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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

March 8, 2006

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This transcript has not been reviewed, corrected and edited and it may contain inaccuracies.

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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

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EARLY SITE PERMIT SUBCOMMITTEE MEETING

+ + + + +

WEDNESDAY, MARCH 8, 2006

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The meeting was held in Room T2B3, Two
White Flint North, Rockville, Maryland, at 8:30 a.m.,
Dana A. Powers, Chairman, presiding.

PRESENT:

DANA A. POWERS	CHAIRMAN
GRAHAM WALLIS	MEMBER
OTTO C. MAYNARD	MEMBER
WILLIAM J. SHACK	MEMBER
MARIO V. BONACA	MEMBER
JOHN D. SIEBER	MEMBER
THOMAS S. KRESS	MEMBER
WILLIAM J. HINZE	ACNW
MICHAEL R. SNODDERLY	DESIGNATED FEDERAL OFFICIAL
DAVID FISCHER	STAFF ENGINEER

C O N T E N T S

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P R O C E E D I N G S

(8:33 a.m.)

1
2
3 CHAIRMAN POWERS: The meeting will now
4 come to order.

5 This is a meeting of the Advisory
6 Committee on Reactor Safeguards, Subcommittee on Early
7 Site Permits.

8 I'm Dana Powers, Chairman of the
9 subcommittee. Members in attendance are Mario Bonaca,
10 Otto Maynard, Tom Kress, Bill Shack, and Jack Sieber
11 somewhere, and Graham Wallis, who thinks he's here,
12 but the most important is we have the benefit of Bill
13 Hinze from the Advisory Committee on Nuclear Waste
14 attending and participating.

15 Welcome, Bill. Glad to have you here to
16 keep us straight on all of this stuff.

17 The purpose of this meeting is to continue
18 our review and discuss further the staff's final
19 safety evaluation report regarding the Exelon
20 Generation Company's application for an early site
21 permit at the Clinton site. The meeting is going to
22 focus on the applicant's performance based seismic
23 hazard analysis methodology.

24 You will recall that this was new to us at
25 our earlier meeting, and that at that earlier meeting

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1 the staff had not approved that methodology, and today
2 we're going to hear more about the details on that.

3 The subcommittee will gather information,
4 analyze relevant issues and facts and formulate
5 proposed positions and actions as appropriate for
6 deliberation by the full committee.

7 Mike Snodderly is our designed federal
8 official for the meeting, but I'd like to introduce
9 the subcommittee today. Fischer, he is going to be
10 Ned's replacement and will be handling early site
11 permits. Dave actually has a history with the ACRS,
12 and so we look forward to working with you closely,
13 Dave.

14 The rules for participation in today's
15 meeting have been announced as part of the notice of
16 this meeting previously published in the Federal
17 Register on February 23rd, 2006. The transcript of
18 the meeting is being kept and will be made available
19 as stated in the Federal Register notice. It is
20 requested that speakers first identify themselves,
21 speak with sufficient clarity and volume so that they
22 can be readily heard.

23 We have received no written comments or
24 requests for time to make oral statements from members
25 of the public regarding today's subcommittee meeting.

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1 That doesn't mean that people can't make comments if
2 they have things to contribute to our information
3 gathering.

4 As I said, we're going to focus a lot on
5 just the seismic issue. I think we'll probably get a
6 status update on open items and things like that, but
7 our real intent is to hone in on this performance
8 based seismic methodology.

9 The contention, as you will recall, at our
10 previous meeting was that this offers not only
11 stability, but perhaps safety advantages. So it's
12 really quite of interest.

13 Do any members of the subcommittee have
14 opening comments they would care to make?

15 (No response.)

16 CHAIRMAN POWERS: Seeing none, I will turn
17 to Laura Dudes, and you're going to give us an
18 introductory comment?

19 MS. DUDES: Well, good morning. I think
20 Marilyn Kray and Exelon will provide the early morning
21 presentation, and then the staff will be up to provide
22 their results on the safety evaluation report.

23 Marilyn.

24 CHAIRMAN POWERS: Not what it says on my
25 agenda. You lead me astray all the time.

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1 (Laughter.)

2 CHAIRMAN POWERS: Marilyn.

3 MS. KRAY: Yes. Well, we appreciate
4 your --

5 CHAIRMAN POWERS: Cover for Laura.

6 MS. KRAY: We appreciate your flexibility
7 and I know we're here at your ready. Thank you, Mr.
8 Chairman.

9 And as you know, it was September of this
10 past year that we were here in, I think, similar
11 seats, and while it seems a short time ago, there has
12 been a lot accomplished, and as you can imagine, this
13 meeting is a significant milestone for Exelon, but
14 it's also a significant milestone for the industry.

15 You are probably aware that the regulatory
16 information conference is ongoing across the street,
17 and while there are certainly some devoted sessions to
18 new plants, the underlying theme throughout all of the
19 sessions and probably more importantly on all of the
20 discussions in the hallways during the network breaks
21 is certainly new plants. And you're going to hear
22 this morning, as you're expecting, detailed
23 discussions on the seismic issues.

24 And while these are certainly critical to
25 the Clinton early site permit project, they are

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1 similarly critical to future ESP as well as COL
2 applicants. So we are grateful to the efforts of both
3 the staff and the industry through the NEI Seismic
4 Issues Task Force to use this pilot application to set
5 perhaps the precedence for some future licensing
6 actions.

7 So, again, we thank the efforts of both
8 the staff and the industry, and with that, I will turn
9 it over to Eddie Grant.

10 MR. GRANT: Thank you, Maryland.

11 If I can get rid of this thing and learn
12 how to use this machine, thank you for bearing with
13 me.

14 My name is Eddie Grant. I'm the lead on
15 the licensing for the safety side of the early site
16 permit. I'd like to take you through the agenda real
17 quickly this morning. What we have in mind, of
18 course, is some quick introductions, just reminders of
19 who we are, what we've been doing.

20 We'll look at significant changes since
21 the draft safety evaluation report. We'll have a few
22 minutes on the geotechnical approach because that was
23 part of that supplemental draft safety evaluation
24 report.

25 Certainly look at the seismic evaluation,

1 and that's where we'll get into the performance based
2 and where we'll spend most of our time.

3 Then we have a few slides to quickly go
4 through the supplemental draft SER issues' closure,
5 and then summarize, and we'll move forward.

6 As I indicated quickly as introductions,
7 you've already hear from Marilyn Kray, who is the
8 project executive sponsor. Tom Mundy is also here
9 with us. He has been the project manager, but he's
10 moving on to the COL applications and going to be
11 managing that project. So Kris Kerr is here with us
12 in the audience. He is now the senior project manager
13 on the early site permit, and like I said, I'm the
14 safety and emergency planning lead, and Bill Maher was
15 the environmental lead. He's back in the audience as
16 well if anything comes up for him.

17 We had quite a support team. CH2M Hill
18 was the prime contractor. They conducted the
19 environmental reviews, did the site redress, did the
20 geotechnical and drafted the emergency plan for us.

21 CH2M Hill then had a number of
22 subcontractors. WorleyParsons did the safety
23 evaluations. GeoMatrix, Mr. Bob Youngs and Kathryn
24 Hanson over here in the audience with us did the
25 seismic evaluations, the PSHA, and looked at the

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1 paleoliquefaction. That's always an interesting
2 topic.

3 And then we had a seismic Board of Review
4 that helped us out with our reviews. As we went
5 through we talked with them a little bit about what we
6 were doing and had a few chats with them about where
7 we should go that led to the change to going to the
8 performance based methodology. As I indicated, they
9 did an expert independent review of all of the
10 information on the seismic side.

11 Carl Stepp was the Chairman of that
12 Seismic Board of Review, and you'll hear from him as
13 we get to the seismic piece. He'll be doing that
14 presentation.

15 There were some others that did various
16 pieces of the geotechnical borings and those types of
17 things.

18 RPK Structural Mechanics Consulting,
19 that's Mr. Kennedy, Bob Kennedy down on the far end.
20 He is, I believe, the leading expert in the
21 performance based methodology, and he'll be sharing
22 some of that information with us today.

23 Sergeant Lundy did a quick draft
24 application review when we thought we were pretty
25 close to going, and of course, Morgan Lewis was our

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1 legal counsel.

2 Just a quick reminder of where we're
3 talking about, as you indicated, the Clinton Station,
4 it's out in central Illinois. There is an existing
5 plant, and it's AmerGen owned. Exelon Generation
6 Company is the applicant, and it's a wholly owned
7 subsidiary of Exelon Corporation.

8 Significant changes since the DSER. You
9 may recall, I know this is focused on the seismic, but
10 we've got a draft SER for everything but the seismic
11 piece back in February of last year, and it had a
12 number of open items and confirmatory items, and then,
13 of course, the supplemental DSER addressing the
14 geotechnical and seismic came out in August.

15 Then we met with you shortly after that in
16 September, and we really had not had a chance at that
17 point to look at or evaluate completely the
18 supplemental draft SER open items.

19 Certainly since that time we have looked
20 at those. We have responded to all of those, and the
21 staff has just issued the FSER, which accepts those
22 responses such that all of the open items are closed.
23 So that's a significant change.

24 The staff had a few confirmatory items
25 that they were looking at, and all of those have been

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1 accomplished. So those are all complete.

2 DR. HINZE: Dr. Powers, could I interrupt
3 here a moment and ask a question? I don't know who I
4 should be asking this of, but obviously the technical
5 work on this is a moving target that continues to
6 expand and grow.

7 Is there a cutoff time specified ESP
8 application in terms of the technical literature and
9 the work that's being done? Is there a cutoff time
10 that we can assume has been used by Exelon?

11 CHAIRMAN POWERS: Well, what Exelon uses,
12 I'll leave them to answer, and I think it's a rule of
13 reason applies here. I don't think you can expect
14 them to have pulled down the latest copy of Geological
15 Society of America or something like that, but they
16 are required by regulation to look at the literature
17 since in the interval of about 1984 and now, and what
18 you're asking is what is now, I think it's the rule of
19 reason here.

20 DR. HINZE: Well, one of the reasons I ask
21 that is that the literature search seems to stop at
22 2004, and there are some interest articles that occur
23 in 2005, and I am just curious as to whether those
24 should be incorporated in or not.

25 CHAIRMAN POWERS: Well, I mean, again,

1 2004 seemed like a reasonable number for me in the
2 application just because somebody has to sit down and
3 write this thing. But if there are insights in the
4 2005 literature that would make qualitative changes to
5 our perceptions, I mean, we can certainly bring those
6 to our attention.

7 DR. HINZE: Good.

8 CHAIRMAN POWERS: All right.

9 MR. GRANT: All right. Again, one of the
10 major changes or more significant changes is that,
11 indeed, the staff has accepted the proposed SSE ground
12 motion spectra for the Clinton Power Station early
13 site permit. There were minor revisions to that
14 ground motion spectra from what you saw in our earlier
15 application as a result of the open items, and we'll
16 address some of those when we're looking at the open
17 items.

18 Again, the more significant changes since
19 the draft SER is that the staff has documented their
20 criteria for establishing what permit conditions are
21 or should be, which items should be permit conditions
22 and which items should be combined license action
23 items.

24 You might remember we had quite a number
25 of proposed permit conditions in the original draft

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1 SER, and that has dropped significantly based on the
2 new criteria, although the combined license action
3 items have gone up, which is probably expected. There
4 will be a lot of things that can't be addressed on an
5 early site permit, and therefore, it's not unexpected
6 that those would be expected to be addressed at the
7 combined license stage.

8 And you'll see that response and closure
9 of a couple of our open items depend on that.

10 What I'd like to turn to now is the
11 geotechnical approach. I'd like to indicate primarily
12 here what we did in relation to building on the
13 existing Clinton Power Station information. Because
14 this is an existing site, there is a lot of
15 information that was readily available in the seismic
16 and geotechnical areas, and we certainly didn't want
17 to just throw that out.

18 And more importantly, we wanted to be as
19 consistent as we could with the sister station. So we
20 looked at the available information as far as regional
21 geology, site geology, what exploration had been done
22 back in the '70s, and the lab testing that had been
23 done on the soils and properties in the area.

24 And then we did some work specifically for
25 the early site permit to confirm those conditions,

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1 that indeed, we got the same answers or close to the
2 same answers that the folks had gotten back in the
3 '70s, and we updated the information particularly in
4 the areas of the geology and doing the literature
5 search and what was available as far as any identified
6 new seismic sources and/or seismic methodologies that
7 were available to evaluate those sources.

8 This is just a quick plot here that shows
9 the original Clinton Power Station site investigation
10 locations. You can see that there are quite a number
11 of areas where we did borings or other types of
12 investigations across the site.

13 And what I'd like to do then is show you
14 a slide that doesn't seem to want to --

15 CHAIRMAN POWERS: Didn't want to come up,
16 huh?

17 MR. GRANT: -- come up. It was there this
18 morning. Is it in your printed copies?

19 Okay. I apologize for this, but you can
20 see not up here, but on your printed copies that,
21 indeed, we overlaid the top dashed area there is where
22 the existing Clinton Power Station is, and the bottom
23 area is where we're proposing to place the early site
24 permit structures.

25 You can see that, indeed, a large number

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1 of the areas that were investigated during the '70s do
2 overlay and encompass the new area, and then, of
3 course, we did some specific investigations in the new
4 area, and again, I just wanted to try to show you --
5 unfortunately I'm not succeeding real well -- on how
6 those matched up.

7 CHAIRMAN POWERS: But we have been over
8 this one before.

9 MR. GRANT: There it is. I've got two
10 nines for some reason. Yes, there is the slide. The
11 blue dots and plus signs or crosses are existing
12 information from back in the '70s, again, from the
13 early Clinton Power Station investigations.

14 The green and orange and red circles,
15 squares and diagonals down in the red dashed area are
16 the new investigations used to confirm that, indeed,
17 the site is exactly in this area as we had thought it
18 was based on the older information.

19 What we found, again, is that the site is
20 relatively uniform across all that property. The
21 soils are fairly stiff, but it is a soil site.

22 The field data shows that the sheer save
23 velocities are, again, consistent with what we saw
24 from the Clinton Power Station investigations, and the
25 lab data showed a good match with the assumed EPRI

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1 soil modulus and damping curves.

2 The red line there shows the information
3 available from what we've done recently, and then a
4 good number of the information, the darker line, I
5 guess, that is dashed shows how it had been identified
6 back at the Clinton Power Station. So, again, a close
7 approximation.

8 And at this point we're going to move away
9 from that and get over into the more important topic
10 for the day, which is the seismic evaluations and how
11 those were done. And I'm going to ask Dr. Carl Stepp
12 to lead this discussion.

13 DR. STEPP: Thank you, Eddie.

14 The seismic valuation, particularly we're
15 now focusing on the SSE ground motion determination,
16 followed largely the guidance and methodologies that
17 are laid out in Regulatory Guide 1.165. This
18 viewgraph shows the areas where we followed the guide
19 rather closely or completely, and the one area in
20 which we departed from the guidance in 1.165.

21 We started as the regulatory guide allows
22 with the EPRI work of the mid-1980s to late 1980s, and
23 we updated that work with current knowledge base
24 through the time of submittal of the licensing
25 application two years ago.

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1 Seismic sources were updated, using that
2 information. Sensitivity studies were done. We did
3 a SSHAC Level 2 evaluation to update the uncertainties
4 in the input parameters for seismic hazard
5 calculations and computed a new PSHA for the site with
6 the updated information.

7 We departed from the regulatory guidance
8 in actually computing the SSE ground motion spectra.
9 Instead of using the reference hazard probability that
10 is specified in the Reg. Guide 1.165, we used the
11 performance based risk informed, I will call it,
12 methodology that you will hear much more about today.

13 Next.

14 In deriving the ground motion from the
15 probabilistic hazard, we followed, again, the
16 regulatory guidance in de-aggregating the hazard
17 across the spectra of interest, spectral frequencies
18 of interest, and determining controlling earthquakes
19 for low and high frequency part of the spectrum, then
20 fitting the ground motion to those derived spectra.

21 We accounted for side effects and did site
22 response analyses following the guidance that is
23 provided in NUREG CR-6728.

24 Just a few examples of updating the
25 information. This shows the seismicity prior to the

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1 application. We used the EPRI work from a catalogue
2 from 1777 through 1985, and that was updated using
3 USGS regional network locations from the USGS
4 catalogue and the council on national seismic systems
5 to 2002, and you can see from these side-by-side
6 comparisons that the pattern of seismicity had
7 changed, and indeed, the rate of seismicity is
8 generally unchanged except for the new add rate zone.

9 We also had new information on
10 liquefaction that had appeared in the literature, and
11 the next line followed up on that information by doing
12 actual site investigations. The map you see here
13 shows areas with new liquefaction information around
14 the site.

15 The liquefaction information has revealed
16 that they are repeated large earthquakes in the New
17 Madrid site and so on during the past 2,000 years that
18 had to be taken in account in assessing the hazard
19 from that zone.

20 It revealed that there are larger
21 earthquakes in the historic/prehistoric past in the
22 Wabash Valley zone.

23 CHAIRMAN WALLIS: I'd like to ask you
24 about that.

25 DR. STEPP: Yes.

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1 CHAIRMAN WALLIS: In the SER in your
2 submittal there's a tremendous discussion, qualitative
3 discussion, of all this stuff, but what matters
4 eventually is the numbers you're going to use, and so
5 I look for the numbers you used for this Wabash
6 Valley, which is interesting because it happened
7 12,000 years ago and then 6,000 years ago. So it's
8 going to -- no. Well, obviously that's not the case.

9 But if we look at the SER on page 21878,
10 it says, "The applicant cited research that this
11 Wabash Valley event 6,000 years ago was in the range
12 7 to 7.5 in magnitude."

13 And then on another page, 204, it says,
14 "The applicant stated that the event 6,000 years ago
15 was in the range of 7.2 to 7.8," which is a different
16 set of numbers, and you know, this is logarithmic. So
17 it's very important whether it's 7.5 or 8, presumably.

18 And then it says, "The EPRI SOG (phonetic)
19 uses the range of 5 to 8," and then there's a
20 qualitative statement on that, page 206, which says,
21 "The applicant made adjustment to increase the maximum
22 magnitude distribution for the Wabash Valley seismic
23 zone."

24 It doesn't say to what, by how much, and
25 why. It simply says that you increase the magnitude.

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1 But I don't see any numbers associated with that
2 increase. So I don't know what magnitude you used and
3 why.

4 And then when I get -- I'm going to go on
5 and give this speech and then you can answer, and it's
6 probably all very easy to clarify -- on page 208 I
7 find that the ten to the minus four high frequency
8 hazard is actually dominated by this Wabash Valley
9 zone, and then it becomes a 6.5 event.

10 Now, how do all of these numbers relate?
11 And when you did increase the maximum magnitude, by
12 who much did you and so on?

13 I mean, it's not clear to me what numbers
14 were used and why.

15 DR. STEPP: Okay. We'll answer, I think,
16 in two parts. First, to address how we increase the
17 maximum magnitude and why and by how much, and then I
18 think the second part is the deaggregation that you
19 referred to, and that will be answered by, I think,
20 Bob Youngs. Will you take the lead on this?

21 MR. YOUNGS: My name is Robert Youngs with
22 GeoMatrix Consultants.

23 The maximum magnitudes that were used in
24 the original EPRI study that was completed in 1985
25 arranged for the Wabash Valley up to the size of

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1 events that had been reported in the literature from
2 the paleoliquefaction information in terms of the size
3 of earthquakes.

4 But the weights that were assigned to the
5 larger magnitudes were relatively low compared to what
6 we would interpret now based on this paleoliquefaction
7 information.

8 So the revision that we did to that source
9 was to change the weighting scheme to give a lot more
10 weight to larger magnitude earthquakes, and on page 2-
11 204 of the SER, down near the bottom in the paragraph
12 under Wabash Valley source zone, at the end of that
13 paragraph they list the distribution of magnitudes
14 that we used.

15 CHAIRMAN WALLIS: Yeah, I guess it's .1,
16 .4, .4, .1. Is that the --

17 MR. YOUNGS: Right. Those are the weights
18 we assigned to those magnitudes.

19 CHAIRMAN WALLIS: I see those, yeah. But
20 someone decided to use all of these numbers. How did
21 you decide and where did you do this increase in the
22 maximum magnitude? Is this increase in the maximum
23 magnitude reflected in this .1, .4, .4, .1
24 distribution?

25 MR. YOUNGS: Yes.

1 CHAIRMAN WALLIS: But that seems to be 7
2 to 7.8, which you've already stated was what happened
3 7,000 years ago, 6,000 years. I don't see them
4 increase.

5 MR. YOUNGS: No, they're increased from
6 what the EPRI expert assessed back in the '80s. So
7 it's an update to the seismic --

8 CHAIRMAN WALLIS: So increase over EPRI.

9 MR. YOUNGS: Yes. So it's a modification
10 of the distribution of maximum magnitude.

11 CHAIRMAN WALLIS: How did you decide what
12 to do? You could have increased it to eight since the
13 EPRI gave a range of five to eight. Why do you sort
14 of restrict -- I don't understand how you decide what
15 numbers to use.

16 MR. YOUNGS: It's an evaluation looking at
17 how various authors have interpreted what the size of
18 those events and giving weight to various
19 interpretations. It's basically a judgment call as to
20 how we feel that the information that we see in the
21 literature would indicate what the largest magnitude
22 should be.

23 CHAIRMAN WALLIS: Well, that seems to me
24 sort of the meat of the whole thing. I mean, I've got
25 200 pages of description, and I have a couple of

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1 paragraphs that say you use these numbers. The
2 justification for those numbers is the whole meat of
3 the application, isn't it, really? The justification
4 is more important than anything else.

5 MR. YOUNGS: Yes.

6 CHAIRMAN WALLIS: And I didn't see that.
7 That's what puzzled me. It isn't my field. I just
8 sort of picked that up as being rather strange.

9 DR. STEPP: The justification is a
10 clarifying comment to the process. As I mentioned in
11 my introduction, we applied SSHAC Level 2 assessment
12 procedure, and it was through that procedure that we
13 arrived at these weights on the numbers.

14 CHAIRMAN WALLIS: I have no idea what that
15 is.

16 DR. STEPP: Well, I'm going to explain it.
17 The SSHAC methodology, this procedure is for assessing
18 subjective uncertainties that has been developed by a
19 combination of NRC and industry support and DOE
20 support, and one level of that, which we applied here,
21 is the Level 2, which is a process by which new
22 information is compiled, and it's assessed against the
23 existing interpretation, which was the EPRI
24 interpretation.

25 CHAIRMAN WALLIS: Is this a Bayesian type

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1 thing, is it?

2 DR. STEPP: The basic EPRI interpretations
3 of the mid-1980s.

4 CHAIRMAN WALLIS: Is this a Bayesian
5 updating type thing?

6 DR. STEPP: It's a subjective updating,
7 not a Bayesian updating, just subjective updating based
8 on the current state of knowledge of the scientific
9 community. So the process that was done here is we
10 updated the information, canvassed the scientific
11 community, and the weights that you see assigned there
12 represent the assessed weights that reflect the
13 current state of the scientific community subjective
14 interpretation.

15 CHAIRMAN WALLIS: And then you make this
16 adjustment to increase the maximum magnitude?

17 DR. STEPP: Yes.

18 CHAIRMAN WALLIS: On top of that?

19 DR. STEPP: Well, that is the process by
20 which we do that.

21 CHAIRMAN WALLIS: That's the result of
22 that. So you weren't yourselves making an adjustment.
23 These numbers come from analyzing the scientific
24 community's --

25 DR. STEPP: The views reflect the

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1 scientific community's views, yes. They're subjective
2 interpretation.

3 CHAIRMAN POWERS: I think it's fair to
4 state that they're completely prescriptive, analytic
5 expression for the SSHAC approach is yet to be
6 derived, that it is --

7 DR. STEPP: Well, it's not a Bayesian
8 approach.

9 CHAIRMAN POWERS: It is an exercise in
10 engineering judgment, seismic engineering judgment.

11 DR. STEPP: It's a process by which
12 scientific and engineering judgment is quantified and
13 weighted.

14 DR. HINZE: As one of the members of the
15 team back in those days, I can tell you that these
16 numbers were just not pulled out of the air, but came
17 as a result of a lot of literature search, a lot of
18 discussion among various disciplines, and the
19 information on which the so-called experts were making
20 their decision were intended to be rather soft. So
21 there had to be a lot of judgment.

22 And that's why it's necessary, I think, to
23 include this probability range that we see this site
24 safety report coming up with.

25 CHAIRMAN WALLIS: So your view is that

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1 they did the right thing here?

2 DR. STEPP: Well, I think they did the
3 right thing, probably the only thing --

4 CHAIRMAN POWERS: Yes.

5 DR. STEPP: -- to be very honest with you.

6 CHAIRMAN WALLIS: What I was missing is
7 the rationale for the non-expert, which explained why
8 what they did was reasonable.

9 MR. YOUNGS: Well, and I think there's an
10 assumption here in preparing this report that everyone
11 understands how all of this comes about, and as I read
12 the report, if I didn't have the background of being
13 involved in the EPRI study, I would have been lost,
14 and so I really understand where your question is
15 coming from Dr. Wallis.

16 CHAIRMAN POWERS: But, I mean, this whole
17 thing speaks back to your original point. Where do
18 you cut this stuff off? Because I mean in this report
19 itself we see that they go to the Tuttle paper, and
20 then they go talk to Ms. Tuttle, and she's changed her
21 mind, and so this goes on and on and one.

22 But I mean, it's --

23 DR. STEPP: Well, it's science.

24 CHAIRMAN POWERS: And it's also the
25 interpretation of single point measurements. I mean,

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1 we've just got to get nature to give us more
2 earthquakes.

3 (Laughter.)

4 DR. STEPP: Well, for example, the
5 operation, the methodology for converting the
6 paleoliquefaction studies into magnitudes, there are
7 a number of different techniques there. There are
8 four different accepted techniques, and they will lead
9 to different answers, and so depending upon the best
10 possible way you can do it, and you need to really
11 combine these, and you have to put some kind of weight
12 of probability for justification on that.

13 CHAIRMAN POWERS: To my mind in looking at
14 this, I think it's comforting to see that not only did
15 they recognize major seismic zones here, but they were
16 willing to adjust the assigned magnitudes to try to
17 get them up to date, and they were willing to
18 recognize even poorly understood seismic centers here,
19 and asking them to get numbers that are justified down
20 to the second decimal point is simply beyond the state
21 of the art is my perception here.

22 DR. STEPP: It's beyond resolution, yeah.

23 CHAIRMAN POWERS: In fact, I had the
24 benefit of consulting with a geoseismologist about
25 this, and she was quite impressed that you got any

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1 numbers at all.

2 CHAIRMAN WALLIS: Yeah, what I was missing
3 was I didn't really expect great accuracy, but when I
4 saw two sets of numbers that's different on different
5 pages, and then I saw this mysterious adjustment to
6 increase the magnitude without explaining what that
7 was and what the numbers were that came out of that
8 and why they were bigger by a certain amount and why
9 you chose to increase them by .2 or .1 or .5 or
10 something, there seemed to be no explanation for these
11 things.

12 So I saw a story which to me was
13 incomplete. That's all.

14 DR. STEPP: Well, I think it's sort of
15 lost in the massive verbiage here, that the
16 paleoliquefaction studies were not available to the
17 experts except in a very superficial way in the New
18 Madrid area, were not available to the experts in the
19 '85 time frame.

20 And so the report does an excellent job,
21 I believe, of bringing that up to date, as you've
22 said.

23 MR. GRANT: One thin that the report does
24 is actually provide references to the EPRI report that
25 was written. I think it was an EPRI report that was

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1 written to document the SSHAC evaluation. So all of
2 that is not, of course, repeated in the site safety
3 analysis report, and again, it requires some
4 familiarity with the SSHAC evaluations when you just
5 get a quick reference to it in the SSAR without going
6 back to look at all of the documentation that was done
7 on how it was done.

8 CHAIRMAN POWERS: You know, when I cruise
9 around in the literature in an undirected and
10 undoubtedly superficial way, I see people attempting
11 to take these data and fit them to explicit
12 distributions, and Kagan distributions come to mind
13 here, but I don't see this discussion of such attempts
14 to fit the distributions here either in your
15 application or in the SER.

16 I mean, this is more an item of curiosity.
17 Why not?

18 DR. STEPP: Well, actually that's a very
19 good question. In the early '80s when we initiated
20 the EPRI SOG studies and NRC was going through similar
21 studies with Lawrence Livermore Lab, we gave a lot of
22 attention to more quantified approaches, and it turns
23 out we concluded at that time that it turns out that
24 those methods are not really very amenable to the very
25 sparse data that we have, has extremely high

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1 uncertainty in the data itself, and the process that
2 we develop, which has later been adopted as the SSHAC
3 methodology, seemed to work really well. It allowed
4 earth scientists to weight data according to their
5 judgments about its resolving power for a certain
6 interpretation, and this has been a much more workable
7 approach than purely quantified Bayesian techniques
8 which are normally --

9 CHAIRMAN WALLIS: Well, can I just round
10 this off? I mean, if it had been eight instead of
11 7.8, would it have made any difference?

12 DR. STEPP: I'm sorry?

13 CHAIRMAN WALLIS: Suppose you had chosen
14 eight instead of 7.8 for your maximum cutoff? This
15 was already limiting at ten to the minus four high
16 frequency hazard. Would it have made any difference
17 to the answer that you got?

18 DR. STEPP: It would have made a
19 difference.

20 CHAIRMAN WALLIS: Would it have been
21 significant?

22 DR. STEPP: Some small difference, yes,
23 depending on the weight given to an eighth, but we're
24 constrained in making those assessments by the range
25 of the data and by the professions, the --

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1 CHAIRMAN WALLIS: So is it sensitive to
2 these assumptions? That's what I'm trying to get at.
3 I mean, is your answer, your bottom line about the
4 site 0--

5 DR. STEPP: Yes.

6 CHAIRMAN WALLIS: -- the 6.5 event that
7 you use and so on, is it critical whether or not the
8 number 7.8 or 8?

9 DR. STEPP: Not critical.

10 CHAIRMAN WALLIS: Does it make a
11 difference?

12 DR. STEPP: It's not critical, but it
13 would make some small difference.

14 CHAIRMAN WALLIS: Some small difference.

15 DR. STEPP: Yeah. It would increase
16 the --

17 CHAIRMAN WALLIS: It would increase the
18 Gs, increase the Gs by five percent, 50 percent?

19 DR. STEPP: Five percent perhaps. I don't
20 know.

21 CHAIRMAN POWERS: Well, I got the
22 impression --

23 DR. HINZE: It depends upon the weight you
24 put on it.

25 DR. STEPP: This process is --

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1 CHAIRMAN WALLIS: Well, suppose we jack
2 the whole distribution up by 22.

3 DR. STEPP: It's really hard to answer in
4 a percentage, but I can give you an example and we
5 will give you an example of the impact and the
6 percentage that we -- of the updating of the New
7 Madrid zone. That would, I think, answer your
8 question more directly.

9 CHAIRMAN POWERS: Yeah, I think that gives
10 a feel for -- I mean, I got the sense that when you
11 adjusted New Madrid you got like about a ten percent
12 change.

13 DR. STEPP: Yeah, nine or ten percent.

14 CHAIRMAN WALLIS: This goes a bit to the
15 question of when you get new information what happens.
16 I mean, this is a very uncertain field, and if there's
17 an event in the Wabash Valley next year, it gives you
18 new information. Is it going to change the answer
19 significantly? That's the kind of thing I'm looking
20 for.

21 DR. STEPP: It won't be large.

22 CHAIRMAN WALLIS: How careful do we have
23 to be about getting sufficiently conservative numbers
24 and things like that?

25 DR. STEPP: Okay. The amount of change in

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1 the hazard is a complex tradeoff between the recurrent
2 rate of the earthquakes and the sizes, and in New
3 Madrid, that source zone, the great impact was the
4 increased rate of large earthquakes based on new data.
5 So it resulted in something like a ten percent or less
6 change in the hazard.

7 CHAIRMAN WALLIS: There's a lot of stuff.
8 There's probabilities; there's distribution, all this
9 stuff.

10 DR. STEPP: Yes, exactly. Integrated, you
11 know, for all of those parameters. It doesn't result
12 in a large change in the hazard.

13 If we transfer in a hypothetical this kind
14 of situation to the Wabash Valley, which is a little
15 closer, and increase the magnitudes, say, we increase
16 it to eight as you suggest; that doesn't change the
17 rate. So the change in the hazard at the site would
18 be proportionally very much less. The rate is very
19 important.

20 CHAIRMAN WALLIS: And so it's once every
21 6,000 years?

22 DR. STEPP: Yeah. So it doesn't change it
23 very much, and I would say -- I don't know. I won't
24 hazard a guess of a percentage, but it's really quite
25 insignificant compared to higher rates.

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1 CHAIRMAN WALLIS: Thank you.

2 DR. STEPP: I think you had one other part
3 to your original question which we have not answered,
4 but --

5 CHAIRMAN WALLIS: Or maybe you've answered
6 it.

7 DR. STEPP: -- if you'll allow us, we'll
8 enter it later because we're coming to that very
9 topic. Okay?

10 On this slide I think there's one more
11 item that I had not discussed, and this is the
12 moderate seismicity in the area of the site. In
13 probabilistic hazard modeling, we define a background
14 zone normally to account for earthquakes and
15 seismicity that are not specifically associated with
16 a specific defined source.

17 And in this case we have well defined
18 within the uncertainty bounds that we work with,
19 sources in the Wabash Valley and the New Madrid zone
20 that contribute to the hazard at the site.

21 The other undefined area is the background
22 zone, and in the background zone we simply define a
23 region that has similar geologic tectonic
24 characteristics and seismicity characteristics that
25 contains the site and allows us to account for all of

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1 the seismicity in the historic record.

2 In this case, our background zone is the
3 Illinois basin region of the site, and that region in
4 the EPRI studies, the maximum earthquakes were defined
5 on the basis of the historic record. In the
6 subsequent time since the mid-1980s, there has been
7 information surfaced about larger potential
8 earthquakes in that area, and the information leading
9 to that is, again, the liquefaction information, and
10 this resulted in our increasing the magnitude
11 distribution for that background zone similarly to the
12 increase that we implemented for the Wabash Valley
13 zone.

14 DR. HINZE: Excuse me. May I ask a
15 question? Are you going to come back to discuss the
16 central Illinois seismic zone as you have defined it?
17 Are you going to discuss that later?

18 DR. STEPP: I do not plan to discuss it
19 later, no.

20 DR. HINZE: May I ask a couple of
21 questions then?

22 DR. STEPP: Okay.

23 DR. HINZE: In talking with some of the
24 experts on liquefaction and who have worked on the
25 Springfield liquefaction sites, I sense that there is

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1 more than one location for the Springfield earthquake,
2 and I wanted to have a lat. and long. for that
3 position so that I can put it on some of my maps to
4 see how it works out.

5 And I'm wondering if there is consistency.
6 I've tried to look at your map to see if there is
7 consistency in where that site is, and I realize that
8 it's dangerous to put a point on a map when we're
9 dealing with a zone, but could you tell us: have you
10 used a consistent location? And which location are
11 you using? Are you using Obermeier's or are you
12 musing McNulty and Obermeier? Which one are you
13 using?

14 I think that would be very useful to have
15 in the report.

16 DR. STEPP: I'll Ask Catherine Hanson to
17 respond.

18 MS. HANSON: My name is Catherine Hanson,
19 and I'm with GeoMatrix Consultants.

20 For the Springfield event, we initially
21 started with the literature, McNulty and Obermeier's
22 paper, summarized their current work at that time. So
23 in our -- we have a complete discussion of the
24 paleoliquefaction previous investigations and in an
25 attachment to Appendix A of the SSAR.

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1 So we used that. McNulty and Obermeier
2 show the distribution of paleoliquefaction features
3 they attribute to an event localized in the
4 Springfield area. They provide what they call an
5 energy center, which is basically a central point
6 which they feel captures the sort of location of the
7 energy that was released during that earthquake.

8 We, in our assessment, we've shown that
9 energy center. We do not rely on that specific
10 location as a specific earthquake, although we have
11 analyzed it in subsequent analyses to look at the
12 impact of an event of that size at that location at
13 Clinton.

14 But we do rely on the general assessment
15 of the magnitude and general location in the central
16 Illinois, suggesting that there are sources of
17 seismicity that could generate moderate size
18 earthquakes in the central Illinois source based on
19 that event, as well as the additional
20 paleoliquefaction sites that we identified in our
21 study.

22 DR. HINZE: So you put your energy source
23 then as the center of the ellipse, if you will, that
24 encompasses the so-called Springfield liquefaction
25 features?

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1 MS. HANSON: That's correct. I mean, as
2 far as figures go, we do acknowledge that there's
3 uncertainty in the actual location of these events and
4 that, in fact, some of these events may be or the
5 liquefaction that you're looking at may be the result
6 of a more distant earthquake source, and we've
7 captured that in our alternative seismic source
8 zonation models that account for possible larger
9 events further to the south or elsewhere in the
10 Illinois-Indiana region.

11 DR. HINZE: Thank you.

12 If I might ask another question, I can't
13 find the figure right now, but you have a new diagram.
14 I believe it's a new diagram showing the location of
15 the central Illinois seismic zone, and this is a
16 rectangle in which the site is located. Can you give
17 me any information? There's nothing in the report
18 that stated how you reach the limits in drawing that
19 diagram.

20 I believe you referred to it as a
21 simplified source zone.

22 MR. YOUNGS: Yes. This is, again, Robert
23 Youngs from GeoMatrix.

24 The simplified source zone diagram was
25 used for the purpose of calculating earthquake

1 recurrence rates based on the modern catalogue and
2 comparing those to the rates based on the EPRI SOG
3 catalogue. So it was just an area that represented
4 the central portion of Illinois to use for the
5 comparison of earthquake recurrence rates from the
6 updated catalogue to the original catalogue. It was
7 not used as an actual seismic source zone in the
8 hazard calculation.

9 DR. HINZE: It probably would be
10 worthwhile really emphasizing in the report because
11 one has a sense that when one looks at the simplified
12 models, you look at the New Madrid, the southern
13 Illinois, the Wabash Valley, and they're very specific
14 to those sites.

15 But the central Illinois which is, indeed,
16 expected from the high frequency end, is very
17 important to the site; that you come up with that
18 rectangle, and it isn't clear to me why that rectangle
19 does not go down and join the zones to the south.
20 That seems to be separated away from it, and I assume
21 that you used in that zone a background, just simply
22 the mid-continent background.

23 MR. YOUNGS: We were using that simplified
24 model to do sensitivity analysis, to compare the
25 effects of changes in maximum magnitude and so forth

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1 as a part of the evaluation of what information that
2 we might need to update and what information that came
3 from EPRI originally is still usable, but ultimately
4 in the actual hazard analysis that was conducted for
5 the site, we used all of the EPRI source zones,
6 encompassed the entire region.

7 DR. HINZE: Why did you put it as a
8 rectangle?

9 MR. YOUNGS: For ease in removing
10 earthquakes for doing calculations for the sensitivity
11 analysis.

12 DR. HINZE: And the actual location of the
13 boundaries of this rectangle?

14 MR. YOUNGS: The rectangle was defined to
15 encompass a region around the site that was large
16 enough to capture local seismicity that would affect
17 the hazard, but to keep the boundaries so that it
18 would not impinge upon the other sources which we were
19 going to do sensitivity on, which were the Wabash
20 Valley and the Madrid.

21 So the actual size that was the bottom
22 boundary of that goes down another 20 kilometers or is
23 irregular, would not affect the comparisons on
24 sensitivity, but it was only used for sensitivities,
25 and it was just defined as a rectangle because that

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1 was an easy thing to do.

2 DR. HINZE: Okay. Thank you.

3 Thanks.

4 DR. STEPP: The next slide is some
5 additional comparison of the Reg. Guide 1.165,
6 Appendix B approach to reference probability as
7 compared to the performance based methods at Exelon
8 followed.

9 The reference probability approach, which
10 is described in Appendix B to 1.165, the reference
11 probability is the annual probability level such that
12 50 percent of the set of modern design currently
13 operating plants have an annual median probability of
14 exceedance (phonetic) that is below one times ten to
15 the minus five as determined at the average of five
16 and ten hertz spectral acceleration with five percent
17 damping.

18 That's the guideline that is contained in
19 the Reg. Guide 1.165 for reference probability.
20 Instead of using that, Exelon elected to use the
21 performance based approach that is described in ASCE
22 4305, and this approach, SSE's, that is, structure,
23 systems and components, will have a target mean annual
24 frequency of ten to the minus five for seismic induced
25 onset of significant inelastic deformation. So it's

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1 a component by component performance based approach.

2 CHAIRMAN POWERS: The issue of the meaning
3 of "significant" in elastic deformation comes.

4 DR. STEPP: We're going to discuss that in
5 the new viewgraph. We can go to that now if you'd
6 like.

7 CHAIRMAN POWERS: I'm a patient person.

8 DR. STEPP: Okay.

9 CHAIRMAN WALLIS: It depends on what it
10 is.

11 DR. BONACA: I have a question just for
12 clarification. The seismic induced onset of
13 significant inelastic deformation at least in the SER
14 is referred to as intended to achieve the criteria of
15 one in ten to the minus five, core damage frequency
16 from seismic initiators.

17 DR. STEPP: Yes.

18 DR. BONACA: And so the question I have is
19 why would that be significantly less than for existing
20 plants when it is being characterized as being derived
21 from a median out to nine existing plants.

22 DR. STEPP: Yes.

23 DR. BONACA: Why that statement at the
24 bottom there.

25 DR. STEPP: This leads into the next

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1 viewgraphs and perhaps the bottom --

2 DR. BONACA: Yes, I don't mind if you want
3 to put it off as long as it gets addressed because I'm
4 confused about that statement there and ten to the
5 minus five.

6 And, actually, I had another question
7 about ten to the minus five. I typically am
8 uncomfortable on a seismic issue on a criterion that
9 only focuses on core damage frequency because I'm
10 concerned about containment, I mean, especially on a
11 large dry you have an assumption of certain
12 performance from containment, and so you would like to
13 to see a criterion there.

14 Now, my concern is reduced by this
15 statement in the first bullet: "seismic induced onset
16 of significant" -- okay, but still, I would like to
17 understand better how that translates into containment
18 performance.

19 MR. KENNEDY: This is Bob Kennedy.

20 If I can keep that from falling down --

21 CHAIRMAN WALLIS: It's called significant
22 inelastic deformation.

23 (Laughter.)

24 MR. KENNEDY: Basically, and there are
25 some follow-on slides that go into this, but I think

1 since the question came up here, let's go through it
2 right now. ASCE 4305 was originally written to
3 replace DOE standard 1020, and it was to cover a wide
4 variety of facilities that had different risks and,
5 therefore, different levels of potential safety goals.

6 So the standard basically assigns five
7 different what I'll call quantitative performance
8 goals in terms of annual frequency of unacceptable
9 performance, and then it defines four different levels
10 of unacceptable performance. So you have 20 different
11 categories actually.

12 The unacceptable performance, the most
13 severe one, is that the structures, systems, and
14 components must remain essentially elastic. That's
15 actually the one we're using because we have to talk
16 in terms of what is unacceptable performance. We use
17 the words "onset of significant inelastic
18 deformation." What that simply means, we've gone
19 beyond essentially the elastic limit.

20 Now, why the word "essentially" rather
21 than just "elastic" is that even when you're at code
22 allowable stresses, there can be some local
23 inelasticities and strike concentration points, but
24 the overall structural system and component behavior
25 remains elastic, and so going beyond remaining

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1 elastic, we use the word "onset of significant
2 inelastic deformation."

3 CHAIRMAN WALLIS: Well, this assumes that
4 the components are all elastic. I mean, they're not
5 brittle. Some materials don't have any elastic
6 deformation, to speak of. The buildings at Stanford
7 University didn't have much elastic deformation when
8 there was an earthquake.

9 MR. KENNEDY: It basically is that you
10 stay within code allowables and behave as essentially
11 a linear elastic system, and not behaving that way is
12 unacceptable performance.

13 Now, for brittle failures, behaving as an
14 essential elastic system in code allowables may put
15 you right on the verge of failure. For a ductile
16 system, that could be a lot of margin beyond that
17 point.

18 The ASCE code has, as I said, four limit
19 states. The most severe is to remain essentially
20 elastic. The next level and the level that is
21 primarily used on DOE facilities is to continue to
22 serve as a confinement barrier. That allows some
23 inelastic failure as long as the failure mode is
24 ductile. If the failure mode is brittle, you don't
25 get any benefit going to that state. The most is what

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1 is called large inelastic deformation, and it's a
2 collapse prevention state.

3 So you can have several different. The
4 ones that are being used here is the most severe of
5 the ASCE categories remaining essentially elastic.

6 DR. SHACK: But again, to address Mario's
7 question, although you talk about CDF, the same
8 criteria would apply to the containment.

9 MR. KENNEDY: Yes. The NRC, for instance,
10 on advanced lightwater reactors -- and we'll get into
11 this in a later viewgraph, too, but rather than
12 holding off -- the NRC requires that all advanced
13 lightwater reactor submittals demonstrate what's
14 called a HCLPF seismic margin, which basically
15 corresponds to on a mean or composite fragility curve
16 the one percent probability of unacceptable
17 performance. They require this HCLPF seismic margin
18 against seismic core damage to be at least 1.67 in
19 SECY 093.

20 So when you're worried about seismic core
21 damage for an advanced lightwater reactor as opposed
22 to for an existing plants, they are required to
23 demonstrate a HCLPF seismic margin of 1.67. The ASCE
24 4305 code aims at a HCLPF seismic margin of 1.0.

25 So this onset of significant inelastic

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1 deformation is defined in terms of a HCLPF seismic
2 margin of 1.0. You would also have to demonstrate for
3 an advanced lightwater reactor that you have a margin
4 of 1.67 against seismic core damage.

5 CHAIRMAN WALLIS: What is significant
6 inelastic deformation of something like a vacuum
7 breaker which is designed to open under a small
8 pressure? If it rattles, it might damage. How do you
9 define something like that in the passive system which
10 has vacuum breakers that have to work between, say,
11 the dry well and the wet well and then modern BWR?

12 MR. KENNEDY: Basically the vacuum
13 breakers that I'm familiar with are typically
14 qualified by testing, testing on a shake table test,
15 and there's no real distinction between. I mean --

16 CHAIRMAN WALLIS: So there's a separate
17 criterion.

18 MR. KENNEDY: -- it's not really a
19 structural failure mode that you're worried about.
20 You want to at least set properly.

21 CHAIRMAN WALLIS: Right, right.

22 MR. KENNEDY: And the word "significant
23 inelastic deformation" or the word "essentially
24 elastic behavior" wouldn't really apply to those
25 items. they would be, in my judgments, automatically

1 applied into this most severe damage state category,
2 Category D. You would have to test and you would have
3 to demonstrate that you --

4 CHAIRMAN WALLIS: Except to a performance
5 on --

6 MR. KENNEDY: -- performed under the test.

7 CHAIRMAN WALLIS: Okay. Thank you.

8 DR. BONACA: But this I understand and I
9 agree with what you're saying, and I can see
10 consistency between the first bullet you have and the
11 third bullet.

12 And then that raises the question of why
13 have you introduced this number one to the minus five
14 core damage frequency that is typical of existing
15 plants. I mean, is it like a fragility study they
16 should do beyond the design value to show the margin
17 that you have?

18 It seems to me that continuing to set ten
19 to the minus five seems to be low and seems to be
20 characteristic of the co-generational plants.

21 MR. KENNEDY: Basically here, again, ASCE
22 43-5 was originally written primarily for use on DOE
23 facilities. It was adopted here because the standard
24 was close to coming out, adopted here for nuclear
25 power plant design. The idea was that if you hold

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1 essentially elastic behavior to mean one times ten to
2 the minus five where seismic core damage frequencies
3 for existing plants average about mean one times ten
4 to the minus five, that we knew there was margin
5 beyond this essentially elastic behavior and that we
6 would be achieving seismic core damage frequency
7 substantially less than one times ten to the minus
8 five.

9 Studies have been done on 28 of the 29
10 sites that were included in coming up with Reg. Guide
11 1.165, of finding out what seismic core damage
12 frequencies -- if you were designing to a design
13 response factor developed by ASCE 43-5 by the most
14 severe criteria therein, the one we're using, seismic
15 design 5(d); if you design to those and you had a
16 HCLPF seismic margin against seismic core damage of
17 1.67 because you're required to have at least that,
18 what seismic core damage frequency would this lead to?

19 For the 28 sites studied using their
20 hazard curves, the seismic core damage frequency
21 numbers came out between about one times ten to the
22 minus six and five times ten to the minus six. There
23 was a range.

24 I'll show you where Clinton comes out
25 within that range. It's on one of the subsequent

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1 slides, but the idea was that if you held this one
2 times ten to the minus five for essentially elastic
3 behavior, that you would be well below that for
4 seismic core damage frequency and you would be able to
5 adopt a professional consensus committee standard.

6 DR. BONACA: I think this is an important
7 discussion that I'm not sure is documented as well in
8 the SER. That's why -- anyway, because everything
9 provides an insight on this margin. In part, I mean,
10 my question was coming. I was trying to figure out
11 how this is going to be done within the PRA, what, in
12 fact, for the plant they're going to do and what kind
13 of target they were going to achieve.

14 DR. STEPP: So perhaps I could just
15 complete the logic on this viewgraph.

16 DR. SHACK: Let me ask. You're very
17 careful on this 1.67 for components to prevent core
18 damage, but do you maintain that also for the
19 containment?

20 MR. KENNEDY: Yes. The SECY 093 maintains
21 that same margin. I'm not a systems engineer, but
22 it's what do you call it, LE?

23 PARTICIPANTS: LERF.

24 MR. BAGCHI: LERF, early release
25 frequency.

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1 My name is Goutam Bagchi, and I really
2 like to address the question that Dr. Shack had asked.
3 Containments are designed for combined internal
4 pressure and SSE load to meet the code allowable
5 minimums. Therefore, if it is only seismic, the
6 containment has a very substantial margin against just
7 the seismic. All containments do, and I have seen
8 most of the new lightwater reactors that have very
9 substantial margin.

10 DR. SHACK: Do we require a margin or it
11 just comes out that way because the design against the
12 pressure, you get the margin?

13 MR. BAGCHI: You get the margin primarily
14 because you design against the pressure and the
15 concrete provides a little bit of shielding. The
16 structure is there. So the inherent --

17 DR. SHACK: Would the 1.67 apply to that
18 component?

19 MR. BAGCHI: Absolutely it would apply.
20 Aside from that, SECY 93-087 requires the continuing
21 performance to be shown that for severe accident
22 loading it has integrity at ASME Service Level C for
23 pressure that builds up 24 hours after the severe
24 accident initiation. It is in the SECY tape.
25 Containment is protected against a much tougher

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1 criterion.

2 MR. KENNEDY: This is Bob Kennedy.

3 Having done a large number of fragility
4 estimates on a large number of plants, I can second
5 what Gouptam just said. First of all, the SECY
6 document does require the 1.67 margin for seismic core
7 damage and for LERF. In actual fact though for LERF
8 it would be higher.

9 Containments have always had substantially
10 higher HCLPF seismic margin capacities than those
11 items that were critical to core damage. So there
12 will be a substantial additional. I don't know what
13 that is. The minimum requirement is that they have at
14 least 1.67, but the fact that they're designed for
15 pressure and seismic leads to higher.

16 DR. STEPP: Okay. To complete the last
17 two points on this viewgraph, the criterion, onset of
18 significant inelastic deformation, we will show in
19 subsequent discussion, and Bob has already explained,
20 I think, to a large degree has a significant margin
21 against SSE failures that might lead to core damage,
22 and we will demonstrate using the subset of existing
23 sites with modern designs that it leads to seismically
24 induced core damage frequency that is significantly
25 less than that population of existing plants.

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1 With that, I think Bob Kennedy will take
2 up the next several viewgraphs and go into a lot more
3 detail about some of the questions that you have
4 raised here.

5 MR. KENNEDY: The idea of a performance
6 based development of a performance based seismic
7 design criteria really started heavy emphasis in
8 around 1985, and it basically came about. We were
9 starting to see that there was a lot of seismic
10 probabilistic hazard curves being developed. It gave
11 us ideas of what was the ground motion in terms of
12 spectral acceleration, in terms of heat ground
13 acceleration. What was the ground motion levels that
14 corresponded to certain annual frequencies of
15 exceedance?

16 Given these seismic hazard curves that
17 define ground motion levels as a function of annual
18 frequency of exceedance, the obvious question is,
19 well, what annual frequency of exceedance should we be
20 aiming at? We have a whole series. Which one of
21 these ground motion levels should we use in design?

22 In addressing that, it became clear that
23 what we really ought to aim at is some kind of
24 performance goal, a target performance goal, and if we
25 knew what target performance goal we wanted to aim at,

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1 we could back figure what ground motion level, what
2 annual frequency of exceedance ground motion level we
3 should design for, given our target performance goal
4 and the level of conservatism in our design criterion.

5 The first document that really documented
6 this approach, there were earlier drafts that came out
7 earlier than what is shown here, but the first one
8 that really documented was Lawrence Livermore National
9 Lab, UCRL 15-910, which was adopted by the DOE in 1990
10 and required for their plants. It basically had four
11 performance levels in it as a function of how much
12 risk individual facilities had. They would be
13 assigned to one of four performance levels.

14 That was replaced in 1994 by DOE Standard
15 1020. Basically it's the same thing, but now it has
16 been upgraded to a DOE standard. that standard was
17 more recently updated in 2002.

18 During this same period of time, the NRC
19 was also looking at updating regulatory guidance, and
20 there is a NUREG CR Report 6728 that recommends in
21 their going to a risk consistent ground motion design
22 spectra as opposed to a hazard consistent.

23 The problem is a uniform hazard response
24 spectrum does not lead to uniform risk because
25 different sites have different slopes to their hazard

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1 curve, and if a steep slope on the hazard curve, you
2 would want to design for an earthquake with a higher
3 uniform hazard annual frequency of exceedance than if
4 it was a very shallow slope.

5 So that was addressed in 6728. It had
6 been previously addressed in UCRL 15910 and DOE
7 Standard 1020.

8 After 2002, DOE from the Defense Nuclear
9 Facilities, DNFSB, Safety Board wanted a professional
10 consensus, a professional committee consensus code as
11 opposed to DOE having their own standard. That led to
12 the development of ASCE 4305, primarily to address DOE
13 facilities, but it expanded upon DOE 1020 where DOE
14 1020 had four categories, it was felt that to be a
15 broader use, the number of categories needed to be
16 expanded. They've been expanded to five different
17 quantitative performance goals that ranged from annual
18 frequencies of exceedance of unacceptable performance
19 of one times ten to the minus three to one times ten
20 to the minus five.

21 We have chosen here the highest of those,
22 the one times ten to the minus five, and then they
23 have four different limit states. So any structure or
24 system component, you would assign it to a
25 quantitative performance goal and a qualitative limit

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1 state. I think I briefly talked limit state.

2 The most severe of these limit states
3 remaining essentially elastic. Now, for use on a
4 nuclear power plant and for use in the Exelon ESP
5 submittal, we have followed the criteria associated
6 with the most severe of those ASCE categories, seismic
7 design category 5D.

8 In any kind of performance based approach,
9 first you need to establish what is going to be your
10 risk goal. That is established by two things, and one
11 is the quantitative annual frequency of unacceptable
12 performance and the other is what constitutes
13 acceptable performance, constituted here by following
14 ASCE 43-05 is acceptable performance is to remain
15 essentially elastic. Therefore, unacceptable is the
16 onset of illastic (phonetic) deformation, and the
17 quantitative goal is set by ASCE 43-5 at mean, one
18 times ten to the minus five.

19 ASCE also then goes on to establish
20 seismic design criteria. The seismic design criteria
21 is a function of the limit state that you are
22 permitted to go to. We have used the most severe of
23 these limit states that are in ASCE 43-5, the limit
24 state remaining essentially elastic.

25 The ASCE criteria associated with

1 remaining essentially elastic is very similar to the
2 seismic design criteria of the NRC and NUREG 0800.
3 Obviously for a nuclear power plant the design
4 criteria would adopt the seismic design criteria of
5 NUREG 0800, but this most severe ASCE criteria is very
6 similar.

7 Now, once you've established your
8 quantitative performance goal, you also need to decide
9 on a reference seismic hazard curve to define a
10 uniform hazard response spectra all at that same
11 annual frequency of exceedance.

12 That hazard curve of values are then
13 adjusted by a factor called a design factor, DF, to
14 hit your risk goals or our performance goal. The
15 uniform hazard response spectra won't directly hit
16 this performance goal. It has to have an adjustment
17 factor.

18 That adjustment factor is based on a
19 couple of assumptions. The first assumption is that
20 your design criteria will meet certain upper limits on
21 the probabilities of unacceptable performance if the
22 design earthquake were to occur. For both ASCE
23 standard and for NUREG 0800, basically for the onset
24 of significant inelastic deformation or coming out of
25 this essentially elastic behavior there's less than a

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1 one percent probability of that occurring at the
2 design earthquake level. There's less than a ten
3 percent change of that occurring at one and a half
4 times the design earthquake level.

5 With these two criteria here, you can then
6 go and create appropriate seismic fragility curves
7 that can then be convolved with the hazard curves.

8 Next slide, please.

9 Now, the specific criteria that's been
10 selected at its highest category, seismic design
11 Category 5D, is the target performance goal is to be
12 less than or equal mean ten to the minus five, and why
13 mean ten to the minus five? That was selected in both
14 DOE 1020 and then subsequently in ASCE 43-05 because
15 the average bias of seismic core damage frequency
16 reported in for plants that have done seismic PRAs has
17 been reported to be about mean one times ten to the
18 minus five. In fact, they range from down around one
19 times ten to the minus seven to around one times ten
20 to the minus four.

21 But the median of that range of means --
22 each one of these is a mean annual frequency of
23 exceedance seismic core damage -- the median of all
24 those means is around one time ten to the minus five.

25 CHAIRMAN POWERS: This always bothers one.

1 If I had been you, I would have fought like crazy
2 never to cite that.

3 MR. KENNEDY: Okay.

4 CHAIRMAN POWERS: Because suppose I do ten
5 more seismic PRAs.

6 MR. KENNEDY: The value would maybe change
7 and maybe not, depending on what --

8 CHAIRMAN POWERS: Maybe change and maybe
9 not.

10 MR. KENNEDY: Yes.

11 CHAIRMAN POWERS: Suppose I'm very crafty
12 and I do ten more on South Texas. I can knock your
13 number down to ten to the minus six if I do enough of
14 these things.

15 MR. KENNEDY: You'd probably have to do
16 more than ten.

17 CHAIRMAN POWERS: May be more than ten.

18 MR. KENNEDY: Because I've got 25 already.

19 CHAIRMAN POWERS: I may have to work a
20 little bit.

21 I mean, it seems to me the entire thrust
22 here is to get stability, and this just invites
23 instability, and the fact is it seems to me the much
24 more plausible reason was ten to the minus fifth, a
25 pretty small number. It's small relative to ten to

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1 the minus four. Why not? I mean, since a totally
2 arbitrary number is going to get selected no matter
3 what here.

4 MR. KENNEDY: I agree with your statement.
5 This is both how DOE 1020 got this number and how the
6 ASCE Committee continued with this number, but I
7 agree. It is an arbitrary number. It's something
8 that I like to say is a policy maker decision.

9 CHAIRMAN POWERS: That's exactly right,
10 and you guys picked ten to the minus fifth in your
11 role of policy making, and you ask, well, is this good
12 enough, and it looks good to me. I mean, when you
13 think about it, the reciprocal is 100,000 years.
14 That's a bunch.

15 MR. KENNEDY: Particularly when I'm going
16 to show that the seismic core damage numbers are less
17 than that.

18 CHAIRMAN POWERS: Yeah. I mean, that part
19 is plausible, and that's part of your philosophy.
20 Well, it doesn't matter, but I mean, stability has to
21 be one of our objectives here.

22 MR. KENNEDY: Well, I think once the
23 criteria is developed, the criteria is the number --

24 CHAIRMAN POWERS: Yes.

25 MR. KENNEDY: -- not --

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1 CHAIRMAN POWERS: Not how we got to it.

2 MR. KENNEDY: Not how we got to it because
3 the actual fact is if these 25 were done today, they
4 would produce higher numbers because the EPRI 03
5 hazard curve is significantly higher than the hazard
6 curve that was used when those numbers were computed.
7 If they were all redone today using the same fragility
8 curves, the core damage risks would be higher than
9 what was recorded.

10 CHAIRMAN POWERS: But I guarantee you that
11 if we insisted that they do them, they would come in
12 lower.

13 MR. KENNEDY: They would sharpen their
14 pencil and eventually get them lower.

15 DR. KRESS: I'm not sure how you translate
16 this into core damage frequency. Is the implied
17 assumption that only SSCs lead the core damage if they
18 fail?

19 MR. KENNEDY: If you're talking about
20 seismic induced core damage frequencies --

21 DR. KRESS: Yeah.

22 MR. KENNEDY: -- it's seismic failure of
23 various structure systems and components coupled with
24 random failures or operator errors that lead to
25 seismic induced core damage. Random failures or

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1 operator errors that do not occur concurrent with
2 seismic don't lead to seismic core damage failures.
3 They lead to other core damage things. When you talk
4 seismic core damage failures, they have to -- the
5 initiator is seismic.

6 DR. KRESS: How do you define what's an
7 SSC in this context? You don't have a plant yet,
8 right?

9 MR. KENNEDY: For a new plant? How it's
10 defined in this context for a new plant is the NRC
11 SECY document does require for advanced lightwater
12 reactors that they must demonstrate that they have a
13 HCLPF seismic margin against core damage of 1.67. In
14 other words, they will have to demonstrate for core
15 damage purposes that the one percent probability of
16 failure point is at least five-thirds of the design
17 basis earthquake letter. That's how it's done here,
18 is every one of these advanced light water reactor
19 plants will have to demonstrate they have that seismic
20 margin against Florida Image and against LERF.

21 Now, if we didn't have that, then we'd
22 have no basis of saying, you know, what will be the
23 seismic core damage frequency HCLPF level of a future
24 plant that isn't fully designed.

25 DR. KRESS: Generally the piping design is

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1 left to the COL. So does this have to be demonstrated
2 at the COL?

3 MR. KENNEDY: Oh, yes.

4 MR. MAYNARD: Basically what you're
5 defining is the seismic response spectrum that then
6 the future plant has to be designed to meet and to
7 meet the margins and various things they have to do.

8 MR. KENNEDY: Yes. The purpose here is to
9 define the design response spectra, the SSC design
10 response spectra. Once that's defined, the plant has
11 to be designed in accordance with NUREG 0800 and in
12 accordance with SECY 093 that it has this margin's
13 requirement in it.

14 In the ASCE 43-5 approach, the uniform
15 hazard response spectra is defined at mean ten to the
16 minus four. The methodology works very well when you
17 define the uniform hazard response spectra at a factor
18 of ten higher than the performance goal probability
19 that you're trying to achieve and you design to
20 conservative design criteria. So the performance goal
21 is mean ten to the minus five. The uniform hazard
22 response spectra is defined at mean ten to the minus
23 four, and that uniform hazard response spectrum is
24 multiplied by a design factor. That design factor is
25 a function of several things. The factor that the

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1 uniform hazard response spectra exceeds the
2 performance goal in this case is a factor of ten.
3 It's a function of the seismic margin conservatism
4 factor. In this case that margin conservatism factor
5 is 1.0, and it's a function of the slope of the hazard
6 curve.

7 Steeper slope hazard curves, its design
8 factor is lower. More shallow slope hazard curves,
9 it's flatter. Typically it ranges from one to two.
10 It cannot be less than one, and for the excellent ESP
11 site because it's a soil site and the ground motion is
12 fairly high, we're in a portion where as you go from
13 ten to the minus four ground motion to ten to the
14 minus five ground motion, the increase in ground
15 motion associated with that is about a factor of two,
16 and that's a fairly steep hazard curve.

17 For this case the design factor ranges
18 from about 1.04 to 1.3. We did perform a
19 probabilistic convolution of hazard and fragility
20 curves. For the fragility curve we did use this
21 minimum HCLPF seismic margin factor of 1.67, and
22 demonstrate that for the ESP site the seismic core
23 damage frequency is less than or about equal to two
24 times ten to the minus six per year, which is
25 significantly less than the median of the existing

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1 plants.

2 A lot of details on this were submitted in
3 a detailed primer type document which is under this
4 storage number. I don't know whether that was
5 received by ACRS from the NRC or not.

6 Let's go on then.

7 DR. KRESS: Do you choose an ESBWR for
8 this site? Then seismic CDF becomes the dominant CDF?

9 MR. KENNEDY: If all of the others are
10 very, very low, seismic could easily be the dominant
11 CDF, yes. The problem with seismic is these hazard
12 curves just keep going on out. It's a real struggle
13 to go from five to -- I mean, going from five times
14 ten to the minus five, for instance, to one times ten
15 to the minus -- I'm sorry -- five times ten to the
16 minus six to one times ten to the minus six for
17 seismic core damage frequency increases the ground
18 motion a factor of 1.6 to two and gets to very high
19 ground motions relative to what we have previously
20 designed plants for.

21 But seismic, yes. I mean, it's very
22 difficult to keep pushing the seismic number down, and
23 it could easily be the dominant.

24 Shall we go to the next? Ah, there it is.

25 Basically what we did, and this has been

1 done for all 28 sites, but I just simply put up the
2 excellent ESP site. If you design to the ACSE method
3 defined design response spectra and you're interested
4 in seismic core damage frequency and you have this
5 HCLPF seismic margin against seismic core damage, then
6 this defines the one percent probability of failure
7 point on the fragility curve. The other thing that
8 defines these fragility curves is the logarithmic
9 standard deviation.

10 For seismic core damage frequency, most
11 appropriately these logarithmic standard deviations in
12 the .3 to .4 range are more appropriate than the
13 higher numbers.

14 We have hazard curves at one hertz, two
15 and a half hertz, five hertz, ten hertz, and we did it
16 for each of these hazard curves and obviously you get
17 a different answer because these hazard curves all
18 have different slopes. They've all had their design
19 value. Design spectra acceleration has been selected
20 by this method, which gives a fairly constant
21 frequency of onset of significant inelastic
22 deformation, but because their slopes are different,
23 it does not give a constant core damage frequency.

24 In reality, most of the equipment from
25 past seismic PRAs, actually seismic core damage

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1 frequency typically depends on the hazard curves in
2 the five to ten hertz range. So probably the most
3 appropriate estimate is this estimate based on the
4 average of the five and ten hertz. But it basically
5 says for the Exelon ESP site, seismic core damage
6 frequency is expected to be in the range of one times
7 ten to the minus six to two times ten to the minus
8 six.

9 For all 28 sites the ASCE method would
10 lead to numbers in the range of one times ten to the
11 minus six to about five times ten to the minus six.

12 I believe that completes what I was to
13 cover.

14 CHAIRMAN POWERS: Question. Maybe this is
15 the right time to ask it. Maybe it is not. In
16 looking at these ground motions, there were a lot of
17 discussions about randomizing things in the
18 presentation, and I guess I came away with two
19 questions.

20 One, do we have a list of all those things
21 that were randomly sampled in this? I mean, is there
22 one list of all those things or do I have to find them
23 in each paragraph of the text where it was done?

24 Second of all, how do you know they're all
25 independent?

1 MR. KENNEDY: You're talking about in
2 arriving at the ground motion at the ground surface?

3 CHAIRMAN POWERS: Yes.

4 MR. KENNEDY: Bob, would you be the right
5 person to answer that? I can attempt to, but I think
6 Bob Youngs would be a better person to answer what you
7 randomized.

8 MR. YOUNGS: I'm not sure exactly what
9 you're referring to in randomization. There were two
10 analyses done. One is the probabilistic seismic
11 hazard analysis in which we use probability models for
12 the location and size of earthquakes and for the
13 ground motions that they may produce to generate the
14 hazard curve.

15 And the second analysis was the site
16 response analysis in which we calculate the
17 amplification of the motions from rock up to the soil
18 surface, and in that application, we randomized the
19 soil properties. Principally we randomized the
20 velocities in the soil layer.

21 So are you referring to --

22 CHAIRMAN POWERS: Yes.

23 MR. YOUNGS: Okay. In terms of the
24 randomization for the second part, the soil layer, we
25 do assume there is correlation in the velocity

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1 structures. So there are models that have been built
2 up looking at a large number of sites and looking at
3 a large number of velocity profiles that indicate the
4 general level of correlation between the velocity and
5 one layer in the velocity and the next layer below it,
6 and we use that correlation model as a part of the
7 randomization. We generate correlated velocity
8 profiles for the site.

9 So there is correlation that we account
10 for in that randomization process.

11 In terms of the seismicity or the PSHA
12 part of the analysis, we don't actually perform a
13 randomization. We actually calculate the frequency of
14 earthquakes at all possible locations on a one
15 kilometer -- basically consider as an approximation of
16 a one kilometer grid across the region.

17 So there is not actually a randomization
18 process in that sampling. We calculated a rate of
19 earthquakes based on the past pattern of earthquake
20 occurrences in the region and used that to define a
21 future rate at each location in the region.

22 CHAIRMAN POWERS: Well, I don't have my
23 sheet of randomizations here, but I got the impression
24 there were more randomizations than that.

25 MR. KENNEDY: Dr. Powers, a number of

1 years ago for a site on soil people developed the
2 ground motion hazard curves using attenuation
3 relationships that were developed from soil site
4 ground motion, develop the surface motion directly
5 using those soils attenuation relationships.

6 The more recent approach basically
7 advocated in NUREG CR-6728 was, no, it is better to
8 define the ground motion probabilistic seismic hazard
9 curve in terms of a reference rock, and the reference
10 rock in EPRI-03 is 9,200 feet per second shear weight
11 velocity rock, and so the probabilistic seismic hazard
12 curve is first defined down here at this 9,200 feet
13 per second rock and then has to be convolved up
14 through the soil layers to get the motion at the
15 ground surface.

16 This convolution process you don't want to
17 work with a single soil profile because you've got a
18 lot of uncertainty on the soil information, and so
19 they do do this process of selecting a best estimate
20 soil profile and variability about that best estimate,
21 and then they do a number of randomized samples to get
22 a mean amplification function.

23 And these randomized samples, as Bob
24 Youngs was mentioning, they do include correlation.
25 You don't assume that this layer in a sample could be

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1 particularly soft and this layer right below it
2 particularly stiff because there is correlation
3 between their stiffnesses.

4 But you come up with this best estimate
5 soil profile and then you randomize the properties
6 about the best estimate profile, but with correlation
7 included in that randomization. This leads to a
8 broader frequency and more realistic response spectra
9 at the ground surface.

10 That's the only place that I'm aware of
11 where there is randomization used in the process.

12 CHAIRMAN POWERS: Okay. Let's go on.

13 DR. HINZE: Can I ask a related question?

14 CHAIRMAN POWERS: Sure, yes.

15 DR. HINZE: You justify the randomization
16 in order to account for the uncertainty and
17 variability. What is the difference -- what's your
18 meaning of the term "uncertainty" and "variability"?
19 You use both of those terms.

20 MR. KENNEDY: Well, when I'm trying to be
21 careful they have a very different meaning.

22 DR. HINZE: Yes.

23 MR. KENNEDY: There is inherent
24 variability from if I had a bore hole here and another
25 bore hole here, there will be differences in the

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1 properties of the soil in these two bore holes. To me
2 that is almost what I would call random variability.

3 I also have uncertainty as to what the
4 real properties are because, for instance, I may know
5 of low strength properties from the soil, but I'm
6 interested in the properties at seismic strengths. So
7 I have to take into account effects at higher
8 strengths. My effective sheer modulus is lower than
9 at low strengths. My effective material damping is
10 higher.

11 DR. HINZE: So measurements.

12 MR. KENNEDY: So there are both
13 uncertainties in my knowledge of the data, and there's
14 random variability of the data. They're not really
15 separated in this case. The randomization process
16 considers both.

17 DR. HINZE: Right.

18 DR. STEPP: Okay. We're ready to go on
19 then. And this slide that is on the screen now we
20 show the site specific performance based ground motion
21 spectra for the vertical and horizontal ground
22 motions. I believe vertical is in the dash. The
23 horizontal is in the solid line.

24 And we compare that with the Reg. Guide
25 1.60, general site independent response spectrum

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1 anchored at .3 G, which is kind of a target for
2 seismic design basis for many of the advanced
3 reactors.

4 There is a step in the derivation of this
5 ground motion which goes to the question that you
6 asked very early on, Dr. Wallis, and if you'd like, we
7 could stop here and respond to that in more detail.

8 Bob Youngs offered a response to that. It
9 involves the deaggregation of the motion and properly
10 accounting for distribution of that in that
11 distribution of the deaggregated motion for the
12 controlling magnitudes that contribute to the hazard
13 at the site.

14 MR. YOUNGS: This is Robert Youngs again.

15 You asked earlier where the magnitude of
16 6.5 came from after we were talking about larger
17 magnitudes. In the process for defining, once we have
18 defined the hazard curve and we now are to do
19 evaluation of the response of the site to the
20 earthquakes that produced that hazard curve, through
21 the process we typically define what is called a
22 controlling earthquake which represents on an average
23 basis all the earthquakes that have contributed to the
24 hazard.

25 The probabilistic analysis considers

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1 earthquakes from magnitude five up to the largest, and
2 there are frequencies, and they all contribute to the
3 hazard curve, and they contributed different amounts
4 depending on their frequency and on their size.

5 Typically, earthquakes nearby, you can get
6 small magnitude earthquakes contributing to the
7 hazard, and as you move further and further away from
8 the site, the earthquakes have to be bigger and larger
9 and larger to contribute significant motion to the
10 site.

11 That is also combined with the fact that
12 small earthquakes occur more frequently than large
13 earthquakes so that we have the combination of large
14 events from a distance and smaller, more frequent
15 events in close contributing to the hazard.

16 And I don't have a slide, but if you have
17 the SER here, the slide figure on page 2-212, the
18 figure here, that shows the history. So the amplitude
19 of those peaks represents basically the relative
20 contribution of earthquakes and different magnitude
21 intervals and different distance intervals to the
22 hazard number at ten to the minus four, and the
23 controlling earthquake is basically the weighted
24 average of that histogram, magnitudes and distances
25 weighted by their relative contribution.

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1 So we come up from that histogram with the
2 number of 6.5 as a weighted average magnitude, and it
3 represents a combination of earthquakes locally in the
4 Wabash Valley and in New Madrid, and it just so
5 happens that it come s out with an average distance
6 that's close to the Wabash Valley distance, but the
7 magnitude is lower than the maximum magnitude in
8 Wabash Valley because the hazard is controlled by
9 earthquakes that are occurring more frequently than
10 the maximum earthquake.

11 And then we use earthquakes of that
12 average magnitude, we use time histories of
13 earthquakes of that size to run the site response
14 analysis to develop the amplification of the rock
15 motions to the soil surface.

16 DR. STEPP: Thank you.

17 The NRC's review of this found the motions
18 acceptable for the ESP site, Clinton ESP site, and the
19 condition is that the motion will be compared with the
20 actual design response spectra at COL stage. Here
21 we've compared them with the .3 sale standard Reg.
22 Guide 160.

23 There were a number of open issues
24 following the August issue of the DSER, and these have
25 all been closed subsequently and resolved. Issue

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1 2.5.1-1 had to do with the sizes of the New Madrid
2 earthquakes. We alluded to earlier in this discussion
3 all seismic information is undergoing continuous
4 evaluation at all times, and there are new estimates
5 of magnitudes that are being proffered for these large
6 earthquakes that occurred now almost 200 years ago.

7 And with this issue had to do with
8 incorporating the latest estimates of those
9 magnitudes.

10 Two, point, five, point, two, dash, one
11 had to do with a distance conversion methodology for
12 EPRI ground motion Model 03. In that model there are
13 a number of different proponent attenuation models are
14 used and weighted, and those proponent models have
15 different measures or metrics for distance from the
16 earthquake source, and this had to do with explaining
17 in detail how those were converted to a single metric.

18 Two, point, five, point, two, dash, two
19 had to do with the use of the site velocity model.
20 You've heard some discussion of that already. The
21 issue of properly representing the variability in the
22 properties in the shallow part of the soil or
23 underlying geologic section at the site.

24 Two, point, five, point, two, dash, three
25 had to do with the proper representation of the site

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1 dynamic properties, and the question there was a
2 comparison of the actual site properties with the
3 dynamic modulus reduction in damping curves that were
4 used at the site.

5 Two, point, five, point, two, dash, four
6 addressed the adequacy of the ground motion estimate
7 at the site, that is, the SSE ground motion derived
8 for the site as compared to local prehistoric
9 earthquakes which we discussed earlier.

10 CHAIRMAN POWERS: Is this where we get
11 into the discussion of what actually moves at the New
12 Madrid site?

13 I mean, New Madrid site seems to have
14 three, as I understand it, three major seismic faults.

15 DR. STEPP: Yes.

16 CHAIRMAN POWERS: And it says an open
17 question of do they all three occur --

18 DR. STEPP: Yes.

19 CHAIRMAN POWERS: -- at roughly the same
20 periods of time or some of them aftershocks or some of
21 them just don't occur.

22 DR. STEPP: Yes.

23 CHAIRMAN POWERS: And just talk to me a
24 little qualitatively of how you came up with this kind
25 of one-third, one-third, one-third when there, in

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1 fact, seem to be about nine possibilities.

2 DR. STEPP: Yes, okay. We responded to
3 that in an earlier request for information, but it can
4 be addressed now, as 2.5.1-1 is part of that response,
5 and again, Dr. Youngs is the person who will address
6 that.

7 MR. YOUNGS: The original assessment in
8 our original submittal was based on an interpretation
9 of a figure that was presented in Tuttle, et al., which
10 from that figure implied that looking at the estimated
11 sizes of the two previous earthquake sequences, the
12 one that occurred in approximately 1450 and the one
13 that occurred in approximately 900 A.D., that one of
14 the three events would have been appreciably smaller
15 than the other two. I can't remember the actual
16 order, but I think in one sequence the northern event
17 seemed to be much smaller and in one sequence the
18 southern event seemed much smaller.

19 So we had interpreted that to imply that
20 in several sequences -- in not all sequences do we get
21 three events of similar size, and in subsequent
22 discussions with her, she indicated that that was,
23 say, an overly favorably interpretation of what she
24 was trying to say in that figure, and that she felt
25 that in all cases the data suggested that all of the

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1 events had been at least as large as magnitude seven.

2 So our revision was to say that in every
3 sequence the ruptures are at least magnitude seven on
4 all three parts of the system, and we just interpreted
5 the one-third, one-third, one-third as that they were
6 smaller than the largest that we saw in 1811. I think
7 on the northern one two out of three times they were
8 roughly the same size, and one time they were smaller,
9 but they were still magnitude seven.

10 CHAIRMAN POWERS: This all raises an
11 interesting question in my mind. When we think about
12 these plants suffering a seismic event, we think about
13 them suffering one seismic event in time, but here
14 with the New Madrid, you kind of get three. I mean,
15 they're spread over a few years. I mean, how do we
16 respond to that?

17 Suppose I have a seismic event of
18 substantial magnitude. Let's say four or, a better
19 number, 7.4 at this new plant that you constructed,
20 and it will cruise right through it, right? No
21 trouble. I mean, we'll shut the plant down. We'll
22 probably have a lot of inspectors come look at it.
23 But in hopefully a short period of time you're back up
24 and operating.

25 Do you?

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1 DR. STEPP: Well, this is an interesting
2 and challenging issue in hazard modeling, which we
3 have given a lot of thought to. This New Madrid
4 strain release behaves as a clustered release, in the
5 most recent sequence, in the 1811 and 12, the three
6 earthquakes that occurred over approximately a three-
7 month period, a little less than three months.

8 One would have to presume that the past
9 sequences may have followed the same pattern. Now,
10 this is a clustered, in a tectonic sense, a clustered
11 set of earthquakes that is for my awareness not
12 normally seen, but it is seen here. So one has the
13 option, you know. The challenge here is whether one
14 models this cluster as a single event with a magnitude
15 representative of the total energy release or models
16 as multiple events the three events with slightly
17 different locations and with energy releases that
18 represent each of the individual sectors of the source
19 that broke in that particular earthquake.

20 It has become the preferred method to
21 model these as separate events, separate earthquakes
22 because they have somewhat distinctive characteristics
23 of sources. There's difference in geographic
24 locations. Mechanisms of the central zone is
25 different than the north and south parts of the zone.

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1 So they have been as a matter of professional
2 preference modeled as separate events in recent hazard
3 studies.

4 Perhaps, Bob Youngs, you would like to
5 amplify on this.

6 CHAIRMAN POWERS: I just through there was
7 a question, and I can be clearly wrong about this,
8 strictly a question on my part, that seismic types
9 were discovering more and more of these clusters. I
10 mean, there's a fairly famous sequence of earthquakes
11 that occur along the Black Sea in Turkey that seem to
12 get one and then six months later get another one and
13 they progressively head toward -- like the Persian
14 Army or something like that.

15 DR. STEPP: But this is a very different
16 mechanism. The Anatolian fault, which you were
17 referring to along the Black Sea is similar to the San
18 Andreas fault, and it connects Baja, California with
19 Cape Mendocino.

20 These earthquakes along the Anatolian
21 fault -- let me back up and say it seems that the
22 strain released along the Anatolian fault zone occurs
23 in spatially sequenced earthquakes. That is true. It
24 turns out that over a period of 100 years or more, you
25 tend to have a kind of clustered strain release along

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1 that entire zone, but it's actually occurring in
2 different sectors of the zone, each earthquake, and
3 that's fairly typical of tectonic strain released
4 worldwide.

5 There is a certain clustering, and you
6 people have referred to it as the strain cycle for
7 particular large plate boundaries, for example.

8 In time of the release of strain and then
9 perhaps a hiatus when that cycle is completed before
10 it's completely started again.

11 CHAIRMAN POWERS: But you see what I'm
12 asking is or I'm curious what does the seismic
13 fragility analysis say. Okay. I've got this plant.
14 It's all in good shape. Nothing ever happened to it.
15 Then something happens and the plant does just fine.

16 Is that fragility analysis now applicable
17 when three months later I get another earthquake?

18 MR. KENNEDY: This is Bob Kennedy.

19 Yeah, I mean, that's a significant issue
20 because after almost every very large ground motion,
21 we gave after shocks and quite a long series of after
22 shocks, typically somewhat less ground motion,
23 sometimes not less, but what we have found both in
24 earth quake experience data and shake table testing
25 data, we have found that if the structure, system or

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1 component remains essentially elastic during the
2 shaking, there's been no degradation.

3 So another one comes along. It will
4 behave basically the same.

5 If the structure, system or component goes
6 inelastic, at the next shaking it will be somewhat
7 more flexible. It will not have the same elastic
8 frequency as it had before the previous shaking, and
9 it will gradually become more flexible, but we have
10 not seen a rapid degradation increase in damage until
11 we reach a stage where under that earlier shaking,
12 let's say we know what its capability would be if it
13 had been just shaken once.

14 Under that early shaking if we've exceeded
15 about 80 percent of its capacity that it would have
16 been able to take if it had only been shaken once, the
17 next shaking it will not have that same capacity as it
18 had for the previous, and so that if we've gone up
19 over 80 percent, about like that, the next one we may
20 -- and let's say we get the same size the next one.
21 We reached 85 percent capacity on the first one. The
22 second one we reached 85 percent of the original
23 capacity. We may suffer very serious damage on the
24 second one.

25 We tried to take that into account with

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1 our variabilities on these fragility curves. I mean
2 as we start to approach -- I mean, our fragility
3 curves cover a significant amount of uncertainty as to
4 what these capacities are. I don't see if we've
5 exceeded the HCLPF capacity we're so far below what we
6 think our realistic capacity is. I don't think we
7 will have changed the HCLPF capacity any.

8 If we start approaching anything
9 approaching our median or best estimate of the
10 capacity is, I think the next time if we knew that had
11 occurred, the fragility curve for the next event would
12 be steeper because we would lower that median.

13 DR. HINZE: If I might, this is even more
14 complicated than you suggest, Dr. Powers, because as
15 I recall at our September discussion we brought up the
16 topic of far field triggering, that is, where
17 earthquakes are triggered far afield, and there was
18 some consensus that perhaps this didn't occur in
19 interplate regimes, such as we have in the mid-
20 continent.

21 And then subsequent to the meeting I
22 recalled Sue Huff's paper in the Seismological Society
23 of America in 2003 in which she and Sieber and
24 Ambruster looked at the possibility of far field
25 triggering from the 1811-1812 New Madrid events and

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1 also the 1886 Charleston event. And they found at
2 distances comparable to the Clinton site triggering.

3 And I'm wondering if this has been taken
4 into account. I mean, this is not only pretty
5 repetitive events, but also there's also the
6 possibility of considering the probability of
7 considering the probability of an event being
8 triggered near the Clinton site as a result of this.

9 And I'm wondering if this was taken into
10 account in the hazard evaluation.

11 DR. STEPP: My answer is not specifically,
12 but I would answer that in the discussion of whether
13 to treat New Madrid as a single composite event with
14 energy release comparable to the co-energy of the
15 three earthquakes vis-a-vis there's three different
16 energy releases closely spaced in time. The concept
17 of triggering enters in. Just people have considered
18 this, for example, with the Anatolian fault and the
19 San Andreas fault. So it would be reasonable to
20 consider that you have one large earthquake occurring
21 in the Mississippi with two earthquakes of comparable
22 size being triggered by that first one.

23 But triggering more distant earthquakes,
24 to my awareness there's no observational evidence of
25 that in the world, in the stable continental region.

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1 DR. HINZE: Hough's paper seems to
2 indicate that. You know, they could be wrong, of
3 course, but they've looked at the historical record on
4 this from the Charleston, Connecticut, from New Madrid
5 down to the Birmingham, Alabama area, Montgomery,
6 Alabama area, and so forth.

7 DR. STEPP: It's really pretty difficult
8 to make that tie very confidently. I mean, it's
9 entirely possible that small earthquakes will occur in
10 time, closely following any large earthquake and not
11 be triggered by that earthquake.

12 So I think there has to be more of a
13 demonstration of proof of that than simply an inferred
14 association.

15 DR. HINZE: Colonel, I understand where
16 you're coming from, but you know, if one reads Hough's
17 paper, there are some pretty good evidence there. For
18 example, the Charleston earthquake producing
19 earthquakes in Southern Indiana that were from
20 newspaper accounts fell -- I don't recall the exact
21 distance -- but 50 kilometers distance between these.

22 So this would indicate that it's not just
23 a very minor earthquake, but it has some felt area.
24 I think it's still an open topic. I think it's one
25 that we need to learn more about because we don't

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1 really understand the triggering events in the western
2 United States.

3 DR. STEPP: It would be an interpretation
4 that is not currently incorporated into the hazard
5 modeling.

6 MS. HANSON: This is Catherine Hanson from
7 GeoMatrix.

8 I'd like to just make one comment on some
9 of the observations that were cited in the Hough, et
10 al., paper as well as the Mueller, et al., paper which
11 also looked at evidence for locating one of the large
12 magnitude events in the sequence farther to the north
13 than had been previously acknowledged by previous
14 investigators.

15 I think there's a lot of controversy about
16 whether there is really evidence for paleoliquefaction
17 of the magnitude that they cite in southern Illinois.
18 I think talking with Dr. Obermeier and various other
19 people there's a question that what they interpret as
20 large sand blows that would have occurred during that
21 event are, in fact, not demonstrated to be such.

22 DR. HINZE: I quite agree with you.
23 Southern Illinois, you know, there seems to be little
24 question but that they were out of line.

25 DR. STEPP: I just would add one other

1 thing to my comment, that it's not specifically
2 modeled in seismic hazard modeling. Notwithstanding
3 we do account for any earthquakes that are in the
4 history directly in the seismic hazard model, and
5 they're accounted for as being associated with a
6 particular source where they occurred.

7 Now, if they were triggered by a more
8 distant source, we would not have that temporal
9 relationship in the model

10 CHAIRMAN POWERS: Let me ask where we
11 stand on the presentation. Do you have significant
12 points you want to make on these opening items?

13 MR. GRANT: We have two or three slides
14 that are short slides.

15 MS. KRAY: From the cover one, yeah.

16 MR. GRANT: We've covered most of these
17 points already.

18 CHAIRMAN WALLIS: You're talking about
19 performance based method, and my impression is that
20 this is a good way to go about things. It makes sense
21 whether I understand the details or not. The approach
22 seems to make sense to me.

23 DR. STEPP: The open issue, 2.5.2-5 had to
24 do with further clarifying the assumptions for
25 implementation of the performance based methodology,

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1 and you have heard discussion of we responded with
2 specific clarifications that the staff requested, and
3 I think you heard discussions of each of those in Dr.
4 Kennedy's earlier presentation.

5 MR. GRANT: There was one geotechnical
6 issue that had to do with whether or not we were going
7 to do additional borings, and we said certainly we're
8 going to.

9 In summary, again, all of the open items
10 are closed. All of the confirmatory items are
11 completed, and the SSE ground motion spectra that we
12 proposed has been accepted.

13 CHAIRMAN POWERS: Any additional questions
14 you'd like to pose to the speaker?

15 MR. MAYNARD: One quick question. I
16 realize the existing station which is tied to its own
17 licensing base. I'm just asking for insights. Going
18 through this for the early site permit, did you gain
19 any insights or did it raise any potential safety
20 questions for the existing site?

21 MR. GRANT: The only insight that we got
22 was that the two methodologies are distinctly
23 different and that you really cannot do a comparison
24 of the two.

25 CHAIRMAN POWERS: Why don't we take a

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1 break until five of?

2 I thank the speakers. It's a very useful
3 introduction to an arcane subject. Well, it's an
4 interesting subject in the sense that one would like
5 to know a lot more than one does, but we still have to
6 act upon what we do know, and sometimes you just have
7 to do the best you can.

8 Let's take a break for 15 minutes and
9 reassemble at five of.

10 (Whereupon, the foregoing matter went off
11 the record at 10:41 a.m. and went back on
12 the record at 10:58 a.m.)

13 CHAIRMAN POWERS: Laura, it strikes me
14 that you get to work with all of the precise sciences,
15 weather, seismic.

16 MS. DUDES: Oranges. Well, I think -- are
17 we going to start?

18 CHAIRMAN POWERS: We are in session.

19 MS. DUDES: I would be happy to provide
20 opening remarks at this time.

21 CHAIRMAN POWERS: If you would be so kind
22 as to provide opening remarks. Guide us through this
23 thicket of complexity.

24 MS. DUDES: Okay. Well, first and
25 foremost I want to introduce the staff members

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1 presenting to you today. I'm sure these gentlemen are
2 all familiar to you:

3 John Segala, the senior project manager
4 for the Clinton early site permit, as well as the
5 senior project manager for early site permits in
6 general, and John should be back before the Committee
7 not only tomorrow for the full committee, but also in
8 the near future for some early site permit lessons
9 learned and this topic probably being one of them.

10 Dr. Cliff Munson and Goutam Bagchi, who
11 will also provide the staff's technical discussion on
12 this.

13 I appreciate the discussion this morning,
14 a very long, detailed discussion on this issue. I
15 think as Marilyn Kray had indicated, this is the first
16 time the staff had seen this method. It's not our
17 preferable approach to review a new technical approach
18 during an application, but the staff did so. The
19 original schedule for this early sites permit
20 completion was changed by approximately seven months
21 so that we could develop an agency-wide, not just a
22 singular Office of Nuclear Reactor Regulation, but an
23 agency of wide consensus on some of the conclusions in
24 the safety evaluation report presented to you.

25 I think the work that was done on Clinton

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1 in this performance based approach will inform generic
2 work that the staff is developing now as we look
3 forward, and that is essential work. I think Marilyn
4 Kray alluded to the NEI Task Force on this issue, and
5 it's essential as we look forward, and I'm sure you
6 know about our 11-plus COLs that we expect to arrive
7 on our doorstep in 2008, many of them on sites that
8 will be using similar methods, and we will be
9 continuing to expand our knowledge in the area of
10 seismic.

11 But even before 2008, we can expect and we
12 do expect our next early site permit to arrive in
13 August 2006, and I have every indication that a
14 similar type of method for this site will be used, and
15 so the education that we have gotten through this
16 first early site permit is beneficial, and we will
17 look forward to expanding on that in the future.

18 So with that, I'm going to turn it over to
19 John Segala.

20 CHAIRMAN POWERS: John, I would appreciate
21 it if you would recognize that we have had substantial
22 discussions here, and that the committee is
23 particularly interested in not so much the historical
24 chain of events, but more in the way you went about
25 reviewing this, where you found the rough spots and

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1 how you resolved those rough spots

2 MR. SEGALA: Okay. I do think that a lot
3 of our earlier work might have been repeated by the
4 applicant. So I'll try to go through very quickly,
5 and then I'll turn it over to Dr. Munson.

6 So we're going to provide an overview of
7 our seismic review and answer any questions you have.
8 I'll briefly touch the milestones for the schedule.
9 We'll discuss how we resolve the open items and have
10 any questions or comments that you might have.

11 Highlights, the application came in on
12 September 25th of 2003 and we've issued our final
13 safety evaluation report on February 17th of 2006.
14 The ACRS full committee meeting is schedule for
15 tomorrow, and we hope to get a letter from the ACRS by
16 the end of March and then incorporate that into our
17 SER and issue that as a NUREG the beginning of May of
18 2006.

19 There are a total of seven seismology and
20 seismology open items in the supplemental draft safe
21 evaluation report. Two of those were related to the
22 performance based approach for determining safe
23 shutdown earthquake. Two of them were other seismic
24 related items, and three of them were geotechnical
25 items.

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1 I'm going to very briefly hit on the two
2 seismic and two geotechnical, and Dr. Munson will
3 discuss the two performance based questions.

4 The first item, 251-1, incorporating the
5 most New Madrid seismic source, the applicant did
6 that. We reviewed that and found that acceptable.

7 Two, five, two, dash, one, clarify the
8 EPRI ground motion. The applicant provided the
9 detailed description of their distance conversion
10 method, and the staff reviewed that and found that
11 acceptable.

12 The next slide on geotechnical open items,
13 252-2, site response model does not accurately
14 represent the variability of the soil. This became
15 clear to us after discussions with the applicant, that
16 they were removing the top 60 feet of the soil. We
17 made that a permanent condition in the final safety
18 evaluation report and closed the open item.

19 Two, five, two, dash, three, site response
20 analysis should use appropriate sheer modules in
21 damping curves. The applicant provided data
22 demonstrating the soil has low plasticity and
23 incorporated 15 percent damping cutoff, and the staff
24 reviewed that and found it acceptable.

25 Two, five, four, dash, one, further soil

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1 exploration needed for COL. That was more of a
2 clarification item. The applicant revised their
3 application to make it clear that they were going to
4 perform further drilling and sampling during the COL
5 stage in accordance with Reg. Guide 1.132, and the
6 staff made this a COL action item in the final safety
7 evaluation report.

8 Just to give you an overview of our
9 experience with this performance based methodology,
10 back in April of 2002 we were first introduced to this
11 method through NUREG CR-6728. The staff participated
12 in the committee that developed ASCE 43-05.

13 We first learned of an applicant doing
14 this performance based approach in Exelon's
15 application, September of 2003. As a result, we
16 informed Exelon that it was going to take us
17 additional time to do the review.

18 We formed a seismic technical advisory
19 group made up of seismic and civil engineering experts
20 from NRR, NMSS, and Research. They served in an
21 advisory role to NRR for the review of this
22 performance based approach for Exelon, and Dr. Andrew
23 Murphy, who is here in the back, is from the Office of
24 Research, and he's the chairman of the seismic TAG.

25 Okay. I'm going to turn it over to Dr.

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1 Munson to go through the performance based review.

2 MR. MUNSON: Before I start on the slides,
3 I'd like to mention that we also had some outside
4 consultation from Brookhaven National Lab, and also
5 the USGS to form our final conclusions regard the
6 performance based approach.

7 As Laura stated in the beginning, it was
8 a challenging review. It did take us extra time, and
9 I hope that we can demonstrate the thoroughness of our
10 review over the next half hour or so.

11 I'd like to start off with what we
12 concluded and then develop each conclusion in more
13 detail, and in the process cover each of the open
14 items that we had on the performance based approach.

15 Our first conclusion was that the
16 performance based approach is based on a sound
17 technical approach.

18 Our second conclusion was that the seismic
19 design using the performance based SSE achieves the
20 safety level generally higher than operating plants.

21 And the third conclusion we reached, that
22 the SSE adequately reflects the local hazard from a
23 Springfield type earthquake.

24 CHAIRMAN POWERS: When you say it
25 adequately reflects Springfield, you mean you just

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1 don't see how they could do much better.

2 MR. MUNSON: I'll cover that when I get to
3 conclusion three, but basically --

4 CHAIRMAN POWERS: Well, am I correct in my
5 assumption that this is a fairly mysterious source of
6 seismic activity?

7 MR. MUNSON: Right. There's no remnant
8 seismicity in the Springfield area that would indicate
9 a source. So it's not a very certain earthquake, in
10 other words. We just wanted to do a sanity check to
11 make sure that ground motion from a Springfield
12 earthquake, given that magnitude and distance, would
13 be enveloped by the performance based SSE.

14 CHAIRMAN POWERS: This surely cannot be
15 the only seismic event that occurs that is not
16 associated with a seismic structure of some sort.

17 MR. MUNSON: Right, and that's why they
18 define this central Illinois as a background source
19 zone, because there is no structure that can be
20 directly correlated to a Springfield earthquake.

21 CHAIRMAN POWERS: What I'm floundering
22 around a little bit on is saying, okay, well,
23 presumably earthquakes can produce a distribution of
24 events, magnitude of events. When you've got a one
25 point source, it's hard to think of a distribution.

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1 So you have to think of analogue sources to arrive at
2 that distribution.

3 Does one do that sort of thing?

4 MR. MUNSON: They used a uniform
5 distribution for the central Illinois source zone so
6 that they didn't limit the Springfield earthquake to
7 that particular location.

8 CHAIRMAN POWERS: Okay.

9 MR. MUNSON: Okay. Back to conclusion
10 one, the overriding goal of the performance based
11 approach is to achieve both high and consistent level
12 of seismic safety in the design of future nuclear
13 power plants. The performance based approach is risk
14 based in that it includes both seismic hazard and
15 fragility information. So both capacity and demand
16 information, and the performance based approach
17 requires structures to be designed to a target
18 performance goal.

19 The performance based SSE can be
20 determined by two approaches. The one that Dr.
21 Kennedy described this morning is the design factor
22 approach, which is an ASCE 43-05. You can also
23 directly integrate the risk equation which is the
24 basis of the performance based approach, and the staff
25 used this approach as a check, a verification on the

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1 assumptions, the modeling assumptions, that the
2 applicant made or that are made in ASCE 43-05.

3 A little bit of description of the design
4 factor method. The performance based SSE is
5 determined by multiplying this design factor times the
6 ten to the minus four uniform hazard response spectra,
7 and this design factor is given by the only variable
8 that appears in this is the amplitude ratio between
9 the ten to the minus five and ten to the minus four
10 uniform hazard response factor.

11 Would you go to the next slide, please?

12 This is a graphical illustration of the
13 approach. At five and ten hertz, the dotted line is
14 the ten to the minus four uniform hazard and the
15 dashed line is the ten to the minus five. So the
16 ratio of these two points are close to two and then
17 the design factor is given by this formula right here,
18 and then you arrive at your safe shutdown earthquake
19 using this formula.

20 CHAIRMAN WALLIS: There's something
21 empirical about this presumably.

22 MR. MUNSON: This is totally --

23 CHAIRMAN WALLIS: Whereas the other method
24 makes some sense. I mean the direct integration of
25 risk equation is something that's logically

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1 explicable. I'm not so sure how much you want
2 engineers integrating.

3 CHAIRMAN WALLIS: You wanted to use the
4 handbook rather than doing it.

5 MR. MUNSON: Yes.

6 CHAIRMAN WALLIS: Do you think they find
7 integration difficult?

8 MR. MUNSON: You need to carry out the
9 integration. You need to carry it out to several
10 places. So you need to have an accurately defined
11 hazard curve. There's several things you need to
12 consider.

13 CHAIRMAN WALLIS: With computers you might
14 be able to do it a little bit quicker than in the
15 past.

16 MR. MUNSON: I mean, we take this approach
17 and we're going to use this approach in the future as
18 a check on any performance based approaches that we
19 receive from industry, but the ASCE 43-05 approach is
20 using design factors and amplitude ratios.

21 MR. BAGCHI: He's using a line and
22 approach that is adopted in a consensus standard.
23 That's an easy thing to do and there is no way to make
24 mistakes. It has been gone through several checks for
25 many sites and it has turned out to be quite

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1 conservative.

2 DR. SHACK: I mean, I think it's unfairly
3 maligns it. I mean they did the risk integral
4 obviously, and they just fit it with a simple
5 function. That's all. I mean, it's a question of we
6 do the integration now or do it later.

7 MR. MUNSON: And to derive the design
8 factor, I mean, they did the integration. They
9 assumed model parameters, and they assume a log normal
10 distribution. I'm going to go through all of this.
11 So why don't you go through?

12 The performance based approach is based on
13 this integral of the hazard curve and the fragility
14 curve, and the purpose is to achieve this target
15 performance frequency that we discussed.

16 Go ahead to the next.

17 This is an example of a hazard curve and
18 a fragility curve. So these two curves are multiplied
19 together and then integrated to determine the SSE that
20 meets the target.

21 The first step is determining the target.
22 So our first open item dealt with your performance
23 target. As we discussed this morning or Bob Kennedy
24 described this morning, the performance target
25 frequency is one times ten to the minus five per year,

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1 and that implies that the probability of onset of
2 inelastic behavior shall be less than ten to the minus
3 five per year.

4 And as Bob also described, the performance
5 target is based on comparison between the IPEEE
6 seismic PRAs and equating the two values, even though
7 the performance target corresponds to a minimum damage
8 state and seismic core damage would correspond to a
9 higher damage state. So the staff felt that that was
10 a conservative comparison, although as was pointed
11 out, it is an arbitrary choice.

12 Our initial concern was does that mean the
13 target will change if the hazard information changes.
14 In other words, -- go ahead to the next -- these 25
15 IPEEE seismic PRA core damage frequencies are
16 dependent on seismic hazard information. As the
17 seismic hazard goes up, these values, the frequency,
18 would go down.

19 So our concern is that -- our initial
20 concern was that this target would be a moving target,
21 but the applicant responded by informing us that this
22 was going to be fixed at the one times ten to the
23 minus five.

24 CHAIRMAN POWERS: I mean, it seems to me
25 we've discussed this before, but earlier today, that

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1 it is a policy decision that says, okay, ten to the
2 minus a fifth is kind of what we want as a target.

3 MR. MUNSON: Right, and we needed to come
4 to the conclusion that that was a reasonable value.

5 CHAIRMAN POWERS: That's right. That's
6 right. You earned your salary when you came up with
7 that decision. Well, it's not an easy decision to
8 come to.

9 DR. BONACA: I think the only point I was
10 talking about, my confusion before is that he equated
11 the PFT to one and ten to the minus five per year as
12 the probability of the onset of inelastic behavior and
13 then the acceptable CDF, one in ten to the minus five
14 period, they're not the same thing.

15 MR. MUNSON: They're not. It's a much
16 more conservative -- it's a very conservative
17 assumption that core damage is equated with onset of
18 significant inelastic --

19 DR. BONACA: That's right. So that's
20 really what leads to that confusion, I think.

21 MR. MUNSON: One of the basic premises of
22 the risk performance based approach is that the hazard
23 curves are linear between ten to the minus four and
24 ten to the minus five.

25 Could you show a hazard curve really

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1 quick?

2 What we're talking about is between these
3 two points the performance based approach assumes a
4 linear on a log-log scale, a linear model on a log-log
5 scale.

6 So we checked that by doing a direct
7 integration not assuming a linear fit versus solving
8 the risk equation and doing a linear fit, and as you
9 can see, if you go back to the picture again, there's
10 a slight -- it's hard to see, but there's a slight
11 downward curvature of these curves.

12 So by assuming a linear fit, it's slightly
13 conservative. If you go back to the table, the values
14 we get by not assuming that linear fit are slightly
15 lower than you get by assuming the linear fit. So we
16 felt that that was an acceptable assumption, that
17 there was a linear fit between --

18 CHAIRMAN WALLIS: It's surprising the
19 effect is go big. It's a ten percent effect or
20 something, or more. In other words, they look pretty
21 linear.

22 MR. MUNSON: Right. So by assuming that
23 linear fit, it's conservative.

24 CHAIRMAN WALLIS: but it's surprisingly
25 effective so bad, considering how really it is pretty

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1 close to linear unless this is --

2 CHAIRMAN POWERS: You don't have to
3 deviate very much in a log-log formation.

4 (Laughter.)

5 CHAIRMAN WALLIS: Maybe it depends on how
6 you draw your line. It depends on how you draw your
7 line.

8 MR. MUNSON: Did you have a -- I had a
9 hand up.

10 CHAIRMAN WALLIS: That's okay. I'm not
11 worried about it.

12 MR. KENNEDY: This is Bob Kennedy. I
13 think I can answer that.

14 When you do the rigorous integration,
15 could you put back up the curve? It's not just
16 between ten to the minus four and ten to the minus
17 five that control the final risk number. That's the
18 central region that controls, but on this plot if
19 you're aiming at ten to the minus five, it's from
20 about five times ten to the minus four to about five
21 times ten to the minus six that controls.

22 And so this linearization is known to
23 introduce some conservative bias depending on how much
24 curvature there is on these plots.

25 MR. MUNSON: right. So for the direct

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1 integration approach we integrate over the whole
2 hazard curve and the whole fragility curve, and this
3 is what the hazard curve looks like on a linear plot
4 instead of a log-log plot.

5 Go ahead.

6 CHAIRMAN WALLIS: The plot is piece-wise
7 linear anyway.

8 MR. MUNSON: The next assumption that they
9 made is that the seismic fragility assumes a model
10 seismic systems structure component, seismic fragility
11 using log normal distribution, and the log normal
12 distribution is the same as the normal distribution
13 with the exception of this term here.

14 CHAIRMAN POWERS: I have to admit that I
15 kept coming back in your SER, kept coming back to
16 that. It's totally stated, the log normal
17 distribution. I think why. Why is this distribution
18 appropriate?

19 MR. MUNSON: The log normal distribution
20 has been used to model fragility forever.

21 Do you have any insight?

22 MR. BAGCHI: You can give that to Bob, but
23 I do know that Professor Linwood had done some study.
24 It was published in Nuclear News, I think, not Nuclear
25 News. I forget the name of the magazine, but anyway,

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1 he looked at all of the distributions, and his
2 conclusion was log normal fits very well.

3 CHAIRMAN POWERS: Well, log normal is an
4 amazingly flexible distribution, and you can get a
5 plausible looking fit with just about any set of data
6 to a log normal distribution.

7 MR. KENNEDY: This is Bob Kennedy.

8 We have in the past done a lot of study on
9 distributions. What I can say is when you go through
10 and you vary damping of structures, you vary natural
11 frequency of structures, you take your response
12 spectra and you do multiple time history analyses, we
13 can show that the demand in the structures fits
14 wonderfully to a log normal distribution at least
15 within the central region, the central region being
16 from the one percent to the 99 percent.

17 I'm not so sure that the tails -- I mean,
18 certainly the log normal distribution having had
19 tailed down to zero and a tail up to infinity, those
20 are not reasonable, but the central region, the demand
21 fits wonderfully. We did nominee analyses on the
22 Diablo Canyon long-term seismic program. We did 300
23 nonlinear time history analyses for a nonlinear
24 response. The data fit very well to a log normal
25 distribution. Capacity data fits also well.

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1 CHAIRMAN POWERS: You sit it fits very
2 well except where it doesn't, and unfortunately where
3 it doesn't is exactly where we're going to do the
4 integration.

5 MR. KENNEDY: No. That's the nice thing
6 about seismic. The hazard curves are so flat that the
7 convolution of hazard and fragility, that probability
8 of failure number you get up there is absolutely
9 totally dominated from about the one percent point on
10 the fragility curve to about the 70 percent point.
11 We've done where we have truncated the log normal at
12 the one percent versus using the log normal, and it
13 makes very little difference in the computed
14 probabilities of failure.

15 In internal events, it's those low
16 frequencies that are important, but when you convolved
17 hazard and fragility curves, it's the part from about
18 the one percent point to the 70 percent point that are
19 important.

20 MR. MUNSON: So with the fragility curve
21 it's approaching zero down here. That's also where
22 your hazard curve is approaching.

23 CHAIRMAN WALLIS: Well, the important part
24 is the curve where you actually convolute the two, and
25 that's what you're going to show us.

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1 MR. MUNSON: Right, right.

2 CHAIRMAN WALLIS: The next slide.

3 MR. MUNSON: First I have to get through
4 this.

5 CHAIRMAN WALLIS: Okay.

6 MR. MUNSON: The two parameters that
7 control the log normal probability density function
8 are the mean and the standard deviation, and we can
9 express the mean in terms of the one percent capacity
10 or HCLPF value, and that point corresponds to the one
11 percent capacity level on a mean fragility curve.

12 So the mean in terms of -- this is the
13 means in terms of the one percent capacity.

14 CHAIRMAN POWERS: Is your log normal
15 distribution correctly written up there?

16 MR. MUNSON: I believe so.

17 CHAIRMAN POWERS: Your equation has units.
18 I would think a probability --

19 CHAIRMAN WALLIS: What's the A doing down
20 there?

21 MR. MUNSON: The A is the ground motion.
22 It's defined in terms of ground motion, the fragility.

23 CHAIRMAN POWERS: It will have units.

24 CHAIRMAN WALLIS: It will have units.

25 CHAIRMAN POWERS: And the probability

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1 density function really shouldn't have, should it?

2 MR. MUNSON: I'm sure this is right with
3 the probability.

4 CHAIRMAN WALLIS: Well, you must be
5 dimensionless if you're going to take its log.

6 CHAIRMAN POWERS: Well, I think you may be
7 correct. It's just that we don't have the
8 differential that you're going to use here. If you're
9 going to integrate this over A as opposed to log A,
10 then you need the A down there.

11 MR. MUNSON: Right. The important step is
12 to quantify the one percent capacity in terms of the
13 SSE times the margin. So this is how the SSE shows up
14 in the log normal PDF.

15 These are the different quartile values
16 for the log normal PDF.

17 And this is how we usually see fragility
18 curves in terms of the cumulative distribution
19 function. This is the one percent HCLPF point.

20 So once we had the SSE written in the
21 fragility PDF, we can determine the SSE that meets the
22 target performance goal. I've already discussed the
23 target and the linear hazard curve. The other two
24 parameter assumptions are the standard deviation is
25 0.4 and that the seismic margin is one.

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1 Again, to test the validity of this
2 assumption we looked at these SSE values for different
3 frequencies and back-calculated what target we achieve
4 by using these SSE values. For betas of .4, .5 and
5 .6, we achieve this target or better. So they're
6 slightly lower frequencies than the target, which is
7 better.

8 For a beta of .3 we're slightly higher
9 than the target, but it's not significant.

10 On the seismic margin, as we discussed
11 this morning, the SECY 93-087 requires a seismic
12 margin of 1.67. Earlier versions of this performance
13 based approach actually took credit for this margin.
14 In the ASCE 43-05 they don't take credit for the
15 margin. They assume only a margin of one.

16 If you solve for the SSE after you solve
17 the integral, the margin appears in the denominator.
18 So if you assume a higher margin, you're going to have
19 a lower SSE.

20 So in summary, just conclusion one. The
21 staff came to the conclusion that the performance
22 based approach achieves both high and consistent level
23 of seismic safety. They don't take credit for a
24 seismic margin. They equate the performance target to
25 seismic core damage frequency, and we were able to

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1 determine that it's based on conservative parameter in
2 modeling assumptions.

3 Conclusion two was that the performance
4 based SSE achieved safety levels generally higher than
5 operating nuclear power plants for the Clinton site.
6 The Commission policy on advanced reactors was that
7 advanced reactors have the same degree of protection
8 as operating nuclear power plants, and that advanced
9 reactors provide enhanced margins of safety.

10 Using the Clinton performance based SSE
11 values and the HCLPF seismic margin of 1.67, what are
12 seismic core damage frequency values and how do these
13 seismic core damage frequency values compare to
14 current nuclear power plants?

15 So we looked at five and ten hertz. These
16 are the two performance based values, and as a check,
17 we looked at what would we get if we had used the old
18 Reg. Guide 1.165. I'm calling it "old." It's not
19 that old, but these are two points that would actually
20 have been on the reg. guide SSE spectrum if we had
21 done the reference probability approach.

22 CHAIRMAN WALLIS: Can you tell me? I'm
23 getting puzzled here. What does SSE mean?

24 MR. MUNSON: Safe shutdown --

25 MR. SIEBER: Safe shutdown.

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1 CHAIRMAN WALLIS: This is the ground
2 motion, right?

3 MR. MUNSON: Ground motion.

4 CHAIRMAN WALLIS: And so when you have a
5 higher MS you get a lower ground motion? I don't
6 understand what you mean by that.

7 MR. MUNSON: Do you want to go back to
8 that slide, please?

9 CHAIRMAN WALLIS: You mean that a given
10 structure can withstand a lower ground motion? Is
11 that what you infer?

12 MR. MUNSON: If you assume a higher
13 margin, you design for a lower SSE.

14 CHAIRMAN WALLIS: But the ground motion I
15 don't understand. They ought to design for a higher
16 ground motion.

17 MR. MUNSON: No, if you take credit for a
18 higher margin, then you can design for a lower SSE.
19 If you take credit for no margin, then you have to
20 have a higher SSE.

21 CHAIRMAN WALLIS: I don't understand. SSE
22 is the ground motion which nature gives you, right?

23 MR. MUNSON: No, SSE is --

24 CHAIRMAN WALLIS: If you want a structure
25 which has a greater margin of safety, it has got to be

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1 stronger.

2 DR. SHACK: No, an SSE is selected.

3 MR. MUNSON: This is the selected
4 performance based SSE.

5 DR. SHACK: You choose.

6 CHAIRMAN WALLIS: Well, I assume you know
7 what you're doing. I'm baffled anyway. I thought a
8 margin of safety was you made the thing stronger than
9 you had to make it for a given SSE.

10 MR. BAGCHI: Perhaps one way to look at
11 that is that this safe shutdown earthquake ground
12 motion is going to be used in the design. This is the
13 early site program. The site has the characteristic
14 nature, has defined based on the probabilistic --

15 CHAIRMAN WALLIS: That's what's in the
16 dots or is it in the left-hand side?

17 MR. MUNSON: That's the SSE.

18 CHAIRMAN WALLIS: What's what nature
19 defined, the dots or the other side?

20 CHAIRMAN POWERS: Nature doesn't design
21 the SSE.

22 MR. MUNSON: The hazard curve is in the
23 dots. So that's what comes from the PSHA.

24 CHAIRMAN WALLIS: And SSE is what you
25 design for?

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1 MR. MUNSON: Yes.

2 CHAIRMAN WALLIS: So if you have a bigger
3 margin, you design it to be a weaker structure?

4 MR. BAGCHI: If you later on assure that
5 we are going to verify something for a margin beyond
6 what the SSE calls for, then it would be stronger.

7 MR. MUNSON: So in other words, if we take
8 credit for a higher margin --

9 CHAIRMAN WALLIS: What do you mean by
10 taking credit for a higher margin? If nature gives
11 you one, and you have the safe margin, then you get an
12 SSE of .6 or something. It means you're now designing
13 for .6 instead of for one? It doesn't make any sense,
14 but maybe I'm just stupid.

15 MR. KENNEDY: Could I make an attempt?
16 I'm not sure I can do any better, but let me make an
17 attempt.

18 If you have a goal, let's say we have a
19 goal, seismic core damage frequency, five times ten to
20 the minus six. So that's our goal. The next thing we
21 need to say is how much margin above our design SSE do
22 we have.

23 If we assume we have a margin at one
24 percent chance of failure, the margin for a one
25 percent chance of failure versus the design is only

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1 1.0, we would have to design for a higher SSE to
2 achieve our performance goal of five times ten to the
3 minus six. Then we would have to do if we said the
4 one percent chance of failure point on the fragility
5 curve is 1.67 times the design SSE.

6 CHAIRMAN WALLIS: This is because your CDF
7 is realistic? Is that what it is in the seismic --

8 MR. KENNEDY: You're trying to aim at a
9 realistic seismic core damage frequency.

10 CHAIRMAN WALLIS: Okay. Now I understand.

11 MR. KENNEDY: And where you set your
12 earthquake could be lower if you have a higher HCLPF
13 margin that you're taking credit for. I think that's
14 all that Cliff is trying to get at there.

15 DR. SHACK: Another way of looking at it
16 is it's the excitation that causes the structure to
17 fail, and if you take a full account of the strength
18 of the structure, obviously you can have a higher
19 expectation. If you take a lower -- if you don't take
20 account of the strength of the structure, you have a
21 lower excitation, and that's what they've done.

22 CHAIRMAN WALLIS: So your CDF is
23 realistic. That's what you mean.

24 DR. SHACK: No.

25 CHAIRMAN WALLIS: That's why it comes up.

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1 DR. SHACK: It's conservative when you do
2 it this way.

3 MR. MUNSON: If you are targeting onset of
4 significant inelastic deformation, which is a lower
5 damage state, then you assume no margin. If you're
6 targeting seismic core damage, then you assume a
7 margin of 1.67.

8 CHAIRMAN WALLIS: Okay.

9 MR. MUNSON: So go ahead to the next
10 slide.

11 If we look at -- Bob showed this in a
12 table this morning. For five and ten hertz, the
13 seismic core damage frequency turns out to be compared
14 to the other 25 sites, has a recurrence interval
15 that's higher than the other sites. If we had used
16 Reg. Guide 1.165, the average of five and ten hertz
17 would be close to ten to the minus seven. So it shows
18 that the Reg. Guide 1.165 that would have given a
19 very, very conservative result.

20 CHAIRMAN WALLIS: An interesting plot.
21 Usually it's frequency which goes the other way.

22 MR. MUNSON: I had decided to do it in
23 terms of recurrence.

24 For conclusion three, we wanted to make
25 sure that the SSE reflected the local hazard, and so

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1 we took a closer look at the Springfield earthquake.
2 We know that it was about 6,000 years ago nearly
3 Springfield, which is about 60 kilometers southwest.

4 Original magnitude estimates were in this
5 range, 6.2 to 6.8. The applicant in response to our
6 open item cited a new study which put the magnitude
7 estimate a little bit lower, down toward 6.3.

8 MR. SIEBER: And that's all based on
9 liquefaction?

10 MR. MUNSON: Liquefaction, the spread of
11 the liquefaction features.

12 CHAIRMAN WALLIS: This is 6.3 plus or
13 minus one uncertainty.

14 MR. MUNSON: Yes.

15 CHAIRMAN WALLIS: Is it an uncertainty of
16 two or something or what is it?

17 MR. MUNSON: I have to look at the recent
18 paper that they're citing. I can't remember off the
19 top of my head what the uncertainty is.

20 CHAIRMAN WALLIS: Well, it's probably
21 pretty big, isn't it, for this kind of earthquake?

22 MR. MUNSON: I would say at least .5.

23 CHAIRMAN WALLIS: And if it changes
24 between estimates by .5, that's probably an indication
25 of uncertainty.

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1 MR. MUNSON: So here's the location of the
2 site. Springfield is right here. These are some of
3 the Wabash Valley. This is the figure from the
4 original paper by Obermeier and McNulty.

5 The applicant did several of their own
6 paleoliquefaction surveys on streams near the site to
7 look for evidence of more of these earthquakes, and
8 what they found was that there's no evidence of
9 repeated moderate to large earthquakes comparable to
10 Springfield. So, in other words, they didn't see
11 paleoliquefaction evidence on the streams closer to
12 their site that showed evidence of this type of large
13 earthquake.

14 We asked Exelon to model the ground motion
15 estimates from Springfield to compare them to the ten
16 to the minus four in performance based SSE. That's
17 the next slide.

18 This is the median ground motion expected
19 from a Springfield earthquake given this magnitude
20 range, and it is the 84th percentile compared to the
21 ten to the minus four UHS.

22 The performance based SSE is slightly
23 higher than this red curve.

24 Go back.

25 For the numeral estimate, as you can see,

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1 it's a little bit lower for a magnitude of 6.3. The
2 median and the 84 percent.

3 Okay. So in summary --

4 CHAIRMAN POWERS: But that presumes that
5 if we had a repeat of the Springfield earthquake, it
6 would be no larger than 6.3, right?

7 MR. MUNSON: Well, the first graph showed
8 from 6.2 to 6.8. So they weighted those, again, like
9 we did for the Wabash Valley.

10 CHAIRMAN POWERS: What I'm saying is you
11 have one sample in the distribution. Okay? And
12 you're uncertain about that, but there's no reason to
13 think your uncertainty caps the terminus of that
14 distribution.

15 MR. MUNSON: Right. So I mean, this is
16 just a deterministic check basically. The
17 probabilistic seismic hazard approach, this is like an
18 old Part 100 check on --

19 CHAIRMAN POWERS: I understand what you're
20 doing, but in the back of your mind you've clearly got
21 -- in fact, on all of these earthquake sources you've
22 got some idea that there is a maximum earthquake that
23 one of these sources can produce, and you have
24 historical evidence of samples from that distribution,
25 but there is a cap on it.

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1 MR. MUNSON: Right.

2 CHAIRMAN POWERS: And what I'm struggling,
3 more out of curiosity than pertinence here, I'll
4 admit, but is how do we know what that cap is. It's
5 clearly not the biggest earthquake that has ever been
6 observed at the site, though I could be close, and
7 especially my understanding of the New Madrid
8 earthquake is, indeed, maybe the maximum is going down
9 as a function of time, but --

10 MR. MUNSON: But the recurrence is going
11 up.

12 CHAIRMAN POWERS: And the recurrence is
13 going up, and that, too, would make a lot of sense,
14 but I mean, what --

15 MR. MUNSON: Would you go to the back-up
16 slides?

17 MR. SIEBER: Don't you have to know
18 something about the geological feature that caused the
19 earthquake to be able to predict?

20 MR. MUNSON: In this case we don't. You
21 rely on that.

22 CHAIRMAN POWERS: There is none.

23 MR. SIEBER: There is none. Well, that's
24 a clue as to how soon it will recur and how big it
25 will be.

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1 CHAIRMAN POWERS: Well, it's not a clue to
2 me of any kind.

3 MR. SIEBER: Well, there's one instance,
4 and there is no source identified.

5 MR. MUNSON: What they look at is the
6 occurrence of these liquefaction features. Over what
7 area can they correlate them? And if it's a large
8 area and the features themselves show a certain
9 thickness, they're able to back calculate a magnitude
10 for that.

11 MR. SIEBER: Right.

12 MR. MUNSON: So it's not the most certain
13 exercise, but I guess this is at Springfield, and then
14 this is some of the liquefaction features they found
15 that were associated with that earthquake.

16 So for going in the probabilistic seismic
17 hazard, they went up to magnitude 6.8 for the
18 Springfield.

19 CHAIRMAN WALLIS: So how do they know it's
20 Springfield? They look around at these streams and
21 they see all of these features and they sort of draw
22 a circle and find its middle or something? There must
23 be a very qualitative sign. There could have been two
24 separate earthquakes in two different places that gave
25 rise to the same features.

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1 MR. MUNSON: They have to do carbon
2 dating.

3 CHAIRMAN WALLIS: But then you have to
4 sort of figure out where it came from, don't you?

5 MR. MUNSON: They have to do carbon dating
6 of material that they find.

7 CHAIRMAN WALLIS: Springfield is just sort
8 of at the center of these symptoms presumably. It's
9 a rash, and Springfield is somewhere near the middle.

10 DR. HINZE: Well, you don't find any other
11 dates from any other of the surrounding areas. So
12 that suggests that it's local.

13 CHAIRMAN WALLIS: So it's in this general
14 area.

15 DR. HINZE: Right.

16 CHAIRMAN WALLIS: In Springfield, because
17 Springfield happens to be near the middle.

18 DR. HINZE: The problem as I see it is
19 that there has been no geological information provided
20 that we can assess whether there's a structure or not.
21 I mean a 6.2 to a 6.8, that's a very reasonable
22 structure, and yet we don't know what the drilling is
23 in that area.

24 CHAIRMAN POWERS: Didn't they give us a
25 map of some sort?

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1 DR. HINZE: No.

2 PARTICIPANT: They did a structural map.

3 DR. HINZE: but the structural map doesn't
4 tell you anything if you don't know the data
5 distribution, and the data distribution that you need
6 is the pre-Pennsylvanian drill holes or you need to
7 have some seismic work done in that area to discern
8 whether there is a structural feature or not.

9 And if you were going to do this really
10 right what you would do is you would do some three
11 dimensional seismic work in that area and look not
12 only at the final result, the sedimentary rugs, but
13 you'd look at the basement rugs as well.

14 MR. MUNSON: And what would help is if we
15 had a lot more earthquakes. I mean, no.

16 (Laughter.)

17 CHAIRMAN POWERS: I keep telling you we've
18 got to have more earthquakes.

19 MR. MUNSON: But as a geophysicist, we
20 would like to see more earthquakes. We could define
21 it. We could locate them along a possible source and
22 get a better idea what's going on, but there are just
23 no earthquakes in that area. So I mean, the people of
24 Springfield don't want more earthquakes.

25 PARTICIPANT: The thing is we want data.

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1 DR. HINZE: The fact that we say that
2 there is no structure just means that we have not
3 looked. We don't have the data in which to look for
4 that. But there's a difference here which we know the
5 correlation and not the information to determine that.

6 CHAIRMAN POWERS: Yeah, I think the staff
7 has been careful about saying there's no known
8 structure in their documents.

9 DR. HINZE: But it also has to be stated
10 why there is no known.

11 CHAIRMAN POWERS: It's not known because
12 we didn't look.

13 DR. HINZE: Right.

14 MR. MUNSON: We would need more
15 earthquakes actually occurring there unless we did do
16 active exploration like you're suggesting.

17 I think that's all the slides I have.

18 DR. HINZE: Let me ask you a related
19 question. One of the open items or one of the
20 requests for further information by the staff was that
21 you would like to have a better definition of the
22 central Illinois seismic zone. Did you get that?

23 MR. MUNSON: I don't believe we asked.
24 I'm trying to remember exactly, but I don't think we
25 characterized the question in that. We wanted to get

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1 an idea of the type of ground motion -- the most
2 severe type of ground motion we would expect from a
3 Springfield type earthquake.

4 I think we were aware of what Bob was
5 talking about this morning, that it's almost there's
6 no -- a rectangular source doesn't make, you know,
7 sense in a geologic fashion, but they use that to
8 envelope the site and encompass all of the local
9 seismicity.

10 So the hazard is determined on the one
11 kilometer grid interval when they do the PSHA. So the
12 boundaries of the source zone are not critical.

13 DR. HINZE: You'd like to have it make
14 some geological sense though, wouldn't you? A lot
15 more comfortable.

16 MR. MUNSON: At least for when you put it
17 up on a map and you see a rectangle you'll know what
18 it is.

19 MR. SIEBER: Assuming the county is
20 related.

21 MR. MUNSON: Yeah, the county line.

22 So hopefully we've demonstrated that we
23 did a very thorough review of this performance based
24 approach. We wanted to make sure that the parameter
25 assumptions, the modeling assumptions that they made

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1 for this approach were conservative and that we were
2 coming up with a safe shutdown earthquake ground
3 motion that we felt comfortable with and that compared
4 favorably with current nuclear power plants.

5 And we found that the performance based
6 SSE generally gives a higher level of seismic safety
7 than existing nuclear power plants.

8 We're continuing to look at performance
9 based. We're continuing to interact with industry
10 looking at this approach, how to refine it further for
11 future applications.

12 CHAIRMAN POWERS: Do you anticipate staff
13 coming out with a reg. guide that endorses this?

14 MR. MUNSON: Perhaps I could have Andy.
15 He's our site tech. chairman, and he's in our research
16 -- address that question.

17 MR. MURPHY: Would you repeat your
18 question, please?

19 CHAIRMAN POWERS: Well, I mean it's not
20 uncommon for the staff to come out with a regulatory
21 guide that says one of these standards is acceptable
22 to the staff for this, and I'm just wondering do you
23 anticipate doing this.

24 MR. MURPHY: Yes, we are anticipating very
25 definitely revising Reg. Guide 1.165, and one of the

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1 items very prominent on our table for consideration at
2 this stage is the ASCE 43-05 standard. Basically we
3 are looking at it, having some contractors look at it
4 for us as well with the determination to make use of
5 it.

6 It would not be at this stage a direct
7 endorsement, but more like speaking at important parts
8 of it because there is an awful lot of material in 43-
9 05 that is not exactly pertinent to our problem.

10 CHAIRMAN POWERS: Okay. That is a little
11 different way of portraying it, but the same net
12 effect.

13 MR. MURPHY: Yes, sir.

14 MR. MAYNARD: Question. You said that
15 this performance based method will result in -- I
16 forget how you put it -- safer plants or plants that
17 have higher margin than the existing plant. I tried
18 to understand.

19 Does that mean that the newer plants will
20 have -- using this methodology, will they have to
21 build the newer plants to a higher design criteria or
22 does it mean that the seismic response spectra comes
23 out less?

24 MR. MUNSON: Well, what will happen is the
25 sites that do COLs or ESPs will come up with the safe

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1 shutdown of earthquake, and then they'll have to pick
2 an advanced reactor design that envelopes the site
3 SSE.

4 MR. BAGCHI: Can I address your question
5 directly?

6 I think that the response spectra will
7 come out higher. The hazard has gone up. The
8 performance based method gives us some kind of a
9 stability with respect to how the designs are
10 incorporated, how the SSE is determined, but clearly,
11 you know, you can compare the existing response
12 spectrum against the new one, and you will see that
13 it's much bigger.

14 MR. MAYNARD: That answers my question.

15 CHAIRMAN POWERS: I mean, that's a
16 phenomenological fact that the earthquakes are now
17 more frequent, and in some cases have higher
18 magnitudes.

19 MR. BAGCHI: Well, that aside, we are
20 targeting a performance. That's the best part of this
21 method.

22 DR. BONACA: But doesn't Figure 29 -- the
23 Figure 29 shows that the performance based approach is
24 still conservative with respect to the current plants,
25 but not as conservative as the one on Reg. Guide

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1 1.165.

2 MR. BAGCHI: That's the crux of the
3 problem with targeting a reference probability. The
4 reference probability will change if only the
5 earthquake hazard at a few specific plants changes,
6 and how much do you chase around this? Then you cast
7 aspersions against the existing plants, like the ones
8 that we are facing today.

9 DR. BONACA: Now I understand about
10 stability. Okay? I understand the issue.

11 DR. SHACK: That sort of implies though
12 that the performance you thought you were getting
13 would be developed in 1.165 is similar to the
14 performance you're getting now out of the performance
15 based thing. Is that true? Was that your intent?

16 MR. MUNSON: The Reg. Guide 1.165 approach
17 is using 1990s hazards.

18 DR. SHACK: No, when they picked the
19 frequency that they presumably looked at, they
20 presumably picked that frequency so they would get
21 some performance.

22 MR. MUNSON: They picked it as the median
23 of all these 25 sites. That's what the reference
24 probability is based on.

25 MR. BAGCHI: Reg. Guide 1.165 really

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1 focused only on hazard. If you go back and read that,
2 you'll see that it is based on the hazard, the
3 assurance was, that the existing 28 sites or 25 sites
4 have SSEs that in the median, the average have the
5 same kind of reference probability.

6 That's why one of the ways would have been
7 to go back and establish a new reference probability,
8 but what would that do? In another five years some
9 change in geoscientists and we're going to have yet
10 another reference probability.

11 So that's a very unstable way to do this.
12 That's why this performance based approach is a target
13 of the performance of the plant.

14 CHAIRMAN WALLIS: Well, it makes sense,
15 but I'm just trying to clarify what you've been saying
16 here. What I think I heard is that if you used this
17 performance based approach, this plant is going to be
18 safer against seismic than the average of existing
19 plants, but it's going to be less safe than if you had
20 used the 1.167 methodology.

21 MR. BAGCHI: That's right.

22 CHAIRMAN WALLIS: So you are relaxing
23 something.

24 DR. BONACA: And the issue is -- the
25 reason why I was pursuing that is, you know, you seem

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1 to imply that you're comfortable with that, and I want
2 to hear it.

3 PARTICIPANT: Well, if we can go back and
4 look at what we had accomplished with Reg. Guide 1.165
5 with a reference probability with only emphasis on
6 hazard, we in hindsight are now finding out that that
7 is a very unstable way to determine how to design the
8 plant for earthquakes.

9 DR. BONACA: I understand the issue of
10 stability. I repeat that.

11 PARTICIPANT: Let me try to address that.

12 DR. BONACA: I still say, you know, we
13 went from one they gave you for a new plant. They set
14 them out to a certain value, 2.1, that gives you
15 stability, but is not as conservative, and so I want
16 to hear from you that you're comfortable with the
17 conservatism that this matter still includes.

18 MR. MUNSON: Well, if you look at Reg.
19 Guide 1.165, the basis of the reference probability is
20 it was the median of all of these SSE sites. So we
21 were picking the middle value of all these 29 sites
22 and setting our reference probability level.

23 Now what we're doing, we're looking at
24 this in terms of seismic core damage frequency in
25 terms of this, and we're seeing a much higher in terms

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1 of recurrence, a much higher value. This is
2 unreasonable. That's 12 million years of recurrence
3 right there.

4 I mean, how can we expect them to design
5 to 12 million years of recurrence?

6 CHAIRMAN POWERS: We do that for Yucca
7 Mountain.

8 MR. MUNSON: I don't want to talk about
9 that.

10 (Laughter.)

11 DR. BONACA: I know that. Now that makes
12 more sense to me, what it is conveying, okay?

13 MR. BAGCHI: As a structural engineer,
14 I'll give you my other sense, which is I've designed
15 a lot of plants. Before I came to the United States
16 31 years ago, I designed plants for seismic
17 resistance, and I know how the response factor
18 evolved, and if you look at the response factor at
19 North Anna ESP site versus the whole site, you'll find
20 that the response factor is much higher. The design
21 would be I mean just in fewer seismic there, it's
22 going to be higher.

23 So we are comfortable with that.

24 CHAIRMAN POWERS: Any other questions for
25 the speakers?

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1 DR. SHACK: Well, it's the question we
2 came to earlier today now. What implications does
3 this higher hazard mean for the existing plants?

4 MR. BAGCHI: We have the Generic Issue 199
5 identified for that, and Office of Research is --

6 MR. MUNSON: Engaged.

7 CHAIRMAN POWERS: Any other questions?

8 (No response.)

9 CHAIRMAN POWERS: Well, than you very
10 much.

11 Do you have any closing comments, Laura?

12 MS. DUDES: No. Just thank you. I think
13 again, you know, this is just the beginning. I know
14 you're going to hear about the issue generically
15 through the reg. guide development and through the
16 generic issue resolution, and we will be approaching
17 this again shortly with our next early site permit.

18 CHAIRMAN POWERS: That brings up the
19 issue. You're presenting at the full Committee.

20 MS. DUDES: Tomorrow.

21 CHAIRMAN POWERS: And what do you think
22 ought to be presented at the full Committee? You
23 catch me a little bit flat footed. Your presentation
24 was an excellent presentation, but I think it might be
25 just a little terse for the full Committee.

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1 Is the applicant intending to present to
2 the full Committee?

3 MR. GRANT: Yes, I believe we have a
4 presentation prepared.

5 CHAIRMAN POWERS: I think your
6 introductory presentation and synopsis would be just
7 excellent for the full Committee. You probably don't
8 need to plunge into the details, but where you've been
9 and where we're going and that you've closed all of
10 the issues probably is the level of detail they need.

11 And then, Laura, you need to figure out --
12 I mean "you" collectively, John -- need to figure out
13 how to communicate fairly succinctly to the committee
14 that you've looked at this in some depth and for the
15 agency as a whole, and I think it's very important for
16 that to come across to the full committee.

17 And I will have to say that you have
18 definitely persuaded me that you've looked very
19 thoroughly. So I would hope that you would persuade
20 the rest of the Committee.

21 Do other members have suggestions on how
22 they present this material?

23 How much time do we have on the Committee
24 schedule? It's fairly short.

25 MR. SNODDERLY: About two hours.

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1 CHAIRMAN POWERS: Oh, well, we have a
2 world of time.

3 (Laughter.)

4 CHAIRMAN POWERS: Lots of time.

5 I don't expect you to get -- okay. We
6 have lots of time, and I don't expect you to get a
7 very close interrogation because most of the people
8 who would interrogate you have already been sitting
9 here. So this is likely to go very quickly I would
10 suspect.

11 DR. BONACA: But there's George.

12 MR. MUNSON: Would you like a more
13 qualitative description of our approach to it rather
14 than these probability density function and --

15 CHAIRMAN POWERS: I think you've hit upon
16 it. With some discussion of this agency-wide will get
17 it across to the full members.

18 MR. MUNSON: Okay.

19 CHAIRMAN POWERS: I mean, don't get me
20 wrong. I liked your presentation a lot, and you
21 succeeded in your mission, which was to persuade me
22 you've done a good job reviewing this material, and I
23 very much got that impression.

24 CHAIRMAN WALLIS: Well, I wouldn't take
25 out all of the quantities of stuff. I think the

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1 business of the two curves that you multiply together
2 to get something with an X on showing that you don't
3 need to worry about the tails and so on is important.
4 I think some of the equations you could do without.

5 A graph like that that really is the core
6 of what you did I think is important to show.

7 MR. MUNSON: Okay.

8 MR. BAGCHI: Dr. Powers, just one point of
9 caution. We did look at this method for this
10 particular site, and it detailed a thorough submittal
11 in the future along the lines of Exelon, would
12 probably receive a lot fewer requests for additional
13 information, but let's keep in mind that our generic
14 guidance is yet to come.

15 CHAIRMAN POWERS: Right, and you should
16 make that point as well.

17 Any other comments to guide them on
18 presenting to the full committee?

19 MR. SEGALA: In terms of the whole review,
20 do you just want me to briefly --

21 CHAIRMAN POWERS: Quick status report
22 because I think we in our interim letter, we gave you
23 a pretty blanket endorsement of what you were doing
24 there save for the fact that we really don't like the
25 way you handle weather.

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1 But other than that, I mean, I think our
2 interim letter essentially closed out all of the
3 issues save the seismic, but a quick status report
4 never hurts.

5 MR. SEGALA: Okay.

6 CHAIRMAN POWERS: Okay. At this point I'm
7 going to go off the record and I want to poll members
8 on comments and developing our draft position. People
9 are certainly welcome to stay and clarify our
10 thinking.

11 (Whereupon, at 12:04 p.m., the meeting was
12 adjourned.)

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CERTIFICATE

This is to certify that the attached proceedings before the United States Nuclear Regulatory Commission in the matter of:

Name of Proceeding: Advisory Committee on
Reactor Safeguards
Early Site Permit
Subcommittee

Docket Number: n/a

Location: Rockville, MD

were held as herein appears, and that this is the original transcript thereof for the file of the United States Nuclear Regulatory Commission taken by me and, thereafter reduced to typewriting by me or under the direction of the court reporting company, and that the transcript is a true and accurate record of the foregoing proceedings.



Eric Hendrixson
Official Reporter
Neal R. Gross & Co., Inc.

Exelon[®]

Nuclear



ACRS Presentation

March 8, 2006

**Early Site Permit Application
Clinton Power Station Site
Final Safety Evaluation Report**

Agenda

- Introductions
- Significant Changes Since Draft Safety Evaluation Report (DSER)
- Geotechnical Approach
- Seismic Evaluation
- Supplemental DSER Issue Closure
- Summary

Introductions - ESP Project Team

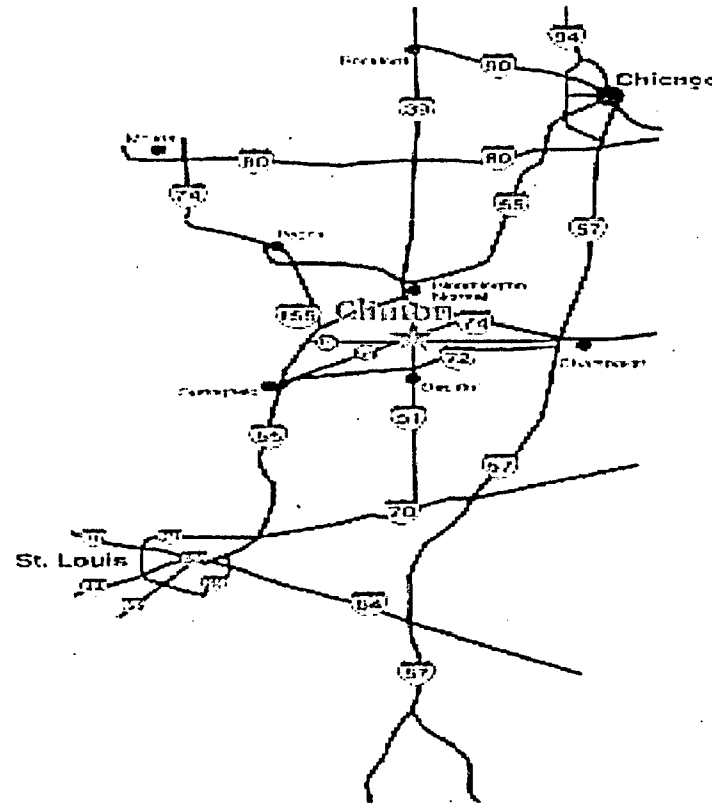
- Marilyn Kray – Project Executive Sponsor
- Christopher Kerr – Sr. Project Manager
- Eddie Grant – Safety / EP Lead
- William Maher – Environmental Lead

Introductions – Support Team

- CH2M Hill (Prime Contractor)
 - Environmental / Redress
 - Geotechnical
 - EP
- CH2M Hill Subcontractors
 - WorleyParsons
 - Safety
 - Geomatrix
 - Seismic
 - Seismic Board of Review
 - Expert, independent review
 - Others
- RPK Structural Mechanics Consulting
 - Seismic
- Sargent and Lundy
 - Draft Application Review
- Morgan Lewis
 - Legal counsel

Introductions – Site Location

- ESP Site Location
 - Central Illinois
 - Clinton Power Station Property
 - AmerGen Owned (EGC Subsidiary)
- Applicant
 - Exelon Generation Company, LLC (EGC)
 - Wholly owned subsidiary of Exelon Corporation



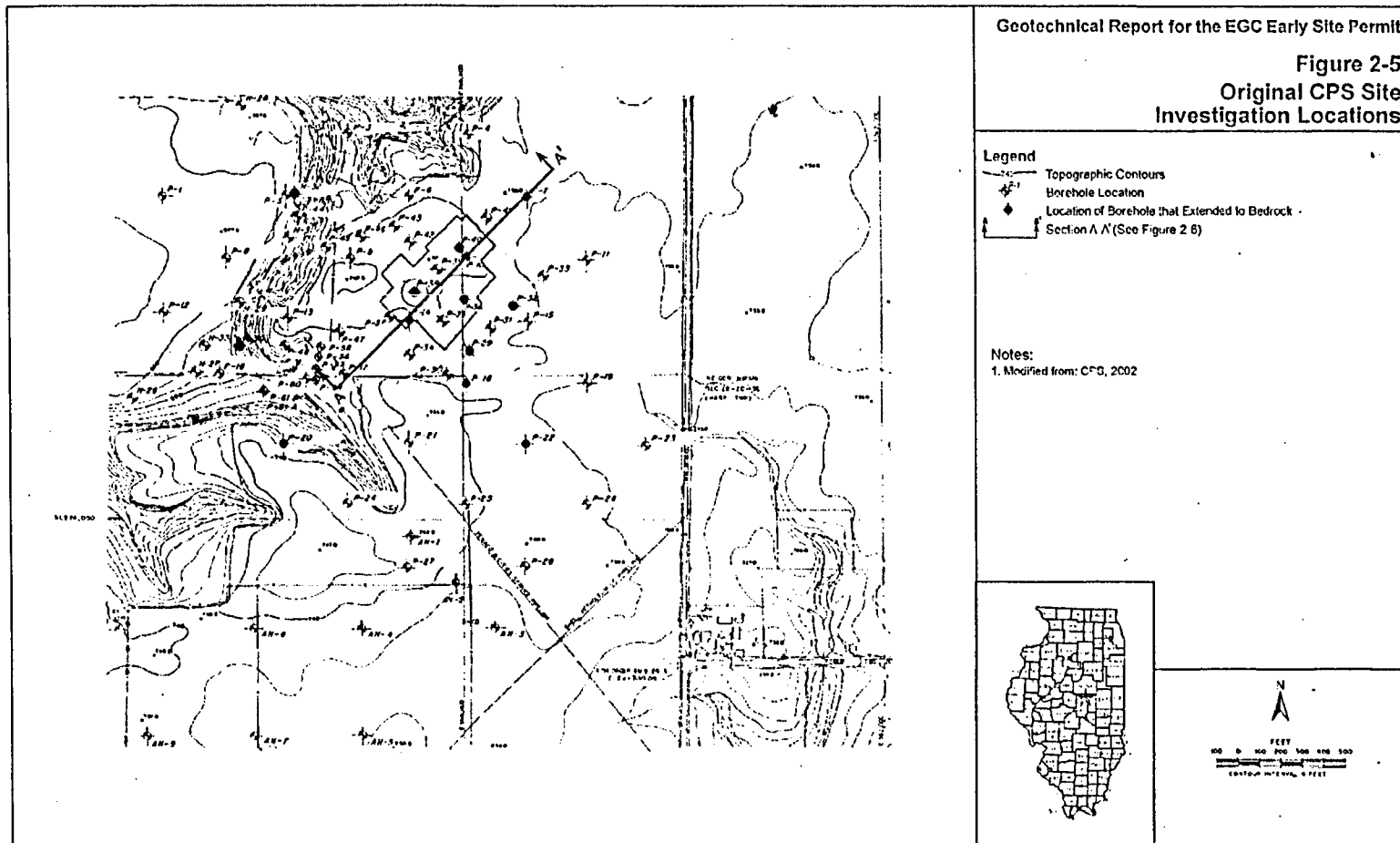
Significant Changes Since DSER

- Closure of all Open Items
- Completion of all Confirmatory Items
- Acceptance of SSE ground motion spectra
 - Minor revisions in response to open items
- Documented Criteria for:
 - Permit Conditions
 - Combined License Action Items

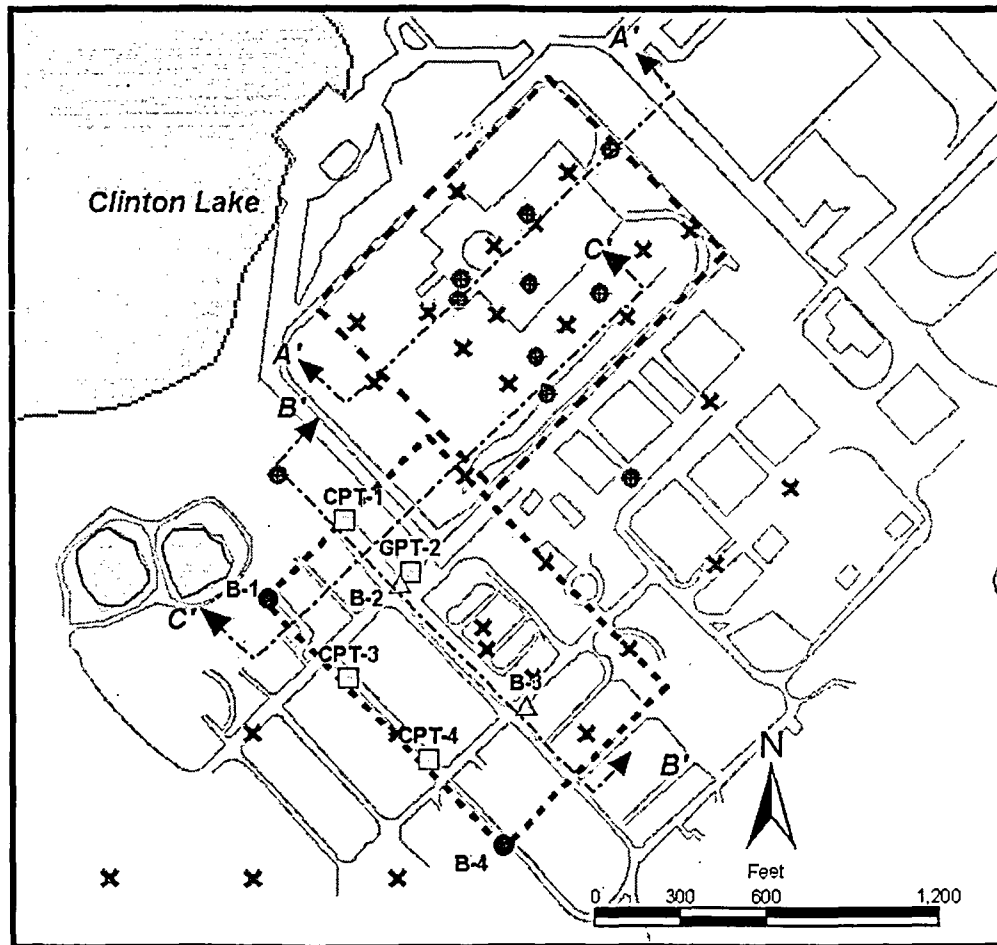
Geotechnical Approach

- Builds on existing CPS information
 - Regional geology
 - Site geology
 - Exploration
 - Laboratory testing
- EGC ESP work
 - Confirm conditions
 - Updated information

Geotechnical Approach (cont'd)



Geotechnical Approach (cont'd)



Modified from
ESP SSAR,
Appendix A,
Figure 3-1

Geotechnical Approach (cont'd)

Site is:

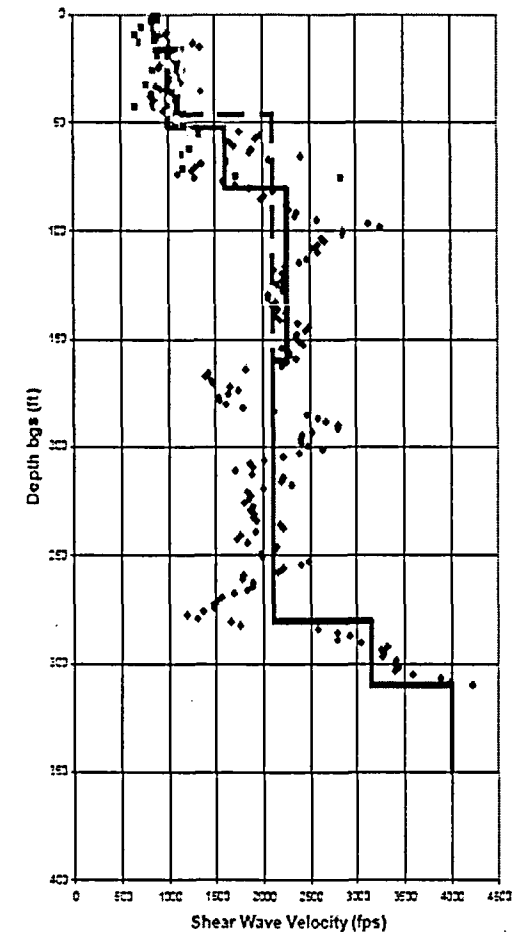
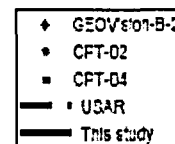
- Relatively uniform
- Stiff soils

Field data shows:

- Shear wave velocities consistent with CPS characterizations

Lab data shows:

- Good match to EPRI soil modulus and damping curves



Seismic Evaluation

SSE Ground Motion Determination

RG 1.165 Methodology

- Investigations
- Seismic sources update
- SSHAC assessment
- PSHA
- Determine SSE ground motion spectra
 - **Relative based -- Reference Hazard Probability Criterion**

EGC ESP Application

- Same
- Same
- Same
- Same
- Determine SSE ground motion spectra
 - **Performance-based – Risk-informed Criterion**

Seismic Evaluation (cont'd)

SSE Ground Motion Determination (cont'd)

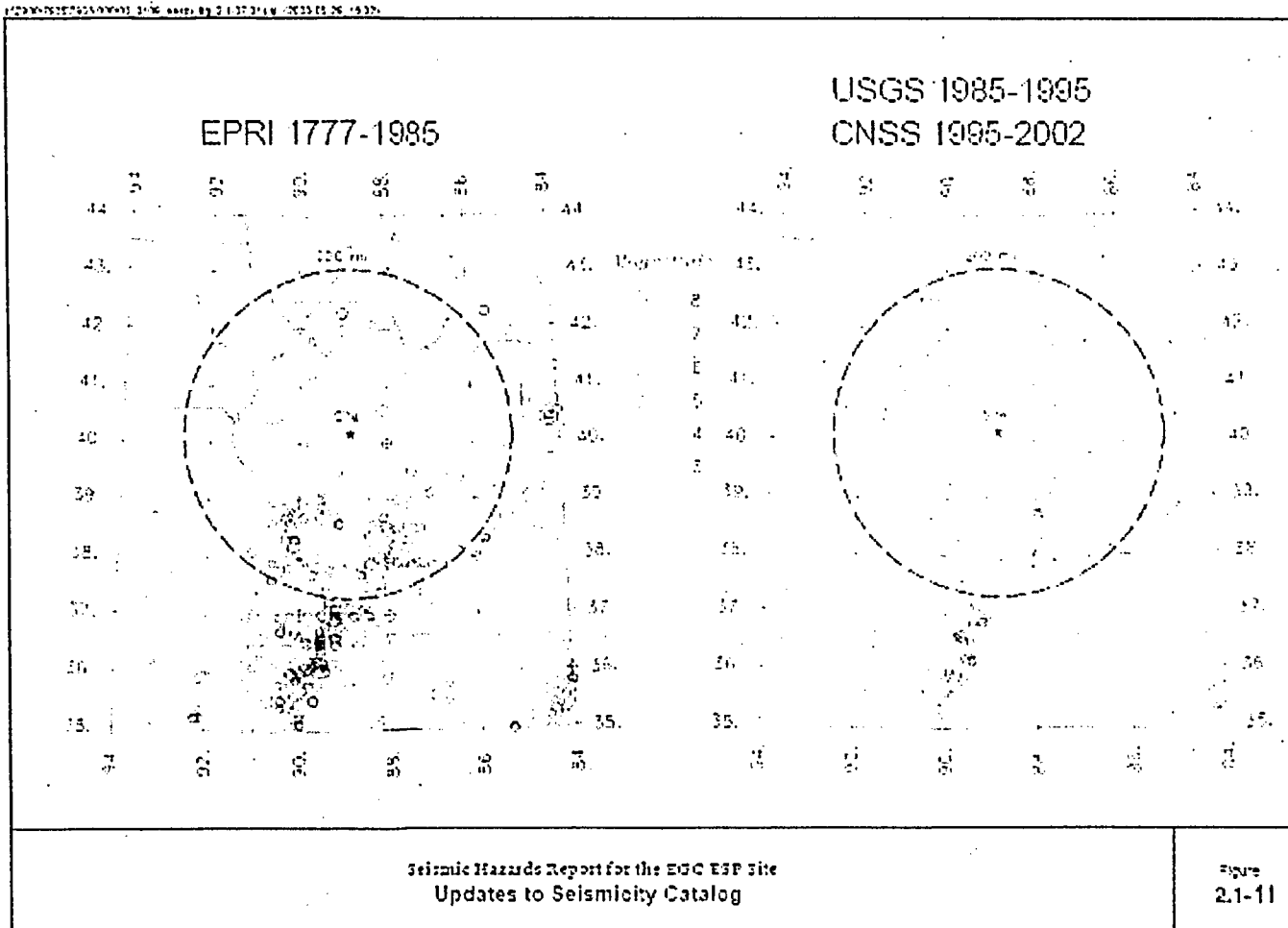
RG 1.165 Methodology

- De-aggregate to identify controlling earthquakes
- Account for site effects

EGC ESP Application

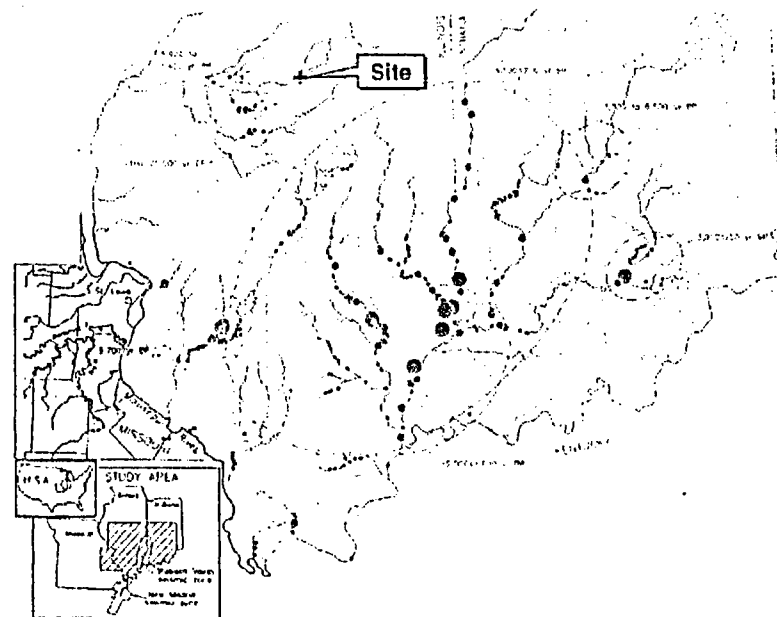
- Same
- Same
[NUREG/CR-6728]

Seismic Evaluation (cont'd)



Seismic Evaluation (cont'd)

- Major new information
 - Repeated large events in New Madrid seismic zone in past 2,000 years
 - Large events in Wabash Valley/ Southern Illinois in past 12,000 years
 - One moderate event with energy center ~30 miles SW of site at Springfield ~6,000 years ago



Seismic Evaluation (cont'd)

Reference Hazard RG 1.165, App. B

- Reference Probability
 - The annual probability level such that 50% of the set of most modern design currently operating plants have an annual median probability of exceeding the SSE that is below this level (1E-5) determined at an average of the 5 and 10 Hz SSE spectra with 5% damping.

Performance-Based ASCE 43-05

- Performance-Based
 - SSCs will have a target mean annual frequency of 1E-5 for seismic induced onset of significant inelastic deformation.
 - Significant margin against SSC failures that might lead to core damage.
 - Leads to seismically induced CDF significantly less than for existing plants

Seismic Evaluation (cont'd)

Performance-Based Approach History

- LLNL UCRL-15910, Design and Evaluation Guidelines for U.S. Department of Energy Facilities Subjected to Natural Phenomena Hazards, 1990
- DOE-Std-1020, Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities, 1994 & 2002
- USNRC NUREG/CR-6728, Technical Basis for Revision of Regulatory Guidance on Design Ground Motions: Hazard- and Risk-Consistent Ground Motion Spectra Guidelines, 2001
- ASCE/SEI 43-05, Seismic Design Criteria for Structures, Systems, and Components in Nuclear Facilities, 2005

Seismic Evaluation (cont'd)

Performance-Based Approach Basis

- Establish Target Seismic Risk Goal, P_{FT} , Against OSID
- Establish Design Criteria Conservatism
 - ASCE Most Stringent Seismic Design Category, SDC-5D
 - Similar to Seismic Design Criteria, NUREG-0800
- Establish UHRS
 - Reference Seismic Hazard Exceedance Frequency, H
- Increase UHRS by "Design (Scale) Factor," DF
(Based on Minimum Seismic Margin Factors for OSID)
 - 1% Probability of Unacceptable Performance for SSE
 - Also 10% Probability of Unacceptable Performance for 1.5xSSE

Seismic Evaluation (cont'd)

Performance-Based Approach Application

- Target Seismic OSID Risk Goal, $P_{FT} \leq \text{mean } 10^{-5}/\text{yr}$
 - Based on Reported Seismic CDF of 25 licensed plants
- Design Criteria, NUREG-0800 ~ ASCE SDC-5D
- UHRS established at mean $10^{-4}/\text{yr}$
- "Design (Scale) Factor," DF = 1.04 to 1.30 for EGC ESP
- Perform Probabilistic Analysis
 - Seismic CDF $\leq \text{mean } 2 \times 10^{-6}/\text{yr}$ for EGC ESP

[[Detailed Derivation (ADAMS ML050250137)]]

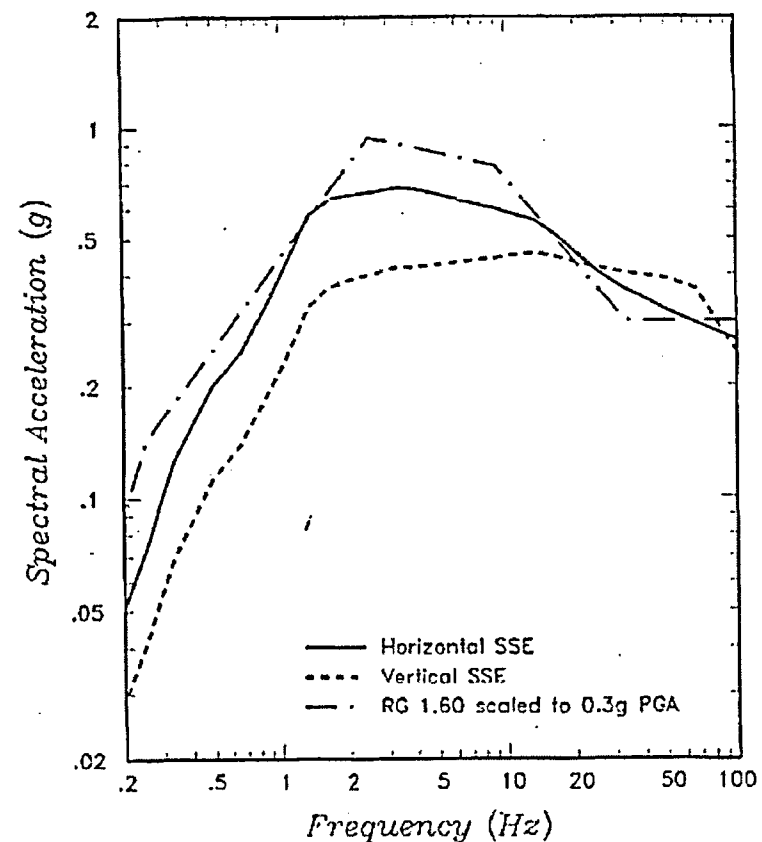
Seismic Evaluation (cont'd)

Seismic CDF for EGC ESP Hazard Curves

β	ASCE Method - SCDF				
	$F_{1\%} = 1.67$ $*1 \times 10^{-5}/\text{yr}$				
	1 Hz	2.5 Hz	5 Hz	10 Hz	Average 5 & 10 Hz
0.3	0.39	0.26	0.22	0.16	0.19
0.4	0.27	0.17	0.14	0.11	0.12
0.5	0.20	0.12	0.11	0.086	0.096
0.6	0.15	0.10	0.087	0.078	0.082

Seismic Evaluation (cont'd)

- Performance-Based EGC ESP SSE Ground Motion Spectra
 - Horizontal DRS
 - Vertical DRS
 - RG 1.60 0.3g PGA (for reference only)
 - Acceptable to NRC Staff
 - Compared to Design Spectra at COL stage



Supp. DSER Issue Closure

- Open Items (7) - resolved
 - 2.5.1-1, New Madrid magnitude estimates
 - 2.5.2-1, Distance-conversion in EPRI '03 Ground Motion Model
 - 2.5.2-2, Site velocity model for response analysis
 - 2.5.2-3, Site dynamic response analysis
 - 2.5.2-4, SSE ground motion adequately represents local prehistoric earthquakes
 - 2.5.2-5, Performance-based method clarification
 - 2.5.4-1, Additional borings

Supp. DSER Issue Closure

- New Madrid magnitude estimates
 - 2.5.1-1, NRC Issue – Incorporate hazard due to recent new estimates of magnitudes of the New Madrid earthquakes

Applicant actions:

- Hazard revised to include the small impact
 - Site response spectra revision < 10%

Supp. DSER Issue Closure (Cont'd)

- Distance-conversion in EPRI 03 Ground Motion Model
 - 2.5.2-1, NRC Issue – Provide further clarification of EPRI 03 Ground Motion Model distance-conversion methodology

Applicant actions:

- Provided detailed description of the EPRI '03 distance-conversion implementation process

Supp. DSER Issue Closure (Cont'd)

- Site velocity model for response analysis
 - 2.5.2-2, NRC Issue – Further justify using a single velocity model for variability in strength and stiffness of site soils

Applicant actions:

- Variability of concern is in top 60 ft of soil profile
 - o This soil will be removed/replaced to address the potential settlement and liquefaction issues
 - o Identified by NRC as proposed Permit Requirement

Supp. DSER Issue Closure (Cont'd)

- Site dynamic response analysis
 - 2.5.2-3, NRC Issue – Demonstrate appropriateness of site dynamic properties model and implement 15% damping cutoff on free-field site response

Applicant actions:

- Provided additional information on soil plasticity and revised analysis using 15% damping cutoff
 - o Site response spectra revision < 2%

Supp. DSER Issue Closure (Cont'd)

- SSE ground motion adequacy
 - 2.5.2-4, NRC Issue – Justify SSE adequacy as bounding local prehistoric earthquakes

Applicant actions:

- Clarifying information provided addressing:
 - o Use of prehistoric earthquake data in PSHA
 - o Determination of controlling earthquake per RG 1.165
 - o Relation of SSE ground motion to controlling earthquake
 - o Comparison of SSE ground motion to estimated local prehistoric earthquake

Supp. DSER Issue Closure (Cont'd)

➤ Performance-Based Method Clarifications

- 2.5.2-5, NRC Issue – Provide additional information regarding assumptions for implementation of the performance-based methodology

Applicant actions:

- Clarifying information provided addressing:
 - o Appropriate mean annual hazard for implementing method
 - o Determination of design factors and assumption of HCPLF margin and SSC capacity
 - o Onset of significant inelastic deformation
 - o Target performance goal value, its stability, and applicability for advanced reactor designs
 - o Similarity of design criteria in SRP and ASCE

Supp. DSER Issue Closure (Cont'd)

➤ Additional borings

- 2.5.4-1, NRC Issue – Additional borings will be needed at COL stage

Applicant actions:

- COL applicant will address additional borings per RG 1.132 guidance

Summary

- All Open Items Closed
- All Confirmatory Items Completed
- SSE Ground Motion Spectra Accepted

Exelon Early Site Permit Seismic Review Status



March 8, 2006

Advisory Committee on Reactor Safeguards Early Site Permit Subcommittee Meeting

John Segala, Senior Project Manager
Office of Nuclear Reactor Regulation

Purpose

- To provide the ACRS an overview of the Exelon early site permit (ESP) application seismic review
- Answer the Subcommittee's questions

03/08/2006

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Meeting Agenda

- Schedule Milestones
- Seismic Open Items
- Presentation Conclusions
- Discussion / Subcommittee questions

03/08/2006

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Completed Milestones

- Received Exelon ESP application - September 25, 2003
- FRN published announcing acceptance – October 31, 2003
- FRN published for mandatory hearing – December 12, 2003
- RAIs issued to the Applicant – July, 27, 2004
- Draft SER issued – February 10, 2005
- Applicant responds to Draft SER open items – April 26, 2005
- Supplemental Draft SER issued – August 26, 2005
- ACRS Full Committee Meeting - September 8, 2005
- ACRS interim letter – September 22, 2005
- Staff provided Final SER to ACRS – February 9, 2006
- **Staff issued Final SER – February 17, 2006**

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Remaining Milestones

- ACRS Full Committee Meeting – March 9, 2006
- ACRS letter assumed – March 30, 2006
- Final SER issued as NUREG – May 1, 2006
- Mandatory hearings begin Fall 2006
- Commission decision assumed mid 2007

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Seismic Open Items

- 7 Seismology and Geology Open Items
 - 2 - Performance-based (PB) approach for determining safe shutdown earthquake (SSE)
 - 2 – Seismic
 - 3 - Geotechnical

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Seismic Open Items

- 2.5.1-1, Incorporate most recent New Madrid seismic source model into the PSHA and SSE
- 2.5.2-1, Clarify the EPRI ground motion attenuation study distance-conversion method

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Geotechnical Open Items

- 2.5.2-2, Site response model does not adequately represent variability of soil properties
- 2.5.2-3, Site response analysis should use appropriate shear modulus and damping curves
- 2.5.4-1, Further soil exploration needed for COL

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8

NRC Experience with the Performance-Based Methodology

- NUREG/CR-6728 (April 2002) first introduced the staff to the performance-based approach
- NRC staff participated on the Committee that developed ASCE 43-05
- Use of a performance-based approach for determining the SSE first identified in Exelon's application in September 2003
- NRC formed a Seismic Technical Advisory Group
 - Seismic & Civil Engineers from NRR, NMSS, and RES
 - Served in an advisory role to NRR for review of performance-based approach

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Exelon's Performance-Based (PB) Safe Shutdown Earthquake (SSE)

NRC staff concluded:

1. PB method based on sound technical approach
2. Seismic design using PB SSE achieves safety level generally higher than operating plants
3. PB SSE adequately reflects local ground motion hazard from Springfield earthquake

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Conclusion 1

PB method based on
sound technical approach

- Overriding Goal: Achieve both high and consistent level of seismic safety in the design of future NPPs
- PB approach is risk-based
 - Incorporates both site specific seismic hazard and structural fragility model
- PB approach requires structures be designed to achieve target performance goal

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Conclusion 1 (Cont.)

- PB SSE determined by two approaches:
 - Design Factor Method (ASCE 43-05)
 - Direct Integration of Risk Equation
- Design Factor Method
 - PB SSE determined by multiplying 10^{-4} UHRS by design factor to achieve target performance goal

$$PB\ SSE = DF \times UHRS_{10^{-4}}$$

$$DF = \text{Max} (0.6A_R^{0.8}, 1.0)$$

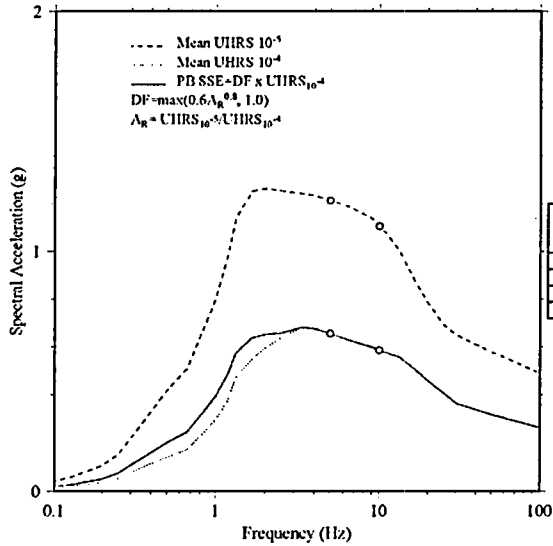
$$A_R = \frac{UHRS_{10^{-5}}}{UHRS_{10^{-4}}}$$

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Conclusion 1 (Cont.)

Exelon Performance Based SSE



Spectral Frequency (Hz)	10-4 Mean UHRS (g)	10-5 Mean UHRS (g)	AR	DF	Horiz. SSE (g)
1	0.297	0.802	2.700	1.328	0.395
2.5	0.638	1.256	1.968	1.031	0.658
5	0.657	1.215	1.849	1.000	0.657
10	0.586	1.107	1.887	1.000	0.586

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Conclusion 1 (Cont.)

- Direct Integration

$$P_{fT} = \int H(a) f_c(a) da$$

P_{fT} = Target Performance Frequency

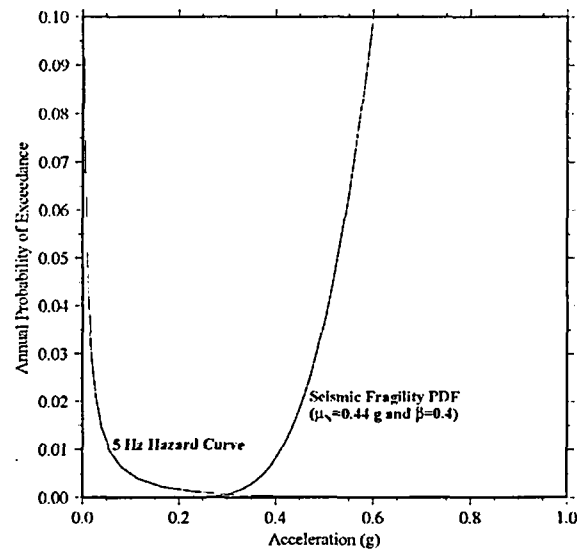
$H(a)$ = Seismic Hazard Curve

$f_c(a)$ = Probability Density Function for SSC Seismic Fragility

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Conclusion 1 (Cont.)



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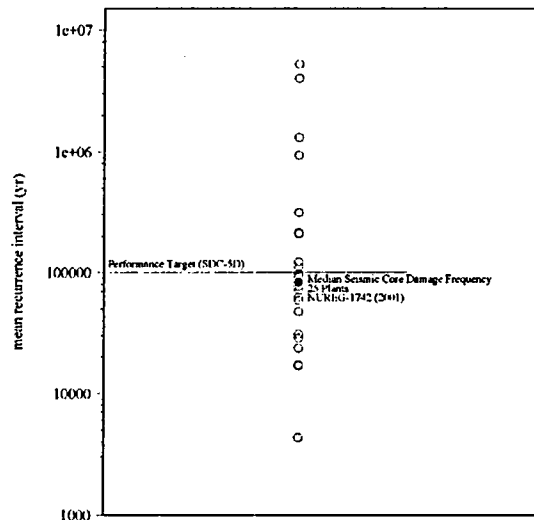
Conclusion 1 (Cont.)

- Performance Target (P_{FT}) is 1×10^{-5} per year
 - Implies probability of onset of inelastic behavior shall be less than $10^{-5}/\text{yr}$
- Basis for $P_{FT} 10^{-5}/\text{yr}$:
 - IPEEE Seismic PRAs conducted for 25 NPPs during mid/late 1990s determined annual seismic CDF values
 - Median SCDF is $1.2 \times 10^{-5}/\text{yr}$
- P_{FT} corresponds to minimum damage state
- SCDF implies a higher damage state

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Conclusion 1 (Cont.)



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Conclusion 1 (Cont.)

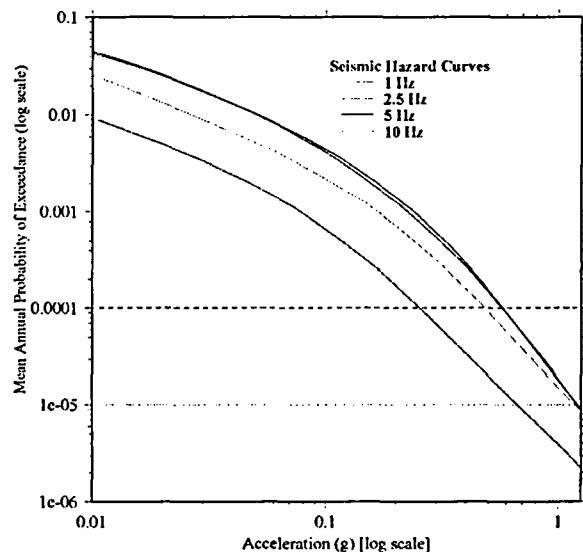
- Seismic Hazard Curve
 - ASCE 43-05 assumes a linear hazard curve between 10^{-4} and 10^{-5}
 - Slight downward curvature of hazard curve

Frequency (Hz)	SSE	
	Risk Integral (g)	Risk Equation (g)
1	0.337	0.395
2.5	0.574	0.658
5	0.604	0.657
10	0.559	0.586

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Conclusion 1 (Cont.)



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Conclusion 1 (Cont.)

■ Seismic Fragility

- PB approach models SSC seismic fragility using lognormal distribution

$$f_c(a) = \frac{1}{\sqrt{2\pi}\beta a} \exp\left[-\frac{1}{2}\left(\frac{\ln a - \mu}{\beta}\right)^2\right], a > 0$$

■ Fragility Parameters: Mean (μ), SD (β)

- Mean expressed in terms of $C_{1\%}$ or HCLPF
- HCLPF corresponds to 1% capacity level on mean fragility curve

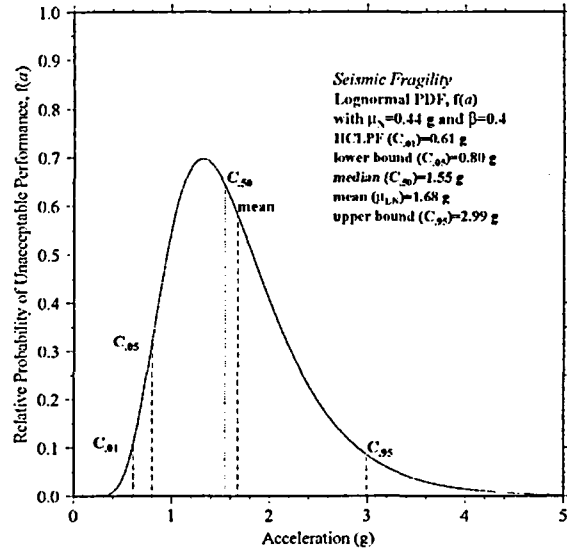
$$\mu = \ln HCLPF + 2.32\beta$$

$$HCLPF = SSE \times M_s$$

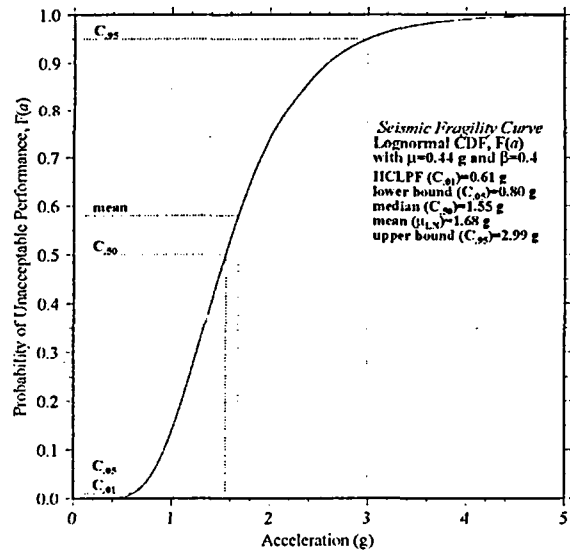
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Conclusion 1 (Cont.)



Conclusion 1 (Cont.)



Conclusion 1 (Cont.)

- Parameter Assumptions
 - SSE is back-calculated by assuming:
 - Target $P_{FT} = 1 \times 10^{-5}/\text{yr}$
 - Linear Hazard Curve
 - $\beta = 0.4$
 - Seismic Margin = 1

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Conclusion 1 (Cont.)

Target Performance Frequency for $\beta = 0.4$

Freq (Hz)	SSE (g)	PFT*10 ⁻⁵ /yr			
		$\beta=0.3$	$\beta=0.4$	$\beta=0.5$	$\beta=0.6$
1	0.395	1.08	0.95	0.7	0.55
2.5	0.658	1.05	0.97	0.73	0.59
5	0.657	1.03	0.96	0.71	0.58
10	0.586	1.02	0.91	0.65	0.52

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Conclusion 1 (Cont.)

- Seismic Margin (M_s)
 - SECY 93-087 requires an overall HCLPF Seismic Margin of 1.67
 - ASCE 43-05 does not take credit for Seismic Margin ($M_s = 1$)
 - Higher M_s results in lower SSE

$$SSE = \frac{1}{M_s} (\dots)$$

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Conclusion 1 (Cont.)

Summary of Conclusion 1:

- PB Approach
 - Achieves both high and consistent level of seismic safety
 - No credit for seismic margin
 - Equates performance target to SCDF for existing NPPs
 - Based on conservative parameter and modeling assumptions

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Conclusion 2 PB SSE achieves safety level generally higher than operating NPPs

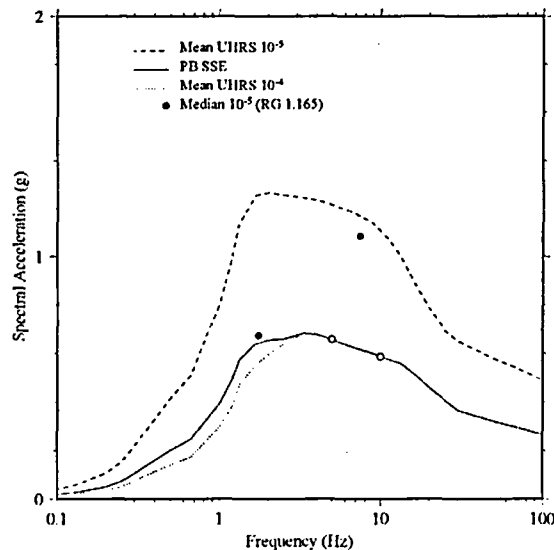
- Commission Policy on Advanced RXs
 - Advanced RXs same degree of protection as operating NPPs
 - Advanced RXs provide enhanced margins of safety
- Using Clinton PB SSE values and HCLPF seismic margin of 1.67 (SECY 93-087)
 - What are SCDF values?
 - How do Clinton PB SCDF values compare to current NPPs?

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Conclusion 2 (Cont.)

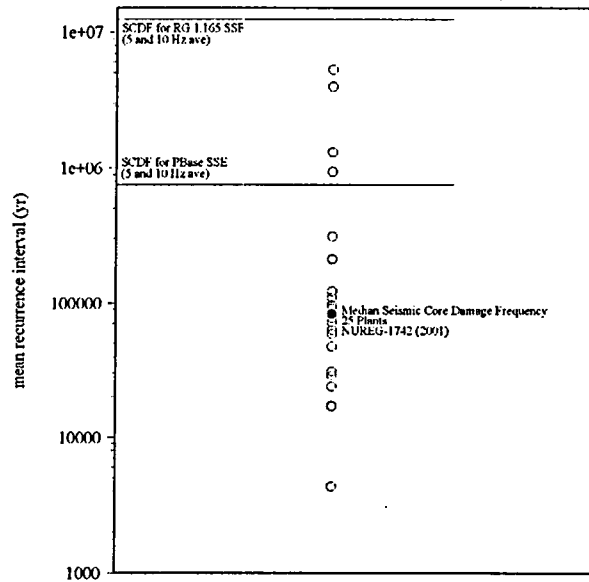
Exelon Performance Based SSE



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Conclusion 2 (Cont.)



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Conclusion 3

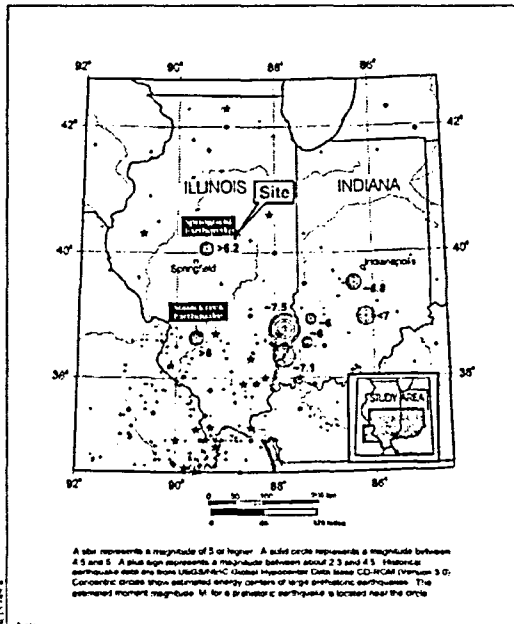
PB SSE adequately reflects
local ground motion hazard

- Staff reviewed SSE to ensure it reflects local seismic hazards
- Greatest seismic hazard for central Illinois from Springfield earthquake
 - Prehistoric earthquake (5900 to 7400 years ago)
 - Near Springfield (60 km SW of ESP site)
 - Magnitude estimates (6.2 to 6.8)
 - Recent Study (M6.3)

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Conclusion 3 (Cont.)



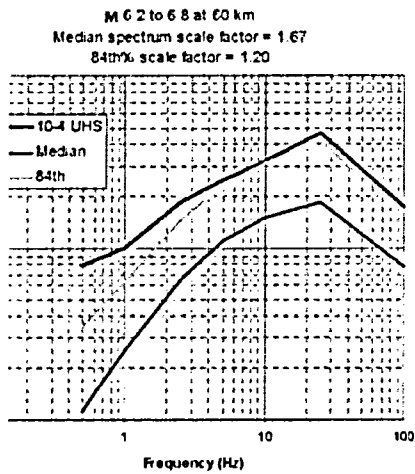
Conclusion 3 (Cont.)

- Exelon conducted Paleoliquefaction surveys on streams near ESP site
 - Found no evidence of repeated moderate to large earthquakes comparable to Springfield earthquake
- Exelon determined ground motion estimates from Springfield earthquake enveloped by UHRS₁₀₋₄ and PB SSE

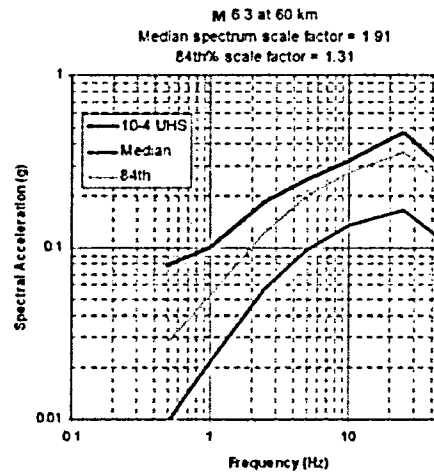
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Conclusion 3 (Cont.)



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Summary

- All seismic open items resolved
- SSE is appropriate for the ESP site
- Questions or comments?

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