9 it a sort of more rigorous way in your mind, what's your
10 judgment? How much would that change?

11 MR. STUTZKE: Well, I have pursued it at a
12 sequence level for the Common Cause Initiatives, where
13 every sequence is individually accounted for, not
14 smeared together. And you get the same result. And
15 it's not required then that the plants be identical. But
16 it is required that the consequences can be added
17 together.

18 MEMBER BALLINGER: Yes, got it.

19 MR. STUTZKE: And you will get the same
20 result. But it's not the case in the Single Unit
21 Initiators.

22 MEMBER BALLINGER: Right.

23 MR. STUTZKE: You get terms like, you know,
24 the frequency of something happening. And, you know,
25 one times the consequence in Unit 2. It's like, boy,

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 those terms are hard to deal with.

2 MEMBER BALLINGER: What do you mean by hard
3 to deal with? Hard to deal with from a technical point
4 of view? Or hard to deal with because they're big?

5 MR. STUTZKE: Hard to deal with in the sense
6 I can't say I bounded it --

7 MEMBER BALLINGER: Oh.

8 MR. STUTZKE: -- and delete them. You
9 know, they remain in the equation. And you can't show
10 that one is bigger than the other.

11 MEMBER BALLINGER: Is there a reason to
12 continue because you're uncertain that there might be
13 a big effect?

14 MR. STUTZKE: Well, I think the real way,
15 it's what I said before. I probably chased this bit of
16 arithmetic as hard as I can chase it for right now, for
17 this notional model.

18 What I'm hoping is that when we get done with
19 Site Level 3 project, I'll be able to smoke test this
20 against the actual results we get from the PRA, and see
21 how one comes. The problem is, because Vogtle doesn't
22 share many systems, I'm not going to get at the real
23 issue.

24 CHAIRMAN STETKAR: That's the only
25 problem. Had it been at a different site you would have

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 been able to really check off all of those boxes.

2 MR. STUTZKE: In which case I'll raise my
3 hand and say, please let us do, you know, a different
4 site where we can try to explore these sorts of things.

5 MEMBER BLEY: Well, one thing you might,
6 from this work and from that, and all of the thinking
7 about this you're doing, it may be reasonable to put
8 together some guidance on doing full site risk
9 assessment. What you need to do to your PRAs to extend
10 it to cover this issue.

11 MR. STUTZKE: Well, in addition to this
12 work I'm doing with the CANDU Owners Group, IAEA is
13 sponsoring a meeting on multi-unit risk. And it will
14 be in Ottawa in November of this year. And IAEA is a
15 sponsor, CSNC is a sponsor, and NRC is a sponsor.

16 And we're trying to collect, you know,
17 thoughts like this. I know Carl will be up there again,
18 and Bob. Because they have some strong thoughts on how
19 to do this.

20 You know, quite frankly, what I've learned
21 on the international front was, people are now becoming
22 appreciative of a problem that nobody's really thought
23 about in any great detail. I mean, why can't I just
24 multiply it by n? You know, scale it up.

25 MEMBER SCHULTZ: Recalling early papers

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 associated with SMR evaluations, and I believe it was
2 an end time approach, multiplied by n.

3 MEMBER BLEY: That was mostly done.
4 There's been some stuff in the past looking at the timing
5 issues, and seeing what that does to the source terms.

6 MEMBER SCHULTZ: Yes, right.

7 MR. STUTZKE: You know, and I know you guys
8 and Carl traced Seabrook pretty heavily, like that. But
9 again, it's not as shared a system.

10 MEMBER BLEY: Right. Seabrook again was a
11 lot closer again to Vogtle.

12 MR. STUTZKE: It's relatively isolated.
13 And so you don't know where you get it.

14 MEMBER CORRADINI: So if we were to pick
15 from the current population of plants something that
16 John was worried about, about shared, what would be some
17 candidates?

18 (Simultaneous speaking.)

19 MR. STUTZKE: Well, Browns Ferry comes to
20 mind.

21 MEMBER BLEY: But it's so unique that it's
22 hardly worthwhile.

23 CHAIRMAN STETKAR: Farley, if I can share.
24 Farley has some bizarre electric power sharing. They
25 had sort of a single --

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 MR. STUTZKE: Right.

2 CHAIRMAN STETKAR: My recollection was,
3 there's sort of one dedicated diesel for each unit. And
4 there are three others that are kind of shared. And
5 they're sort of a two unit, two train per unit plant.
6 I don't remember the cooling water systems there.

7 MR. STUTZKE: Turkey Point used to have a,
8 what I called a one and half ECCS.

9 CHAIRMAN STETKAR: Yes.

10 MR. STUTZKE: A partner CCS that would
11 decide where it needed to put you, needed help.

12 CHAIRMAN STETKAR: Anything more for the
13 staff? I have a couple of administrative things to do
14 here. And then we'll go around the table. First of all,
15 do we have any comments from anyone in the audience? I
16 think we have the --

17 MEMBER SCHULTZ: John, I did have one
18 question for John. You talked about things changing.
19 And I wanted to get an appreciation for the schedule for
20 changes that. Is there one laid out for --

21 MR. KAUFFMAN: Yes.

22 MEMBER SCHULTZ: -- modification of that?

23 MR. KAUFFMAN: There's a schedule laid out.
24 I don't happen to have it with me. The MD is out for
25 comment now. And it is to be finalized by November of

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 this year.

2 MEMBER SCHULTZ: Good. Thank you.

3 CHAIRMAN STETKAR: Thanks. I'm sorry,
4 Stephen. I didn't mean to cut you off. We do have the
5 bridge line open. I know we had some folks on the bridge
6 line.

7 Just for our help, if there's someone out
8 there could you just say something, so I can confirm that
9 it's open? We, unfortunately don't have any other more
10 efficient way to do that. So if someone's out there,
11 could you please just say something?

12 MR. STALLONE: Yes. I'm Marty Stallone.

13 CHAIRMAN STETKAR: Oh, wait. Thank you.
14 Thank you very much. I really appreciate that. Now,
15 if there's anyone out there who has any comments that
16 they'd like to make, we'll entertain those. Hearing
17 none, we'll re-close the bridge line.

18 And as usual for subcommittee meetings, I'd
19 like to go around the table and see if any of the members
20 have any final comments that they'd like to make. And
21 I'll start off with our esteemed consultant first.

22 CONSULTANT SHACK: Well, I was very
23 interested in it. I thought it was an interesting thing.
24 The discussion today helped me understand the difference
25 between Ps and Qs a little better. And seems largely

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 the heart of the matter. One minor question. Does that
2 go back to the '47 paper? Is that where you dig that
3 out of?

4 MR. STUTZKE: Yes.

5 CONSULTANT SHACK: Okay. I'll go chase
6 that a little bit more.

7 MR. STUTZKE: That's just plotting points.

8 CONSULTANT SHACK: Yes, I know. I plot
9 points a lot.

10 MR. STUTZKE: I like it because I can
11 remember it. It's what I was taught at University of
12 Maryland. I think if the choice of plotting point
13 changes your answer you're probably up to no good.

14 CONSULTANT SHACK: I'm all set.

15 CHAIRMAN STETKAR: Harold?

16 MEMBER RAY: Well, I guess I would just say,
17 or observe, that LERs, licensees don't like to submit
18 LERs. And they only do it when they have to. And I think
19 if we limit our exploration of events to those which
20 forced an LER to be submitted, it would be too narrow
21 a population of data.

22 And, I'd just say, come close to a number
23 of events that are relevant to all of this, both on the
24 switch yard side and the cooling water side, and so on.
25 They didn't trigger LERs.

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 But, believe me, they should be taken note
2 of in this kind of work. It's looking at low probability
3 event. And I don't know how to do that, other than
4 through some expert panel, or something of that kind.
5 And that's all I want to say.

6 CHAIRMAN STETKAR: Great. Steve?

7 MEMBER SCHULTZ: I really appreciate both
8 presentations that we heard this morning, and the work
9 that's gone into both the process improvement, as well
10 as you John. And then for Marty, the analytical work
11 here. Clearly a lot of both thoughtful approaches, as
12 well as the detailed analytics.

13 I'm very interested to learn about the
14 response from peers at PSAM, as well as in November as
15 the SMR conference, risk conference. It's very
16 important. And I'd certainly like to hear more about
17 this in about a year, associated with the response.

18 And I'm glad you're using what you've gotten
19 from the calculational structure to then look at what
20 the operational experience can also tell. Thank you.

21 CHAIRMAN STETKAR: Dennis?

22 MEMBER BLEY: Yes, I literally, I think it
23 was a nice covered job. But I think the more broad thing
24 I'm interested in is I think we ought to explore this
25 process of looking at this stage on these the way we do

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 with the reg guys.

2 I mean, they come in, we parse them out to
3 one person to look and see if the committee ought to look
4 at it. And I think that would be helpful. We ought to
5 be thinking about these issues as they arise. And I
6 think that would be helpful for us.

7 CHAIRMAN STETKAR: When you say as they
8 arise, probably when they get to this stage? That's
9 discreet, yes.

10 MEMBER BLEY: That's arise for me.

11 CHAIRMAN STETKAR: Okay. I didn't want to
12 leave the impression of when they first --

13 MEMBER BLEY: No, no.

14 CHAIRMAN STETKAR: -- something first
15 comes across their desk. Mike?

16 MEMBER RYAN: Nothing else, John. Thank
17 you. Thank you for your presentation.

18 CHAIRMAN STETKAR: Joy?

19 MEMBER REMPE: I wanted also to express my
20 thanks. But I also agree with Steve that I hope that
21 there is some follow-up after your meetings, the IAEA
22 meeting. And I think after we look at the SMRs that are
23 coming through that it would be relevant. So hopefully
24 there is some follow-up.

25 CHAIRMAN STETKAR: Mike?

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 MEMBER CORRADINI: I guess I have a
2 question for Marty. So, you're doing this after the memo
3 came out in December, as just an interested individual
4 that can't get your hands off of it? Or has RES been
5 given the user need to pursue this?

6 MR. STUTZKE: To pursue?

7 MEMBER CORRADINI: This further.

8 MR. STUTZKE: This further? No. This is
9 --

10 MEMBER CORRADINI: It's a done deal?

11 MR. STUTZKE: It's done.

12 MEMBER CORRADINI: So, the reason I'm
13 asking a question like that is, to me this is going to
14 come up again, and again, and again. So it seems to me
15 whether there's a user need or not, this would be useful
16 to do. So, let me just ask the question.

17 Is the staff asking something from us that
18 we could help move that along? Or is the staff happy
19 that this is not a user need, and it's dead, and I'm the
20 only one?

21 CHAIRMAN STETKAR: Mike, for some
22 perspective you're not aware of, the staff didn't come
23 to us, we asked them to come.

24 MEMBER CORRADINI: Ah.

25 CHAIRMAN STETKAR: So Marty's not pursuing

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 this in the interest of his being really interested in
2 following stuff. We asked him to --

3 MEMBER CORRADINI: Because you're home at
4 night, and you have nothing better to do.

5 CHAIRMAN STETKAR: I'm sure Marty lives,
6 breathes and eats this stuff.

7 MEMBER CORRADINI: What I'm really asking
8 is, this may seem as a non user need at this point within
9 the staff. But I have a funny feeling this is going to
10 come back very quickly.

11 CHAIRMAN STETKAR: Right.

12 MR. STUTZKE: Well, you know, there's a
13 couple of things. One is, we as a staff are generally
14 interested in this multi-unit sort of thing. So, I mean,
15 within the Office of Research, because of the Site Level
16 3 project, NRO had its working group for the multi-module
17 risk paper, like that. We've gotten funding to go on
18 big international trips, like to Toronto and Ottawa.

19 (Simultaneous speaking.)

20 (Laughter.)

21 MR. STUTZKE: For the record, I stayed at
22 the Toronto Airport hotels.

23 CHAIRMAN STETKAR: It was December, no
24 doubt.

25 (Simultaneous speaking.)

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701

1 MR. STUTZKE: But we generally had this
2 intent to continue to pursue it. Like I said, IAEA has
3 talked to us, and we'll go play it with them.

4 MEMBER CORRADINI: Okay. Thank you. Then
5 I have nothing.

6 CHAIRMAN STETKAR: As a final comment I
7 don't have anything else to add, other than thanks a lot
8 for bringing all of this together, and taking the time
9 to educate us on the process. I think it is a really
10 clever analysis.

11 And as one final closing comment, if you
12 want to hear about somebody who had a simultaneous dual
13 unit trip of 2,040 megawatts going off line like that,
14 come and talk to me. And with that, we are adjourned.

15 (Whereupon, the meeting in the
16 above-entitled matter adjourned at 10:35 a.m.)

17

18

19

20

NEAL R. GROSS

COURT REPORTERS AND TRANSCRIBERS
1323 RHODE ISLAND AVE., N.W.
WASHINGTON, D.C. 20005-3701



United States Nuclear Regulatory Commission

Protecting People and the Environment

Advisory Committee on Reactor
Safeguards (ACRS)
Sub Committee
Generic Issues Program
Overview

Regulatory Guidance & Generic Issues Branch
Office of Research

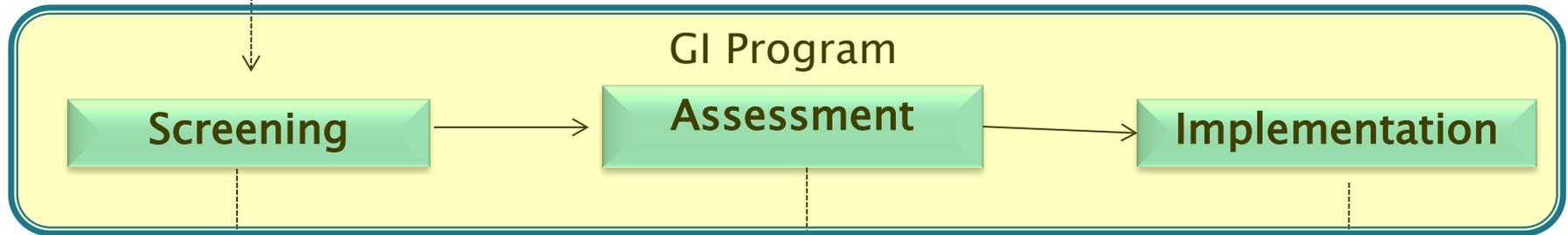
March 5, 2014

Background

- ▶ Staff initiated screening process for Generic Issues (GI) program
- ▶ Multi-unit risk issue became a pre-GI in 2008
- ▶ Memo with results issued 12/2/2013 (screened out on low risk and ability to adequately determine risk)

3 Stage GI Program

Issue
submitted to
GI Program



Issue exits program when:

- 1) Referred to other regulatory process for action
- 2) Referred for additional research
- 3) Fails criteria

Licenses
actions
completed and
verified. Issue
closed.

GI Criteria

- 1) Must affect public health and safety
- 2) Applies to two or more facilities
- 3) Is not readily addressable through other established regulatory processes
- 4) Can be resolved by regulation, policy, or guidance
- 5) Can have its risk or safety significance adequately determined or estimated
- 6) Must be well defined, discrete, and technical
- 7) Must involve review, analysis, or action by the licensees

Multi-unit events

- ▶ Multi-unit core damage sequences may:
 - challenge the ability of the plant operating personnel
 - require resources beyond those available for single units
 - increase offsite consequences
- ▶ Current siting of units
 - 32 sites with 2 operating reactors
 - 3 sites with 3 operating reactors
 - Some sites are physically near each other
- ▶ Quantification of risk requires development of a PRA that addresses above issues

GI Process Results

- ▶ **GI Criterion:**
 - Must affect public health and safety, which includes a risk significance component
- ▶ A highly simplified (notional) analysis suggests that multi-unit risk for sites with currently operating plants are likely to meet the NRC safety goal policy for single units
- ▶ Interim regulatory actions are not necessary while pursuing further insights into multi-source site risk

GI Process Results

- ▶ GI Criterion
 - Risk or safety significance can be adequately determined (i.e., does not require longer term studies to evaluate).
- ▶ Multi-source site risk is extremely difficult to analyze for all unique site characteristics and plant designs, as confirmed by ongoing RES research for one site

Going Forward

- ▶ NTFF follow-up actions are further reducing multiunit risk for low probability/high consequence events.
 - On-site and off-site equipment
 - Procedures
 - Emergency response staffing
 - Seismic and flooding walkdowns
- ▶ Staff is continuing to pursue further insights into multi-source site risk as part of ongoing efforts, e.g. Level 3 PRA
 - NRC staff is developing Level 3 PRA for one multi-unit site
 - Results anticipated on 2017

Notional Model for Multi-Unit Risk

Martin Stutzke, RES/DRA

Agenda

- ▶ Background
- ▶ Delineating multiunit accident sequences
- ▶ Mathematical derivation
- ▶ Example estimates

Remember that all models are wrong;
the practical question is how wrong do they have to be to not
be useful.

Box, G. E. P., and Draper, N. R., (1987), *Empirical Model
Building and Response Surfaces*, John Wiley & Sons, New York,
NY

Multiunit Site Statistics

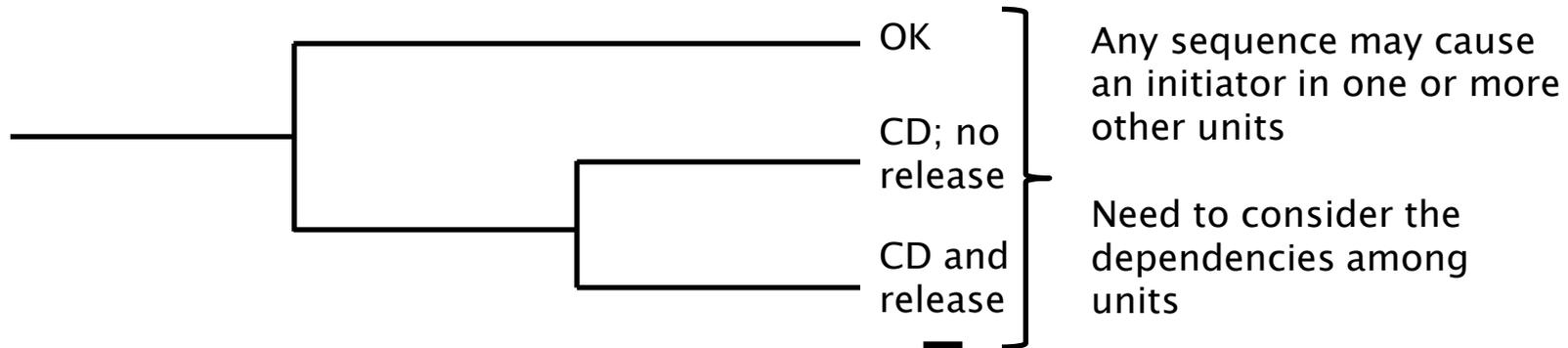
Category	Number of Sites	Notes		
Dual-unit sites	30	ANO Beaver Valley Braidwood Brunswick Byron Calvert Cliffs Catawba Comanche Peak D.C. Cook Diablo Canyon	Dresden Farley Hatch Indian Point La Salle Limerick McGuire Millstone North Anna Peach Bottom	Point Beach Prairie Island Quad Cities St. Lucie Sequoyah South Texas Surry Susquehanna Turkey Point Vogle
Triple-unit sites	3	Browns Ferry Oconee Palo Verde		
Adjacent sites	2	Salem 1&2 and Hope Creek Nine Mile Point 1&2 and FitzPatrick		

These counts exclude the two-unit San Onofre site where both units are being permanently shutdown, the two additional units under construction at the Summer site, and the two additional units under construction at the Vogle site.

Site Risk Assessment

- ▶ Site risk = risk to the public due to operation of the nuclear power plants at a site
 - Accidents that affect one radiological source (typical PRA) and
 - Accidents that affect combinations of radiological sources
- ▶ Sources of radiological hazard
 - Reactors
 - Spent fuel pool
 - Dry cask storage
- ▶ Approaches
 - Site Level 3 PRA
 - Naïve estimate (number of units x single-unit risk)
 - Notional model (adapt the results of a single-unit PRA to estimate the total site risk)

Simple View of a Level 3 PRA



Set of Release Sequences

- Frequency, Λ_i
- Consequence, C_i

$$risk = \sum_{i=1}^n \Lambda_i C_i$$

Practical Limitation
May only have high-level risk and frequency contributors (not the individual sequence frequencies and consequences)

Classes of Initiating Events

- ▶ Common-cause initiators (CCIs): Simultaneously challenge all units at the site (e.g., earthquakes)
- ▶ Single-unit initiators (SUIs): Challenge one unit, but may cause multiunit accidents due to:
 - Shared support systems
 - Spatial interactions (e.g., flood and fire propagation pathways)
 - Common-cause failures
 - Operator actions
- ▶ The distinction between CCIs and SUIs is a key concept for developing the notional model!

Nomenclature and Assumptions for CCI Risk Contribution

n = number of identical units

f_{CCI} = frequency of the CCI

$P_{k,CCI}^{(n)}$ = Pr{release from exactly k of n units | CCI}

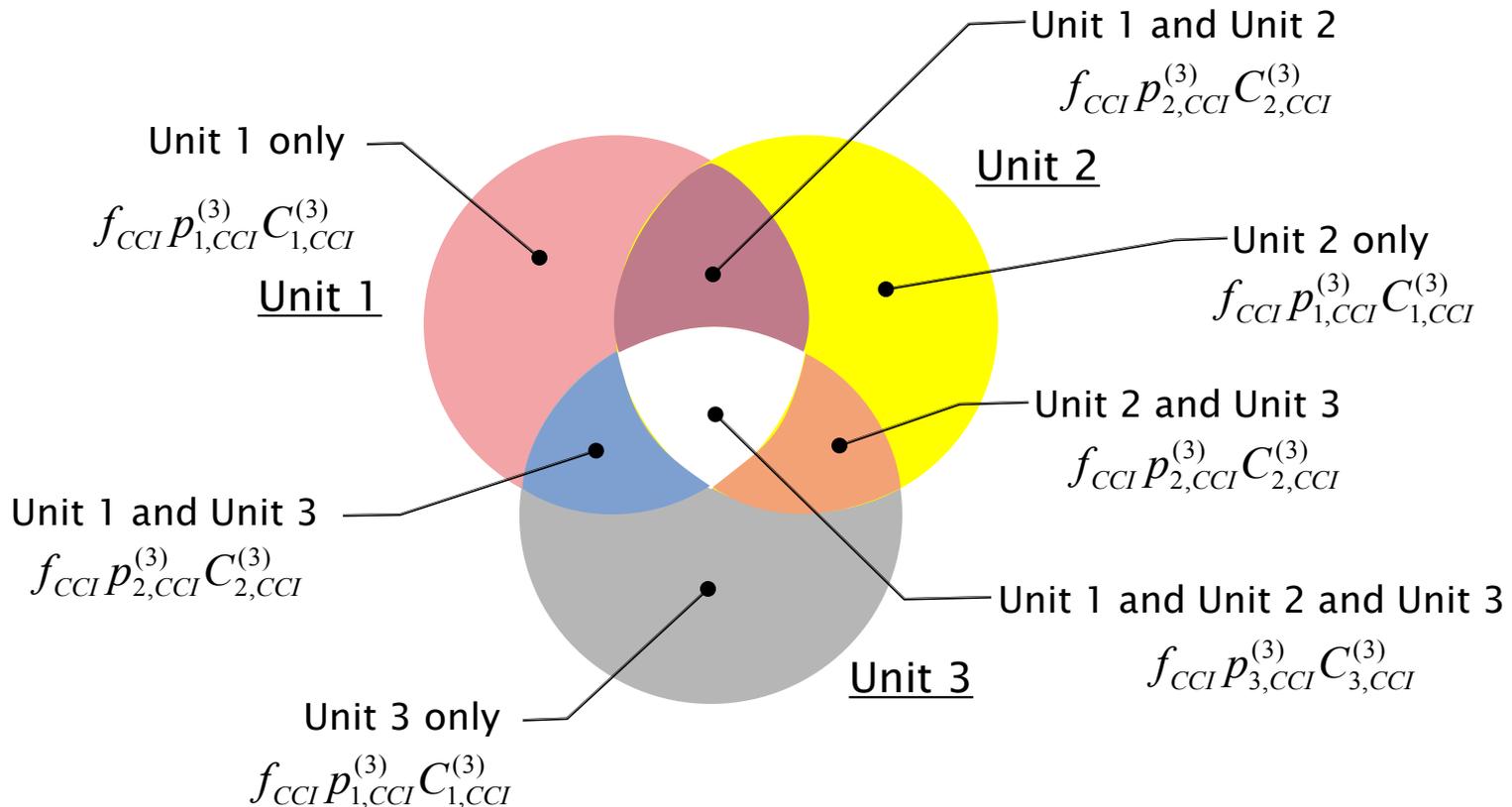
$C_{k,CCI}^{(n)}$ = frequency weighted average consequence due to release from exactly k of n units after CCI

Assumption #1: The units are identical

Assumption #2: Consequence is proportional to the number of units involved

$$C_{k,CCI}^{(n)} = k C_{1,CCI}^{(n)}$$

CCI Contributions to Multi-Unit Risk



Risk Due to CCIs

Expression for single-unit risk due to CCIs (add the parts within one circle)

$$R_{\text{single-unit,CCI}}^{(n)} = f_{\text{CCI}} C_{1,\text{CCI}}^{(n)} = f_{\text{CCI}} \sum_{k=1}^n \binom{n-1}{k-1} P_{k,\text{CCI}}^{(n)} C_{1,\text{CCI}}^{(n)}$$

Expression for multiunit risk due to CCIs (add all of the parts)

$$R_{S,\text{CCI}}^{(n)} = f_{\text{CCI}} \sum_{k=1}^n \binom{n}{k} P_{k,\text{CCI}}^{(n)} C_{k,\text{CCI}}^{(n)}$$

After using Assumption #2 and simplifying:

$$R_{S,\text{CCI}}^{(n)} = n f_{\text{CCI}} C_{1,\text{CCI}}^{(n)} \sum_{k=1}^n \binom{n-1}{k-1} P_{k,\text{CCI}}^{(n)} = n R_{\text{single-unit,CCI}}^{(n)}$$

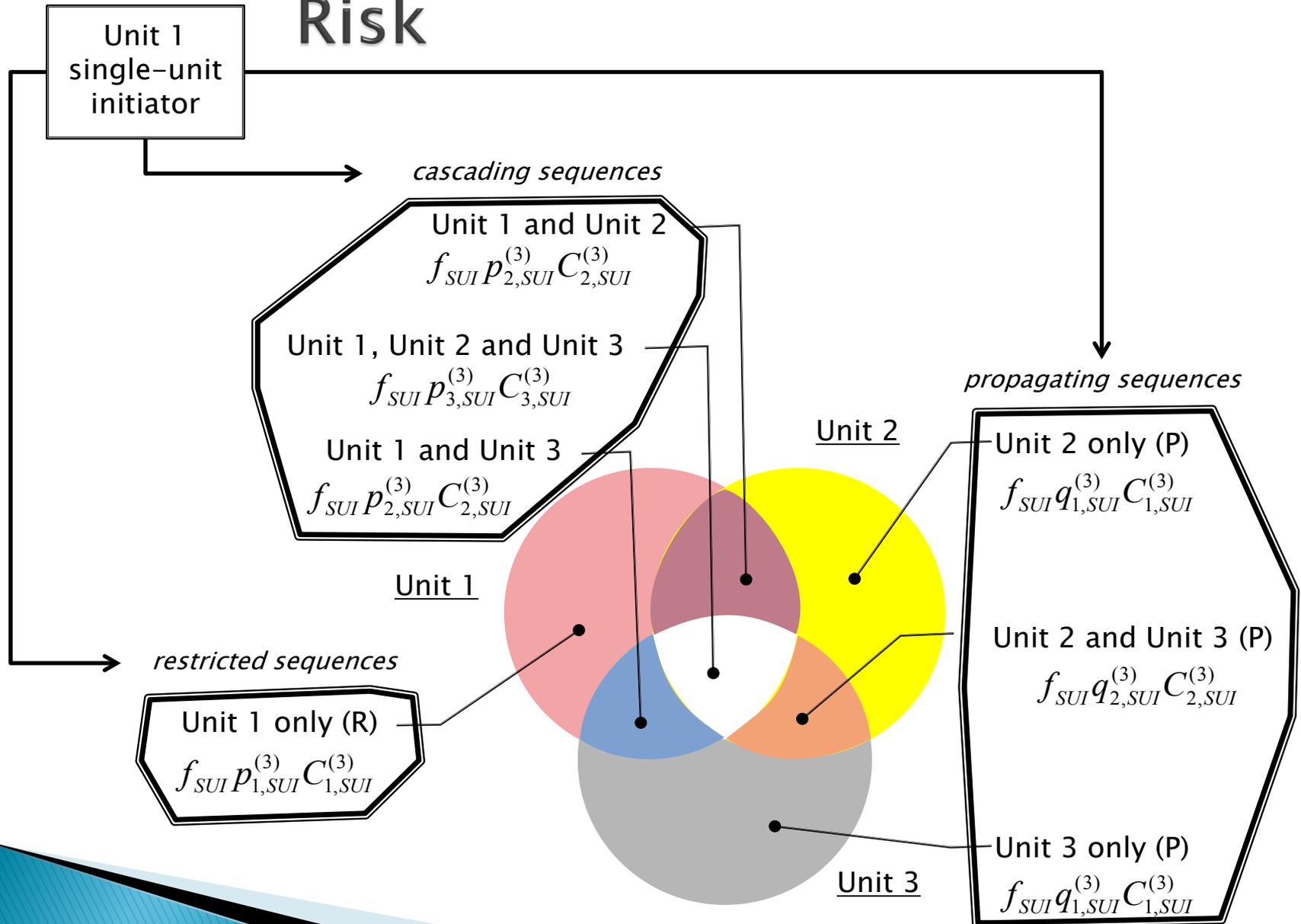
SUI Sequence Taxonomy

- ▶ Cascading sequence: Core damage and release in the unit where the SUI occurred, and also in one or more additional units
- ▶ Propagating sequence: No core damage or release from the unit where the SUI occurred, but core damage and release in one or more additional units
- ▶ Restricted sequence: Core damage and release only in the unit where the SUI occurred

Nomenclature for SUI Risk Contribution

- n = number of identical units
- f_{CCI} = frequency of the SUI
- $P_{k,CCI}^{(n)}$ = Pr{release from exactly k of n units due to restricted and cascading sequences | SUI}
- $q_{k,CCI}^{(n)}$ = Pr{release from exactly k of n units due to propagating sequences | SUI}
- $C_{k,CCI}^{(n)}$ = frequency weighted average consequence due to release from exactly k of n units after CCI

CCI Contributions to Multi-Unit Risk



Risk Due to SUIs

Using Assumption #1, the expression for multiunit risk due to SUIs is:

$$R_{S,SUI}^{(n)} = nf_{SUI} \left[\underbrace{\sum_{k=1}^n \binom{n-1}{k-1} p_{k,SUI}^{(n)} C_{k,SUI}^{(n)}}_{\text{restricted and cascading contribution}} + \underbrace{\sum_{k=1}^{n-1} \binom{n-1}{k} q_{k,SUI}^{(n)} C_{k,SUI}^{(n)}}_{\text{propagating contribution}} \right]$$

Risk Due to SUIs (Con't.)

Using Assumption #2 and simplifying:

$$R_{S,SUI}^{(n)} = n^2 f_{SUI} C_{1,SUI}^{(n)} \underbrace{\sum_{k=1}^n k \binom{n-1}{k-1} p_{k,SUI}^{(n)}}_{\text{single-unit risk due to SUIs}} - n(n-1) f_{SUI} C_{1,SUI}^{(n)} \sum_{k=2}^n \binom{n-2}{k-2} \underbrace{(p_{k-1,SUI}^{(n)} - q_{k-1,SUI}^{(n)})}_{\text{The q's include the probability that the SUI causes an initiator in one or more additional units as well as the probability of core damage and release in one or more additional units. So:}}$$

single-unit risk due to SUIs

The q's include the probability that the SUI causes an initiator in one or more additional units as well as the probability of core damage and release in one or more additional units. So:

As a result:

$$R_{S,SUI}^{(n)} < n^2 R_{\text{single-unit},SUI}$$

$$p_{k-1,SUI}^{(n)} > q_{k-1,SUI}^{(n)}$$

Total Multi-Unit Site Risk

$$R_S^{(n)} < n R_{\text{single-unit},CCI} + n^2 R_{\text{single-unit},SUI}$$

- Can bound the total multiunit site risk using the results of a single-unit PRA
 - Only need to partition results into CCI and SUI contributions
- Method provides little insight into risk contributors
- Needs further development to include:
 - Shutdown and low-power states
 - Spent fuel (spent fuel pool and dry cask storage)

What Does It All Mean?

- ▶ There is no guidance for acceptable site risk
 - During formulation of the Safety Goal Policy Statement in the early 1980s, the Commission decided not to impose a bias against multi-unit sites (*Safety Goals for Nuclear Power Plant Operation*, NUREG-0880, Rev. 1, May 1983, ADAMS Accession No. ML071770230, page 33, 2nd paragraph)
 - SRM dated 9/14/2005 to SECY-05-0130, *Policy Issues Related to New Plant Licensing and Status of the Technology-Neutral Framework for New Plant Licensing*
 - Quantitative health objectives (QHOs) currently interpreted on a per-reactor basis, e.g., the derivation of risk surrogates in App. D of NUREG-1860, *Feasibility Study for a Risk-Informed and Performance-Based Regulatory Structure for Future Plant Licensing*
 - QHO for individual early fatality risk $\leq 5E-7/y \leftrightarrow LERF \leq 1E-5/y$
 - QHO for individual latent cancer fatality risk $\leq 2E-6/y \leftrightarrow CDF \leq 1E-4/y$
- ▶ One way to proceed: Compare the site risk to the per-reactor QHOs. If site risk < single-unit QHOs, then no immediate safety concern

Example Application: Estimate of Site Individual Latent Cancer Fatality Risk

- ▶ Frequency information:
 - SPAR and SPAR-EE models (80% flood multipliers)
 - NFPA 805 submittals (80% fire multipliers)
 - Earthquakes (GI-199)
 - Tornados (NUREG/CR-4461)
- ▶ Consequence information:
 - NUREG-1150
 - SOARCA
 - Scoping multiunit MACCS2 calculations, which indicate that multiunit risk is less than linear (sub-additive)
 - Conditional probability of latent cancer fatality (CPLCF) ranges from 10^{-5} to 10^{-3} ; used 10^{-3}

Scoping Estimates of Multiunit Site ILCFR

Site	Units	Single-Unit Initiators							Common-Cause Initiators				Site ILCFR				
		Int. Events CDF	Internal Flood			Internal Fire			Total CDF	Seismic		Tornado CDF		Total CDF			
			Source	Multiplier	CDF	Source	Multiplier	CDF		Source	CDF						
Arkansas Nuclear	2	7.2E-06		0.55		4.0E-06		5.7		4.1E-05		5.2E-05	GI-199	4.1E-06	7.2E-05	7.6E-05	3.6E-07
Beaver Valley	2	5.6E-05		0.55		3.1E-05		5.7		3.2E-04		4.1E-04	GI-199	4.8E-05	7.1E-06	5.5E-05	1.7E-06
Braidwood	2	8.7E-06		0.55		4.8E-06		5.7		4.9E-05		6.3E-05	GI-199	7.3E-06	4.1E-05	4.8E-05	3.5E-07
Browns Ferry	3	4.1E-06		0.55		2.2E-06		5.7		2.3E-05		2.9E-05	GI-199	5.4E-06	1.1E-04	1.2E-04	6.2E-07
Brunswick	2	8.7E-06		0.55		4.8E-06	NFPA 805			1.5E-05		2.9E-05	GI-199	1.5E-05	1.8E-05	3.3E-05	1.8E-07
Byron	2	1.3E-05		0.55		6.9E-06		5.7		7.1E-05		9.1E-05	GI-199	5.8E-06	4.1E-05	4.7E-05	4.6E-07
Calvert Cliffs	2	2.1E-05		0.55		1.1E-05		5.7		1.2E-04		1.5E-04	GI-199	1.2E-05	8.9E-06	2.1E-05	6.5E-07
Catawba	2	3.0E-05		0.55		1.6E-05		5.7		1.7E-04		2.1E-04	GI-199	3.7E-05	2.1E-05	5.8E-05	9.7E-07
Comanche Peak	2	1.5E-05		0.55		8.4E-06		5.7		8.7E-05		1.1E-04	GI-199	4.0E-06	2.0E-05	2.4E-05	4.9E-07
D.C. Cook	2	3.3E-05		0.55		1.8E-05	NFPA 805			1.3E-05		6.5E-05	GI-199	1.2E-05	8.8E-05	1.0E-04	4.6E-07
Diablo Canyon	2	1.6E-05		0.55		8.7E-06		5.7		9.1E-05		1.2E-04	licensee	4.0E-05	1.2E-07	4.0E-05	5.4E-07
Dresden	2	8.5E-07		0.55		4.7E-07		5.7		4.8E-06		6.2E-06	GI-199	1.9E-05	4.1E-05	6.0E-05	1.4E-07
Farley	2	2.3E-05		0.55		1.3E-05	NFPA 805			5.9E-05		9.5E-05	GI-199	2.8E-05	3.2E-05	6.0E-05	5.0E-07
FitzPatrick/Nine Mile Point																	2.2E-07
FitzPatrick	1	4.3E-06		0.55		2.3E-06		5.7		2.4E-05		3.1E-05	GI-199	6.1E-06	1.0E-05	1.6E-05	
Nine Mile Point	2	1.2E-05		0.55		6.3E-06	NFPA 805			2.1E-05		3.9E-05	GI-199	5.6E-06	1.0E-05	1.6E-05	
Hatch	2	7.2E-06		0.55		4.0E-06		5.7		4.1E-05		5.2E-05	GI-199	2.2E-06	2.2E-05	2.4E-05	2.6E-07
Hope Creek/Salem																	6.5E-07
Hope Creek	1	5.3E-06		0.55		2.9E-06		5.7		3.0E-05		3.9E-05	GI-199	2.8E-06	8.4E-06	1.1E-05	
Salem	2	3.4E-05	SPAR-EE			8.3E-05	SPAR-EE			2.8E-05		1.5E-04	GI-199	7.4E-06	8.4E-06	1.6E-05	
Indian Point	2	9.7E-06	SPAR-EE			3.1E-06	SPAR-EE			5.4E-05		6.7E-05	GI-199	1.0E-04	8.4E-06	1.1E-04	4.8E-07
La Salle	2	3.2E-06		0.55		1.8E-06		5.7		1.8E-05		2.3E-05	GI-199	3.7E-06	4.1E-05	4.5E-05	1.8E-07
Limerick	2	2.3E-06	SPAR-EE			4.1E-08	SPAR-EE			4.2E-06		6.4E-06	GI-199	5.3E-05	8.4E-06	6.1E-05	1.5E-07
McGuire	2	7.4E-06		0.55		4.0E-06		5.7		4.2E-05		5.3E-05	GI-199	3.1E-05	2.1E-05	5.2E-05	3.2E-07
Millstone	2	4.1E-06		0.55		2.2E-06		5.7		2.3E-05		3.0E-05	GI-199	1.5E-05	8.4E-06	2.3E-05	1.7E-07
North Anna	2	1.3E-05		0.55		7.0E-06		5.7		7.3E-05		9.3E-05	GI-199	4.4E-05	8.9E-06	5.3E-05	4.8E-07
Oconee	3	1.4E-05		0.55		7.9E-06	NFPA 805			6.1E-05		8.3E-05	GI-199	4.3E-05	2.5E-05	6.8E-05	9.6E-07
Palo Verde	3	8.9E-06		0.55		4.9E-06		5.7		5.1E-05		6.4E-05	see note	3.8E-05	1.3E-07	3.8E-05	6.9E-07
Peach Bottom	2	3.4E-06	SPAR-EE			5.3E-08	SPAR-EE			6.6E-07		4.1E-06	GI-199	2.4E-05	6.6E-06	3.1E-05	7.8E-08
Point Beach	2	9.3E-06		0.55		5.1E-06		5.7		5.3E-05		6.8E-05	GI-199	1.1E-05	2.7E-05	3.8E-05	3.5E-07
Prairie Island	2	4.1E-06		0.55		2.3E-06	NFPA 805			5.2E-05		5.8E-05	GI-199	3.0E-06	5.3E-05	5.6E-05	3.5E-07
Quad Cities	2	4.3E-06		0.55		2.4E-06		5.7		2.5E-05		3.1E-05	GI-199	2.7E-05	1.3E-04	1.6E-04	4.4E-07
Saint Lucie	2	2.7E-06		0.55		1.5E-06		5.7		1.5E-05		1.9E-05	GI-199	4.6E-05	7.8E-06	5.4E-05	1.8E-07
Sequoyah	2	1.4E-05		0.55		7.7E-06		5.7		8.0E-05		1.0E-04	GI-199	5.1E-05	4.1E-05	9.2E-05	5.9E-07
South Texas	2	8.4E-06		0.55		4.6E-06		5.7		4.8E-05		6.1E-05	GI-199	6.3E-06	5.3E-06	1.2E-05	2.7E-07
Surry	2	2.8E-06	SPAR-EE			5.0E-05	SPAR-EE			5.3E-06		5.9E-05	GI-199	5.7E-06	8.9E-06	1.5E-05	2.6E-07
Susquehanna	2	1.9E-06		0.55		1.0E-06		5.7		1.1E-05		1.4E-05	GI-199	1.3E-05	1.3E-05	2.6E-05	1.1E-07
Turkey Point	2	1.7E-06	SPAR-EE			1.0E-08	NFPA 805			7.3E-05		7.5E-05	GI-199	1.0E-05	4.6E-06	1.5E-05	3.3E-07
Vogtle	2	3.1E-05		0.55		1.7E-05		5.7		1.8E-04		2.2E-04	GI-199	7.1E-06	1.4E-05	2.1E-05	9.4E-07

maximum 1.7E-06

Palo Verde seismic CDF estimated shortly after the Fukushima Dai-ichi event using GI-199 methods

Less than the per-unit QHO