1 MS. NAKAHARA: I don't believe so.

2 DR. CORNELL: I'm going to hedge on this

3 one. I know I have discussed with Holtec people

4 the results of this particular analysis and how

5 they did it, and I have -- but I am not sure, to

6 the best of my memory whether I've seen this

7 particular document or not.

8 JUDGE FARRAR: Ms. Nakahara, what again

9 is the document? Since it's now in the witness's

10 possession, if he would --

11 MS. NAKAHARA: If he would read the

12 title.

13 JUDGE FARRAR: What is it?

14 DR. CORNELL: PFS Site Specific HI-STORM

15 Drop/Tipover Analyses.

16 JUDGE FARRAR: By Holtec?

17 DR. CORNELL: For PFS by Holtec. Holtec

18 report No. HI-2012653.

19 JUDGE FARRAR: Didn't we see that at

20 some point?

21 MR. GAUKLER: It certainly was

22 discussed, and parts of it may have been shown in

23 terms of the testimony of Dr. Ostadan or

24 Dr. Bartlett.

25 MR. TRAVIESO-DIAZ: If I could clarify.

1 I believe an attachment to this document in which
2 the Young's Modulus, modulus of elasticity was
3 discussed, Attachment B was discussed in various
4 testimony.
5 JUDGE FARRAR: Okay.
6 MR. TRAVIESO-DIAZ: But not the entire
7 document, and certainly not the bulk of the report
8 itself.
9 JUDGE FARRAR: Ms. Nakahara, are you on
10 a new subject?
11 MS. NAKAHARA: Just a couple more
12 questions to follow up on this document.
13 JUDGE FARRAR: Okay, go ahead.
14 Q. (By Ms. Nakahara) Dr. Cornell, in your
15 discussion with Dr. Singh or Dr. Soler, did you
16 discuss the methodology used to calculate the
17 impact on the casks from tipover?
18 A. Yes, generally.
19 Q. Did you discuss the assumptions made in
20 the calculations?
21 A. Most of them, I'm sure. Many of them, I
22 should say.
23 Q. Do you recall what the assumptions were?
24 Sorry.
25 A. I'm sure there are many, many numerical

1 values that go into those, starting with the
2 dimensions of the cask and the nature of the
3 surface on which it lands and properties of
4 materials, et cetera. Are there any specific ones
5 you'd like to ask me about?
6 Q. Do you agree -- strike that.
7 Do you recall what the initial angular
8 velocity for the cask was?
9 A. For this hypothetical tipover accident,
10 I believe that was zero.
11 Q. And if, in fact, the casks would tip
12 over due to a seismic event, do you agree that the
13 initial angular velocity would be zero?
14 A. That's an interesting question
15 physically, actually. The initial velocity would
16 probably clearly have to be something greater than
17 zero or it would not be moving in that direction,
18 that is tipping over. But it might, in fact, start
19 at that velocity at a different angle than was
20 presumed in this analysis.
21 MS. NAKAHARA: Your Honor, I'm going to
22 go onto a different Holtec document, if you'd like
23 to ask questions.
24 JUDGE FARRAR: Yeah. A couple of
25 questions ago, the matter of SHAKE table testing

1 came up. If you were the decision maker here,
2 whether you were part of the NRC Staff at that
3 level or you were sitting here, what advantage
4 would be gained by doing SHAKE table tests? Would
5 that add substantially to the information base?
6 Would it give you reassurances as a decision maker?
7 And what exact type of tests would you do?
8 DR. CORNELL: Yes, I would say any -- in
9 any seismic assessment, if one is permitted to
10 actually do a physical test of the item you're
11 designing or analyzing, you would gain information
12 about it. And when you gain information, you gain
13 confidence. You lower uncertainty bands. That's
14 inevitably true, I believe. In practice, it's
15 seldom necessary to do so, seldom believed to be
16 necessary to do so when doing nonlinear dynamic
17 analyses of a facility. Exactly what tests I would
18 do in this context, I'm probably not the best one
19 to answer that question, but it would probably
20 involve -- we're talking about the tipover analysis
21 or the seismic dynamic analysis? The latter?
22 JUDGE FARRAR: Both, I think. Just keep
23 talking.
24 DR. CORNELL: Okay. If I felt it
25 necessary to gain better confidence with respect to

1 the tipover analysis, and I had unlimited
2 resources, I would take the HI-STORM cask and put
3 it in the proposed position and let it drop, and
4 see what it looked like when I got done. I would
5 have to let that drop onto a surface and material
6 which would have the degree of flexibility
7 anticipated by application and try to reproduce the
8 conditions I would expect to find in the field as
9 well as I could. Analogously I would --
10 JUDGE FARRAR: And what scale would you
11 do?
12 DR. CORNELL: With unlimited resources,
13 I would do a full scale. I think in particular
14 with respect to the tipover analysis, it would be
15 very difficult to do anything less, because the
16 interesting elements there are exactly how this is
17 constructed, how these cushioning devices between
18 the cask and the canister, which are there
19 precisely to absorb energy in such a tipover
20 analysis, one would really have to go to a full
21 scale development if possible.
22 JUDGE FARRAR: With fuel rods in them or
23 dummy fuel --
24 DR. CORNELL: I think I would stop short
25 of the radiation.

1 JUDGE FARRAR: But would you need --
2 would you need dummy rods, at least you'd want to
3 see what would happen to the --
4 DR. CORNELL: Actually, if this were to
5 be done in a systematic way, I would probably start
6 with something that represents them. That would be
7 a simpler model, and if I don't get much damage to
8 the canister, then I don't really care what's
9 happened to the rods inside.
10 JUDGE FARRAR: Okay. Then you had
11 another alternative which was the --
12 DR. CORNELL: You're going to give me
13 the option to test the dynamic analysis also.
14 JUDGE FARRAR: Right.
15 DR. CORNELL: That, of course, is a much
16 more elaborate exercise generally, because it
17 involves a SHAKE table test, a dynamic testing. If
18 that were to be done, it would be done with -- in
19 that case, probably a scaled representation. We're
20 interested here primarily in sort of a rigid body
21 behavior of these casks, not with their deformation
22 and so on. And that would -- but it would again --
23 depending on what portion of the entire analysis is
24 involved, whether -- if you're concerned about the
25 characterization of the soil, it would take a model

1 that included the soil. If you're concerned about
2 the characterization of the pad-to-soil interfaces,
3 you would want that, et cetera.
4 JUDGE FARRAR: So you could do the casks
5 -- there was testimony earlier in the case that I
6 understood to indicate it would be easier to do the
7 cask on the pad than to also try to recreate the
8 soil conditions.
9 DR. CORNELL: Oh, absolutely,
10 absolutely. It would be very difficult to recreate
11 the soil conditions. It goes to the question of
12 where you believe your uncertainty is. If you
13 could isolate that and if your concern was exactly
14 how the characterization had been -- what that
15 characterization had been of the relationship
16 between the cask and its surface, you could limit
17 the test to that.
18 JUDGE FARRAR: But before I asked you
19 this question, you had been talking as though there
20 were something you could also do with the soils.
21 DR. CORNELL: Oh, in principle, one
22 could build a model but the soils are tested also
23 on SHAKE tables, and one could build up an entire
24 model of that full system; soil, pad, cask. It
25 would presumably have to be scaled to a very small

1 level because of the masses involved. And it would
2 be very difficult to scale anything -- to probably
3 test anything at the more local soil behavior.
4 JUDGE FARRAR: And I take it that what
5 you said, if you did these tests, it would help
6 reduce the area that Dr. Lam and you talked about
7 reducing the area that you don't know? We all
8 don't know what we don't know, that would help
9 reduce that somewhat?
10 DR. CORNELL: There are two elements we
11 talked about. One is to characterize your
12 uncertainty. In other words, we can do, but let's
13 say a standard deviation of some kind, and it might
14 narrow that value of that standard deviation.
15 Dr. Lam introduced the additional issue of unknown
16 unknowns. If there was something that people had
17 forgotten about entirely, it might come out in such
18 a test. I think it's hard to recognize what that
19 might be in this case.
20 JUDGE LAM: Professor Cornell, on the
21 SHAKE table test, isn't it -- a freestanding cask
22 would cause some difficulty in the test, isn't that
23 true? When you put a cask on a pad and then shake
24 it, somehow you've got to be able to restrain the
25 pad if it were to move?

1 DR. CORNELL: Precisely. These tests
2 can be dangerous. And you would set up presumably
3 restraints that would somehow -- if you thought
4 under the shaking level you took it to, the casks
5 might actually tip over, you would have to set up
6 some kind of catching device, presumably, to keep
7 it from fully tipping over just to protect the
8 instrumentation.
9 JUDGE FARRAR: This pad in real life is
10 I think 60 by 37 or something; is that right,
11 roughly.
12 DR. CORNELL: Yes.
13 JUDGE FARRAR: If you were commissioned
14 to do the SHAKE table test, how big would you make
15 your scale model pad? As a practical matter, in
16 terms of the kinds of facilities you can work with
17 in a laboratory or in a research facility?
18 DR. CORNELL: Well, I should say, if I
19 were commissioned to do this, I would immediately
20 hire several really good consultants to back me up
21 on this process. And they would give me good
22 advice on it. I can tell you that there are very,
23 very few, if any, facilities in the world that
24 could take a combination of the size of the cask --
25 I mean of the pad in full scale, particularly if we

1 include all the mass of soil and all these other
2 things, and also try to shake them to the levels of
3 acceleration that one would be interested in to get
4 them into these potential tipping and tipover
5 conditions. All of those take more power in the
6 machinery and so on. So one would have to scale it
7 down simply to get it onto readily available
8 testing facilities. And then as with any scale
9 model, you introduce the question of what
10 uncertainties have I introduced by the scaling
11 process? You have to trade those off some way.
12 JUDGE FARRAR: Would you make it as
13 small as the table you're sitting at which might be
14 two by six or something?
15 DR. CORNELL: I think I would like it to
16 be considerably larger than that, yes.
17 JUDGE FARRAR: Okay. Ms. Nakahara, you
18 could continue for a little while or it may be a
19 good time -- it's almost 12:30 -- good time for a
20 lunch break.
21 MS. NAKAHARA: I could do either. It's
22 at the pleasure of the Board.
23 JUDGE FARRAR: Well, if you are
24 compelled to move ahead, this is kind of the time
25 we set. Let's go off the record for a second and

1 discuss lunch timing and arrangements. Off the
2 record.
3 (A discussion was held off the record.)
4 JUDGE FARRAR: Having discussed the
5 parties' needs, we'll stick with the hour for
6 lunch. It's now 12:30, we'll be back here at 1:30.
7 (Noon Recess.)
8 JUDGE FARRAR: Back on the record for
9 the afternoon session and State was going to
10 continue its cross-examination.
11 MS. NAKAHARA: Thank you, your Honor.
12
13 CONTINUED CROSS-EXAMINATION
14 BY MS. NAKAHARA:
15 Q. Dr. Cornell, if you recall before we
16 took a lunch break I was asking you questions about
17 Holtec's analysis. I have one more document to ask
18 you about. Are you familiar with the PFSF beyond
19 design basis scoping analysis Revision 1 prepared
20 by Holtec dated April 19, 2002? And Ms. Chancellor
21 will bring you the document.
22 A. Again, I have to say I don't believe I
23 have seep this entire report but I'm aware of many
24 of the conclusions and I have discussed the basic
25 methods that they have used.

1 Q. And you also discussed the input
2 parameters that Holtec used in their analysis?
3 A. Some of them, yes.
4 Q. Did you also you discuss the assumptions
5 they used in their analysis?
6 A. Some of them, yes.
7 Q. And I have one more document to ask you
8 about. In your testimony -- I guess I shouldn't
9 characterize it as one. I have a few more. But in
10 your testimony you've referenced the Sandia report
11 entitled Seismic Analysis Report on HI-STORM 100
12 Casks at Private Fuel Storage Facility, Revision 1,
13 prepared by Vincent Luk and others, dated March 31,
14 2002. Ms. Chancellor will bring you this document.
15 Have you reviewed this report?
16 MR. GAUKLER: Are sure you have the
17 correct date on that in terms of his testimony?
18 Are you referring to his testimony?
19 MS. NAKAHARA: Dr. Cornell refers to the
20 report in his testimony.
21 MR. GAUKLER: I don't believe it is
22 Revision 1.
23 MS. NAKAHARA: I'm sorry. Thank you.
24 MR. TURK: Maybe for clarification we
25 should indicate to the Doctor the fact that there

1 are two reports. Would that be appropriate?
2 A. I saw the earlier report, and I know
3 some of the conclusions from this report. But
4 again, I don't think I have seen this one
5 specifically.
6 Q. (By Ms. Nakahara) Okay. Did you review
7 the earlier report?
8 A. Yes.
9 Q. And you reviewed the assumptions made in
10 that report?
11 A. Yes.
12 Q. Did you have any concerns with the
13 assumptions made in the report?
14 A. Concerns? No, I don't believe so.
15 Q. Did you review the methodology used in
16 Dr. Luk's report?
17 A. Yes. The basic methodology, yes.
18 Q. Back to your response to question 38. I
19 have similar questions with respect to other
20 testimony proffered by PFS in this matter that I've
21 asked you with respect to Dr. Singh and Dr. Soler,
22 just to give you a preview. Your opinion that the
23 storage cask has a risk reduction level in the
24 range of five to twenty also relies on the
25 testimony filed by Mr. Bruce Ebbeson; correct?

1 MR. GAUKLER: Are you talking about the
2 cask or other aspects of the facility?
3 Q. Other aspects. Let me withdraw that
4 question.
5 Your opinion that the canister transfer
6 building has a risk reduction level in the range of
7 five to twenty relies on the testimony filed by Mr.
8 Bruce Ebbeson; correct?
9 A. I believe I have said that because the
10 canister transfer building is, I would put it in
11 the category of typical of nuclear power plant
12 SSCs, I could come to that conclusion without
13 additional testimony. But in addition to that
14 information, I have Mr. Ebbeson's testimony as to
15 beyond design basis assessments that they have
16 made, some of the kinds of margins that they have
17 identified. Although that reinforces my opinion.
18 Q. Have you specifically reviewed Mr.
19 Ebbeson's calculations for his beyond design basis
20 analysis?
21 A. Those that he presents in his testimony,
22 I have seen, yes.
23 Q. Yes.
24 A. But not detailed calculations.
25 Q. And also with respect to answer 38, is

1 it true your opinion, in part, that the storage pad
2 and the canister transfer building has a risk
3 reduction level in the range of five to twenty also
4 relies on the testimony filed by Mr. Paul Trudeau?
5 Is that correct?
6 A. That is with respect to the foundation
7 design and stability, foundation stability.
8 Particularly the stability of the canister transfer
9 building and the pads, yes.
10 Q. And are you familiar with the specific
11 seismic -- strike that.
12 Are you familiar with the sliding
13 bearing capacity and overturning for the canister
14 transfer building and the storage pads prepared by
15 Mr. Trudeau?
16 A. Again, I have not seen all of his
17 detailed calculations but I know the results of his
18 testimony and those were useful to me.
19 Q. Did you review the methodology that Mr.
20 Trudeau used?
21 A. I did not review the precise
22 methodology. I presume it is standard nuclear
23 power plant practice.
24 Q. And did you review the assumptions Mr.
25 Trudeau used in his calculations?

1 A. I looked at many of them, discussed it
2 with him, and I also read his testimony where he
3 showed me the results of making, let's say
4 conservative assumptions, reducing some
5 conservatisms, those kinds of studies, yes.
6 Q. In your response to question 41, isn't
7 it true you acknowledge that you are unsure whether
8 the risk reduction range of five to twenty applies
9 to foundations?
10 A. What I said here that I have adopted,
11 for what I call the typical components such as
12 buildings, the use of that inference from nuclear
13 power plant PRA, probabilistic risk assessment,
14 results. Being less familiar with those particular
15 PRA assumptions, those particular facilities, those
16 particular types of behavior, foundation behavior,
17 I am not depending solely on that procedure to make
18 my assessment as to what those risk reduction
19 factors are. Instead, I depend upon the
20 assessments made by Mr. Trudeau, or Mr. Ebbeson.
21 Q. In your response to question 49, you
22 refer to the use of seismic struts. Correct? It's
23 actually on page 27 in your response to question
24 40.
25 A. Yes, I do refer to the struts there,

1 yes.

2 Q. Are you aware that in Mr. Ebbeson's

3 testimony he states, under the code acceptance

4 criteria, the nominal capacity of the seismic strut

5 is 400 kips; and Mr. Ebbeson calculates the maximum

6 strut load due to the 2000 year return period

7 earthquake is 395 kips.

8 A. Yes, I saw that in his testimony.

9 Q. So you are aware of the slim design

10 margins with respect to the seismic struts?

11 A. That is a slim margin with respect to

12 the design basis margins and the design basis

13 procedures used, yes. But it does not imply, in my

14 mind, a slim margin with respect to the real

15 earthquake levels.

16 Q. In your response to question 49, you

17 discuss your opinion that because the seismic

18 struts are used for a fraction of the time, that it

19 reduces the annual likelihood of failure. Is that

20 correct?

21 A. Yes, I do.

22 Q. If the use of the seismic struts is

23 increased beyond that testified by Mr. Lewis, isn't

24 it true the failure rate, the annual likelihood of

25 failure would increase?

1 A. Yes, it is true that it would increase.
2 However, as I point out here, one can show, in my
3 mind, that this risk reduction factor is five to
4 twenty or more without taking advantage of that
5 additional twenty percent factor. That factor in
6 itself gives me the factor of five.
7 Q. Back to your response to question 38,
8 your opinion that the storage pads would have a
9 risk reduction level in the range of five to
10 twenty -- I'm sorry?
11 A. I'm looking on page 38 and of course it
12 is answer 38.
13 Q. Question 38. I'm sorry.
14 A. Give me one moment. Yes. That's a
15 short question. Getting lots of questions on
16 there.
17 Q. Yes. Your opinion that the storage pads
18 have an implicit risk reduction level in the range
19 of five to twenty relies in part on the testimony
20 of Dr. Wen Tseng? Is that correct?
21 A. Yes. He is certainly was part of my --
22 Q. Are you familiar with the design, the
23 design of the storage pad discussed in his
24 testimony? The analysis of the -- strike that.
25 Are you familiar with the analysis of

1 the design of the storage pad discussed in his
2 testimony?
3 A. I have read his testimony about that,
4 yes.
5 Q. Have you reviewed the ICEC report
6 prepared by Mr. Tseng's company entitled Storage
7 Pad Analysis and Design Calculation Number
8 G(PO)17-2, Revision 3, dated April 5, 2001?
9 A. No, I have not reviewed that report.
10 Q. Have you discussed the methodology used
11 by Dr. Tseng in his analysis with Dr. Tseng?
12 A. No, I do not believe I have discussed
13 that with him. I'm aware of what he has done.
14 Q. Have you discussed the input parameters
15 used by ICEC in their analysis with Dr. Tseng?
16 A. With Dr. Tseng, no.
17 Q. Or with anyone else at ICEC?
18 A. Yes. The important input parameters
19 include the ground motion. But that certainly has
20 been discussed with many people and I'm familiar
21 with the assumptions that have been made there, the
22 general assumptions that have been made.
23 Q. Are you aware that the force time
24 histories used by ICEC in their analysis were
25 derived from the nonlinear analysis performed by

1 Holtec?

2 A. Yes, I have read that in testimony.

3 Q. Are you aware of the issues raised by

4 the State of Utah with respect to other parts of

5 this contention, Parts C and D?

6 A. Yes, I'm generally aware of those.

7 Q. Are you aware that the State raises

8 issues that go to the merits of the design and

9 seismic analysis of the SSCs?

10 A. That go to the merits of the design?

11 Q. Let me try and clarify. Are you aware

12 that many of the issues raised by the State in this

13 contention question the adequacy of the seismic

14 analysis of the storage cask?

15 A. Yes, I am aware that the State is

16 contending those issues.

17 Q. And you are also aware that many of the

18 issues raised in this contention question the

19 adequacy of the seismic analysis for the canister

20 transfer building?

21 A. Yes, I have seen those discussions.

22 Q. And just to close the loop, you are

23 aware of many of the issues raised by the State in

24 its contention question the adequacy of the seismic

25 analysis of the storage pads? Is that correct?

1 A. I understand that they question whether
2 the design basis ground motion in the analyses have
3 demonstrated that they have met the, let's say,
4 standard review plan and other proposed criteria.
5 Q. Earlier this morning there was
6 discussion relating to your testimony with respect
7 to your answer 80 on page 47 and the average mean
8 annual -- I'm sorry. Go ahead and turn to it.
9 A. Yes, I see that answer now.
10 Q. The discussion this morning related to
11 the average mean annual probability of exceeding
12 the safe shutdown earthquake for nuclear power
13 plants in the Western U.S. of two times ten to the
14 minus four or 5000 years. Correct?
15 A. Yes. That's what my answer says and I
16 believe that is what is documented.
17 Q. Do you recall how many nuclear power
18 plants that number was based on, that mean was
19 based on?
20 A. I don't recall the exact number. It's
21 probably between six and ten.
22 Q. Do you recall how many nuclear power
23 plants the Central and Eastern U.S. mean of one
24 times ten to the minus four was based on?
25 A. Well, there are some 90 plants in the

1 central and eastern United States. But the
2 numbers, the ten to the minus fours were typically,
3 as I recall, based on the more modern plants. And
4 that number, again, I don't know the precise number
5 but it's on the order of 25 to 30, to my
6 recollection.
7 Q. Dr. Cornell, I'm going to have Ms.
8 Chancellor show you table C-2 from the summary of
9 composite mean exceedance probabilities for nuclear
10 power plants in the western United States, which is
11 out of the topical report, Preclosure Seismic
12 Design Methodology for Geologic Repository at Yucca
13 Mountain dated August, 1977, to refresh your memory
14 with respect to the Western U.S. nuclear power
15 plants.
16 JUDGE FARRAR: Did you say '77?
17 MS. NAKAHARA: I probably said '77. And
18 I probably meant 1977.
19 JUDGE FARRAR: '77 or '97?
20 MS. NAKAHARA: '97.
21 MR. TURK: Ms. Chancellor is showing me
22 the document. It is '97.
23 MS. CHANCELLOR: August of '97.
24 A. I see the table.
25 Q. (By Ms. Nakahara) How many nuclear

1 power plants are identified for the western United
2 States?
3 A. Five.
4 Q. And I apologize but how many did you
5 estimate were based on the eastern United States?
6 A. I said my recollection was about 25 to
7 30, if I recall what I said.
8 Q. As a statistician, can you compare for
9 us the uncertainty in these two means, being the
10 means for the Western United States and the mean
11 for the Eastern United States nuclear power plant
12 number?
13 MR. TURK: May I ask for a
14 clarification, your Honor?
15 JUDGE FARRAR: Yes.
16 MR. TURK: I don't know if we are
17 talking about sites with more than one reactor as
18 being represented by a single item or not.
19 JUDGE FARRAR: Five for the west is --
20 A. Sites. For example, Diablo Canyon is
21 mentioned once and it represents two units.
22 JUDGE FARRAR: Right. What else?
23 A. Palo Verde, San Onofre, Washington
24 nuclear plant two and three.
25 JUDGE FARRAR: I thought there were

1 others.

2 A. There are others, certainly. Trojan.

3 Q. But isn't it true that table is the

4 basis for the safe shutdown earthquake that you

5 refer to in answer 80 having a probability of

6 exceeding the safe shutdown earthquake of two times

7 ten to the minus four?

8 A. Yes, it is. And now we go back to your

9 question which was roughly speaking as a

10 statistician could I estimate the uncertainty

11 associated with those mean estimates?

12 Q. Yes.

13 A. Well, the mean estimates are what they

14 are. The means are what they are. They are just

15 the average of those five numbers in the case of

16 the West, and the average of the let us say 25

17 numbers in the East. Without more information, I

18 could not estimate the uncertainty in those two

19 cases. I would need to know additional information

20 such as all of the data or the standard deviation

21 of the data, additional information.

22 Q. Do you have an opinion on whether the

23 base for the mean, the population for the mean, the

24 uncertainty would increase when you have a smaller

25 population considered in your mean than if you have

1 a larger population?

2 A. Only if the standard deviations are the

3 same.

4 Q. Dr. Cornell, do you think there is a

5 sufficient basis for setting a different standard

6 for new nuclear power plants in the Western United

7 States, say a 5000 year return period design basis

8 earthquake as opposed to a 10,000 year return

9 period design basis earthquake for new nuclear

10 power plants in the Central and Eastern U.S.?

11 A. I'm sorry. Is that the question before

12 us? I don't think I'm prepared to make a statement

13 about that.

14 Q. That's fine.

15 JUDGE FARRAR: Before you take that

16 document away, I'm still confused. What kind of

17 table would only list -- why do they only list five

18 western facilities?

19 A. It may be that those are the only ones

20 for which they have done the probabilistic seismic

21 hazard analysis.

22 JUDGE FARRAR: Okay.

23 A. I don't know that's the case, but that

24 would be one reason why they would have only taken

25 a subset.

1 JUDGE FARRAR: And the last question Ms.
2 Nakahara asked, do I correctly understand the
3 problemistic rules applicable in the West for new
4 nuclear power plants if there were such a thing
5 these days, would call for 10,000 year return
6 period earthquake?
7 A. I think that question would be better
8 put to the Staff.
9 JUDGE FARRAR: Yeah, but you have been
10 working on this for a little while.
11 A. If we look at Reg Guide 1165, which is a
12 regulatory guide which says one could use that
13 procedure as we discussed earlier, and it would
14 pass muster with the Staff, the argument there is
15 based on a median estimate as opposed to a mean
16 estimate, and what is stated there is one would use
17 a median estimate of ten to the minus five in the
18 Eastern and Central United States and one could
19 also use that in the West, but they also give some
20 other opportunities for relief by alternative
21 procedures. That's, I think, perhaps what is
22 currently written.
23 JUDGE FARRAR: But I thought the
24 problemistic approach in the regulations for
25 nuclear power plants called for doing 10,000 year

1 return periods for critical structures generally.
2 A. The regulations, Part 100, say only that
3 one should use an analysis that includes the
4 uncertainties. And one way that could be done is
5 with probabilistic hazard analysis. No numbers
6 prescribed in that Part 100.23. One goes to the
7 Reg Guide to get the guidance that says that can be
8 satisfied with this median ten to the minus five
9 number. There is subsequent information in the
10 literature from the Staff that said that they
11 considered that equivalent to a mean of ten to the
12 minus four, at least in the Central and Eastern
13 United States. And this information suggests it
14 may be a bit higher than that in the Western. The
15 mean may be a bit higher than that in the Western
16 United States for reasons we discussed with Mr.
17 Turk.
18 JUDGE FARRAR: Go ahead, Ms. Nakahara.
19 Q. (By Ms. Nakahara) To follow up some of
20 the answers you had to Mr. Turk's questions this
21 morning, in answer 91 of your testimony you discuss
22 the IBC 2000, International Building Code 2000, and
23 the use of an importance factor. Correct?
24 A. Yes.
25 Q. To clarify Mr. Turk's questioning about

1 the importance factors for structures that contain
2 hazardous material, can you tell us whether the
3 term "hazardous" in building codes like the IBC
4 2000 applies to spent nuclear fuel facilities?
5 A. I cannot tell you personally whether
6 that is the case or not. It sounds like it applies
7 to me, but I have not or I was not involved in
8 making those definitions.
9 Q. Isn't it true that PFS has not developed
10 a fragility curve for the HI-STORM 100 at the PFS
11 site?
12 A. I have certainly not done one and I have
13 not seen one.
14 Q. In response to question 94, you state
15 that in virtually all areas of public safety,
16 hazards are measured in terms of frequency of
17 occurrence, (e.g. as measured in annual
18 probabilities, in probabilities for fifty-year
19 period, or in per human lifetime units) and the
20 same safety criteria are specified regardless of
21 the length of the activity in question, the
22 exposure time, the estimated facility life, or the
23 licensing duration. Is that correct?
24 A. I state that, yes.
25 Q. Can you explain why you believe the

1 safety criteria should be specified regardless of
2 the length of activity?
3 A. Can I explain why I believe that is done
4 that way?
5 Q. Yes. Can you expand upon why you
6 believe that is the correct manner to look at risk?
7 A. I believe that's the correct manner to
8 look at risk or at -- it's the first order thing
9 one should look at in looking at life safety risk
10 conditions because it puts different risks on a
11 comparable basis, such as annual frequency, I guess
12 is probably the most common one used. And because
13 it's probably the most commonly used standard, for
14 example as indicated in my testimony in Reg Guide
15 1174 of the NRC.
16 And furthermore, probably the reasons
17 why that's appropriate are some of those suggested
18 here; that is, that one of the justifications that
19 has been put forward using that is that it's a
20 question of replacement. For example, for design
21 of buildings, it is not appropriate that if I
22 design an apartment building for a ten-year
23 lifetime versus another apartment for a
24 hundred-year lifetime, that I should use different
25 safety standards for those two buildings, because

1 that building that is used for a ten-year lifetime
2 may be replaced by another building for a ten-year
3 lifetime and by another building for a ten-year
4 lifetime, and people must live in buildings
5 somewhere. So the argument is the annual frequency
6 is the best way to make those safety criteria
7 comparisons. I should not give any relief to the
8 building which has only a ten-year lifetime.
9 Q. You reference --
10 JUDGE FARRAR: Let me interrupt there.
11 That argument is good as far as it goes but suppose
12 you were designing, which you wouldn't be doing, an
13 apartment building for 10,000 year life at some
14 point. The life of the building in this example,
15 or any other example, gets so long that wouldn't
16 you take another look at what year flood or what
17 year earthquake you were designing against?
18 A. Probably not, because we are talking not
19 in terms of what is the safety of the facility. It
20 is obviously more likely to get knocked down
21 sometime during its lifetime. But if I talk in
22 terms of public safety to people who are living in
23 it, then people are going to be living somewhere,
24 whether it is in my ten year building or my 10,000
25 year building. And therefore, they should be

1 exposed to the same risk of losing their life,
2 whether they are in a long-term facility or
3 short-term facility.
4 JUDGE FARRAR: And if that is slightly
5 counter-intuitive to me, can you help me?
6 A. Then you are together with a lot of
7 people for which it is slightly counter-intuitive.
8 JUDGE FARRAR: Thank you.
9 Q. (By Ms. Nakahara) Dr. Cornell, in your
10 response, you refer to the NRC has used, "The
11 subsidiary performance objectives are the risk
12 metrics Core Damage Frequency, usually measured in
13 per annum terms." Is that correct?
14 A. Yes.
15 Q. And you believe that is, of course,
16 looking at an annual risk versus a lifetime risk.
17 A. Yes, I do.
18 Q. Dr. Cornell, you're familiar with the
19 Staff's document SECY-01-0178 entitled Modified
20 Rule- Making Plan, 10 CFR Part 72, Geological and
21 Seismological Characteristics for Siting and Design
22 of Dry Cask Independent Spent Fuel Storage
23 Installations? Is that correct?
24 A. Yes, I have read that document.
25 Q. Isn't it true in that document the Staff

1 relies not on an annual risk probability, but they
2 cite for one of the bases for this document the
3 total probability of exceedance for a design
4 earthquake at the ISFSI facility with an
5 operational period of zero to twenty years --
6 strike that. Let me start over.
7 Isn't it true that the Staff in this
8 document rely, in part, for using a mean annual
9 probability of 2000 years, includes the total
10 probability of exceedance for a design basis
11 earthquake at an ISFSI with an operational period
12 of 20 years?
13 A. It's my recollection that they do use
14 that argument. I think in comparing the design
15 line from twenty years with the ISFSI versus that
16 of the hundred years of the surface facility at
17 Yucca Mountain. They do use that argument.
18 Q. And for this specific facility that we
19 are talking about that will be located in the
20 statute of Utah with spent fuel, wouldn't it be
21 appropriate for the citizens of the State of Utah
22 to view the acceptable risk and exposure time while
23 the spent fuel is in Utah versus an annual risk?
24 A. No. That doesn't seem necessary to me.
25 I think people of the State of Utah want a

1 particular or reasonably consistent set of safety
2 criteria to be applied. And those should be
3 applied, in my opinion, on an annual basis.
4 Q. And your Honor, if we could take two
5 minutes, I may have way over-estimated how many
6 more questions I have.
7 JUDGE FARRAR: While you are doing that,
8 let me pursue this question getting back to my
9 counter-intuitive problem. Is the answer to my
10 concern that if I lived in that building for 10,000
11 years, the risk, the cumulative risk to me would be
12 greater than the risk to me if I lived in that
13 building for ten years.
14 A. Absolutely.
15 JUDGE FARRAR: Okay. And then that ties
16 in with the State's question, the cumulative risk
17 to someone living near the proposed PFS facility
18 for 40 years is greater than the cumulative risk to
19 someone who thought they would be living there only
20 20 years.
21 A. That is also correct. It is consistent
22 with that argument, yes. At least their fatality
23 risk due to accidents from that facility, however
24 large that might be.
25 JUDGE FARRAR: But that wouldn't change,

1 that fact wouldn't change how you would recommend
2 the facility be designed.
3 A. No, it would not.
4 JUDGE FARRAR: Okay.
5 Q. (By Ms. Nakahara) Thank you,
6 Dr. Cornell. I have no further questions at this
7 time.
8 JUDGE LAM: Professor Cornell, we had
9 heard from Dr. Khan and Dr. Ostadan, the State of
10 Utah's expert witnesses, stating that the use of
11 finite element nonlinear analyses can be a risky
12 proposition. Specifically they had stated that
13 these type of nonlinear analyses can be very
14 sensitive to the selection of the input parameters.
15 My question is since you just mentioned that you
16 had reviewed Dr. Luk and Dr. Soler's work, what is
17 your opinion of the use of these finite element
18 nonlinear analyses in predicting the dynamic
19 performance of this particular facility?
20 Specifically, do you consider them a risky approach
21 or do you consider them acceptable industrial
22 practice?
23 A. The nonlinear dynamic analyses, as
24 suggested, can be sensitive to some input
25 parameters. They are very insensitive to other

1 input parameters. I would always, and I think most
2 of my earthquake engineering colleagues would
3 agree, we would always prefer to see a nonlinear
4 dynamic analysis made of a building or other
5 facility and when we are trying to understand how
6 it will behave under earthquake levels, that would
7 put it into or take it out of the linear regime and
8 put it into this nonlinear regime. One gains
9 information and insight from those analyses that
10 are often missing in linear analysis. So they are
11 always a useful piece of information as to clearly
12 judged in their use, how much information to take
13 from them away towards making subsequent design
14 judgments. But I would always encourage them to be
15 made. In other words, I would recommend that they
16 be used in, let's say, future nuclear facility
17 analysis, although it is not necessary to do that
18 to establish adequate safety margins.
19 JUDGE LAM: So the use of finite element
20 nonlinear analyses are not necessarily an
21 unreliable approach?
22 A. Absolutely not. No. Typically they are
23 reliable.
24 JUDGE LAM: Do they depend to a great
25 extent on the expertise of the user?

1 A. They depend to a greater extent on the
2 expertise of the user than does a linear analysis,
3 particularly than does a linear static analysis.
4 And that is one reason why a structural engineering
5 community goes to this two-handed approach; that
6 is, even though we are interested in what is going
7 to cause my building and my facility to fail, and
8 that's an earthquake with a very large return
9 period and a small probability, we nonetheless sort
10 of transform the problem back into lower ground
11 motions, DBE level ground motions, and then
12 evaluate the structure on a linear basis. Often on
13 a linear static basis. That's standard practice
14 for evaluation of facility in an earthquake because
15 it's easier to do. It can be done by a larger
16 group of people with less expertise. And that's
17 one good reason why it is useful to go through this
18 somewhat convoluted exercise of doing our design
19 and confirmation, both regulatory conditions, in
20 this linear regime rather than in the rarer
21 earthquake nonlinear regime. It may seem strange,
22 but that's the way it is done in order to
23 facilitate the process.
24 JUDGE LAM: So sometimes simplicity has
25 its merits.

1 A. Simplicity has enormous merits. It
2 would be very difficult and not, in fact, feasible
3 to live in earthquake country if we had to use
4 $100,000 analyses for building a $25,000 house or
5 something. We don't have many $25,000 homes in
6 California. But it would certainly increase the
7 houses, the cost of houses, even in California
8 should we have to encourage that kind of analysis.
9 And it is true for buildings and nuclear power
10 plants, as well.
11 JUDGE LAM: Thank you, Professor
12 Cornell.
13 JUDGE FARRAR: Dr. Cornell, could you
14 take a look at Answer 26 at the bottom of Page 14.
15 And I'm talking about the mean return period. And
16 then compare it with Answer 80 on Page 47.
17 A. All right. I have the two places
18 identified.
19 JUDGE FARRAR: Where you talk about the
20 mean annual probability of exceedance. And I will
21 let you frame my question. The answer I want, I
22 want to make sure I understand the difference in
23 the concepts between the mean return period to
24 failure or the mean return failure of the
25 earthquake and the mean annual probability of

1 exceeding the earthquake. I think I have it, but
2 I'm not sure I can frame the question. But you
3 know what I'm talking about.
4 A. I believe so. The practice is that with
5 the left hand -- I'm going to be a two-handed
6 scientist. On the left hand we establish the mean
7 annual return period of the design basis
8 earthquake.
9 JUDGE FARRAR: And that's --
10 A. That's 2000 years or five times ten to
11 the minus four.
12 JUDGE FARRAR: Right.
13 A. On the other hand we put margins into
14 our criteria that make the facility able to
15 withstand earthquakes of much smaller probabilities
16 or longer return periods such that the return
17 period to an event which we call failure is larger
18 than that of the design basis ground motion.
19 JUDGE FARRAR: Is the first number, the
20 mean return period of the earthquake, the same as
21 the mean annual or the inverse of the mean annual
22 probability of exceeding the earthquake?
23 A. Those two are inverse related, yes.
24 JUDGE FARRAR: Okay.
25 A. Inversely related. It's an adverb.

1 JUDGE FARRAR: Thank you for asking my
2 question and providing the answer. That's the kind
3 of witness I like.
4 A. Provided I get the right question.
5 JUDGE FARRAR: I think that concludes
6 the Board's questions. Mr. Gaukler, your turn for
7 redirect.
8 MR. GAUKLER: I should go before Mr.
9 Turk? That's fine with me.
10 JUDGE FARRAR: No. He has done his
11 cross. This is your first turn to be heard, since
12 he and the State and the Board have asked all their
13 questions.
14
15 REDIRECT EXAMINATION
16 BY MR. GAUKLER:
17 Q. Dr. Cornell, earlier in the questioning
18 by Judge Lam this morning he was asking you a
19 question why you believed the 2000 year mean return
20 period earthquake is sufficient to protect public
21 health and safety for the PFSF as opposed to, say,
22 a 3000 year mean return period earthquake or 4000
23 year mean return period earthquake. Could you
24 please address that question specifically?
25 A. Yes. I'm afraid I probably did not

1 answer that part of his question. We got off onto
2 some other tangent. The question before me is, is
3 the 2000 year return period earthquake sufficient
4 to provide ultimately adequate public safety? And
5 my conclusion is yes, I believe it is adequate to
6 provide sufficient public safety. And I make that
7 judgment based on knowledge of what the levels of
8 these conservatisms are and a judgment, therefore,
9 as to what levels of the probability of these
10 serious accidents might be or upper bounds on the
11 probabilities of those accidents. And conclude
12 that those probabilities are on the order of
13 10,000, one on 10,000, or 10,000 year mean return
14 period. Orders of that probability or less. That
15 or safer.
16 Therefore, if you ask me the same
17 question for a 3000 year or 4000 year earthquake I
18 would say yes, of course, those are adequate, too,
19 because they imply even smaller probabilities of
20 failure. If the question is what about 1000 years,
21 I would have to re-address the question. But off
22 the top of my head, I think that might be all
23 right, too.
24 Q. And you were talking about why you
25 believe an order of probability of failure of one

1 times ten to the minus four or less for a serious
2 accident is sufficient to protect public health and
3 safety for a facility like the Private Fuel Storage
4 facility.
5 A. Right. The bases are two-fold. The
6 first goes to the discussion related to the issue
7 of a graded approach to safety which suggests that
8 if the public safety implications, the hazards
9 associated with the failure of the facility, are
10 less severe, one should be permitted a higher
11 failure probability. And correspondingly, if they
12 are more severe, one should address a lower failure
13 probability. We have sort of two basic reference
14 points there. I believe I established that the
15 mean annual probability of something like a core
16 damage accident in a nuclear power plant is of the
17 order -- based on judgments coming out of the PRA
18 and others, it's been demonstrated to be ten to the
19 minus five probability of a serious or something
20 could become a serious accident at a nuclear power
21 plant.
22 So by the argument of a graded approach,
23 an ISFSI, which I think all would agree has less
24 hazardous damage or implications than that of a
25 power plant, should be permitted a larger failure

1 probability than ten to the minus five. The other
2 end of the spectrum, we have something like typical
3 buildings where these probabilities of failure can
4 be estimated to be in the sort of ten to the minus
5 three range, around a 1000 years or a bit better
6 than that. And that gives me two bounds. And we
7 typically make these kinds of failure probability
8 decisions basically in a logarithmic scale. So ten
9 to the minus five on one end, ten to the minus
10 three on one end. This proposed number for my
11 basis somewhere in the range of ten to the minus
12 four seems to be about the right relationship in
13 terms of the relative hazard of these three types
14 of facilities.
15 The second basis for this argument is
16 the DOE standards. DOE is an organization like the
17 Nuclear Regulatory Commission, responsible for
18 public safety. And in addition they have the much
19 broader range of facilities. Doe has facilities
20 that range from simple warehouses and office
21 buildings through facilities of a hazard level much
22 like that of an ISFSI, to nuclear power plants.
23 They have that whole range of facilities.
24 And in considering the question of what
25 these failure or tolerable allowable probabilities

1 for seismic criteria should be for those
2 facilities, they came to the conclusion that for
3 nuclear power plants they ought to be ten to the
4 minus five, and for facilities they denote PC3 such
5 as an ISFSI, that should be ten to the minus four.
6 So those are two places that help benchmark and
7 establish why this ten to the minus four target
8 that I referred to is appropriate for public
9 safety.
10 JUDGE FARRAR: How does that tie in with
11 the old one in a million we used to talk about
12 thirty years ago?
13 A. The one in a million which, in fact,
14 shows up in the document that I was given by Ms.
15 Nakahara earlier, is typically a number that is
16 used for example screening out incidents, screening
17 out initiators. If they are less than ten to the
18 minus 6 you can get rid of them. You don't need to
19 go further down the chain to figure out what the
20 release implications would be. You can get rid of
21 the problem at that early stage.
22 Q. (By Mr. Gaukler) You were questioned by
23 Ms. Nakahara or the Board, I forget which, about
24 whether PFS had done a probability risk assessment,
25 a PRA, to make it simpler. Do you believe that it

1 is necessary for PFS to do a PRA to reach a
2 determination such as you made in connection with
3 your testimony?
4 A. No, I do not believe it is necessary to
5 do a full-blown quantitative probabilistic seismic
6 risk assessment for the entire facility because the
7 objective here in my mind is to demonstrate that
8 this failure probability is of the order of ten to
9 the minus four or less. So I simply need to
10 demonstrate and convince myself, as I have, that
11 starting with the 2000 year return period and with
12 the conservatisms which give me this additional
13 factor of five to twenty or more, that the net
14 result without going into further quantitative
15 detail is sufficient to demonstrate ten to the
16 minus four.
17 I judged that five to ten factor in part
18 for some components based on their analogy with
19 nuclear power plant components; on others it was
20 clear from studies such as the beyond design basis
21 estimates and certain margins estimates made by Mr.
22 Trudeau for some of the foundations, made by
23 Holtec, and by the Staff consultant, Dr. Luk, for
24 well beyond design basis; namely 10,000 year
25 earthquakes where they showed there would not even

1 be cask tip-over, that we could judge that without
2 going into more refined detail as to exactly how
3 large that margin really is and how much
4 uncertainty there is about it. It is sufficient to
5 judge from those conditions alone that you have
6 established your probability of failure below that
7 number. It is simply a checking observation, not
8 an analysis exercise.
9 Q. And would you say for the same reason,
10 therefore, that it is not necessary to generate
11 fragility curves here?
12 A. Yes. A fragility curve would be exactly
13 one of the pieces of the larger puzzle which is the
14 PRA. And it consists of estimating that precisely
15 as well as you can what that margin is, trying to
16 evaluate it, and judging what the variability about
17 it is. Again, for those purposes it is only
18 necessary to show that the margin is sufficiently
19 large that one could meet this ten to the minus
20 four condition or criteria that was set up. And
21 knowing typical range of what these uncertainty
22 grants are or measures of uncertainty that go into
23 the fragility curve that I know how much allowance
24 I need to make in my mind for that aspect of the
25 problem to reach this same conclusion.

1 Q. In the same respect, you said you had
2 not quantified the uncertainties in the Holtec
3 analysis or the dynamic analysis. Uncertainties
4 and potential for failure of the Holtec HI-STORM
5 cask. Why didn't you do a quantification? The
6 same reason again?
7 A. Basically, yes. And specifically this
8 is a case where I could not fall back directly on
9 any particular uncertainty quantification on
10 nuclear power plants, but many of the elements are
11 precisely the same; how much the uncertainty might
12 be in the soil structure interaction analysis.
13 Those would be comparable.
14 And one of the major sources of
15 uncertainty in the typical PRA done for a nuclear
16 power plant is the fact that this, as we were
17 discussing earlier, this projection as to how the
18 facility will behave in the nonlinear regime near
19 failure is projected in those studies on the basis
20 of linear analysis. They do not do nonlinear time
21 history analyses when doing PRAs for nuclear power
22 plants. It's a judgment or projection made by the
23 specialist from the results of linear analysis.
24 So any time one has the additional
25 information of an explicit nonlinear analysis such

1 as the finite elements analysis we talked about
2 before, one is reducing the uncertainty from the
3 level one would have where the basis is just a
4 conventional PRA analysis. So those, again, are
5 reducing the uncertainties.
6 Q. So if I understand your answer, you are
7 saying the nonlinear analysis done by Holtec and by
8 Dr. Luk of the HI-STORM cask stability actually
9 served to reduce uncertainty in this estimation of
10 performance that normally exists in a nuclear power
11 plant seismic PRA?
12 A. Yes, it does.
13 Q. In the same vein, you were talking about
14 shake table testing and potential model testing.
15 Do you believe that shake table testing or model
16 testing is necessary to reach a proper
17 determination in this case as to the appropriate
18 design period earthquake?
19 A. No, I do not. As I indicated earlier,
20 we do many assessments of structural behavior and
21 behavior of facilities. And they include, one way
22 or another, this assessment of what the behavior
23 will be in the extreme range under larger
24 earthquakes. And we very seldom do shake table
25 testing. One depends on that shake table testing

1 to validate the various models that are used in the
2 process.
3 And in this case it becomes clear to me,
4 not only because we have the additional information
5 of the nonlinear analysis done at an earthquake
6 level with the probability very close to that
7 probability level we are seeking, namely ten to the
8 minus four, that that analysis itself shows or
9 predicts no failure, no tipover even, much less
10 failure that would lead to hazardous release.
11 There is, in my mind, clearly adequate additional
12 margin beyond that to convince me that we can reach
13 these kinds of numbers without the additional
14 information that would come from such shake table
15 testing. And as we discussed this morning,
16 introducing shake table testing for elements of
17 this size would require reducing them in scale
18 which you would, in turn, introduce its own set of
19 uncertainties.
20 JUDGE FARRAR: But all those models are
21 only models. You are not -- are you comfortable
22 enough with them that it doesn't help to have a
23 dose of reality? But maybe you are saying shake
24 table isn't reality, either.
25 A. A shake table is another model. And a

1 shake table test like the nonlinear analysis would
2 bring some more information to the table, to be
3 sure. But I think in this case there is sufficient
4 margin enough to demonstrate that this ten to the
5 minus four accident failure probability is easily
6 reached without the need of the shake table, to go
7 back to the question.
8 JUDGE FARRAR: You have been doing this
9 for 30 years.
10 A. More. For 34.
11 JUDGE FARRAR: I don't want to be like
12 Mr. Turk and not add correctly. Is it not possible
13 to become too enamored of the models and lose sight
14 of making sure they are anchored in reality?
15 A. That's a danger. I'm not, myself, a
16 detailed modeler. I sort of -- my role in all of
17 these exercises is typically to bring together the
18 information from the ground motion and the hazard
19 and what is known and estimated by the specialists
20 in those areas and to try to make the total
21 judgment. Which is not to say that more testing is
22 not useful. In fact, more testing is going on as
23 we speak to test old reinforced concrete buildings.
24 Just because we have a lot of them and we are not
25 going to get rid of them and we would like to know

1 better how safe they are. And that's an area where
2 some of the models are not as strong as we would
3 like them to be.
4 Q. (By Mr. Gaukler) Now, does the shake
5 table test or other type of tests introduce
6 uncertainties of its own?
7 A. Yes. I just mentioned that.
8 Particularly the scaling down of everything.
9 Q. And so what you might gain on the one
10 end, you might lose on the other end? Is that
11 fair?
12 A. One would gain some and one would lose
13 some. How the net would come out . . .
14 Q. Also, I'd like go back to the question
15 that was talked about just in terms of suggestion
16 that the struts in the canister transfer building
17 have a slim margin against earthquake failure. You
18 indicated, I think Ms. Nakahara pointed out that
19 the design basis of the struts was I think 395 kips
20 which is within about five kips of the code
21 allowable of 400 kips.
22 A. Yes.
23 Q. How much margin do the struts have,
24 given that design basis and that allowable, before
25 they actually fail in earthquake situation?

1 A. The struts, I believe, are from my
2 understanding of them, and I have looked into the
3 nature of those elements, are again representative
4 of typical nuclear power plant type components.
5 They are made of ductile materials. And materials
6 with ultimate strengths higher than the yield
7 strengths, et cetera. Much higher than the code
8 allowables. In like components, the capacity to
9 resist earthquakes as measured in the strength of
10 the earthquake is at least factors of two or three
11 larger. And this is quantified in terms of
12 probabilities by, say, with these kinds of
13 elements, which factor might be five to ten or
14 twenty or more. And particularly the ductility of
15 these elements, that is their ability to deform
16 well into the nonlinear regime and well past the
17 elastic regime, is the primary source of excess
18 capacity or margin in this dynamic loading
19 condition.
20 As Mr. Ebbeson pointed out, he has
21 another margin of 40 or 50 percent with respect to
22 the code allowable to the ultimate strength. On
23 the strength axis there is maybe only a 40 or 50
24 percent margin. But because, as he indicated, the
25 nature of the ground motion is to go back and

1 forth, the nature of the building is to go back and
2 forth. And so the struck element in this extreme
3 earthquake would be making excursions in and out of
4 the linear and nonlinear element and in and out of
5 the linear and nonlinear regime. And what's most
6 important is it is capable of taking very large
7 deformations, six and eight times the elastic
8 deformation. And that's the key measure of how
9 much capacity it has in terms of earthquake
10 response. Dynamic response.
11 Q. So the earthquake, the capacity of the
12 struts to resist an earthquake is greater in
13 magnitude than the difference in percentage between
14 its ultimate strength or ultimate static strength
15 versus its design strength?
16 A. Very much so, yes. In fact, one could
17 argue that for ductile components of this type, of
18 their total capacity to resist earthquakes as
19 measured by the strength of the ground motion,
20 perhaps only 20 percent of that is in the linear
21 range. Maybe 80 percent of it is in the nonlinear
22 range which is beyond where we are checking it by
23 the code criteria.
24 Q. I don't believe I have any further
25 questions.

1 JUDGE FARRAR: Dr. Cornell, when you and
2 I said inverse before, was that the same as
3 reciprocal or should we have said reciprocal?
4 A. We could have said the same thing and it
5 would is meant the same thing.
6 JUDGE FARRAR: Okay. Mr. Turk?
7 MR. TURK: Thank you, your Honor. I do
8 have follow-on questions. Not very much. Maybe
9 ten or so minutes, if that much.
10
11 RECROSS EXAMINATION
12 BY MR. TURK:
13 Q. Dr. Cornell, there was some discussion
14 about your role as a consultant in the rule-making
15 process, and some mention was made of the ICF
16 company. Were you a consultant to the NRC staff or
17 a consultant to ICF or a consultant to some other
18 organization?
19 A. I was a consultant to ICF.
20 Q. And ICF, in turn, was a contractor with
21 the NRC?
22 A. Was a contractor with the NRC.
23 Q. You also indicated at some point that
24 you did not recommend the 2000 year ground motion
25 to PFS and Judge Farrar asked you a question about

1 that. He asked you to explain that and you
2 indicated you were not involved with PFS at the
3 time they made that decision. Do you have a view
4 as to whether the 2000 year return period ground
5 motion is the appropriate standard to be used here?
6 A. I believe it's the appropriate standard
7 to be used here, yes. And I discussed in my
8 testimony, I believe, that with the standards we
9 are using for evaluation in that design basis, it
10 gives low failure probabilities and provides
11 adequate public safety.
12 Q. There's also some discussion of the
13 average mean annual probability of exceedance for
14 the Western United States nuclear power plants.
15 And I believe counsel for the State showed you a
16 table in which five different sites were listed.
17 Do you recall the mean annual probability of
18 exceedance at each of those sites?
19 A. No.
20 MR. TURK: Could we ask, your Honor,
21 that the document be shown to the witness again so
22 we can put that into the record?
23 JUDGE FARRAR: Certainly.
24 MR. TURK: My reason is the average of
25 the means is not necessarily the mean used at each

1 of those sites, or the mean found to exist at each
2 of those sites.
3 MS. NAKAHARA: We will give it to you as
4 soon as we find it.
5 MR. TURK: May we go off the record for
6 a moment?
7 JUDGE FARRAR: Yes.
8 (Discussion off the record.)
9 JUDGE FARRAR: Back on the record. I
10 think we found a copy of the document for the
11 witness.
12 MR. TURK: For the record, let me
13 identify it again. This is a document entitled
14 Topical Report, YMP/TR-003-NP. Entitled
15 Pre-closure Seismic Design Methodology for Geologic
16 Repository at Yucca Mountain, Revision 2." And
17 it's dated August, 1997. Is that correct, Doctor?
18 A. Yes, it is.
19 Q. And if you would, turn to Table C-2 on
20 Page C-18. And could you read into the record for
21 each of the plants listed on that table what is the
22 composite mean exceedance probability listed?
23 A. For each plant, as well as the mean?
24 This is the number for each plant, and this is the
25 mean value.

1 JUDGE FARRAR: And these are the five
2 Western ones?
3 A. Yes.
4 Q. Maybe you could just read across for
5 each of the horizontal lines; state the plant name,
6 what it states, and the composite mean exceedance
7 probability what it states.
8 A. There are two means involved here, which
9 makes it difficult. For each plant, for example
10 the first plant is Diablo Canyon, it provides a
11 number as to the mean estimate of the exceedance
12 probability. You recall our discussion between the
13 mean and the median. This is the mean, and it
14 gives that number as 1.7 e minus 04, or 1.7 times
15 ten to the minus four. The next plant, Palo Verde,
16 it gives 3.8 e minus ten to the minus five. For
17 San Onofre it gives three ten to the minus four.
18 For Washington Nuclear Plant 2 it gives 2.8 ten to
19 the minus four. And for Washington nuclear plant
20 -- it must be a typo, happens to them, too. Plant
21 3, greater than 2.2 ten to the minus four.
22 Q. Now, if you will also note on the side
23 of that table somebody has pencilled in the
24 equivalent return period.
25 A. Yes.

1 Q. Have you ever attempted to do a similar
2 correlation to put down a return period as it
3 relates to the mean annual exceedance probability?
4 A. Well, as we established, one is the
5 inverse or the reciprocal of the other, and I have
6 not done that myself, but someone has done that.
7 If I take their numbers --
8 Q. May I hand you a calculator?
9 A. Yes, you may.
10 Q. This little $5 calculator has traveled
11 so far with me.
12 A. I would prefer an H P.
13 JUDGE LAM: He is used to something more
14 luxurious than yours.
15 A. And HPs come from all the technical
16 people.
17 Q. Can you calculate for each of the
18 periods you stated, and indicate which they are as
19 you give the calculation. What is the return
20 period for each those.
21 A. Yes, I can do that if I can find the
22 right function here on this one. There it is.
23 Easier than I thought. Okay. For the first it is
24 5882 years.
25 Q. That is Diablo Canyon?

1 A. That is Diablo Canyon. For the second
2 it's 26,316 years, to be exact.
3 JUDGE FARRAR: Which one?
4 Q. That is Palo Verde?
5 A. Yes. For San Onofre it is 3333 years.
6 For Washington Nuclear Plant 2 it is 3571 years.
7 And for Washington nuclear plant 3 it's something
8 less than 4545 years.
9 Q. Thank you very much.
10 May we have a moment, your Honor?
11 (Discussion off the record.)
12 MR. TURK: May we go back on the record?
13 JUDGE FARRAR: Yes.
14 Q. (By Mr. Turk) On the same table at the
15 bottom of the table are two other entries. One of
16 them is the horizontal line, and it reads "sample
17 mean". And below that there's a horizontal line
18 which states "sample median". I'm going to hand
19 the document back to you again and I'd ask you to
20 state what are the mean exceedance probabilities
21 stated for those, and I would ask you to do the
22 calculation again on what is the return period.
23 A. The sample mean of the mean exceedance
24 probabilities is something greater than 2.0 times
25 ten to the minus four. And that one I can do in my

1 head. It's something less than 5000 years. The
2 sample median is something greater than 2.2 times
3 ten to the minus 4. And we had that number
4 earlier. So the implication is the return period
5 is something less than the median of these mean
6 probabilities; is something less than 4545.
7 Q. Now, could you explain those terms,
8 sample mean and sample median, as they are used
9 there, if you are aware?
10 A. Well, I'm sure I know what the sample
11 mean is. It means those five numbers first read
12 off for each of the five plants are summed and
13 divided by five.
14 The sample median is probably obtained
15 by ordering the five numbers and taking the central
16 or the third from the top or third from the bottom.
17 Q. And in this case the 2.2 times ten to
18 the minus four looks like the same number used for
19 Washington nuclear power plant system number 3?
20 A. It does. And two numbers are lower than
21 that and two of the numbers are higher than that,
22 confirming that that would be the sample median.
23 Q. Thank you very much.
24 Your Honor, we have no further
25 questions.

1 JUDGE FARRAR: Ms. Nakahara, we will
2 give you, of course, another go-around.
3 Q. Given that Dr. Cornell has shown us his
4 math skills, I'm going to set a dangerous precedent
5 and I have no further questions.
6 MR. TURK: I did forget one, if I may be
7 permitted.
8 MS. NAKAHARA: I may have to retract my
9 "no questions" statement.
10 JUDGE FARRAR: That barely made it, Mr.
11 Turk. But go ahead.
12
13 CONTINUED REDIRECT EXAMINATION
14 BY MR. TURK:
15 Q. Dr. Cornell, I recently saw an article
16 of a race horse named Seattle Slew, and they not
17 only named the races the horse had run which was,
18 of course, the triple crown, they also named the
19 fact or identified the fact that that horse had
20 sired 117 winners. I didn't notice anything in
21 your resume about particular off-spring of yours.
22 Is it correct that your son just won the Nobel
23 Peace Prize in physics?
24 A. Almost correct. He one the Nobel Prize
25 in physics. Not the peace prize. But that's

1 pretty close, yes. And I have many fewer than 117
2 offspring.
3 MS. CHANCELLOR: He is obviously not
4 from Utah, your Honor.
5 JUDGE FARRAR: We all get to the stage
6 where we are known as our children's parents, and
7 it's not a bad place to be. We send our
8 congratulations to him. It's not often most of us
9 get to even a second degree of separation from
10 someone so accomplished.
11 And speaking of that, we certainly
12 appreciate you sharing your insights and opinions
13 with the Board. And since there are no more
14 questions, you may be excused with thanks of the
15 Board.
16 A. Thank you.
17 JUDGE FARRAR: Now, ready to shift gears
18 to the Staff panel?
19 MR. TURK: We will be ready shortly. We
20 have to make some corrections to documents, and if
21 you'd give us perhaps twenty minutes we will be
22 ready at that time.
23 JUDGE FARRAR: It's time for our break.
24 It is five minutes of 3:00. Let's be back at 3:15.
25 (A break was taken.)

1 JUDGE FARRAR: You think we are nearly
2 ready to restart. Gentlemen, you have previously
3 been sworn but it was a long time ago so let's do
4 it again, and Dr. Chen. All of you stand and raise
5 your right hand.
6
7 John A. Stamatakos, Rui Chen,
8 and Martin W. McCann, Jr.,
9 having been called as witnesses and duly sworn,
10 testify as follows:
11
12 MR. TURK: Thank you, your Honor. The
13 Staff is presenting to you a panel of three
14 witnesses consisting of, in the center, Dr. John
15 Stamatakos, whom you have met before. He is the
16 principal scientist at the CNWRA in San Antonio,
17 Texas. He is a structural geologist and
18 geophysicist.
19 To his right is Dr. Martin McCann who is
20 president of Jack R. Benjamin & Associates in
21 Mountain View, California. He is a consultant to
22 the CNWRA and through the CNWRA is consultant to
23 the NRC staff. Dr. McCann is a consulting
24 professor of civil and environmental engineering at
25 Stanford University and has experience in

1 probabilistic hazard analysis including probably
2 seismic hazard analysis.
3 At the other side of the table is
4 Dr. Chen. Dr. Chen was formerly been at the Center
5 for Nuclear Regulatory Waste Analysis. I think I
6 scrambled those words. She is an expert in
7 geological engineering and geosciences. She has
8 worked at the Center for some period of time, has
9 since moved to California where she performs
10 independent consulting services, and has been
11 employed at the California State University at
12 Chico. Did I say that correctly?
13 DR. CHEN: On a temporary basis.
14 Temporary, part-time basis.
15 MR. TURK: The three witnesses before
16 you assisted the Staff in performing its assessment
17 of the Applicant's Request for Exemptions using a
18 probabilistic seismic hazard analysis with a 2000
19 year return period. In addition, Dr. Chen had been
20 involved in the Three Mile Island Unit 2 spent fuel
21 debris ISFSI at the Idaho National Engineering and
22 Environmental Laboratory, which has been the
23 subject of some testimony and debate in the
24 proceeding.
25 At this time, your Honors, I would like

1 to proceed with my direct examination.

2 JUDGE FARRAR: All right.

3 DIRECT EXAMINATION

4 BY MR. TURK:

5 Q. Drs. McCann, Stamatakos, and Chen, good

6 afternoon. Thank you for joining us and taking the

7 time to have been here during the past week, Drs.

8 McCann and Stamatakos. And Dr. Chen, thank you for

9 joining us at this time.

10 I'd ask whether you have before you a

11 copy of the prefiled testimony you prepared for

12 submittal in that proceeding.

13 DR. McCANN: Yes.

14 DR. KHAN: Yes.

15 DR. CHEN: Yes.

16 Q. Is that entitled NRC testimony of John

17 A. Stamatakos, Rui Chen, and Martin W. McCann, Jr.

18 Concerning Unified Contention Utah L/QQ Part E

19 (Seismic Exemptions) dated April 1, 2002?

20 DR. STAMATAKOS: Yes.

21 DR. McCANN: Yes.

22 DR. CHEN: Yes.

23 Q. And have you each prepared a statement

24 of your professional qualifications?

25 DR. STAMATAKOS: Yes.

1 DR. KHAN: Yes.

2 DR. CHEN: Yes.

3 Q. And is your statement of professional

4 qualifications attached to the prefiled testimony

5 you submitted in this proceeding?

6 DR. McCANN: Yes.

7 DR. CHEN: Yes.

8 DR. KHAN: Yes.

9 Q. Now, is it correct that some of you have

10 made changes to your professional qualifications

11 since the testimony was pre-filed in April?

12 DR. McCANN: Yes.

13 Q. And I believe two of you have made

14 changes. Dr. McCann, let me start with you first.

15 Could you identify the change that you have made in

16 your professional qualification statement?

17 DR. McCANN: Yes. I need to correct you

18 again, our offices are in Menlo Park, not Mountain

19 View, California.

20 Q. And I was sure I had it right this time

21 because I messed it up before.

22 DR. McCANN: And I'm a consulting

23 professor at Stanford. It's a part-time position.

24 I think you said professor, which is not correct.

25 On the bottom of the first page of my professional

1 qualifications, that's included in the testimony.
2 There is an additional item entered at
3 the bottom of the page that refers to work
4 performed for the Electric Power Research
5 Institute. And that work involved developing
6 generic guidance to support utilities in the future
7 who might consider submitting an early site permit
8 application for a future nuclear power plant. And
9 that guidance, at least to the extent that I was
10 involved in it, related strictly to seismic siting
11 issues.
12 Q. And when was that work performed?
13 DR. McCANN: That was performed in
14 approximately the May, June, July time frame last
15 year.
16 Q. 2001?
17 DR. McCANN: 2001. Correct.
18 Q. And that's the only change you have made
19 to your professional qualification statement?
20 DR. McCANN: Yes.
21 Q. Dr. Stamatakos, have you made any
22 changes to your professional qualifications?
23 DR. STAMATAKOS: No.
24 Q. Dr. Chen, have you made changes to your
25 professional qualifications?

1 DR. CHEN: Yes.

2 Q. And could you describe the changes? And
3 we have distributed to the court reporter and the
4 Board members the revised qualification statements
5 and we have given copies to counsel for the State
6 and Applicant, as well.

7 JUDGE FARRAR: All right.

8 DR. CHEN: On first page of my
9 professional qualification, the term of employment,
10 on the second item, employment history on the
11 second item, I just updated from 08-01 to 01-02
12 instead of "to present", because this was an older
13 version. At that time I was still teaching.

14 And I deleted some enterings like some
15 basic items like computer scales. I thought they
16 were less relevant. Selected graduate courses and
17 memberships, I just deleted those entrances. And I
18 updated some publications. Under publication, the
19 first item, the revised version, the first item of
20 the revised version I just added the issues where
21 the paper was published. Previously it was in
22 press.

23 Q. And is that the first paper listed, the
24 listing Ofoegbu, G. I., et cetera?

25 DR. CHEN: Yes.

1 Q. "Geomechanical and thermal effects on
2 moisture flow at the proposed Yucca Mountain
3 Nuclear Waste Repository."
4 DR. CHEN: Correct. Under Reports, I
5 added three most recent reports. The first three
6 in the updated version.
7 JUDGE FARRAR: All right.
8 Q. That's on Page 3 of your publication
9 list, the first three items?
10 DR. CHEN: Page 8 of the new version.
11 Q. Just so we are clear, which ones those
12 are? The first item, the ones listed under (b)
13 Reports, it is included as H-S-I-U-N-G?
14 DR. CHEN: I was looking at the older
15 version. I'm sorry.
16 Q. Which are the ones you have added?
17 DR. CHEN: You are right. Page 3 of
18 publication. H-S-I-U-N-G, S. R. Chen, et al, 2002.
19 That's the one added.
20 JUDGE FARRAR: And then the next two,
21 also?
22 DR. CHEN: The next to it and the one
23 following.
24 JUDGE FARRAR: Okay. Fine.
25 DR. CHEN: Three consecutive ones.

1 Q. Okay. Drs. McCann, Stamatakos, and
2 Chen, are there any changes to the testimony itself
3 that you have made?
4 DR. McCANN: There was one typo.
5 JUDGE FARRAR: And that's been marked.
6 Q. It's been marked but the other parties
7 aren't aware of it yet. I didn't have enough
8 copies to hand them so we will identify for the
9 record where this occurs so they can mark their
10 copies?
11 JUDGE FARRAR: Okay.
12 DR. McCANN: It's on Page 25. The
13 fourth line from the top. It says, "Ground motions
14 within an a mean --" and the word "an" should be
15 stricken.
16 MR. GAUKLER: What question and answer
17 was that?
18 JUDGE FARRAR: On Page 25, fourth line.
19 DR. McCANN: Answer 19 which starts on
20 Page 4 and continues on Page 25.
21 Q. In the paragraph that begins with the
22 word "second".
23 MR. GAUKLER: Okay.
24 Q. Four lines down there's the word "an"
25 before the word "a".

1 JUDGE FARRAR: An extra article
2 included.
3 Q. And do you have any other corrections or
4 revisions to make to your testimony or your
5 professional qualification statements?
6 DR. McCANN: No.
7 DR. KHAN: No.
8 DR. CHEN: No.
9 Q. And with these corrections that you have
10 made today, is your written testimony and are your
11 statements of professional qualifications true and
12 correct to the best of your knowledge, information,
13 and belief?
14 DR. McCANN: Yes.
15 DR. CHEN: Yes.
16 DR. KHAN: Yes.
17 Q. And do you adopt your written testimony
18 as now revised as your sworn testimony in this
19 proceeding?
20 DR. McCANN: Yes.
21 DR. KHAN: Yes.
22 DR. CHEN: Yes.
23 MR. TURK: Your Honor, that concludes my
24 direct examination. We do have a number of
25 documents we'd like to introduce, which I think

1 would be appropriate to do at this time.

2 JUDGE FARRAR: Let's see if there's any

3 objection to this testimony.

4 MS. CHANCELLOR: Yes, there is, your

5 Honor.

6 JUDGE FARRAR: All right.

7 MS. CHANCELLOR: In the motion in

8 limine, Mr. Turk identified or the State in its

9 motion alleged that there was no designation as to

10 who was answering which questions. And in footnote

11 8 of Mr. Turk's response he identifies what members

12 of the panel are principally responsible for

13 answering the questions. And I would request that

14 those designations be marked on the testimony.

15 MR. TURK: For the record, your Honor, I

16 don't have the response before me. Could I ask Ms.

17 Chancellor to read into the record what that

18 designation was?

19 JUDGE FARRAR: Let me first ask what

20 went wrong here, because I recall some time ago the

21 State made this objection about some Applicant

22 testimony - it might have been on aircraft - and we

23 held up, as a model, the way the Staff did it; that

24 the Staff --

25 MS. CHANCELLOR: You mean the way the

1 Applicant did it?

2 JUDGE FARRAR: No. I thought your first

3 objection, some time ago, was that it being missing

4 in the Applicant's.

5 MR. GAUKLER: And we supplied a list.

6 JUDGE FARRAR: And we had an argument

7 and I remember being influenced by the fact that

8 the Staff routinely seemed to provide it. And so

9 the Applicant took the hint and did the change and

10 we have all been doing that since.

11 What went wrong here, Mr. Turk?

12 MR. TURK: Your Honor, I don't think

13 anything went wrong. The State filed a motion

14 seeking to strike the testimony because the names

15 had not been particularized. And we then, in our

16 response to their motion, told them, "Here are the

17 names of the people who are principally responsible

18 for each of the answers given in the testimony."

19 So they have that information. Now, it is panel

20 testimony --

21 JUDGE FARRAR: No, I meant what went

22 wrong that I thought it was always the Staff

23 practice to have this show on the testimony.

24 MR. TURK: Some testimony, your Honor,

25 involves different pieces. For instance, when you

1 saw Mr. Pomerening and Dr. Ofoegbu, one of those
2 persons provided the soils input and one provided
3 the structural input. Those were easy answers to
4 segregate.
5 This panel performed a collaborative
6 work. The next exhibit we introduce will show that
7 all of their names are on the document. So there's
8 no clear demarcation. However, with respect to her
9 request to note who should she direct questions to,
10 who is principally responsible, we identified with
11 each question who the lead person is to answer, but
12 we cannot say the other people were not involved in
13 preparing the answer or not responsible for the
14 answer.
15 JUDGE FARRAR: In light of that answer,
16 Ms. Chancellor, and the fact that Mr. Turk informs
17 us -- Mr. Turk, do we have the document with the
18 footnote?
19 MR. TURK: Yes.
20 JUDGE FARRAR: You served that on us at
21 some point?
22 MR. TURK: Yes. And we argued it during
23 the telephone conference call, motions in limine.
24 It's the response of April 22.
25 MS. CHANCELLOR: I can read it into the

1 record if you want.

2 JUDGE FARRAR: I don't know that we need

3 to. The real benefit of it is for the people who

4 are doing the cross-examination, to help them know

5 who to focus on. We don't -- we can dig out that

6 document at the right time. And to me, if you have

7 it in front of you, and Mr. Gaukler you have it in

8 front you?

9 MR. GAUKLER: No, I don't. But that's

10 okay.

11 JUDGE FARRAR: Okay. There's no sense,

12 I'd rather not take the time to read it in.

13 MR. TURK: I would note because, it is

14 collaborative testimony, we have identified the

15 lead but the other witnesses may well have

16 information or something to impact as they are

17 cross-examined. So we would ask that they be heard

18 if they wish to add.

19 JUDGE FARRAR: Let me tell the

20 witnesses, two of the witnesses have been here but

21 Dr. Chen, you have not been so fortunate to be here

22 for four weeks watching us. What we have done is

23 we have allowed the lawyers to direct a question to

24 a particular member of the panel and to insist on

25 an answer from that member of the panel. Of

1 course, that answer can be, "I don't know." If you
2 are asked a question that you don't know, it is
3 better to say, "I don't know," than to make one up.
4 Second, we have also allowed the lawyers
5 then to go ahead and ask the others if they have
6 something to add, or most times we have allowed the
7 other members of the panel to add something,
8 although once in a while the lawyer has a
9 particular point they are trying to make with one
10 witness and on that occasion we will let the lawyer
11 just proceed with that witness and your own counsel
12 will later on come back to you and ask if you have
13 anything to add. So let's proceed on that basis.
14 Ms. Chancellor, you had an objection
15 which in substance we have overruled.
16 MS. CHANCELLOR: Yes, your Honor.
17 MR. TURK: In light of the ruling I
18 would ask that the testimony be accepted, admitted,
19 and bound into the record as if read.
20 JUDGE FARRAR: We will do that. The
21 reporter will bind it into the record at this point
22 as if read.
23 (Prefiled testimony of John A. Stamatakos,
24 Rui Chen, and Martin McCann follows.)
25 JUDGE FARRAR: And Mr. Turk, you have

April 1, 2002

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
PRIVATE FUEL STORAGE, L.L.C.	)	Docket No. 72-22-ISFSI
	)	
(Independent Spent	)	
Fuel Storage Installation)	)	

NRC STAFF TESTIMONY OF
JOHN A. STAMATAKOS, RUI CHEN AND
MARTIN W. McCANN, JR., CONCERNING UNIFIED
CONTENTION UTAH L/QQ, PART E (SEISMIC EXEMPTION)

Q1. Please state your names, occupations, and by whom you are employed.

A1(a). My name is John A. Stamatakos ("JAS"). I am employed as a Principal Scientist at the Center for Nuclear Waste Regulatory Analyses ("CNWRA"), which is a division of the Southwest Research Institute ("SwRI"), in San Antonio, Texas. I am providing this testimony under a technical assistance contract between the staff of the Nuclear Regulatory Commission ("NRC Staff" or "Staff") and the CNWRA at the SwRI. A statement of my professional qualifications is attached hereto.

A1(b). My name is Rui Chen ("RC"). I am employed as an independent consultant in geological engineering and geosciences. From April 1995 to August 2000, I was employed as a Research Engineer and Senior Research Engineer at the Center for Nuclear Waste Regulatory Analyses ("CNWRA"), in San Antonio, Texas, where I was involved in various matters including the technical analysis of mechanical, thermal, and hydrological processes in complex geomechanical and geotechnical engineering systems related to the proposed Yucca Mountain repository; and the evaluation of seismic hazard analyses and seismic design related to proposed spent fuel storage facilities, including the proposed PFS Facility. I am providing this testimony under a technical

assistance contract between the NRC Staff and the CNWRA of the SwRI. A statement of my professional qualifications is attached hereto.

A1(c). My name is Martin W. McCann, Jr. ("MWM"). I am employed as President of Jack R. Benjamin & Associates, Inc., in Menlo Park, California. I am also a Consulting Professor of Civil and Environmental Engineering at Stanford University. Among my duties at Jack R. Benjamin & Associates, Inc., I serve as a consultant to the Center for Nuclear Waste Regulatory Analyses ("CNWRA"), which is a division of the Southwest Research Institute ("SwRI"), in San Antonio, Texas. I am providing this testimony under a technical assistance contract between the NRC Staff and the CNWRA of the SwRI. A statement of my professional qualifications is attached hereto.

Q2. Please describe your current responsibilities.

A2(a). (JAS) In my position as Principal Scientist at the CNWRA, I currently serve as the Principal Investigator for several projects involving technical evaluation of structural deformation and seismicity, including tectonics and neotectonics research. My work includes field analyses of the structural and tectonic elements of the Basin and Range province in the southwestern United States, and the evaluation of seismic and faulting hazards at various nuclear facilities.

A2(b). (RC) In my position as an independent consultant, I have provided technical assistance and consulting services to the CNWRA at SwRI involving a broad range of problems in underground rock engineering, seismic hazard assessment, and earthquake engineering; including the evaluation of seismic and geotechnical hazards at various nuclear facilities. I also teach graduate and undergraduate courses in the fields of geotechnical engineering and geosciences in the Department of Civil Engineering and College of Natural Sciences at the California State University at Chico, California.

A2(c). (MWM) In my position as President of Jack R. Benjamin & Associates, Inc., I provide consulting services to private industry and government entities, both in the United States and abroad, in the area of risk analysis for critical facilities, development of generic standards and guidelines for use in assessing seismic hazards and in the assessment of seismic hazards at specific sites, with emphasis in the area of probabilistic seismic hazard analysis ("PSHA"). As part of my responsibilities, I have provided technical assistance and consulting services to the CNWRA at SwRI in its review of various PSHAs, including the PSHA for the U.S. Department of Energy's ("DOE") proposed Yucca Mountain repository and other DOE nuclear facilities. In addition, in my position as a Consulting Professor of Civil and Environmental Engineering at Stanford University, I am involved in activities related to the collection and evaluation of data on dams and dam incidents.

Q3. Please explain what your duties have been in connection with the NRC Staff's review of the application filed by Private Fuel Storage, L.L.C. ("PFS" or "Applicant") for a license to construct and operate an Independent Spent Fuel Storage Installation ("ISFSI") on the Reservation of the Skull Valley Band of Goshute Indians, geographically located within Skull Valley, Utah (the "proposed PFS Facility").

A3(a). (JAS) As part of my official responsibilities, I assisted the NRC Staff in its evaluation of the Applicant's request for an exemption from certain regulations pertaining to seismic analyses and requirements related to the Applicant's construction and operation of the proposed PFS Facility. My specific role was to conduct the Staff's evaluation of the Applicant's probabilistic seismic hazard analysis ("PSHA"), including seismic ground motions and faulting hazards. In this regard, I co-authored, with Drs. McCann and Chen, a document entitled "Seismic Ground Motion and Faulting Hazard at Private Fuel Storage Facility in the Skull Valley Indian Reservation, Tooele County - Final Report," issued by the CNWRA in September 1999. Further, I assisted in

preparation of the Staff's "Safety Evaluation Report Concerning the Private Fuel Storage Facility," issued on September 29, 2000 ("SER"); and I assisted in preparation of Supplement No. 2 to the SER, dated December 21, 2001 ("SSER Supplement No. 2"). Those two documents have now been incorporated into the NRC Staff's "Consolidated Safety Evaluation Report Concerning the Private Fuel Storage Facility," issued in March 2002 ("Consolidated SER").

In addition, among my other duties, I assisted the NRC Staff in preparing the "NRC Staff's Response to Applicant's Motion for Summary Disposition of Utah Contention L, Part B," dated December 7, 2001; and I assisted the NRC Staff in preparing its responses to various discovery requests which were filed by the State of Utah ("State"), including the Staff's responses of February 14 and July 12, 2000 (Response and Supplemental Response to the State's Sixth Request); December 7, 2000 (Response to the State's Tenth Request); November 16, 2001 (Response to the State's Fourteenth Request); and December 4, 2001 (Supplemental Response to the State's Twelfth Request).

A3(b). (RC) As part of my official responsibilities, I assisted the NRC Staff in its evaluation of the Applicant's request for an exemption from certain regulations pertaining to seismic analyses and requirements, related to the Applicant's construction and operation of the proposed PFS Facility. My specific role was to participate in the Staff's evaluation of seismic hazard analyses and seismic design for the proposed PFS Facility. In this regard, I co-authored a document entitled "Seismic Ground Motion and Faulting Hazard at Private Fuel Storage Facility in the Skull Valley Indian Reservation, Tooele County - Final Report," issued by the CNWRA in September 1999. Further, I assisted in preparation of the Staff's "Safety Evaluation Report Concerning the Private Fuel Storage Facility," issued on September 29, 2000 ("SER"), and I assisted in preparation of Supplement No. 2 to the SER, dated December 21, 2001 ("SSER Supplement No. 2"). Those two

documents have now been incorporated into the NRC Staff's "Consolidated Safety Evaluation Report Concerning the Private Fuel Storage Facility," issued in March 2002 ("Consolidated SER").

In addition, among my other duties, I was involved in the NRC Staff's review of the seismic exemption request for the Three Mile Island Unit 2 ("TMI-2") ISFSI at the Idaho National Engineering and Environmental Laboratory ("INEEL") located in southeastern Idaho, and I co-authored a related report entitled, "Seismic Ground Motion at Three Mile Island Unit 2 Independent Spent Fuel Storage Installation Site in Idaho National Engineering and Environmental Laboratory - Final Report," CNWRA-98-007, issued in June 1998 (Chen and Chowdhury, 1998).

A3(c). (MWM) As part of my official responsibilities, I assisted the NRC Staff in its evaluation of the Applicant's request for an exemption from certain regulations pertaining to seismic analyses and requirements, related to the Applicant's construction and operation of the proposed PFS Facility. My specific role was to conduct the Staff's evaluation of the probabilistic seismic hazard analysis for the proposed PFS Facility. In this regard, I co-authored a document entitled "Seismic Ground Motion and Faulting Hazard at Private Fuel Storage Facility in the Skull Valley Indian Reservation, Tooele County - Final Report," issued by the CNWRA in September 1999. Further, I assisted in preparation of the Staff's "Safety Evaluation Report Concerning the Private Fuel Storage Facility," issued on September 29, 2000 ("SER"), and I assisted in preparation of Supplement No. 2 to the SER, dated December 21, 2001 ("SSER Supplement No. 2"). Those two documents have now been incorporated into the NRC Staff's "Consolidated Safety Evaluation Report Concerning the Private Fuel Storage Facility," issued in March 2002 ("Consolidated SER").

Q4. What is the purpose of this testimony?

A4. The purpose of this testimony is to provide the NRC Staff's views concerning the acceptability of the Applicant's seismic exemption request, which is the subject of Unified Contention Utah L/QQ, Part E.

Q5. Please describe the Commission's regulatory requirements related to the seismic analysis and design that you considered in your evaluation of the PFS application for an independent spent fuel storage installation.

A5. (JAS) The Commission's requirements governing the seismic analysis and design for an ISFSI are set forth in 10 C.F.R. Part 72. In general, 10 C.F.R. § 72.90 requires an evaluation of site characteristics that may directly affect the safety or environmental impact of the proposed facility, including an evaluation of the frequency and severity of external natural events that could affect the safe operation of the ISFSI. Pursuant to 10 C.F.R. § 72.92, an applicant must identify and assess the natural phenomena that may exist or can occur in the region of the proposed facility, with respect to their potential effects on safe operation, including consideration of the occurrence and severity of important natural phenomena; and 10 C.F.R. § 72.98(a) requires identification of the regional extent of external phenomena that are used as a basis for the design of the facility.

Pursuant to 10 C.F.R. §72.122(b)(1), structures, systems, and components important to safety ("SSCs") must be designed to accommodate the effects of, and be compatible with, site characteristics and environmental conditions and to withstand postulated accidents. Further, § 72.122(b)(2) requires that SSCs be designed to withstand the effects of natural phenomena, including earthquakes, without impairing their capability to perform safety functions, and that the design bases for the SSCs must reflect (i) appropriate consideration of the most severe of the natural phenomena reported for the site and surrounding area, with appropriate margins to take into account the limitations of the data and the period of time in which the data have accumulated, and (ii) appropriate combinations of the effects of normal and accident conditions and the effects of natural phenomena.

In addition, pursuant to 10 C.F.R. § 72.102, an ISFSI applicant is required to address the geological and seismological characteristics of its proposed site. For sites located west of the Rocky Mountain Front (west of approximately 104° west longitude) and in other areas of known potential seismic activity, 10 C.F.R. § 72.102(b) requires that "seismicity will be evaluated by the techniques of appendix A of [10 C.F.R. Part 100]." Further, 10 C.F.R. § 72.102(f) requires that for sites which have been evaluated under the criteria in 10 C.F.R. Part 100, Appendix A, the "design earthquake (DE) for use in the design of structures . . . . must be equivalent to the safe shutdown earthquake (SSE) for a nuclear power plant."

Appendix A to 10 C.F.R. Part 100 (which is cited in 10 C.F.R. § 72.102(b) and (f)), establishes seismic and geologic siting criteria for nuclear power plants ("NPPs"). Appendix A sets forth the criteria to be used by NPP license applicants in conducting the geologic and seismic investigations necessary to determine site suitability; it describes "procedures for determining the quantitative vibratory ground motion design basis at a site due to earthquakes" and "information needed to determine whether and to what extent a [NPP] need be designed to withstand the effects of surface faulting"; and it identifies "other geologic and seismic factors required to be taken into account in the siting and design of [NPPs]" (*Id.*, Part II). Part IV of Appendix A describes the geologic, seismic and engineering investigations that are required; Part V describes the process to be followed in determining the seismic and geologic design bases for the facility; and Part VI describes the application of these matters to the facility's engineering design.

In particular, Part V(a) of 10 C.F.R. Part 100, Appendix A, discusses the process to be followed in determining the design basis for vibratory ground motion, including identification of the safe shutdown earthquake for a nuclear power plant. Appendix A, Part III, defines the safe shutdown earthquake as that earthquake, "based upon an evaluation of the maximum earthquake potential" shown in site and regional investigations, which produces "the maximum vibratory ground

motion" at the site for which certain SSCs are designed to remain functional; the SSE is commonly referred to as the NPP's "design basis earthquake." The approach specified in Appendix A implies the use of a "deterministic seismic hazard analysis" ("DSHA") to calculate the SSE, because it considers only the largest possible earthquake that could occur at a location closest to the site, and does not consider how frequently the seismic events occur that control the deterministic ground motion. Thus, analyses using the Part 100, Appendix A methodology determine the SSE for a NPP, without regard to the uncertainties associated with the evaluation of earthquakes (*e.g.*, size, location, magnitude) and the assessment of ground motions, and do not consider the probability of occurrence of the SSE.

Q6. Has PFS sought an exemption from any of the regulatory requirements referred to above, with respect to its ISFSI application?

A6. Yes. On April 2, 1999, the Applicant submitted a request for an exemption from the seismic design requirements in 10 C.F.R. § 72.102(f)(1), to allow its use of a PSHA and considerations of risk to establish the design earthquake ground motion levels at the proposed PFS Facility. The Applicant's exemption request also proposed to design the Facility based on ground motions that have a mean annual probability of exceedance of 1×10^{-3} (or the reciprocal 1,000-year return period).

Q7. Did the Staff conduct an evaluation of the Applicant's seismic exemption request?

A7. Yes.

Q8. Please summarize the nature of the Staff's evaluation of the exemption request.

A8. Inherent in the PFS exemption request are two related questions: (1) Should the Applicant be permitted to substitute a PSHA for the DSHA required by the regulations in 10 C.F.R. Part72; and (2) if the PSHA is used, what is the appropriate mean annual probability of exceedance (*i.e.*, return period) for the seismic design ground motions. At the Staff's request, we conducted

an evaluation of the Applicant's seismic exemption request, which is described in Section 2.1.6.2 of the Consolidated SER. As part of this evaluation, we provided a detailed analysis of the Applicant's request, in a report entitled "Seismic Ground Motion at the Private Fuel Storage Facility Site in the Skull Valley Indian Reservation," issued in September 1999 (Stamatakos, et al., 1999). This evaluation included an independent technical review of the seismic hazard investigations at the proposed PFS site, as described in the Consolidated SER (Section 2.1.6) and Stamatakos, et al. (1999).

As set forth in the Consolidated SER, in April 1999, after extensive site characterization studies were performed by Geomatrix Consultants, Inc., the Applicant submitted a request for an exemption from the deterministic seismic design requirements of 10 C.F.R. § 72.102(f)(1). The exemption request proposed to instead use a probabilistic seismic hazard analysis ("PSHA") along with considerations of risk to establish the design earthquake ground motions at the proposed PFS site. The original exemption request also proposed to design the PFS Facility to ground motions with a mean annual probability of exceedance of 1×10^{-3} (1,000-year return period).

To support its evaluation of the PFS exemption request, the Staff asked the CNWRA to conduct a technical review of the seismic and faulting hazard investigations at the proposed PFS Facility site. The objectives of the CNWRA seismic and faulting hazard investigations were (1) to conduct an independent review of seismic and faulting hazard studies at Skull Valley and, in particular, to identify seismic and faulting issues important to siting the proposed PFS Facility; (2) to evaluate the adequacy and acceptability of the PFS seismic and faulting design approach; and (3) to make recommendations regarding the PFS proposed seismic design approach and design basis ground motions. These objectives were accomplished through a survey of state-of-the-art literature (including documents submitted by PFS), analyses of relevant NRC regulations, and CNWRA independent analyses of geophysical data, sensitivity studies of model alternatives, and

consideration of uncertainties. Seismic issues important to siting the proposed PFS Facility included (a) characterization of potential seismic sources, (b) estimation of ground motion attenuation, (c) assessment of probabilistic and deterministic ground motion hazards, (d) assessment of probabilistic surface faulting hazards, and (e) development of design basis ground motions in compliance with applicable regulations and regulatory guidance.

Based on the review of the PSHA conducted by Geomatrix Consultants, Inc. (1999), the Staff concluded that the PFS seismic and surface faulting hazard results provide an adequate basis for development of the design seismic ground motions for the proposed PFS Facility. In fact, the Staff's analyses concluded that the results of the PSHA are conservative, mainly because of conservative assumptions in the seismic source characterization.

Following issuance of the CNWRA report (Stamatakos, et al., 1999), the Staff continued to evaluate the exemption request in light of the additional site characterization information that was provided by the Applicant. This new information included the Applicant's updates to the PSHA in 2000 and 2001, some of which led the Applicant to increase its estimated seismic hazard at the site. These revisions included modifications to the site velocity model, the ground motion attenuation relationships adopted from the Yucca Mountain study, and the approach used in the site response analysis. In the aggregate, these revisions resulted in an increase in the ground motion hazards estimated at the PFS site. For example, based on the new information, the Applicant increased its estimate of the peak horizontal acceleration (5×10^{-4} mean annual probability of exceedance) from 0.53g (as reported in 1999) to 0.711g (as reported in 2001). The Applicant's PSHA revisions have not affected our conclusions regarding the acceptability of the PFS exemption request. Details concerning the Staff's evaluation and conclusions with respect to the adequacy and results of the Applicant's PSHA are documented in the Consolidated SER (Sections 2.1.6.1 and 2.1.6.2) and in Stamatakos, et al. (1999).

Q9. Please provide a summary of the factors considered by the Staff in determining whether a PSHA may be utilized in lieu of the DSHA required in 10 C.F.R. Part 72.

A9. Although 10 C.F.R. Part 72 requires a deterministic approach for the seismic hazard assessment of an ISFSI site located west of the Rocky Mountain Front, the Commission and Staff have taken certain actions which indicate general approval of the use of PSHA methodology

First, the Commission has indicated that the uncertainty associated with evaluating seismic design ground motions for NPPs must be addressed. In this regard, the Commission has issued regulations and regulatory guidance that approve this approach in determining the SSE for a nuclear power plant, as set forth in 10 C.F.R. § 100.23 and Regulatory Guide 1.165, "Identification and Characterization of Seismic Sources and Determination of Safe Shutdown Earthquake Ground Motion" (1997). In addition, the Commission has initiated a rulemaking effort to amend 10 C.F.R. Part 72, to permit the use of a PSHA to establish the design basis ground motions for SSCs important to safety at an ISFSI. *See* SECY-98-126, as modified in SECY-01-0178. Second, as set forth in SECY-98-071, the Commission has previously reviewed and approved a request for an exemption from the deterministic seismic requirements in 10 C.F.R. § 72.102(f)(1), to allow the use of a PSHA to establish the design ground motions at the Three Mile Island Unit 2 ("TMI-2") spent fuel debris ISFSI, located at the Idaho National Engineering and Environmental Laboratory.

The Commission's actions in considering an alternative to the deterministic approach specified in 10 C.F.R. Part 100, Appendix A, appear to reflect the recognition that the PSHA methodology has certain advantages as compared to a DSHA. For example, a DSHA considers only the most significant earthquake sources and events with a fixed site-to-source distance. A PSHA, on the other hand, incorporates the contribution of all potential seismic sources and considers the range of source-to-site distances, earthquake magnitudes, and the randomness of earthquake ground motions. Most importantly, the PSHA methodology evaluates uncertainty in the

assessment of seismic hazards. In doing so, it provides a more complete estimate of the earthquake hazards at a proposed site, for use in establishing the design basis ground motions.

Q10. Please identify the mean annual probability of exceedance (*i.e.*, the return period) that the Applicant proposed for use in conjunction with its PSHA.

A10. The Applicant's exemption request, as originally submitted, proposed design ground motions that have a mean annual probability of exceedance of 1×10^{-3} (1,000-year return period). In reviewing the Applicant's exemption request, the Staff found that the Applicant's proposed use of a 1×10^{-3} mean annual probability of exceedance (1,000-year return period) lacked sufficient regulatory and technical bases. Thereafter, in August 1999, the Applicant revised its exemption request to use design ground motions that have a mean annual probability of exceedance of 5×10^{-4} (2,000-year return period).

Q11. Has the Staff reached a conclusion as to whether the Applicant's seismic exemption request is acceptable?

A11. Yes. As set forth in Section 2.1.6.2 of the Staff's Consolidated SER (pages 2-50 to 2-51), the Staff has concluded that the use of the PSHA methodology and a mean annual probability of exceedance of 5×10^{-4} (2,000-year return period) are acceptable bases to determine the seismic design ground motions of the proposed PFS Facility. Accordingly, the Staff has concluded that the Applicant's exemption request should be granted.

Q12. Please describe the bases for this conclusion, insofar as it is based upon the Applicant's PSHA.

A12. The Staff considered a number of technical and regulatory factors in its evaluation of the Applicant's seismic exemption request. These included (1) the Applicant's exemption request and the PSHA submitted in support thereof; (2) our evaluation of the Applicant's PSHA; (3) the Commission's acceptance, in various regulatory documents, of a PSHA approach in

determining the seismic design basis for NRC-licensed facilities (as reflected in amendments to 10 C.F.R. Parts 50 and 100, issuance of Reg. Guide 1.165, and approval of the Rulemaking Plan in SECY-98-126); and (4) the Commission's 1998 approval of the exemption request for the TMI-2 ISFSI at INEEL.

With respect to the technical analysis supporting the Applicant's seismic exemption request, we found the Applicant's PSHA results to be conservative. As stated in the Consolidated SER (page 2-48), this determination was based upon our review of the geological and seismotectonic setting, historical seismicity, potential seismic sources and their characteristics, ground motion attenuation modeling, probabilistic and deterministic estimates of ground motion hazards, development of design basis ground motions, and independent Staff analyses.

One aspect of the Staff's review included the interpretations of fault geometries for the newly discovered East and West faults in Skull Valley, based on reflection seismic data and forward modeling of gravity data by Geomatrix Consultants, Inc., developed in 1999. Staff review of the Applicant's fault models (models defining the size, location, and activity of seismogenic faults in the region) shows that the assessment by Geomatrix Consultants, Inc. may have led to an overly conservative hazard result (perhaps by as much 50% or more, based on a comparison to Salt Lake City PSHA results, as discussed below). For example, independent analysis of proprietary industry gravity data (reported in Stamatakos et al., 1999) does not support the interpretation that the West fault (one of the faults very near the site) is an independent seismic source. Rather, the Staff concluded that the West fault is a splay of the larger East fault, incapable of independently generating large magnitude earthquakes. By contrast, in the Geomatrix fault model, the West fault is considered capable of producing large-magnitude earthquakes.

Another aspect of the Applicant's seismic source characterization that appears to be conservative is the site-to-source distance models used in the ground motion attenuation

relationships and the development of distributions of maximum earthquake magnitude based on the dimensions of fault rupture. This conclusion of additional conservatism is derived from a slip tendency analysis (Morris et al., 1996) of the Skull Valley fault systems that was performed by the Staff. The Staff's slip tendency analysis shows that segments of the East fault and the East Cedar Mountain fault nearest the PFS site have relatively low slip tendency values compared to segments farther north in Skull Valley. As discussed in the Consolidated SER (pages 2-38 to 2-40), these relatively low slip tendency results indicate that the seismic source characterization of the PSHA study conducted by Geomatrix Consultants, Inc. (Geomatrix Consultants, Inc., 1999a and 2001a) is conservative.

In slip tendency analysis, the underlying assumption is that the regional stress state controls slip tendency and that there are no significant deviations due to local perturbations of the stress conditions. This assumption is supported by a similar slip tendency analysis of the Wasatch fault, which shows the highest slip tendency values for the segments of the fault considered to be most active (Machette et al., 1991).

The Staff's slip tendency analysis was completed using an interactive stress analysis program (3DStress™) that assesses potential fault activity relative to crustal stress. For Skull Valley, the stress tensor is defined with a vertical maximum principal stress (σ_1), a horizontal intermediate principal stress (σ_2) with azimuth of 355°, and a horizontal minimum principal stress (σ_3) with an azimuth of 085°. The stress magnitude ratios are $\sigma_1/\sigma_3 = 3.50$ and $\sigma_1/\sigma_2 = 1.56$. This orientation for the principal stresses was based on recent global positioning satellite information (Martinez, et al., 1998a). The Staff's slip tendency analysis assumed a normal-faulting regime, with rock density equal to 2.7 g/cc, fault dip equal to 60°, water table at a depth of 40 m, and a hydrostatic fluid pressure gradient.

The results of the Staff's slip tendency analysis indicate that fault segments with approximately North-South strikes (azimuth = 175°) are optimally oriented for future fault slip. Faults with north northeast-south southwest strikes have high slip tendency values. In contrast, fault segments with northwest-southeast strikes, such as the East fault near the proposed PFS Facility site and the southern segments of the East Cedar Mountain fault also near the proposed PFS Facility site, have relatively low slip tendency values. Therefore, these fault segments are less likely to slip in the future than fault segments further from the site. In this regard, it should be noted that fault rupture close to the site greatly influences the seismic hazard. The closer the earthquake is to the site, the larger the resulting ground motions will be as compared to an earthquake with an equal magnitude on a fault segment farther away from the site.

In the Applicant's site-to-source distributions used in the ground motion attenuation equations, Geomatrix Consultants, Inc. (1999a) assumed uniform distributions of earthquake ruptures along active fault segments, without regard to the orientation and slip tendency of the fault segment. Given the slip tendency analysis described above, this assumption by Geomatrix Consultants, Inc. (1999a) is conservative. Based on its own slip tendency analysis, the Staff has concluded that seismic source models that incorporate slip tendency would result in a lower ground motion hazard than the one developed by the Applicant.

In addition, the slip tendency results in the Staff's analysis suggest that Geomatrix Consultants, Inc. (1999a) may have overestimated the maximum magnitude of the East and East Cedar Mountain faults near the proposed PFS site. In its Safety Analysis Report ("SAR"), the Applicant first developed conceptual models of the physical dimensions of fault rupture -- either rupture area or trace length of surface fault rupture -- based on the geologic record (Geomatrix Consultants, Inc.,1999a). Second, the Applicant developed distributions of maximum magnitudes for each active fault using empirical scaling relationships developed from the magnitudes and

associated rupture dimensions of historical earthquakes (e.g., Wells and Coppersmith,1994). In developing the fault segment models, the Applicant conservatively assumed that the entire mapped length of the surface trace length represents active fault segments. Thus, these maximum fault dimensions produce conservative estimates of maximum magnitude.

The Staff's slip tendency analysis indicates that parts of the East and East Cedar Mountain faults near the proposed PFS Facility site have relatively low slip tendency values. Thus, these faults may actually be smaller than is represented in the fault models used by the Applicant to estimate maximum magnitude. Fault rupture models developed using slip tendency analysis would lead to fault models with smaller rupture dimensions (length or area) than those used by Geomatrix Consultants, Inc. (1999a). Because the Applicant derived distributions of maximum magnitude for each active fault from empirical scaling relationships of rupture area or rupture length, application of the slip tendency analysis would result in smaller predicted maximum magnitudes than those developed by the Applicant. Smaller maximum magnitudes would reduce the overall ground motion hazard.

The conservative nature of the Applicant's source characterization and the PSHA results presented in the SAR is evident when the results are compared to PSHA results for other sites in Utah, especially those in and around Salt Lake City. Such a comparison shows that the seismic hazard in Skull Valley was calculated by the Applicant to be higher than the seismic hazards for sites at, or near, Salt Lake City, despite the fact that fault sources near Salt Lake City are larger and more seismically active than fault sources near the PFS site. For example, the results of the Applicant's PSHA for Skull Valley (Geomatrix Consultants, Inc., 2001a) suggest that it is 1.5 times more likely that a ground motion of 0.5g horizontal peak ground acceleration or greater will be exceeded at the PFS site (assuming hard rock site conditions), than at Salt Lake City, based on the USGS National Earthquake Hazard Reduction Program (Frankel et al., 1997). This is shown

in a Figure entitled "Comparison of Western U.S. Hazard Curves," which the Staff intends to submit as an Exhibit in this proceeding.

Similarly, the 2,000-year horizontal peak ground acceleration for Skull Valley (soil hazard) as estimated by the Applicant, is actually higher than the 2,500-year ground motions for the nine sites along the Wasatch Front that were evaluated as part of the Utah Department of Transportation I-15 Reconstruction Project (Dames & Moore, Inc., 1996). For example, the horizontal PGA calculated at the nine sites in the I-15 corridor study range between 0.561g and 0.686g, based on a mean annual probability of exceedance of 4×10^{-4} (2,500-year return period) -- as compared to the Applicant's estimated horizontal PGA of 0.711g, based on a mean annual probability of exceedance of 5×10^{-4} (2,000-year return period) at the PFS site. It should also be noted that the ground motions estimated by the Applicant in Skull Valley are higher than those estimated for the I-15 corridor, despite the close proximity of Salt Lake City to the Wasatch fault -- which has a slip rate nearly ten times greater than the Stansbury or East Faults (cf. Martinez et al., 1998; Geomatrix Consultants, Inc., 1999a), and is capable of producing significantly larger magnitude earthquakes than the faults near the proposed PFS Facility site in Skull Valley (cf. Machette et al., 1991; Geomatrix Consultants, Inc., 1999a). Because the Applicant's estimate of the seismic hazard is conservative, the proposed ground motions based on the mean annual probability of exceedance of 5×10^{-4} (2,000-year return period) provides an additional margin of safety in the seismic design.

As further stated in the Consolidated SER (pages 2-48 to 2-49), the Staff found that the Applicant's exemption request was acceptable in that:

> (1) Seismic events that could potentially affect the site were identified and the potential effects on safety and design were adequately assessed.

(2) Records of the occurrence and severity of historical and paleoseismic earthquakes were collected for the region and evaluated for reliability, accuracy, and completeness.

(3) Appropriate methods were adopted for evaluations of the design basis vibratory ground motion from earthquakes based on site characteristics and current state of knowledge.

(4) Seismicity was evaluated by the techniques of 10 C.F.R. Part 100, Appendix A. The seismic hazard, however, was evaluated using a probabilistic approach as stated in the request for an exemption from the requirements in 10 C.F.R. § 72.102(f)(1).

(5) The liquefaction potential or other soil instability from vibratory ground motions was appropriately evaluated.

(6) The design earthquake was found to have a value for the horizontal ground motion greater than 0.10g with the appropriate response spectrum and, thus, a site-specific analysis was appropriate.

(7) The Applicant's considerations with respect to the approach taken to model the epistemic uncertainty in ground motions and near-source effects were adequate.

(8) As discussed in Stamatakos, et al. (1999), the Applicant adequately applied adjustment factors for the near-fault effect using the state-of-the-art techniques and applied procedures described in Regulatory Guide 1.165 (1997) for developing the design-basis ground motion. The associated response spectra and design basis motion levels were found to be adequate.

Q13. Has the Staff reached a conclusion as to whether the Applicant's exemption request is acceptable, insofar as it is based upon seismic design ground motions that have a mean annual probability of acceptance of 5×10^{-4} (2,000-year return period)?

A13. Yes. The Staff has concluded that the Applicant's use of a PSHA and ground motions that have a mean annual probability of exceedance of 5×10^{-4} (2,000-year return period) provides an acceptable basis for the seismic design of the proposed PFS Facility. Apart from considerations as to the acceptability of the Applicant's PSHA (discussed above), the Staff based its conclusions upon the following considerations with respect to the appropriate probability of

exceedance (return period) to be utilized in establishing the seismic design of the proposed PFS Facility, as set forth in the Consolidated SER (pages 2-49 to 2-51).

First, as stated in SECY-98-071, the radiological hazard posed by a dry cask storage facility is inherently lower than operating commercial nuclear power plants, noting that "a major seismic event at an ISFSI storing spent fuel in dry casks or canisters would have minor radiological consequences compared with a nuclear power plant, spent fuel pool, or single massive storage structure." SECY-98-071, at 2. As further stated therein, "the design earthquake for cask and canister technology need not be as high as a nuclear power plant safe shutdown earthquake." *Id.* (citing comments in Statement of Consideration, "Licensing Requirements for the Storage of Spent Fuel in an Independent Spent Fuel Storage Installation," 45 Fed. Reg. 74,693, 74,697 (1980).

Second, as set forth in the Consolidated SER (page 2-50), the seismic design for commercial NPPs is based on a determination of the SSE ground motion. Heretofore, this ground motion has been estimated using a deterministic approach in the initial licensing of a NPP. Based on an analysis of the SSEs for existing nuclear power plants, in Regulatory Guide 1.165 the Staff established the appropriate Reference Probability to determine the SSE at future NPP sites in connection with the use of a PSHA approach under 10 C.F.R. § 100.23. The Reference Probability was determined to be a 1×10^{-5} median annual probability of exceedance (approximately equivalent to a 100,000-year return period). The Reference Probability, which is defined in terms of the median probability of exceedance, corresponds to a mean annual probability of exceedance of 1×10^{-4}. That is, the same design ground motion that has a median Reference Probability of 1×10^{-5}, has a mean annual probability of exceedance of 1×10^{-4}. Further, analyses of SSEs at nuclear power plants in the western United States (where the proposed PFS Facility would be sited), show that the average mean annual probability of exceeding the safe shutdown earthquake is 2.0×10^{-4} -- which is equivalent to a <u>5,000-year return period</u>. U.S. Department of Energy,

"Preclosure Seismic Design Methodology for a Geologic Repository at Yucca Mountain, TR-003-NP, Rev. 2 (1997).

Based on the foregoing considerations, the Staff determined that the mean annual probability of exceedance of the seismic design ground motions at the proposed PFS Facility may be greater than 1×10^{-4} (*i.e.*, something less than a 10,000-year return period). Specifically, the Staff found that in considering the reduced risk posed by an ISFSI as compared to a nuclear power plant, a mean annual probability of exceedance of 5×10^{-4} (2,000 year return period) as a basis to determine the seismic design ground motions appropriately may be used for the proposed PFS Facility.

Finally, in addition to the above considerations, as discussed in Consolidated SER (page 2-51), the Staff favorably considered two other instances in which seismic design ground motions with an annual probability of exceedance of 5×10^{-4} (2,000-year return period) was found to be appropriate. These are (a) the U.S. Department of Energy's issuance of a Standard concerning the use of PSHAs for DOE facilities, DOE-STD-1020-94, "Natural Phenomena Hazards Design and Evaluation Criteria for [DOE] Facilities" (April 1994, as revised January 1996), and (b) the Commission's 1998 approval of a 5×10^{-4} mean annual probability of exceedance (2,000-year return period) for seismic design ground motions at the TMI-2 ISFSI at INEEL, described in SECY-98-071.

Q14. Please describe the extent to which the Staff relied upon the "two other instances" :eferred to in the last paragraph of your response to Question 13, in determining to approve the PFS seismic exemption.

A14. With respect to the first of these two matters, DOE-STD-1020-94 defines four performance categories for SSCs important to safety (in addition to a "PC-0" category that has no associated safety considerations). The Staff considered that DOE-STD-1020-94 provided an

appropriate reference for characterizing the grades of radiological hazards at nuclear facilities such as ISFSIs and NPPs. Further, DOE-STD-1020-94 established the mean hazard annual probability of exceedance for seismic design for the range of SSCs at DOE sites, including ordinary structures (such as warehouses and office buildings) to structures presenting various levels of radiological hazards. Within this range of facilities considered by the DOE are nuclear fuel facilities like the proposed PFS ISFSI. In particular, DOE-STD-1020-94 requires that PC-3 SSCs (which are analogous to SSCs at a dry spent fuel storage facility) be designed for ground motions that have a mean annual probability of exceedance of 5×10^{-4} (2,000-year return period). It should be noted, however, that while the Staff referred to DOE-STD-1020-94, the Staff did not adopt that standard as a regulatory criterion for use in licensing or regulating the proposed PFS Facility or any other NRC-licensed facility.

With respect to the second matter identified above, the Staff referred to the Commission's prior acceptance of a mean annual probability of exceedance of 5×10^{-4} (2,000-year return period) as the basis for establishing the seismic design ground motions for the TMI-2 ISFSI at INEEL, which is discussed in SECY-98-071 and CNWRA-98-007 (Chen and Chowdhury, 1998). The TMI-2 ISFSI was designed to passively store spent nuclear fuel debris in dry storage casks, similar to the passive storage of spent nuclear fuel in dry storage casks at the proposed PFS Facility. In referring to the Commission's approval of the TMI-2 ISFSI seismic design ground motion, the Staff found it to constitute an appropriate point of reference, notwithstanding the fact that it did not establish a regulatory criterion having generic applicability.

In summary, the Staff considered that these points of reference provided relevant technical and regulatory insights for consideration in deciding that a seismic design based on ground motions that have a mean annual probability of exceedance of 5×10^{-4} (2,000-year return period) is appropriate for the proposed PFS Facility.

Q15. Are you familiar with Unified Contention Utah L/QQ, Subpart E?

A15. Yes. As admitted by the Licensing Board, Unified Contention Utah L/QO, Subpart E, states as follows:

> **Unified Consolidated Contention Utah L/QQ (Geotechnical)**
>
> * * *
>
> **E. Seismic Exemption.**
> Relative to the PFS seismic analysis supporting its application and the PFS April 9, [sic] 1999 request for an exemption from the requirements of 10 C.F.R. § 72.102(f) to allow PFS to employ a probabilistic rather than a deterministic seismic hazards analysis, PFS should be required either to use a probabilistic methodology with a 10,000-year return period or comply with the existing deterministic analysis requirement of section 72.102(f), or, alternatively, use a return period significantly greater than 2000 years, in that:
>
> 1. The requested exemption fails to conform to the SECY-98-126 (June 4, 1998) rulemaking plan scheme, i.e., only 1000-year and 10,000-year return periods are specified for design earthquakes for safety-important systems, structures, and components (SSCs) -- SSC Category 1 and SSC Category 2, respectively -- and any failure of an SSC that exceeds the radiological requirements of 10 C.F.R. § 72.104(a) must be designed for SSC Category 2, without any explanation regarding PFS SSC compliance with section 72.104(a).
>
> 2. PFS has failed to show that its facility design will provide adequate protection against exceeding the section 72.104(a) dose limits.
>
> 3. The staff's reliance on the reduced radiological hazard of stand-alone ISFSIs as compared to commercial power reactors as justification for granting the PFS exemption is based on incorrect factual and technical assumptions about the PFS facility's mean annual probability of exceeding a safe shutdown earthquake (SSE), and the relationship between the median and mean probabilities for exceeding an SSE for central and eastern United States commercial power reactors and the median and mean probabilities for exceeding an SSE for the PFS facility.
>
> 4. In supporting the grant of the exemption based on 2000-year return period, the staff relies upon the United States Department of Energy (DOE) standard,

DOE-STD-1020-94, and specifically the category-3 facility SSC performance standard that has such a return period, notwithstanding the fact the staff categorically did not adopt the four-tiered DOE category scheme as part of the Part 72 rulemaking plan.

5. In supporting the grant of the exemption based on the 2000-year return period, the staff relies upon the 1998 exemption granted to DOE for the Idaho National Engineering and Environmental Laboratory (INEEL) ISFSI for the Three Mile Island, Unit 2 (TMI-2) facility fuel, which was discussed in SECY-98-071 (Apr. 8, 1998), even though that grant was based on circumstances not present with the PFS ISFSI, including (a) existing INEEL design standards for a higher risk facility at the ISFSI host site; and (b) the use of a peak design basis horizontal acceleration of 0.36 g that was higher than the 2000-year return period value of 0.30 g.

6. Because (a) design levels for new Utah building construction and highway bridges are more stringent; and (b) the PFS return period is based on the twenty-year initial licensing period rather than the proposed thirty- to forty-year operating period, the 2000-year return period for the PFS facility does not ensure an adequate level of conservatism.

Q16. Do you agree with the assertion in Part E of this contention, that PFS "should be required either to use a probabilistic methodology with a 10,000-year return period or comply with the existing deterministic analysis requirement of section 72.102(f), or, alternatively, use a return period significantly greater than 2000 years"?

A16. No.

Q17. Please provide the bases for this conclusion.

A17. First, as set forth in the Staff's Consolidated SER and discussed above, the Applicant's use of a PSHA methodology is acceptable. The Commission has indicated that, in adopting a risk-informed philosophy for regulation, probabilistic methods are appropriate, as shown in recent revisions to NRC regulations (*e.g.*, 10 C.F.R. Parts 50 and 100) and the issuance of regulatory guidance (*e.g.*, Regulatory Guide 1.165). In addition, the PSHA methodology has been

accepted by the scientific and engineering community as a well-founded approach to evaluate seismic hazards and, in particular, to incorporate the uncertainties in the evaluation process.

Second, for the reasons discussed above, the use of a return period of 10,000 years, or a return period that is "significantly greater than 2,000 years" is not necessary; rather, the use of ground motions with a 2,000-year return period provides an adequate basis for the seismic design of the proposed PFS Facility, particularly when considering the lower radiological risk that an ISFSI with a dry cask storage system presents as compared to a nuclear power plant. This matter is discussed in greater detail below, with respect to Part E, paragraph 3 of the contention.

Q18. In Part E, paragraph 1 of the contention, the State asserts that the Applicant's exemption request "fails to conform to the SECY-98-126 (June 4, 1998) rulemaking plan scheme," in which only 1000-year and 10,000-year return periods are specified for design earthquakes for [SSCs]", and that "any failure of an SSC that exceeds the radiological requirements of 10 C.F.R. § 72.104(a) must be designed for SSC Category 2." Do you believe this presents a valid concern?

A18. No.

Q19. Please provide the bases for this conclusion.

A19. First, the Staff does not consider that SECY-98-126 established a regulation or proposed regulation, but only set out a proposed regulatory approach. Further, the Commission has now approved a modification of that proposed regulatory approach in SECY-01-0178, which supercedes the approach proposed in SECY-98-0126. The favored option in SECY-01-0178 proposes a seismic design in conjunction with a PSHA methodology under 10 C.F.R. Part 72, based on ground motions with a mean annual probability of exceedance of 5×10^{-4} (2,000 year return period ground motion). Thus, the Staff does not view the approach specified in SECY-98-126 as having regulatory significance at this time, especially in light of the Commission's approval of the modified rulemaking plan in SECY-01-0178.

Second, the approach proposed in SECY-98-126 was not followed by the Commission in its approval of the TMI-2 ISFSI exemption request, where the Commission approved an exemption from the deterministic criteria of 10 C.F.R. § 72.102(f)(1) and allowed the ISFSI applicant to use a PSHA with a seismic design based on ground motions with ~~an~~ a mean annual probability of exceedance of 5×10^{-4} (2,000-year return period). Thus, in the only other ISFSI seismic exemption approved to date, the Commission did not follow the approach reflected in the original rulemaking plan, but instead followed the approach that is reflected in the subsequent modified rulemaking plan, based on a PSHA methodology with ground motions having a mean annual probability of exceedance of 5×10^{-4} (2,000 year-return period). While the Staff does not view the TMI-2 ISFSI exemption as establishing a generic precedent, the TMI-2 exemption does provide a pertinent reference point.

Third, in adopting the regulations in 10 C.F.R. Part 72, the Commission indicated that the design earthquake for an ISFSI should be determined on a <u>case-by-case</u> basis.

> [F]or ISFSI's which do not involve massive structures, such as dry storage casks and canisters, the required design earthquake will be determined on a case-by-case basis until more experience is gained with the licensing of these types of units.

Statement of Consideration, 45 Fed. Reg. at 74,697. The Staff's approval of the PFS exemption request constitutes such a case-specific approval, as contemplated in the Commission's Statement of Consideration, and is based upon consideration of the safety of the proposed PFS Facility in the event of an earthquake, as compared to the radiological risks of a major seismic event at a nuclear power plant.

Q20. In Part E, paragraph 2 of the contention, the State asserts that "PFS has failed to show that its facility design will provide adequate protection against exceeding the section 72.104(a) dose limits." Do you believe this presents a valid concern?

A20. No.

Q21. Please provide the bases for this conclusion.

A21. We believe that the State's assertion that PFS has failed to show that its facility design will provide adequate protection against exceeding the dose limits in 10 C.F.R. § 72.104(a) is misplaced. As discussed in the NRC Staff's Testimony of Michael Waters, filed herewith, we understand that this regulatory standard applies to normal operations and anticipated occurrences -- *i.e.*, events which are anticipated to occur during the license term -- rather than design basis earthquakes, for which the dose limits specified in 10 C.F.R. § 72.106(b) would apply. Moreover, as set forth in the NRC Staff's testimony of Daniel J. Pomerening, Vincent Luk and Michael Waters filed herewith, and in the Consolidated SER (Chapter 15), we understand that the HI-STORM 100 storage casks are not expected to slide into each other, tipover, or release radiological materials in the event that design basis (or significantly larger) earthquake ground motions occur at the proposed PFS Facility.

Q22. In Part E, paragraph 3 of the contention, the State asserts that "the Staff's reliance on the reduced radiological hazard of stand-alone ISFSIs as compared to commercial power reactors as justification for granting the PFS exemption is based on incorrect factual and technical assumptions about the PFS facility's mean annual probability of exceeding a safe shutdown earthquake (SSE), and the relationship between the median and mean probabilities for exceeding an SSE for central and eastern United States commercial power reactors and the median and mean probabilities for exceeding an SSE for the PFS facility." Do you believe this presents a valid concern?

A22. No.

Q23. Please provide the bases for this conclusion.

A23. This conclusion is supported by a number of considerations. First, as discussed above, the Commission has recognized that the potential consequences of seismically initiated

failures at the proposed PFS Facility would be much less severe than the potential consequences of seismically-induced failures at an operating nuclear power plant. The PFS SAR proposes static operations involving spent nuclear fuel that is continuously contained in a multi-purpose canister ("MPC") inside a shipping, transfer or storage cask, as compared to complex operations at nuclear power plants which involve the fission of nuclear material at elevated temperatures and pressures, and/or the storage of spent nuclear fuel in spent fuel pools without the confinement boundary afforded by an MPC. In this regard, in considering the appropriate mean annual probability of exceedance (return period) for seismic design ground motions, the Staff was guided by the Commission's Statement of Consideration in adopting 10 C.F.R. Part 72, in which the Commission stated:

> Radiological risks to the public result from a release of radioactive materials and their dispersal to the environment. Once in place, spent fuel storage is a static operation and during normal operations the conditions required for the release and dispersal of significant quantities of radioactive materials are not present. There are no high temperatures or pressures present during normal operations or under design basis accident conditions to cause the release and dispersal of radioactive materials. This is primarily due to the low heat generation rate of spent fuel with more than one year of decay before storage in an ISFSI required by the rule [in Part 72] and with the low inventory of volatile radioactive materials readily available for release to the environs.

45 Fed. Reg. at 74,694.

Second, Regulatory Guide 1.165 determined the Reference Probability (e.g., the annual probability of exceedance) to be used to determine the safe shutdown earthquake (SSE) at future nuclear power plant sites, based on an analysis of the SSEs at 29 existing NPP sites. As set forth therein, the 29 plant sites used in the analysis were relatively recent power plant designs that used the Regulatory Guide 1.60 (1973) or similar spectral shapes in their seismic design; further, the use of these 29 NPP sites, and the use of the Reg. Guide 1.60 spectral shapes, was found to ensure "an adequate level of conservatism in determining an SSE consistent with licensing decisions."

Significantly, the analysis performed in Regulatory Guide 1.165 used the median probability of exceedance of the SSEs, and established a Reference Probability for nuclear power plant SSEs of 1×10^{-5} (100,000-year return period).

Further analysis of Regulatory Guide 1.165, provided in "Revision of Seismic and Geologic Siting Criteria (Murphy, et al., 1997), indicates the median-based Reference Probability determined for 29 NPP sites, is approximately an order of magnitude smaller than a similarly determined mean-based Reference Probability that is derived from the mean probability of exceeding the NPP site SSEs. Thus, the median-based Reference Probability in Regulatory Guide 1.165 of 1×10^{-5} (100,000 year return period) is approximately equal to a mean-based Reference Probability of 1×10^{-4} (10,000 year return period).

The above comparison of mean and median values suggests that the appropriate mean-based Reference Probability for SSEs for new nuclear power plants would be 1×10^{-4} (10,000 year return period). A similar conclusion was reached by DOE in Appendix C of its recent revision to DOE-STD-1020-94 (*i.e.*, DOE-STD-1020-2002). In that analysis, DOE analyzed the mean annual probability of exceedance of 69 NPP SSEs, and concluded that the appropriate mean-based reference probability is slightly greater than 1×10^{-4} (10,000 year return period). It should be noted that these 69 NPPs are all in the Eastern United States.

The Staff came to a similar conclusion about the appropriate mean annual probability of exceedance for the seismic design ground motion, in its evaluation of the TMI-2 ISFSI exemption request. In the safety evaluation attached to SECY-98-071, the Staff stated:

> [DOE] Standard 1020 defines four performance categories (PCs) for structures, systems, and components (SSCs) important to safety, with PC 4 facilities being those with potential accident consequences similar to a commercial nuclear power plant. Such facilities must have a design earthquake equal to the mean seismic ground motion with a 10,000-year return period.

SECY-98-071, at 3 (emphasis added).

Similarly, the safety evaluation attached to SECY-98-071 indicated that both DOE PC-4 facilities and commercial nuclear power plants must be designed to withstand "the mean seismic ground motion with a 10,000-year return period," and further stated that under Regulatory Guide 1.165 ("Identification and Characterization of Seismic Sources and Determination of Safe Shutdown Earthquake Ground Motion"), "a future NPP licensed by the NRC in the western United States would be allowed to design to this same level." SECY-98-071, Attachment at 3.

In fact, following the procedures of Regulatory Guide 1.165 for NPPs in the western United States, the average annual probability of exceeding the SSE would be greater than 1×10^{-4} (10,000-year return period). Such an evaluation was carried out by DOE, which concluded that the mean annual probability of exceeding the design basis ground motions for NPPs in the western United States is approximately 2×10^{-4} (5,000-year return period).

In light of the fact that the radiological risks of an ISFSI are inherently lower than the radiological risks at NPPs, and thus an ISFSI's design ground motions need not be as large (*i.e.*, improbable) as those used for NPP design, the Staff concluded that the appropriate mean annual probability of exceedance of the proposed PFS Facility's seismic design ground motion should be greater than the NPP value of 1×10^{-4} (10,000-year return period), and may be greater than the average mean annual probability of exceeding the SSE at NPPs in the western United States of approximately 2×10^{-4} per year (5,000-year return period).

In sum, contrary to the State's assertion, the Staff correctly understood the difference between mean and median values, and properly considered the mean annual probability of exceeding the seismic design ground motions.

Q24. In Part E, paragraph 4 of the contention, the State asserts that "in supporting the grant of the exemption based on 2000-year return period, the staff relies upon the United States Department of Energy (DOE) standard, DOE-STD-1020-94, and specifically the category-3 facility

SSC performance standard that has such a return period, notwithstanding the fact the staff categorically did not adopt the four-tiered DOE category scheme as part of the Part 72 rulemaking plan." Do you believe this presents a valid concern?

A 24. No.

Q25. Please provide the bases for this conclusion.

A25. The Staff did not adopt DOE-STD-1020-94 in approving the 2,000-year return period as the basis to determine the seismic design ground motions of the proposed PFS Facility. Rather, as discussed above, the Staff referred to the DOE Standard as a point of reference, in that DOE-STD-1020-94 established a mean reference probability corresponding to a 2,000-year return period as the basis for determining the design ground motions for DOE Performance Category-3 SSCs. DOE PC-3 facilities are generally comparable to NRC-licensed ISFSIs. Accordingly, while the Staff referred to the DOE Standard, it did not attempt to impose DOE-STD-1020-94 as a regulatory standard on the proposed PFS Facility, nor did it find any reason to require an NRC license applicant (here, PFS) to justify its seismic exemption request on the type of analysis that DOE might conduct under the DOE Standard, in order to meet all the specified DOE requirements.

The underlying philosophy of DOE-STD-1020-94 is to use a risk-graded approach in establishing the seismic (or other) hazard's mean annual probability of exceedance, and in establishing design and evaluation criteria to satisfy performance goals for different categories of critical facilities. Although not expressed in the same terminology, the Staff's evaluation and approval of a seismic design ground motion corresponding to a 2,000-year return period for the proposed PFS Facility relies on a consideration of risk. Thus, as discussed above, the Staff considered (a) the Commission's risk-related statements in the Statement of Consideration issued upon its adoption of the regulations in 10 C.F.R. Part 72; (b) the Commission's previous approval of the seismic design ground motion with a 2,000-year return period for the TMI-2 ISFSI, which

included a quantitative risk assessment; and (c) the DOE standard which similarly recognizes that PC-3 facilities present lower radiological risks than PC-4 facilities (which are similar to a NPP). For example, in SECY-98-071, the Staff stated as follows:

> The staff also considered the relative risk posed by the ISFSI. The staff examined relative risk by referring to DOE Standard 1020 . . . . This standard takes a graded approach to designing critical facilities, requiring facilities with greater accident consequences to use higher design requirements for phenomena such as earthquakes . . . . Dry spent fuel storage facilities such as the TMI-2 ISFSI, are PC 3 and must have a design earthquake equal to the mean ground motion with a 2000-year return period. Considering the minor radiological consequences from a canister failure, and the lack of a credible mechanism to cause a failure, the staff finds that the DOE approach of using the 2000-year return period mean ground motion as the design earthquake for dry storage facilities is adequately conservative.

SECY-98-071 at 3. Thus, considerations of radiological risk entered into the Staff's determination to approve the use of a seismic design ground motion with a 2,000-year return period, as derived from the Applicant's PSHA for the proposed PFS Facility.

Q26. Are you familiar with DOE's issuance of a revision to DOE-STD-1020-94, in a DOE-STD-1020-2002, dated January 2002?

A26. Yes.

Q27. Are your conclusions affected by this development?

A27. No. In DOE-STD-1020-2002, DOE revised its Standard by changing the hazard annual probability of exceedance for the seismic design ground motion for PC 3 SSCs, from a mean annual probability of exceedance of 5×10^{-4} (2,000-year return period) to 4×10^{-4} (2,500-year return period). The Staff has discussed this development with the DOE official responsible for making this change (Dr. Harish Chander). Based on these conversations, we understand that the revision was not based upon technical considerations, but instead was undertaken in order to make the DOE standard consistent with U.S. Geological Survey National Earthquake Hazard Reduction

Program ("NEHRP") maps, and thereby result in analytical descriptions of seismic hazards that can be more readily used in conjunction with the USGS NEHRP maps.

Notwithstanding DOE's revision of this Standard, the fact that DOE made this change in the hazard annual probability of exceedance for determining the seismic design ground motion for PC-3 facility SSCs from 5×10^{-4} (2,000-year return period) to 4×10^{-4} (2,500-year return period), is inconsequential. This revision results in a small change in the mean probability of exceedance of the seismic design motion, as compared to the uncertainty in the estimate of the probability of exceedance of earthquake ground motions. For these reasons, DOE's revision to DOE-STD-1020-2002 does not affect our conclusion as to the acceptability of the PFS seismic exemption request, insofar as it is based upon an analogy to DOE's PC-3 hazard annual probability level.

Q28. In Part E, paragraph 5 of the contention, the State asserts that "in supporting the grant of the exemption based on the 2000-year return period, the Staff relies upon the 1998 exemption granted to DOE for the [TMI-2 ISFSI], . . . even though that grant was based on circumstances not present with the PFS ISFSI, including (a) existing INEEL design standards for a higher risk facility at the ISFSI host site; and (b) the use of a peak design basis horizontal acceleration of 0.36 g that was higher than the 2000-year return period value of 0.30 g." Do you believe this presents a valid concern?

A28. No.

Q29. Please provide the bases for this conclusion.

A29. The Staff's evaluation of the TMI-2 ISFSI exemption request and the reasons for granting that request are clearly described in the TMI-2 ISFSI docket, including SECY-98-071. Specifically, with respect to the assertions in this part of Contention Utah L/QQ, Part E, it should be noted that (a) "existing INEEL design standards for a higher risk facility at the INEEL host site" did not play any role in the approval of the TMI-2 ISFSI exemption request; and (b) although the

TMI-2 ISFSI had been designed to a slightly higher standard than the ground motion that has a 2,000-year return period (5×10^{-4} mean annual probability of exceedance), the Commission approved the lower 2,000-year ground motion as the acceptable seismic design basis for the facility. Both of these conclusions are evident in SECY-98-071.

The State's reference to "existing INEEL design standards" appears to be a reference to the INEEL architectural engineering ("AE") standards. The INEEL AE standards resulted in DOE's selection of a peak design basis horizontal acceleration for the Idaho Chemical Processing Plant ("ICPP") site of 0.36 g, including the effects of soil amplification. Inasmuch as the TMI-2 ISFSI was placed at the ICPP site, DOE utilized the same standard in constructing the lower-risk TMI-2 ISFSI. However, DOE's decision to utilize that same standard in constructing the TMI-2 ISFSI did not result in a determination by the Staff that a 0.36 g ground motion be used as the basis for approving the exemption request.

Second, in approving a design basis ground motion for the TMI-2 ISFSI, the Staff (and Commission) approved the use of design ground motions that have a mean annual probability of exceedance of 5×10^{-4} (2,000-year return period), with an associated peak horizontal acceleration of 0.30 g, as an acceptable design basis for the facility. Thus, SECY-98-071 states, "[g]iven the absence of radiological consequences from any credible seismic event, the Staff finds that the DOE Standard 1020 risk-graded approach of using the 2000-year mean return period ground motion as the DE (design earthquake) is adequately conservative."

The TMI-2 ISFSI exemption is pertinent in another respect. In this regard, we note that the Staff's (and the Commission's) approval of a 2,000-year return period design basis ground motion for the TMI-2 ISFSI was based, in part, on an assessment of the radiological risks at that facility. Thus, in SECY-98-071, the Staff noted that it had considered the public health and safety consequences of a major seismic event occurring at the facility. Accident analyses for the design

basis ground motion at the TMI-2 ISFSI showed that the consequences were bounded by a canister drop onto the concrete pad -- and that the casks and canisters were designed to withstand such events with no release of radioactive materials. Likewise, accident analyses for the proposed PFS Facility have similarly concluded that a cask drop event would not result in the release of radioactive materials, as is discussed in the NRC Staff's testimony of Michael Waters, filed herewith. Thus, the TMI-2 ISFSI example is also analogous for this reason, with respect to the Applicant's seismic exemption request for the proposed PFS Facility.

Q30. In Part E, paragraph 6 of the contention, the State asserts that "because (a) design levels for new Utah building construction and highway bridges are more stringent; and (b) the PFS return period is based on the twenty-year initial licensing period rather than the proposed thirty- to forty-year operating period, the 2000-year return period for the PFS facility does not ensure an adequate level of conservatism." Do you believe this presents a valid concern?

A30. No.

Q31. Please provide the bases for this conclusion.

A31. We believe that the State's first assertion ("design levels for new Utah building construction and highway bridges are more stringent") is not correct. A comparison between the probability of exceedance of the design basis ground motions is not the appropriate metric on which to judge the level of conservatism in the design of facilities of different types. Rather, an appropriate comparison should consider all elements of the seismic design process, including the probability of exceeding the seismic design ground motions, the factors of safety and conservatism in the seismic design and evaluation of SSCs, requirements with regard to design details and quality assurance, and the consequences of failure. For example, DOE-STD-1020-94 considers the differences between the factors of safety that are provided in building codes for ordinary structures and those provided for critical facilities such as nuclear reactors. Inasmuch as SSCs

important to safety at the proposed PFS Facility will be designed to NRC seismic design requirements, the resulting factors of safety and conservatism will be greater than those achieved by building codes. Thus, the State's assertion is invalid, in that it does not discuss these factors.

Further, the State's second assertion ("the PFS return period is based on the twenty-year initial licensing period rather than the proposed thirty- to forty-year operating period") is misplaced. Consistent with established engineering practice, design basis earthquake ground motions are based on the risk at a facility, which includes a mean annual probability of exceedance, determined using the existing information, and potential consequences of seismically initiated failures. The Staff's approval of the PFS exemption request was based on the use of seismic design ground motions that have a mean annual probability of exceedance of 5×10^{-4} (2000-year return period) -- *i.e.*, this determination was based on the mean annual seismic hazard at the facility, and not upon a consideration of the licensing period. In the event that PFS receives a license and later seeks to extend or renew the license term, the Staff would evaluate that request based on available information and analyses at that time.

Q32. Does this conclude your testimony?

A32. Yes.

JOHN A. STAMATAKOS
Principal Scientist
Center for Nuclear Waste Regulatory Analyses
Southwest Research Institute
6220 Culebra Rd. (Bldg. 189)
San Antonio, Texas 78238

EDUCATION:

B.A., Geology, Franklin and Marshall College, Lancaster, Pennsylvania, 1981
M.S., Geology, Lehigh University, Bethlehem, Pennsylvania, 1988
Ph.D., Geology, Lehigh University, Bethlehem, Pennsylvania, 1990

GENERAL QUALIFICATIONS:

Dr. Stamatakos is a structural geologist and geophysicist with international research experience in regional and global tectonics. Dr. Stamatakos has conducted research on a range of topics including paleomagnetism, neotectonics, kinematics of fault block rotations in strike-slip, normal, and thrust fault systems, effects of internal strain on the magnetic properties of deformed rocks, evolution of curvature in arcuate mountain belts, and age and sequence of deformation in folded and faulted mountain belts. This research has focused on the northern and central Appalachians in the eastern United States and Canada, the Hercynian mountains in Germany and northern Spain, the Rocky Mountains and Basin and Range in the western United States, and the northern Cordilleran Mountains in Alaska. Other strengths include numerical modeling of deformation, magnetostratigraphy, rock magnetism, and exploration geophysics.

As a Principal Scientist in the Center for Nuclear Waste Regulatory Analyses, Dr. Stamatakos is the Principal Investigator for structural deformation and seismicity, including tectonics and neotectonics research. Tectonics research at CNWRA currently includes compiling a tectonics Geographic Information System (GIS) database, field analyses of the structural and tectonic elements of the Basin and Range province in southwestern United States, evaluation of seismic and faulting hazards at nuclear facilities (including the proposed repository at Yucca Mountain, Nevada; the proposed storage facilities at Skull Valley, Utah; INEEL, Idaho; and Diablo Canyon, California; and the Fuel Fabrication Facilities at Paducah, Kentucky and Savannah River, South Carolina). These investigations, sponsored by the U.S. Nuclear Regulatory Commission, currently support development of the structural, seismological, and tectonic framework for evaluation of risk of earthquakes and volcanic activity, and the effects of structures and tectonic processes on groundwater flow in the region surrounding nuclear facilities.

Prior to coming to CNWRA, Dr. Stamatakos held positions as a visiting faculty at the University of Michigan and as a postdoctoral fellow at the Eidgenössische Technische Hochschule (ETH) in Zurich, Switzerland. At the University of Michigan, Dr. Stamatakos taught courses in field mapping, structural geology, geophysics, and tectonics. Dr. Stamatakos has written or collaborated on nearly 50 papers and reports on seismology, structural geology, tectonics, and geophysics. He has made presentations at international conferences in the U.S., Canada, Asia, and Europe and has won an outstanding paper award from the American Geophysical Union.

Dr. Stamatakos is associate editor of the Geological Society of America Bulletin, former GP Editor for EOS of the American Geophysical Union, and is a regular reviewer of papers for the Journal of Geophysical Research, Earth and Planetary Science Letters, Journal of Geophysics, Journal of Structural Geology, Physics of the Earth and Planetary Sciences, Tectonophysics, Journal of Geology, Geophysical Journal International, Geological Society of America Bulletin, and Geophysical Research Letters as well as grant proposals for the National Science Foundation.

Acquired NSF and similar institutional grant support for research. Taught geology and geophysics at both undergraduate and graduate levels, including two summer field camp sessions. Co-developed and taught advanced field course for petroleum-industry geologists. Supervised undergraduate, master, and Ph.D. research, including service as external committee member on several masters theses and a Ph.D. dissertation.

Memberships: Seismological Society of America, Geological Society of America, American Geophysical Union, Sigma Xi.

PROFESSIONAL EXPERIENCE

2002: Principal Research Scientist, Center for Nuclear Waste Regulatory Analyses, Southwest Research Institute, San Antonio, Texas

1996-2002: Senior Research Scientist, Center for Nuclear Waste Regulatory Analyses, Southwest Research Institute, San Antonio, Texas.

1995-1996: Research Scientist, Center for Nuclear Waste Regulatory Analyses, Southwest Research Institute, San Antonio, Texas.

1995-2001: Adjunct Research Scientist, Department of Geological Sciences, University of Michigan, Ann Arbor, Michigan.

1999-2002: Adjunct Professor, Incarnate Word University, Palo Alto College, University of Texas at San Antonio, all in San Antonio, Texas.

1992-1994: Visiting Assistant Professor, Department of Geological Sciences, University of Michigan, Ann Arbor, Michigan.

1990-1992: Research Associate: Eidgenössische Technische Hochschule (ETH), Institut für Geophysik, Zürich, Switzerland.

1984-1990: Research and Teaching Assistant, Lehigh University, 1984–1990.

1981-1983: Petroleum Geologist, Analex Geosciences, 1981–1983.

RESEARCH INTERESTS:

Global and regional tectonics through the study of earthquake seismology, paleomagnetism, structural geology, neotectonics, magnetostratigraphy, potential-field geophysics (gravity and magnetics), fission-track thermochronology, and numerical modeling.

PUBLICATIONS

Stamatakos, J.A., J. M. Trop, and K. D. Ridgway, 2001, Late Cretaceous paleogeography of Wrangellia: Paleomagnetism of the MacColl Ridge Formation, southern Alaska, Revisited: *Geology*, v29, p.947–950.

Ferrill, D.A., A.P. Morris, J.A. Stamatakos, and D. Sims, 2000, Crossing Conjugate Normal Fault: *American Association of Petroleum Geologists*, v. 84, p. 1543–1559.

Connor, C.B., J.A. Stamatakos, D.A. Ferrill, B.E. Hill, G.O. Ofoegbu, M.F. Conway, B. Sagar, and J. Trapp, 2000, Geological factors controlling patterns of small-volume basaltic volcanism: Application to a volcanic hazards assessment at Yucca Mountain, Nevada: *Journal of Geophysical Research*, v. 105, p. 417–432.

Ferrill., D.A., J.A. Stamatakos, and D. Sims, 1999, Normal fault corrugation: Implications for growth and seismicity of active normal faults: *Journal of Structural Geology*, v. 21, p.1027-1038, 1999.

D. Sims, D.A. Ferrill, and J.A. Stamatakos, 1999, Role of ductile décollement zone horizons in the development of pull-apart basins: Experimental results and natural examples: *Journal of Structural Geology*, v. 21, p. 533–554.

Stamatakos, J.A., and D.A. Ferrill, 1998, Comment on "Strike-slip fault system in Amargosa Valley and Yucca Mountain, Nevada," *Tectonophysics*, v. 294, p. 151–160.

Stamatakos, J.A., D.A. Ferrill, and K.P. Spivey, 1998, Paleomagnetic constraints on the tectonic evolution of Bare Mountain, Nevada, *Geological Society of America Bulletin*, v. 100, p. 1530–1546.

Connor, C.B., J.A. Stamatakos, D.A. Ferrill, and B.E. Hill, 1998, Comment on "Anomalous strain accumulation in the Yucca Mountain area", Nevada, *Science*, v. 282, p.107b.

Ferrill, D.A., Morris, A.P., S.M. Jones, and J.A. Stamatakos,1998, Extensional layer-parallel shear and normal faulting, *Journal of Structural Geology*, v. 20, p. 355–362.

Gray, M. B., and J. A. Stamatakos, 1997, A new model for evolution of fold and thrust belt curvature based on integrated structural and paleomagnetic results around the Pennsylvania salient, *Geology*, v. 25, p.1067–1070

Clyde, W. C., J. P. Zonneveld, J. A. Stamatakos, G. G. Gunnell, and W. S. Bartels, 1997, Magnetostratigraphy across the Wasatchian-Bridgerian boundary (Early to Middle Eocene) in the western Green River basin, *Journal of Geology*, v. 105, p. 657–669.

Ofoegbu, G. I., D. A. Ferrill, K. J. Smart, and J. A. Stamatakos, 1997, Uncertainties in earthquake magnitudes from surface displacements based on finite element modeling, *International Journal of Rock Mechanics and Mining Science*, v. 34, no 3-4, paper number 233.

Van der Voo, R., J. A. Stamatakos, and J. M. Parés, 1997, Kinematic constraints on thrust-belt curvature from syndeformational magnetizations in the Lagos del Valle Syncline in the Cantabrian Arc, Spain, *Journal of Geophysical Research,* v. 102, p.10,105–10,119.

Connor, C. B., S. Lane-Magsino, J. A. Stamatakos, R. H. Martin, P. C. LaFemina, B. H. Hill, and S. Lieber, 1997, Magnetic surveys help reassess volcanic hazards at Yucca Mountain, Nevada, *EOS, Transactions of the American Geophysical Union,* v. 78: p. 73, 77–78.

Ferrill, D.A., J.A. Stamatakos, and H.L. McKague, Quaternary slip history of the Bare Mountain fault (Nevada) from the morphology and distribution of alluvial fan deposits: REPLY, *Geology,* v. 25, p. 190.

Conway, F.M., D.A. Ferrill, C.M. Hall, A.P. Morris, J.A. Stamatakos, C.B. Connor, A. Halliday, and C. Condit, 1997, Timing of volcanism along the Mesa Butte Fault in the San Francisco Volcanic Field, Arizona from $^{40}AR/^{39}Ar$ Ages: Implications for the longevity of cinder cone alignments, *Journal of Geophysical Research,* v. 102, p. 815–824.

Stamatakos, J.A., C.B. Connor, and R.H. Martin, 1997, Quaternary volcanism and basin evolution of Crater Flat, Nevada from detailed ground magnetic surveys of the Little Cones, *Journal of Geology,* v. 105, p. 319–330.

Ferrill, D.A., Stamatakos, J.A., S.M. Jones, Rahe, B., McKague, H.L., R.H. Martin, and A.P. Morris, 1996, Quaternary slip history of the Bare Mountain Fault (Nevada) from the morphology and distribution of alluvial fan deposits, *Geology,* v. 24, p. 559–562.

Todaro, S. M., J. Stamatakos, B. A. van der Pluijm, and R. Van der Voo, 1996, Near-Laurentian paleogeography of the Lawrence Head volcanics of central Newfoundland, northern Appalachians, *Tectonophysics,* v. 263, p. 107–121.

Parés, J. M., R. Van der Voo, and J. Stamatakos, 1996, Paleomagnetism of Permian and Triassic redbeds of NW Spain and their bearing on the tectonic evolution of the Cantabrian Arc, *Geophysical Journal International*, v. 126, p. 893–901.

Stamatakos, J., A. M. Hirt, and W. Lowrie, 1996, The age and timing of folding in the central Appalachians from paleomagnetic data, *Geological Society of America Bulletin*, v. 108, p.815–829.

Stamatakos, J., A. Lessard, R., B. A. van der Pluijm, and R. Van der Voo, 1995, Paleomagnetic and magnetic fabric results from the Springdale and Wigwam redbeds of Newfoundland and their implications for the Silurian paleopole controversy, *Earth and Planetary Science Letters,* v. 132, p.141–155.

Pares, J. M., R. Van der Voo, J. Stamatakos, and A. Pérez-Estaún, 1994, Remagnetization and post-folding oroclinal rotations in the Cantabrian/Asturian Arc, northern Spain, *Tectonics,* v. 13, p.1461–1471.

Clyde, William C., J. Stamatakos, and P. D. Gingerich, 1994, Chronology of the Wasatchian Land-Mammal Age (Early Eocene): Magnetostratigraphic results from the McCullough Peaks Section, northern Bighorn Basin Wyoming, *Journal of Geology,* v. 102, p. 367–377.

Stamatakos, J., R. Van der Voo, B. van der Pluijm, S. Potts, and T. Torsvik, 1994, Comment on the Early Silurian Paleolatitude of the Springdale Group redbeds of central Newfoundland: A paleomagnetic determination with a remanence anisotropy test for inclination error, *Geophysical Journal International,* v. 119, p.1009–1013.

van Der Pluijm, B. A., R. Van der Voo, S. S. Potts, and J. Stamatakos, 1993, Early Silurian paleolatitudes for central Newfoundland from paleomagnetism of the Wigwam Formation: Discussion, *Canadian Journal of Earth Sciences*, v. 30, p.644–645.

Stamatakos, J. and A. M. Hirt, 1993, Paleomagnetic considerations of the development of the Pennsylvania salient in the central Appalachians, *Tectonophysics*, v. 231, p. 237–255.

Stamatakos, J. and K. P. Kodama, 1991, The effects of grain scale deformation on the Bloomsburg Formation pole; *Journal of Geophysical Research*, v. 96, p. 17,919–17,933.

Stamatakos, J. and K. P. Kodama, 1991, Flexural flow folding and the paleomagnetic fold test; An example of strain reorientation of remanence in the Mauch Chunk Formation; *Tectonics*, v. 10, p. 807–819.

Stamatakos, J., K. P. Kodama, T. P. Pavlis, and L. Vittorio, 1989, Paleomagnetism of Cretaceous and Paleocene sedimentary rocks across the Castle Mountain Fault, south central Alaska: in J. W. Hillhouse ed., *Deep Structure and Past Kinematics of Accreted Terranes, IUGG, Geophysics Monograph 50*, p. 151-177.

Stamatakos, J., K. P. Kodama and T. P. Pavlis, 1988, Paleomagnetism of Eocene plutonic rocks, Matanuska Valley, Alaska, *Geology*, v. 16, p. 618–622.

Reports

Stamatakos, J.A., R. Chen, S Hsiung, and A.H. Chowdhury. 2002. Review of Seismic and Geotechnical Hazards Assessments for Mixed Oxide Fuel Fabrication Facility, Savannah River, South Carolina, Center for Nuclear Waste Regulatory Analyses, Southwest Research Institute, San Antonio, Texas.

Hsiung, S., R. Chen, A. Chowdhury, D. Daruwalla, B. Dasgupta, M. Diaz, D. Dunn, R. Green, S. Green, D. Gute, M Lesher, P Mackin, C. Manepally, D. Pomerening, O. Povetko, B. Russell, M. Smith, and J. Stamatakos. 2002. Acceptance review of License Application and Safety Analysis Report for Idaho Spent Fuel Facility, Center for Nuclear Waste Regulatory Analyses, Southwest Research Institute, San Antonio, Texas.

Waiting, D.J., R. Chen, J.G. Crider, W.M. Dunne, R.W. Fedors, D.A. Ferrill, M.B. Gray, B.E. Hill, P.C. LaFemina, H.L. McKague, A.P. Morris, D.W. Sims, and J.A. Stamatakos. 2001. Technical Assessment of Structural Deformation and Seismicity at Yucca Mountain, Nevada: Center for Nuclear Waste Regulatory Analyses, Southwest Research Institute, San Antonio, Texas.

Stamatakos, J.A., S, Hsiung, and A.H. Chowdhury. 2001. Final Review Plan for Seismic and Geotechnical Hazards Assessment of Mixed Oxide Fuel Fabrication Facility, Savannah River Site, South Carolina: Center for Nuclear Waste Regulatory Analyses, Southwest Research Institute, San Antonio, Texas.

Stamatakos, J.A, and K.P. Kodama. 2001. Strain and Paleomagnetism in the Bloomsburg Formation at the Delaware Gap Fold: *Guidebook for the 66th Annual Field Conference of Pennsylvania Geologists*, p. 28–34.

Stamatakos, J.A., A.H. Chowdhury. M.P. Miklas, R.T. Green, T. Krauthammer, and C.B. Connor, 2000, Review of Site Characteristics of Naval Reactors Spent Fuel ISFSI Site at INEEL: Preliminary Safety Evaluation Report - Final Letter Report, Center for Nuclear Waste Regulatory Analyses, Southwest Research Institute, San Antonio, Texas.

Farrell, D.A., A. Armstrong, J.R. Winterle, D.R. Turner, D.A. Ferrill, J.A. Stamatakos, N.M. Coleman, M.B. Gray, S.K. Sandberg. 1999. Structural controls on groundwater flow in the Yucca Mountain region, Center for Nuclear Waste Regulatory Analyses, Southwest Research Institute, San Antonio, Texas.

Chen, R., J.A. Stamatakos, A.H Chowdhury. 1999. Review of the Probabilistic Seismic Hazard Analyses for the Paducah Gaseous Diffusion Plant - Final Report, Center for Nuclear Waste Regulatory Analyses, Southwest Research Institute, San Antonio, Texas.

Stamatakos, J.A., R. Chen, M.W. McCann, Jr, A.H. Chowdhury. 1999. Seismic Ground Motion and Faulting Hazard at Private Fuel Storage Facility in the Skull Valley Indian Reservation, Tooele County, Utah, Center for Nuclear Waste Regulatory Analyses, Southwest Research Institute, San Antonio, Texas.

Justus, P.S., J.A., Stamatakos, D.A., Ferrill, and H.L.McKague. 1998, U.S. Nuclear Regulatory Commission's Resolution Report on Type I Faults and Tectonic Models: *Proceedings of the Eighth International Conference of High-Level Radioactive Waste Management, American Nuclear Society*, p. 233–235.

Chen, R., J.A. Stamatakos, and A.H. Chowdhury. 1998. Final Review Plan for Probabilistic Seismic Hazard Assessment of Paducah Site: Center for Nuclear Waste Regulatory Analyses, Southwest Research Institute, San Antonio, Texas.

Ferrill., D.A., J.A. Stamatakos, and D. Sims, 1997, Faults, traps, compartments and conduits: What hydrocarbons find that you may miss, Advance Field Course for Petroleum Geologists. Southwest Research Institute, San Antonio, Texas.

Stamatakos, J.A., P.S. Justus, D.A. Ferrill, R. Chen, and G.I. Ofoegbu, 1997, Structural Deformation and Seismicity, in *NRC High-Level Radioactive Waste Program Annual Progress Report: Fiscal Year 1996. NUREG/CR-6513, CNWRA96-OIA*, Budhi Sagar, ed., San Antonio, Texas.

Stamatakos, J.A., D.A. Ferrill, D.P. Cederquist, and R. Van der Voo, 1996, Structural framework of Alleghanian sequential deformation in the southwestern limb of the Pennsylvania salient from paleomagnetic and rock magnetic studies, in R. P. Nickelsen ed., *61st Annual Field Conference of Pennsylvania Geologists Guidebook*, p. 14–26.

McKague, L. J.A. Stamatakos, and D.A. Ferrill, 1996, Type I faulting in the Yucca Mountain Region, CNWRA 96-007, Center for Nuclear Waste regulatory Analyses, San Antonio, Texas.

Stamatakos, J.A., and D.A. Ferrill, 1996, *Tectonic Processes in the Central Basin and Range Region*, NRC High-Level Radioactive Waste Research at CNWRA, July-December, 1995, CNWRA 95-02S,B. Sagar, ed., Center for Nuclear Waste Regulatory Analyses, San Antonio, Texas, p. 6.1–6.25.

Ferrill, D.A., G.L. Stirewalt, D.B. Henderson, J.A. Stamatakos, A.P. Morris, B.P. Wernicke, and K.H. Spivey, 1996, *Faulting in the Yucca Mountain region: Critical review and analyses of tectonic data from the Central Basin and Range*, NUREG/CR-6401, CNWRA 95-017, Center for Nuclear Waste Regulatory Analyses, San Antonio, Texas.

Ferrill, D.A., D.B. Henderson, J.A. Stamatakos, K.H. Spivey, and A.P. Morris, 1995, Tectonic *Processes in the Central Basin and Range Region*, NRC High-Level Radioactive Waste Research at CNWRA, January-June, 1995, CNWRA 95-01S, B. Sagar, ed., Center for Nuclear Waste Regulatory Analyses, San Antonio, Texas, p. 6.1–6.27.

MARTIN W. McCANN, Jr.

President, Jack R. Benjamin & Associates, Inc.
530 Oak Grove Avenue Suite 101
Menlo Park, CA 94025

Education

B.S. - Civil Engineering, Villanova University, 1975
M.S. - Structural Engineering, Stanford University, 1976
Ph.D. - Civil Engineering, Stanford University, 1980

Memberships

Association of State Dam Safety Officials
United States Committee on Large Dams
Earthquake Engineering Research Institute
Seismological Society of America

Committees

National Academy of Engineering, National Research Council - Committee on Risk-Based Analyses for Flood Damage Reduction
Association of State Dam Safety Officials Affiliate Member Advisory Committee
U.S. Society on Dams Dam Safety Subcommittee
American Nuclear Society - ANS-2.29 Subcommittee Chairman - Probabilistic Analysis of Natural Phenomena Hazards for Nuclear Materials Facilities

Awards

1994 Engineering News-Record - Newsmaker
1995 Association of State Dam Safety Officials - Presidents Award

Experience

Jack R. Benjamin & Associates, Inc., Mountain View, CA (since 1979)

Dr. Martin W. McCann, Jr. is President of Jack R. Benjamin & Associates, Inc. (JBA). From 1984 to 1989 he served as Vice President of the corporation. His professional experience includes probabilistic hazards analysis, including seismic and hydrologic events, reliability assessment, probabilistic risk analysis (PRA) for critical facilities, systems analysis, and seismic engineering.

Dr. McCann is currently a consultant to the Southwest Research Institute, Center for Nuclear Waste Regulatory Analyses, in San Antonio, TX, and is participating in the CNWRA review of the probabilistic seismic hazard analysis (PSHA) on behalf of the U.S. Nuclear Regulatory Commission (NRC) with respect to the high level waste repository site proposed by the U.S. Department of Energy (DOE) to be located at Yucca Mountain, Nevada.

Dr. McCann recently provided support for the EPRI in developing a guidance document for utilities planning to submit an early site permit application for new commercial nuclear power plants. He authored the section of the guidance document dealing with seismic siting issues.

Dr. McCann is a consultant to the Swiss nuclear regulatory authority (HSK) in the area of probabilistic seismic hazard assessment. He prepared comprehensive guidelines for conducting detailed probabilistic seismic hazard assessments in Switzerland for nuclear power plant sites.

As a consultant to Bechtel National Corporation, Dr. McCann is leading the effort to perform a PRA for the tank waste processing facility on the DOE Hanford site. As part of this project, the team led by Dr. McCann is developing seismic systems models for the facility, conducting seismic fragility assessments and quantifying the frequency of exceedance of radiological dose levels to facility workers, co-located workers and the public.

As part of seismic studies conducted for nuclear power plants as part of the NRC Individual Plant Examination for External Events, Dr. McCann supported the development of seismic systems models (event and fault trees) and performed seismic risk calculations. These plants included Pilgrim, Kewaunee, Point Beach, Palisades, and Fort Calhoun.

As part of an NRC, DOE and Electric Power Research Institute (EPRI) project, Dr. McCann provided technical support for the Senior Seismic Hazards Advisory Committee that developed improved methods to conduct probabilistic seismic hazard studies. As part of his participation, Dr. McCann contributed to the committee's final report.

As part of a study at the DOE Savannah River Site, Dr. McCann was the project manager of a program to evaluate the risk to nuclear reactor facilities due to seismic events. JBA provided the seismic hazard and fragility input to the risk assessment. In addition, JBA conducted the risk quantification calculations, using software developed at JBA. For the Savannah River Site, Dr. McCann conducted an extensive comparative evaluation of the EPRI and Lawrence Livermore National Laboratory (LLNL) seismic hazard assessments. This study, which involved extensive modification of the EPRI and LLNL seismic hazard software, identified the source of the differences between the two studies and developed a single, composite estimate of the site hazard.

As part of a DOE, industry and EPRI study to evaluate future advanced light water reactor designs, Dr. McCann performed an extensive hazard assessment for the eastern United States. In this analysis the seismic hazard was mapped for the entire eastern United States at a grid spacing of 25 km. These hazard results were used to map the risk of a future nuclear power plant located anywhere in this area.

Dr. McCann was the project manager of a program to conduct an independent review of the EPRI seismic hazard software package, EQHAZARD. Following completion of the software review, JBA maintains the codes for EPRI according to Quality Assurance Standards.

Dr. McCann served on an expert panel organized by the CNWRA that reviewed approaches for fault hazard assessment at high-level waste repository sites.

Dr. McCann was the project manager of a study to evaluate the risk of failure of three lock and dam structures on the Upper Ohio River. This study was concerned with a 25-year projection of the frequency of the loss of function of the navigation locks due to natural and man-made hazards.

Dr. McCann directed a preliminary probabilistic risk assessment for PAR Pond Dam at the DOE Savannah River Site. The study included an assessment of the frequency of dam failure due to seismic, hydrologic, and static load events.

As part of the DOE and LLNL natural phenomena hazards project, Dr. McCann prepared the flood design criteria in Design and Evaluation Guidelines For Department of Energy Facilities Subjected to Natural Phenomena Hazards, UCRL-15910. He was the course lecturer for the flood part of the DOE workshop on natural phenomena hazard. The workshop addresses the DOE flood design guidelines, probabilistic flood hazard assessment and flood design strategies.

Dr. McCann was the project manager of an effort supported by LLNL to review the potential flood hazards at DOE facilities in the United States. The principal objective of this work is to conduct a preliminary, cost-effective review in order to screen those sites that may require an in-depth probabilistic flood hazard analysis. The results of this preliminary effort are a series of recommendations to minimize the risk at each DOE site due to flood hazards. Preliminary flood hazard studies have been performed for nine DOE sites.

Under the direction of Dr. McCann, JBA performed a probabilistic flood hazard assessment for the DOE Hanford Reservation, located adjacent to the Columbia River. The flood hazard assessment considered the possibility of extreme flood events and upstream dam failure as potential causes of onsite flooding.

As a subcontractor to Sandia National Laboratories (SNL) for the NRC Unresolved Safety Issue on Decay Heat Removal, JBA performed probabilistic flood studies at a number of nuclear power plant sites. These studies involved an assessment of the frequency of extreme floods and the frequency of core damage.

Dr. McCann was the project manager of an EPRI-sponsored study to evaluate the engineering characteristics of small-magnitude earthquakes. As part of this study the threshold level of ground motion required to damage nuclear power plant structures and equipment was estimated.

Dr. McCann assisted EPRI in developing an industry position regarding the seismic design basis for future nuclear power plants. As part of this effort, Dr. McCann worked with industry representatives and the NRC to develop an effective, stable approach for seismic siting.

Dr. McCann participated in a project to develop a NRC external event PRA procedures guide and a review document for seismic and external flood hazards.

In the 1980's, Dr. McCann participated in the review of seismic probabilistic risk assessments conducted for the Zion, Indian Point, Limerick, Millstone, and Oconee nuclear power plants.

Department of Civil Engineering, Stanford University (since 1981) - Consulting Professor

Currently, Dr. McCann is the chairman of the National Performance of Dams Program (NPDP) Executive Committee. The NPDP is headquartered at Stanford. The program operates and maintains a library and database on dam incidents. The library contains over 10,000 documents, including the U.S. Committee on Large Dams incident files. Dr. McCann is directing the development of a web-based digital library system. The digital library and database will be an online resource on dams and their performance.

Dr. McCann was the director of a project to develop PRA procedures for the evaluation of dams. The project was supported under a contract with the Federal Emergency Management Agency (FEMA). The objectives of the project included the development of a probabilistic screening procedure to assign priorities to dams in a jurisdiction based on a cost-effectiveness criteria. A methodology to conduct a detailed PRA of existing dams due to all stimuli was also developed.

As part of the FEMA project, Dr. McCann has presented workshops on the probabilistic assessment of dams in the U.S. and in foreign countries.

Working with the Association of State Dam Safety Officials, Dr. McCann was a chairman of a committee to develop a national standard for reporting the performance of dams. The result of this work was the publication of the Guidelines for Reporting the Performance of Dams.

Dr. McCann is the Chairman of the National Dam Safety Information Technology Committee. The purpose of the committee is to develop a strategic plan for the collection, archiving and access to information on dams in the U.S. The committee is comprised of state, federal and private sector engineers.

Partial List of Technical Publications and Reports

McCann, Jr., M. W., and H. C. Shah, "Determining the Strong Motion Duration of Earthquakes," Bull. Seism. Soc. Am., 69, 1979.

Geller, R. J., G. A. Frazier and M. W. McCann, Jr., "Dynamic Finite Element Modeling of Dislocations in a Laterally Heterogeneous Crust," Journal of the Physics of the Earth, 27, 1979.

McCann, Jr., M. W., and H. C. Shah, "RMS Acceleration for Seismic Risk Analysis: An Over-view," Proceedings, U.S. National Conference on Earthquake Engineering, Stanford University, 1979.

McCann, Jr., M. W., F. Sauter and H. C. Shah, "A Technical Note on PGA-Intensity Relations with Applications to Damage Estimation," Bull. Seism. Soc. Am., 70, 1980.

McCann, Jr., M. W., "RMS Acceleration and Duration of Strong Ground Motion," Technical Report No. 46, The John A. Blume Earthquake Engineering Center, Stanford University, 1980.

McCann, Jr., M. W., "A Bayesian Geophysical Model for Seismic Hazard," Technical Report No. 47, The John A. Blume Earthquake Engineering Center, Stanford University, 1980.

McCann, Jr., M. W., and D. M. Boore, "Variability in Ground Motions: Root Mean Square Acceleration and Peak Acceleration for the 1971 San Fernando, California Earthquake," Bull. Seism. Soc. Am., 73, 1983.

Reed, J. W., and M. W. McCann, Jr., "A Review of the Indian Point Probabilistic Safety Study, Seismic, Flooding and Wind," in Review and Evaluation of the Indian Point Probabilistic Safety Study, Kolb, G. J., et al., NUREG/CR-2934, SAND82-2929, 1982.

McCann, Jr., M. W., "Probabilistic Analysis of the Frequency of Random Dam Failure," JBA Technical Report 194-010-01, Mountain View, California, January, 1983.

Shah, H. C., and M. W. McCann, Jr., "Risk Analysis--It May Not Be Hazardous to Your Judgment," paper presented as a keynote lecturer at the Dam Safety Research Coordination Conference, Denver, Colorado, 1982.

Reed, J. W., and M. W. McCann, Jr., "A Review of the Zion Probabilistic Safety Study Seismic and Flooding," JBA Report 106-010-01 to Sandia National Laboratories, 1983.

Reed, J. W., M. W. McCann, Jr., and C. A. Kircher, "Insights Into Probabilistic Risk Assessment for External Hazards," Proceedings of the Fourth International Conference on Applications of Statistics and Probability in Soil and Structural Engineering, Florence, Italy, 1983.

McCann, Jr., M. W., H. C. Shah, and J. B. Franzini, "Application of Risk Analysis to the Assessment of Dam Safety," Department of Civil Engineering, Stanford University, Stanford, California, 1983.

McCann, Jr., M. W., H. Echezuria, and E. Kavazanjian, Jr., "Root Mean Square and Peak Ground Acceleration," JBA Technical Report 139-010-01, 1983.

McCann, Jr., M. W., "Uncertainty in Ground Motion Predictions," USGS Open-File Report No. 83-845, Site-Specific Effects of Soil and Rock on Ground Motion and their Implications for Earthquake-Resistant Design, 1983.

Kavazanjian, Jr., E., H. Echezuria, M. W. McCann, Jr., "Probabilistic Seismic Hazard in Terms of RMS Acceleration," Earthquake Engineering and Soil Dynamics, Vol. 4, 1985.

Reed, J. W., and M. W. McCann, Jr., "Review of Seismic PRAs and Recommendations for Improvement," presented at PVP Conference, San Antonio, Texas, 1984.

Reed, J. W., M. W. McCann, Jr., and J. Iihara, "Analytical Techniques for Performing Probabilistic Seismic Risk Assessment of Nuclear Power Plants," presented at ICOSSAR '85, Kobe, Japan, 1985.

McCann, Jr., M. W., J. B. Franzini, and H. C. Shah, "Preliminary Safety Evaluation of Existing Dams--Volume I," John A. Blume Earthquake Engineering Center, Technical Report 69, Stanford University, Stanford, California, 1985.

McCann, Jr., M. W., J. B. Franzini, and H. C. Shah, "Preliminary Safety Evaluation of Existing Dams--Volume II, A User Manual," John A. Blume Earthquake Engineering Center, Technical Report 70, Stanford University, Stanford, California, 1985.

McCann, Jr., M. W., et al., "Probabilistic Safety Analysis Procedure Guide," Prepared for U.S. Nuclear Regulatory Commission, NUREG/CR-2815, BNL-NUREG-51559, Vol. 2, Rev. 1, August 1985.

Shiu, K. K., J. W. Reed, and M. W. McCann, Jr., "Review of Seismic Probabilistic Risk Assessment and the Use of Sensitivity Analysis," Brookhaven National Laboratory, Prepared for U.S. Nuclear Regulatory Commission, BNL-NUREG-37010, 1985.

McCann, Jr., M. W., "An Introduction to Flood Probabilistic Risk Assessment Methodology," Proceedings, Department of Energy Natural Phenomena Hazards Mitigation Conference, Las Vegas, Nevada, 1985.

Kennedy, R. P., S. A. Short, J. R. MacDonald, M. W. McCann, Jr., and J. W. Reed, "Progress Towards Developing Consistent Design and Evaluation Guidelines for DOE Facilities Subjected to Natural Phenomena Hazards," Proceedings, Department of Energy Natural Phenomena Hazards Mitigation Conference, Las Vegas, Nevada, 1985.

McCann, Jr., M. W., "Historic Seismicity Analysis for the Savannah River Plant," prepared for E.I. du Pont de Nemours & Company, Inc., 1986.

McCann, Jr., M. W., and G. A. Hatem, "Progress Report, Development of a Library and Database on Dam Failures In the U.S.," The John A. Blume Earthquake Engineering Center, Stanford University, Progress Report to Federal Emergency Management Agency, 1986.

McCann, Jr., M. W., et al., "Seismic Hazard Methodology for the Central and Eastern United States, Volume 1: Part 1: Theory," NP-4726, Electric Power Research Institute, Palo Alto, California, 1988.

McCann, Jr., M. W., et al., "Seismic Hazard Methodology for the Central and Eastern United States, Volume 2: Programmer's Manual," NP-4726, Electric Power Research Institute, Palo Alto, California, 1988.

McCann, Jr., M. W., et al., "Seismic Hazard Methodology for the Central and Eastern United States, Volume 3: User's Manual," NP-4726, Electric Power Research Institute, Palo Alto, California, 1988.

McCann, Jr., M. W., et al., "Seismic Hazard Methodology for the Central and Eastern United States, Vol. 4: Applications," NP-4726, Electric Power Research Institute, Palo Alto, CA, 1988.

McCann, Jr., M. W. and J. W. Reed, "Selection of a Lower-Bound Magnitude for Seismic Hazard Analysis," Electric Power Research Institute, Palo Alto, California, 1989.

Jack R. Benjamin and Associates, Inc., "Natural Phenomena Hazards Modeling Project: Preliminary Flood Hazard Estimates for Screening Department of Energy Sites, Part 1: Methodology," JBA Report 105-140, prepared for Lawrence Livermore National Laboratory, Mountain View, California, 1987.

Jack R. Benjamin and Associates, Inc., "Natural Phenomena Hazards Modeling Project: Preliminary Flood Hazard Estimates for Screening Department of Energy Sites, Part 2: Bendix Plant, Kansas City, Missouri," JBA Report 105-140, prepared for Lawrence Livermore National Laboratory, Mountain View, California, 1987.

Jack R. Benjamin and Associates, Inc., "Natural Phenomena Hazards Modeling Project: Preliminary Flood Hazard Estimates for Screening Department of Energy Sites, Part 3: Mound Facility, Miamisburg, Ohio," JBA Report 105-140, prepared for Lawrence Livermore National Laboratory, Mountain View, California, 1987.

Jack R. Benjamin and Associates, Inc., "Natural Phenomena Hazards Modeling Project: Preliminary Flood Hazard Estimates for Screening Department of Energy Sites, Part 4: Pinellas Plant, St. Petersburg, Florida," JBA Report 105-140, prepared for Lawrence Livermore National Laboratory, Mountain View, California, 1987.

Jack R. Benjamin and Associates, Inc., "Natural Phenomena Hazards Modeling Project: Preliminary Flood Hazard Estimates for Screening Department of Energy Sites, Part 5: Sandia National

Laboratory, Livermore, California," JBA Report 105-140, prepared for Lawrence Livermore National Laboratory, Mountain View, California, 1987.

Jack R. Benjamin and Associates, Inc., "Natural Phenomena Hazards Modeling Project: Preliminary Flood Hazard Estimates for Screening Department of Energy Sites, Part 6: Los Alamos Scientific Laboratory, Los Alamos, New Mexico," JBA Report 105-140, prepared for Lawrence Livermore National Laboratory, Mountain View, California, 1987.

Jack R. Benjamin and Associates, Inc., "Natural Phenomena Hazards Modeling Project: Preliminary Flood Hazard Estimates for Screening Department of Energy Sites, Part 7: Rocky Flats Plant, Golden, Colorado," JBA Report 105-140, prepared for Lawrence Livermore National Laboratory, Mountain View, California, 1987.

Jack R. Benjamin and Associates, Inc., "Natural Phenomena Hazards Modeling Project: Preliminary Flood Hazard Estimates for Screening Department of Energy Sites, Part 8: Pantex Plant, Amarillo, Texas," JBA Report 105-140, prepared for Lawrence Livermore National Laboratory, Mountain View, California, 1987.

Jack R. Benjamin and Associates, Inc., "Natural Phenomena Hazards Modeling Project: Preliminary Flood Hazard Estimates for Screening Department of Energy Sites, Part 9: Sandia Laboratories, Albuquerque, New Mexico," JBA Report 105-140, prepared for Lawrence Livermore National Laboratory, Mountain View, California, 1987.

Jack R. Benjamin and Associates, Inc., "Probabilistic Flood Hazard Assessment For the N Reactor, Hanford, Washington," JBA Report 105-130, Prepared for Lawrence Livermore National Laboratory, Mountain View, California, 1988.

McCann, Jr., M.W., "SRS PRA of Reactor Operation - Level 1 External Events, Appendix A - Probabilistic Seismic Hazard Evaluation," Westinghouse Savannah River Company, Aiken, South Carolina, July 1990.

McCann, Jr., M. W., N. Markevich, and C. Cecilio, "Probabilistic Hydrologic Risk Assessment: Input for the Decision Maker," Proceedings, Annual Conference, Association of State Dam Safety Officials, San Diego, California, September 29, 1991.

McCann, Jr., M. W., "National Center on the Performance of Dams," Proceedings, Annual Conference, Association of State Dam Safety Officials, San Diego, California, September 29, 1991.

McCann, Jr., M. W. and A. C. Boissonnade, "Probabilistic Hydrologic Risk Assessment of Dams," Prepared for Pacific Gas and Electric Company, Department of Research and Development, San Francisco, CA, July 1991.

McCann, Jr., M. W. and A. C. Boissonnade, "Seismic Hazard for the Savannah River Site, A Comparative Evaluation of the EPRI and LLNL Assessments," prepared for Westinghouse Savannah River Company, March 1992.

Jack R. Benjamin and Associates, Inc., "Preliminary Probabilistic Risk Assessment for Par Pond Dam," prepared for Westinghouse Savannah River Company, December 10, 1992.

Jack R. Benjamin and Associates, Inc., "Flood Screening Evaluation for the New Production Reactor Site at the Idaho National Engineering Laboratory," prepared for Lawrence Livermore National Laboratory, 1992.

Jack R. Benjamin and Associates, Inc., "A Comparative Assessment of Historic Seismicity and Expert Seismicity Model - Dr. Joseph Litehiser," prepared for Lawrence Livermore National Laboratory, April 1993.

Jack R. Benjamin and Associates, Inc., "A Comparative Assessment of Historic Seismicity and Expert Seismicity Model - Dr. Gilbert Bollinger," prepared for Lawrence Livermore National Laboratory, April 1993.

McCann, Jr., M.W., et al., *Guidelines for Reporting the Performance of Dams,* National Performance of Dams Program and the Association of State Dam Safety Officials, 1994.

McCann, M.W., et al., "Probabilistic Seismic Hazard Assessment for the U.S. Army Chemical Demilitarization Facility, Tooele, Utah," Prepared for Science Applications International Corporation, Abingdon, Maryland, June 1995.

McCann, M.W., et al., "Probabilistic Seismic Hazard Assessment for the U.S. Army Chemical Demilitarization Facility, Umatilla, Oregon," Prepared for Science Applications International Corporation, Abingdon, Maryland, September 1995.

McCann, M.W., et al., "Probabilistic Seismic Hazard Assessment for the U.S. Army Chemical Demilitarization Facility, Pine Bluff, Arkansas," Prepared for Science Applications International Corporation, Abingdon, Maryland, October 1995.

McCann, M.W., et al., "Probabilistic Seismic Hazard Assessment for the U.S. Army Chemical Disposal Facility, Pueblo, Colorado," Prepared for Science Applications International Corporation, Abingdon, Maryland, September 1995.

McCann, Jr., M.W. and L. Manuel, L., "Methodology for Seismic Reliability Assessment of Outlet Operations at Dams," Proceedings of the 2nd International Conference on Dam Safety Evaluation, Trivandrum, India, November 1996.

McCann, Jr., M.W., "National Performance of Dams Program," Proceedings of the 2nd International Conference on Dam Safety Evaluation, Trivandrum, India, November 1996.

Manuel, L., M.W. McCann, Jr., and J.C. Stepp, "Probabilistic Seismic Hazard Assessment for the Tomari Nuclear Power Plant Site," Prepared for Obayashi Corporation, Tokyo, Japan, December 1996.

McCann, Jr., M.W., "Risk Assessment for Dams - The Thaw," Proceedings of the Association of State Dam Safety Officials Annual Conference, Pittsburgh, PA, 1997.

McCann, Jr., M.W. and M.J. Robertson, "Estimating Loss-of-Life Due to Dam Failures: Pitfall, Fallacies and Recommendations," Proceedings of the Association of State Dam Safety Officials Annual Conference, St. Louis, MO, 1999.

Stamatakos, J.A., R. Chen, M.W. McCann, Jr, A.H. Chowdhury, "Seismic Ground Motion and Faulting Hazard at Private Fuel Storage Facility in the Skull Valley Indian Reservation, Tooele County, Utah," Center for Nuclear Waste Regulatory Analyses, Southwest Research Institute, San Antonio, Texas, 1999.

McCann, M.W., Jr., "Probabilistic Seismic Hazard Analysis for the Anniston Chemical Demilitarization Facility, Anniston, Alabama," prepared for Science Applications International Corporation, October, 2000.

Committee on Risk-Based Analysis for Flood-Loss Reduction (contributing author), *Risk Analysis and Uncertainty,* National Academy Press, Washington, D.C. , 2000.

Rui Chen

11 Burney Drive
Chico, CA 95928

Primary Technical Areas:

* Computational, experimental, and theoretical rock mechanics and geological engineering
* Earthquake engineering and seismology, seismic hazard assessment, structural geology, and neotectonics
* Computer applications and programming

Summary of Qualifications:

* Seventeen years of post-graduate research experience
* Seven years of consulting/industrial experience
* Numerical modeling of rock deformation and fracturing
* Laboratory experience in rock testing and data acquisition
* Consulting experience in rock mechanics and geological engineering
* Application of U.S. regulations in radioactive waste management and disposal and associated compliance review

---

EDUCATION

1/89 - 2/93 Ph.D., Civil and Geological Engineering, The University of Manitoba, Winnipeg, Canada
Thesis: *In Situ and Laboratory Studies of Potash Deformation - with Reference to Saskatchewan Potash*

9/82 - 7/85 M.Sc., Seismotectonics, Graduate School, the University of Science and Technology of China and Institute of Geology, State Seismological Bureau of China, Beijing, China
Thesis: *Earthquake Mechanisms and Repeated Activities of the Western Branch of Xiaojiang Fault Zone, Southeastern Edge of the Qinghai-Tibet Plateau*

9/78 - 7/82 B.Sc., Seismology and Geomechanics, The Geological University of China at Wuhan, China
Thesis: *Earthquake Seismicity in Jiangchuang Basin*

EMPLOYMENT HISTORY

09/00 - present Independent consultant in geological engineering and geosciences

08/01- 01/02 Adjunct Lecturer, Development of Civil Engineering and College of Natural Sciences, California State University, Chico

09/98 - 08/00 Senior Research Engineer, Center for Nuclear Waste Regulatory Analyses, Southwest Research Institute, San Antonio, Texas, USA.

04/95 - 09/98	Research Engineer, Center for Nuclear Waste Regulatory Analyses, Southwest Research Institute, San Antonio, Texas, USA.
07/93 - 04/95	Staff Engineer, RE/SPEC Inc., Rapid City, South Dakota, USA.
11/92 - 06/93	Consultant, RE/SPEC Inc., Rapid City, South Dakota, USA.
11/88 - 06/93	Graduate Assistant, Department of Geological Engineering, The University of Manitoba, Winnipeg, Manitoba, Canada.
09/85 - 10/88	Research Associate, Institute of Crustal Dynamics, State Seismological Bureau of China.
09/83 - 08/85	Research Assistant, Institute of Geology, State Seismological Bureau of China.

EXPERIENCE

Dr. Chen's experience includes academic-based research and industry-related consulting. Her areas of expertise include experimental, theoretical, and computational rock mechanics; seismology and earthquake engineering; neotectonics; structural geology; and software development.

Dr. Chen's professional activities began in 1983 when she headed the Institute of Geology at the State Seismological Bureau (SSB) of China, in Beijing, as a research assistant. There she was involved in research projects in seismicity and earthquake mechanisms along active fault zones and in active basins in Southwestern and Northwestern China. An early project included seismicity analyses in the Jiangchuang Basin on the Honghe River Fault Zone in Southwestern China. Other projects included mapping geological and geomorphic features along the 1920 Haiyuan Earthquake (M=8.5) Fault Zone and neotectonic and geomorphic mapping, paleoseismic trenching, and seismicity analyses along the Xiaojiang Active Fault Zone. The latter study resulted in the first qualitative evaluation of the slip rate and earthquake recurrence intervals along the fault zone. These results are included in the national database for large-scale active fault zones in China.

Dr. Chen's experience in interdisciplinary research started in 1985 when she joined the Rock Mechanics Division at the Institute of Crustal Dynamics, SSB of China, Beijing, as a research associate. There, she extended her professional activities to include computational and experimental rock mechanics. She managed a project on double-shear rock friction tests for investigating the stability of fractured rock mass. Results from this study were applied to evaluate the stability of concealed fault zones and salt solution-mining induced seismicity in Zigong Anticline, Sichuan Province of China. This work included constructing a structural model for the Zigong Anticline based on geophysical survey data and back analysis of the tectonic stress field using non-linear, viscoplastic finite element methods.

From 10/88 to 06/93, Dr. Chen worked on industrial research projects in the Department of Civil and Geological Engineering at the University of Manitoba as a graduate assistant. There, she led research in two areas of rock mechanics and mining: the yield behavior of deep potash pillars and rock bimodularity. She investigated mining-induced deformation and fracturing in potash mines under contract with the Potash Corporation of Saskatchewan, with matching funding from the Natural Sciences and Engineering Research Council of Canada. The accomplishments in this research included underground mapping of deformational patterns in exposed cross sections of yield pillars after substantial deformation, and correlation of the observed deformation to time-dependent finite strain and shear failure in the pillars using modern techniques in quantitative structural geology. The research led to better understanding of the stress-control design methodology in underground soft rock mining. It also led to several external reports, papers, and presentations to government, commercial, and scientific organizations. She also performed experimental and constitutive research on potash relaxation behavior and on the differences in elastic moduli for rocks in tension and compression, adapted the results on material bimodularity to a special-purpose finite element computer program to study the influence of bimodularity on the behavior of underground structures, and developed computer codes for test control and data acquisition for a sophisticated servo-controlled material testing system. While pursuing her Ph.D. education in the University of Manitoba, she provided technical consulting services to RE/SPEC Inc. on a legal case regarding water inflow into potash mines in Esterhazy, Canada. These services included evaluation of the microseismic monitoring system at the mines, seismic data analyses, and evaluation of the effects of seismicity on mine stability.

During her employment with RE/SPEC Inc. (7/93 - 4/95), Dr. Chen served as Technical Lead on industry and government contracts and performed numerous numerical (finite element and finite difference) simulations in support of experiments at the Waste Isolation Pilot Plant (WIPP) in New Mexico for long-term containment of radioactive wastes. The areas supported include engineering design alternative analyses, and the sealing and backfill programs (crushed salt consolidation and concrete bulkhead experiments). The analyses performed used predictive technology developed for the WIPP to simulate the thermal-mechanical behavior of salt to determine the response of repository seals and closure times for rooms and shafts. She was also involved in the evaluation of consolidation constitutive models for crushed salt in support of the sealing program at the WIPP, including a state-of-the-art literature survey to select candidate models, using BMDP (a statistical software package) and self-developed computer codes to evaluate parameters and their correlations, and constitutive model development. She has also performed numerous two and three dimensional finite element and boundary element modeling studies on underground mining and storage caverns to determine safe operating conditions and to evaluate structural integrity. This work was performed for commercial clients including DynMcDermott Petroleum Operations Company, the Dow Chemical Company, the Warren Petroleum Company, Texas Eastern Products Pipeline Company, and AKZO Mining Company, etc. Another of her interest areas is object-oriented software development for Windows-based applications. She developed a graphical user interface (Visual SalGas) for Solution Mining Research Institute's commercial software known as SALGAS (a numerical leaching model with cavity hydraulics and gaseous pad calculations for design of salt rock solution caverns). A demo-version of Visual SalGas was distributed to SMRI memberships world wild and the full-version has been purchased by companies in the United States, Canada, and Europe.

At the Center for Nuclear Waste Regulatory Analyses (CNWRA) at Southwest Research Institute (SwRI), Dr. Chen performed technical activities related to geological engineering to assist the Nuclear Regulatory Commission (NRC) in licensing the nation's first geological repository for high-level radioactive waste, which is proposed to be developed at Yucca Mountain, Nevada. She was involved in CNWRA analyses of mechanical, thermal, and hydrological processes in complex geomechanical and geotechnical engineering systems. She was involved in review of technical reports produced by the U.S. Department of Energy in supporting its license application for the proposed Yucca Mountain repository in areas such as site geology and seismology, repository design and construction (including seismic design of surface and subsurface facilities), and stability analyses of emplacement drifts and ground support under thermal and dynamic loads for preclosure safety and postclosure performance assessments. She performed independent confirmatory analyses and research to support such reviews. Her role at the CNWRA also includes a Project Manager for geomechanical analyses and their application in gas, oil, and underground storage industries for commercial clients. She was also a Principal Investigator in providing technical support, including evaluation of seismic hazard analyses and seismic design, for the NRC licensing activities related to the nation's spent nuclear fuel dry-storage facilities, including TMI-2 ISFSI and the proposed Private Fuel Storage Facility. These evaluations included review and independent analyses and provided input to the NRC safety evaluation reports, environmental impact statements, and other National Environmental Policy Act documentation required under Title 10 Code of Federal Regulations. She also conducted geotechnical review and independent analyses to support NRC regulation of the uranium mining industry, including slope stability, foundation stability, and liquefaction analyses.

Since relocating to California and becoming an independent consultant, she has provided technical assistance and consulting services to CNWRA at SwRI in solving a broad range of problems in underground rock engineering, seismic hazard assessment, and earthquake engineering. She is also teaching graduate and undergraduate courses at California State University, Chico.

LIST OF PUBLICATIONS

a). Refereed Journals and Conference Proceedings

Ofoegbu, G.I., S. Painter, R. Chen, R.W. Fedors, and D.A. Ferrill. 2001. Geomechanical and thermal effects on moisture flow at the proposed Yucca Mountain Nuclear Waste Repository. *Nuclear Technology,* 134 (3): 241-262.

Chen, R., G.I. Ofoegbu, and S.M. Hsiung. 2000. Modeling drift stability in fractured rock mass at Yucca Mountain, Nevada - Discontinuum approach. *Proceedings, the Fourth North American Rock Mechanics Symposium, Rock Around the Rim,* the University of Washington, Seattle, Washington, July 31 - August 3, 2000.

Chen, R. 1999. Analyses of drift stability and rockfall due to earthquake ground motion at Yucca Mountain, Nevada. *Proceedings of the 37th U.S. Rock Mechanics Symposium, Rock Mechanics for Industry*, B. Amadei, R.L. Kranz, G.A. Scott, and P.H. Smeallie, eds., 759-766.

Chen, R., M.P. Ahola, S.M. Hsiung, and A.H. Chowdhury. 1999. Thermal-mechanical stability of emplacement drifts for a proposed nuclear waste repository at Yucca Mountain. *Environmental Geotechnology 1&2: Proceedings, 4th International Symposium on Environmental Geotechnology and Global Sustainable Development,* August 9-13, 1998, Boston, MA.

Institutional Review - Center for Nuclear Waste Regulatory Analyses, Southwest Research Institute, Submitted to *The International Handbook of Earthquake and Engineering Seismology,* per invitation by the editor.

Stamatakos, J.A., D.A. Ferrill, A.P. Morris, D. Sims, and R. Chen. 1999. Structural evolution of Crater Flat Basin, South Central Nevada, USA. Accepted for presentation at *the 1999 International Geologic Conference*, to be held in Rio de Janeiro, August 2000.

Stamatakos, J.A., P.S. Justus, A. Ghosh, S. Hsiung, M. Miklas, R. Chen, and A-b.K. Ibrahim. Evaluation of radiological risk from seismotectonic processes at the candidate high-level repository at Yucca Mountain Nevada, USA, Accepted for presentation at *the 1999 International Geologic Conference*, to be held in Rio de Janeiro, August 2000.

Stamatakos, J.A., D.A. Ferrill, A.P. Morris, D. Sims, and R. Chen. 1999. Three-dimensional geometry of the Bare Mountain Fault (Nevada): Implications for Fault Kinematics and Basin Evolution. *EOS Supplement*, April 27., 1999 Spring Meeting, S328-S329.

Chen, R. and B. Stimpson. 1997, Simulation of deformation and fracturing in potash yield pillars, *Canadian Geotechnical Journal* 34(2): 283-292.

Chen, R. and L.J. Lorig. 1997. Numerical modeling of the effects of fault slip on fluid flow around extensional faults: Discussion. *Journal of Structural Geology* 19(11): 1423-1426.

Chen, R. and B. Stimpson. 1995. Triaxial stress relaxation tests on Saskatchewan potash. *Canadian Geotechnical Journal* 32: 11-21.

Chen, R., G.D. Callahan, M.C. Loken, and F.D. Hansen. 1995. Research on crushed-salt constitutive model development. Abstract for the *IUGG XXI General Assembly*, July 2-14, Boulder, Colorado.

Ratigan, J.L., J.D. Nieland, R.Chen, K.D. Mellegard, and T.W. Pfeifle. 1995. Numerical modeling of Weeks Island subsidence and laboratory testing of Weeks Island salt. *Proceedings of the Solution Mining Research Institute 1995 Spring Meeting*, April 30-May 3, New Orleans, Louisiana.

Zhang, B. C., R. Chen, and L. Hong. 1995. Relationship between seismicity and water injection in Ziliujing Anticline. *International Symposium on Reservoir-Induced Seismicity (ISORIS'95)*, Beijing, China.

Chen, R., W.C. Brisbin, and B. Stimpson. 1993. Mining induced deformation in potash yield pillars, Vanscoy, Saskatchewan. *Canadian Geotechnical Journal* 30: 297-307.

Chen, R. and B. Stimpson. 1993. Indirect tension tests on rock - analytical/numerical correction for material bimodularity. *ASTM Geotechnical Testing Journal* 16: 238-245.

Chen, R. and B. Stimpson. 1993. Interpretation of indirect tensile strength tests when moduli of deformation in compression and in tension are different. *Rock Mechanics and Rock Engineering* 26: 183-189.

Stimpson, B. and R. Chen. 1993. Measurement of rock elastic moduli in tension and in compression and its practical significance. *Canadian Geotechnical Journal* 30: 338-347.

Zhang, B.C., R. Chen, H. Li, Y.N. Qi, J.Z. Mao, P. Liu, and F.Q. Li. 1993. Relationship between seismicity and water injection in Ziliujing Anticline. *ACTA Seismologica Sinica* 6(3): 769-774.

Zhang, B.C., R. Chen, H. Li, Y.N. Qi, J.Z. Mao, P. Liu, and F.Q. Li. 1993. Relationship between seismicity and water injection in Ziliujing Anticline. *Earthquake Research* 15(2): 253-256 (in Chinese).

Chen, R., W.C. Brisbin, and B. Stimpson. 1992. A hypothesis for yield pillar behavior in potash mining based on field observations. *Proceedings, 16th Canadian Rock Mechanics Symposium*, P.K. Kaiser & D.R. McCreath eds., June 15-19, Sudbury, Canada, 85-92.

Chen, R., M.L. Ayari, and B. Stimpson. 1991. Influence of material bimodularity on the behavior of underground mining structures. *Proceedings, 13th Canadian Congress of Applied Mechanics*, Winnipeg, Canada, 720-721.

Chen, R. and B. Stimpson. 1991. The measurement of rock moduli in compression and tension and its practical significance. *Proceedings, 44th Canadian Geotechnical Conference*, Sept. 29-Oct. 2, 1991, Calgary, Canada. Paper No. 34.

Stimpson, B. and R. Chen. 1991. A new technique for measuring the bimodularity of rock. *Proceedings, 13th Canadian Congress of Applied Mechanics*, Winnipeg, Canada, 788-789.

Chen, R., B.Z. Zhang, Y.N. Qi, S.G. Lo, and L. Pong. 1990. Inversion of tectonic stress field and construction of structural model for Zigong Anticline, Southwestern China. *Crustal Tectonic Movements* 3: 187-199 (in Chinese).

Chen, R. 1989. Grey system and its application in geological sciences. *Bulletin of Young Scientist Society in Institute of Crustal Dynamics, State Seismological Bureau of China* 3: 5-7 (in Chinese).

Zhao, X. and R. Chen. 1989. The wedge rotation basins and barrier structures in stick-slip fault zones. *Earthquake Research in China* 5(3): 55-60 (in Chinese).

Chen, R. and P. Li. 1988. Slip rate and earthquake recurrence intervals on the western branch of Xiaojiang Fault Zone in China. *Seismology and Geology* 10(2): 1-13 (in Chinese).

Chen, R., Y.S. Ma, and B.Z. Zhang. 1987. Distribution of stresses and displacement along fractures in double shear experiments. *Special Volume of the 2nd National Symp. on Tectonophysics*, Beijing, China, 344-368 (in Chinese).

Ma, Y.S. and R. Chen. 1987. Experimental research on double shear friction. *Special Volume of the Second National Symp. on Tectonophysics*, Beijing, China, 152-164 (in Chinese).

b). **Reports**

Hsiung, S., R. Chen, A. Chowdhury, D. Daruwalla, B. Dasgupta, M. Diaz, D. Dunn, R. Green, S. Green, D. Gute, M Lesher, P Mackin, C. Manepally, D. Pomerening, O. Povetko, B. Russell, M. Smith, and J. Stamatakos. 2002. Acceptance review of License Application and Safety Analysis Report for Idaho Spent Fuel Facility, Center for Nuclear Waste Regulatory Analyses, Southwest Research Institute, San Antonio, Texas

Stamatakos, J.A., S. Hsiung, R. Chen, and A.H. Chowdhury. 2002. *Review of Seismic and Geotechnical Hazard Assessments of Mixed Oxide Fuel Fabrication Facility, Savannah River, South Carolina.* Prepared by Center for Nuclear Waste Regulatory Analyses for Nuclear Regulatory Commission.

Waiting, D.J., R. Chen, J.G. Crider, W.M. Dunne etc. 2001. *Technical Assessment of Structural Deformation and Seismicity at Yucca Mountain, Nevada.* Prepared by Center for Nuclear Waste Regulatory Analyses for Nuclear Regulatory Commission.

Chen, R. 2000. *Thermal-Mechanical Effects on Ground Support Design and Drift Performance in Fractured Rock Mass at Yucca Mountain, Nevada.* CNWRA2000-04. Prepared by Center for Nuclear Waste Regulatory Analyses for Nuclear Regulatory Commission.

Chen, R., J. Stamatakos, and A.H. Chowdhury. 1999. *Review of the Probabilistic Seismic Hazard Analyses for the Paducah Gaseous Diffusion Plant - Final Report*, prepared by Center for Nuclear Waste Regulatory Analyses for Division of Fuel Cycle Safety and Safeguards, Nuclear Regulatory Commission, September.

Chen, R., P. Mackin, and J. Weldy. 1999. *Technical Evaluation Report, Kennecott Uranium Company Reclamation Plan for the Sweetwater Uranium Project.* Prepared by Center for Nuclear Waste Regulatory Analyses for Nuclear Regulatory Commission. May.

Issue Resolution Status Report, Key Technical Issue: Repository Design and Thermal-Mechanical Effects—Revision 3, Prepared for Division of Waste Management Office of Nuclear Material Safety and Safeguards, Nuclear Regulatory Commission, July, 2000. (With S. Hsiung, G. Ofoegbu, A. Chowdhury, and R. Nataraja).

Issue Resolution Status Report, Key Technical Issue: Structural Deformation and Seismicity Chapter 4.0-Revision 3, Prepared for Division of Waste Management Office of Nuclear Material Safety and Safeguards, Nuclear Regulatory Commission, July, 2000. (With J. Stamatakos and others).

Hsiung, S., G. Ofoegbu, R. Chen, A. Chowdhury, and R. Nataraja. 1999. *Issue Resolution Status Report, Key Technical Issue: Repository Design and Thermal-Mechanical Effects-Revision 2*, Prepared by Center for Nuclear Waste Regulatory Analyses for Division of Waste Management Office of Nuclear Material Safety and Safeguards, Nuclear Regulatory Commission, July.

Stamatakos, J., R. Chen, M. McCann, and A. H. Chowdhury. 1999. *Seismic Ground Motion and Faulting Hazard at Private Fuel Storage Facility in the Skull Valley Indian Reservation, Tooele County, Utah - Final Report,* prepared by Center for Nuclear Waste Regulatory Analyses for Nuclear Regulatory Commission, September.

Chen, R. 1998. *Analyses of Drift Instability and Rockfall Due to Earthquake Ground Motion at Yucca Mountain, Nevada*: Progress Report, prepared by Center for Nuclear Waste Regulatory Analyses for Nuclear Regulatory Commission, September.

Chen, R. 1998. *Salt Deposits in China, Phase I: Reconnaissance Survey*, final project summary report, prepared by Center for Nuclear Waste Regulatory Analyses for Salt Mining/Storage & Pipeline Technology Center, The Dow Chemical Company, June.

Chen, R. and A.H. Chowdhury. 1998. *Seismic Ground Motion at Three Mile Island Unit 2 Independent Spent Fuel Storage Installation Site in Idaho National Engineering and Environmental Laboratory - Final Report,* CNWRA 98-007, prepared by Center for Nuclear Waste Regulatory Analyses for Nuclear Regulatory Commission.

Chen, R., J. Stamatakos, and A.H. Chowdhury. 1998. *Final Review Plan for Probabilistic Seismic Hazard Assessment of Paducah Site*, letter report, prepared by Center for Nuclear Waste Regulatory Analyses for Division of Fuel Cycle Safety and Safeguards, Nuclear Regulatory Commission, April.

Deere, L., A. Armstrong, R. Chen, A. Chowdhury, B. Hill, P. Mackin, M. Miklas, D. Pomerening, J. Simonis, J. Weldy, and D. Deere. 1998. *Safety Evaluation Report of Three Mile Island Unit 2 Independent Spent Fuel Storage Installation Safety Analysis Report.* Prepared by Center for Nuclear Waste Regulatory Analyses for Nuclear Regulatory Commission. November.

Ghosh, A., J. Stamatakos, S. Hsiung, R. Chen, A.H. Chowdhury, and H.L. McKague. 1998. *Key Technical Issue Sensitivity Analysis with SEISMO and FAULTO Modules Within the TPA (Version 3.1.1) Code*, letter report, prepared by Center for Nuclear Waste Regulatory Analyses for Nuclear Regulatory Commission., February.

Green, R.T., R. Chen, A. Armstrong, and G. Rice. 1998. *Thermal-Hydrologic Modeling Progress Report,* letter report, prepared by Center for Nuclear Waste Regulatory Analyses for Division of Waste Management, Nuclear Regulatory Commission, May.

Hsiung, S., G. Ofoegbu, R. Chen, A. Chowdhury, and R. Nataraja. 1998. *Issue Resolution Status Report, Key Technical Issue: Repository Design and Thermal-Mechanical Effects-Revision 1*, Prepared by Center for Nuclear Waste Regulatory Analyses for Division of Waste Management Office of Nuclear Material Safety and Safeguards, Nuclear Regulatory Commission, June.

Stamatakos, J.A., D.F. Ferrill, D. Sims, and R. Chen. 1998. *Technical Input on Review and Acceptance Criteria for Issue Resolution Status Report, Rev 1.0, Key Technical Issue: Structural Deformation and Seismicity*. Prepared by Center for Nuclear Waste Regulatory Analyses for Office of Nuclear Material Safety and Safeguards, Nuclear Regulatory Commission. May.

Turner, D.R., J. Weldy, A. Armstrong, R. Chen, and A.H. Chowdhury. 1998. *Final Environmental Impact Statement for the Construction and Operation of an Independent Spent Fuel Storage Installation to Store the Three Mile Island Unit 2 Spent Fuel at the Idaho National Engineering and Environmental Laboratory*, NUREG-1626. Prepared by Center for Nuclear Waste Regulatory Analyses for Nuclear Regulatory Commission.

Chen, Rui, G.I. Ofoegbu, and D.A. Ferrill. 1997. *Geomechanical Modeling of an Actively Deforming Salt Body*. Final Report, prepared by Center for Nuclear Waste Regulatory Analyses for Shell E&P Technology Co.

Turner, D.R., A. Armstrong, R. Chen, A.H. Chowdhury, and J. Weldy. 1997. *Initial Review to Evaluate the Adoption of the U.S. Department of Energy Programmatic Environmental Impact Statement and Environmental Assessment for the Nuclear Regulatory Commission Environmental Impact Statement*, letter report, prepared by Center for Nuclear Waste Regulatory Analyses for Nuclear Regulatory Commission, August.

Ahola, M.P., R. Chen, H. Karimi, S.M. Hsiung, and A.H. Chowdhury. 1996. *A Parametric Study of Drift Stability in Jointed Rock Mass, Phase I: Discrete Element Thermal-Mechanical Analysis of Unbackfilled Drifts*. CNWRA 96-009, Prepared by Center for Nuclear Waste Regulatory Analyses for Nuclear Regulatory Commission.

Ghosh, A., R. Chen, M.P. Ahola, and A.H. Chowdhury. 1996. *Review Comments on ESF Alvove Ground Support Analysis, and ESF Ground Support - Structural Steel Analysis*. Prepared by Center for Nuclear Waste Regulatory Analyses for Nuclear Regulatory Commission.

Hsiung, S.M., R. Chen, A.H. Chowdhury, A. Ghosh, M.S. Nataraja, and B.N. Jagannath. 1996. Repository Design and Thermal-Mechanical Effects. *NRC High-Level Radioactive Waste Program Annual Progress Report: Fiscal Year 1996*, Chapter 7, NUREG/CR-6513, No.1, p. 7-1 through 7-19.

Stamatakos, J.A., P.S. Justus, D.A. Ferrill, R. Chen, and G.I. Ofoegbu. 1996. Structural Deformation and Seismicity, *NRC High-Level Radioactive Waste Program Annual Progress Report: Fiscal Year 1996*, Chapter 3, NUREG/CR-6513, No.1, p. 3-1 through 3-33.

Chen, R. and M.C. Loken. 1995. *Effect of Radial Clay Waterstop on DRZ Development Around the Shafts at WIPP*, Calculation File 325/10/01, prepared by RE/SPEC Inc., Rapid City, SD, for Sandia National Laboratories, Albuquerque, NM.

Chen, R. and H. Karimi. 1995. *Review Comments on Exploratory Studies Facility Design Package 2C: Topopah Spring North Ramp*, prepared by Center for Nuclear Waste Regulatory Analyses, Southwest Research Institute, San Antonio, Texas, for Nuclear Regulatory Commission, Contract NRC-02-93-005.

Chen, R. and H. Karimi. 1995*b*. *Review Comments on Site Characterization Progress Report: Yucca Mountain, Nevada-Number 11*, prepared by Center for Nuclear Waste Regulatory Analyses for Nuclear Regulatory Commission.

Callahan, G.D., M.C. Loken, L.L. Van Sambeek, R. Chen, T.W. Pfeifle, J.D. Nieland, and F.D. Hansen. 1995. *Evaluation of Potential Crushed-Salt Models*, SAND95-2143, prepared by RE/SPEC Inc., Rapid City, SD, for Sandia National Laboratories.

Hsiung, S.M., A. Ghosh, G.L. Stirewalt, B. Henderson, C.A. Fenrich, and R. Chen. 1995. *Development of Rock Mechanics Properties Database - Progress Report*, Prepared by Center for Nuclear Waste Regulatory Analyses for Nuclear Regulatory Commission.

Chen, R. 1994*a*. *DRZ Extent Around the Lower Short-Term Seal of the Air Intake Shaft*, Calculation File 325/03/03, prepared by RE/SPEC Inc., Rapid City, SD, for Sandia National Laboratories, Albuquerque, NM.

Chen, R. 1994*b*. *Literature Review of the Constitutive Model for Crushed Salt*, Calculation File 325/04/02, prepared by RE/SPEC Inc., Rapid City, SD, for Sandia National Laboratories, Albuquerque, NM.

Chen, R. and M.C. Loken. 1994. *Concrete/Steel Panel Seal Structural Response*, Calculation File 325/03/01, prepared by RE/SPEC Inc., Rapid City, SD, for Sandia National Laboratories, Albuquerque, NM.

Chen, R. and J.D. Nieland. 1994. *Determination of Effective Seal Vertical Thickness as a Function of Time*, Calculation File 325/05/02, prepared by RE/SPEC Inc., Rapid City, SD, for Sandia National Laboratories, Albuquerque, NM.

Chen, R. and J.D. Nieland. 1994. *Effect of Initial Density of Crushed Salt on WIPP Shaft Seals*, Calculation File 325/05/04, prepared by RE/SPEC Inc., Rapid City, SD, for Sandia National Laboratories, Albuquerque, NM.

Chen, R., J.D. Osnes, and J.L. Ratigan. 1994. *Visual SalGas User's Manual (Version 1.20)*, prepared by RE/SPEC Inc., Rapid City, SD, RSI-0528, for Marketing Recipients.

Chen, R., J.D. Osnes, and J.L. Ratigan. 1994. *Visual SalGas User's Manual (Version 1.10)*, prepared by RE/SPEC Inc., Rapid City, SD, RSI-0499, for Dow Hydrocarbons, Plaquemine, LA.

Chen, R. and J.L. Ratigan. 1994. *Incremental Casing Stresses in Warren Petroleum LPG Storage Well No. 23*, external memorandum, RSI(RCO)-171/4-94/38, prepared by RE/SPEC Inc., Rapid City, SD, for the Warren Petroleum Company.

Nieland, J.D., R. Chen, and J.L. Ratigan. 1994. *Numerical Modeling of Weeks Island Subsidence*, prepared by RE/SPEC Inc., Rapid City, SD, RSI-0509, for DynMcDermott Petroleum Operations Company, New Orleans, LA.

Ratigan, J.L., R. Chen, and J.D. Osnes. 1993. *Geomechanics Modeling of Salt Web Between Dow Wells No. 11 and No.14*, external memorandum, RSI(RCO)-288/9-93/20, prepared by RE/SPEC for Dow Chemical Company.

Chen, R., W.C. Brisbin, and B. Stimpson. 1991. Mining-Induced Deformation in Potash Yield Pillars. *Fracture in Potash*, NSERC Research Partnership Program, Department of Geological Engineering, University of Manitoba, Report No. 21, 1-19.

Chen, R. and B. Stimpson. 1991. *Material Bimodularity - Theoretical and Numerical Solutions*, report, Department of Geological Engineering, University of Manitoba.

Chen, R., Y.G. Yuan, and M.L. Ayari. 1991. *A Microcomputer-Based, Interactive FEM Program Incorporating Material Bimodularity*, report, Department of Geological Engineering, University of Manitoba.

Chen, R. and B. Stimpson. 1990. *Summary of Multiple-Stage Repeated Relaxation and Reverse Loading Triaxial Tests on Evaporites*, report, Department of Geological Engineering, University of Manitoba.

Li, F. Q., B. Z. Zhang, R. Chen. 1988. *Characteristics of Crustal Stress Field Around the Proposed Three Gorges Dam and Its Implications to Reservoir-Induced Seismicity*, progress report to State Council of China (in Chinese).

1 exhibits?

2 MR. TURK: Staff Exhibits Q, R, S, T,

3 and U. I'd like to go through these one by one.

4 JUDGE FARRAR: Are these the same, Mr.

5 Turk, that you prefiled?

6 MR. TURK: Yes.

7 Your Honor, the first exhibit that we

8 are distributing to the Board members and court

9 reporter is what has been marked by the Staff as

10 Staff Exhibit Q. It is entitled Seismic Ground

11 Motion and Faulting Hazard at Private Fuel Storage

12 Facility in the Skull Valley Indian Reservation,

13 Tooele County, Utah, Final Report, and it is

14 indicated that it is prepared by John A.

15 Stamatakos, Rui Chen, Martin W. McCann, Jr., and

16 Asadul Chowdhury at the Center for Nuclear Waste

17 Regulatory Analyses, San Antonio, Texas, September,

18 1999.

19 JUDGE FARRAR: Let's pause for a moment

20 and have the reporter mark this.

21 (STAFF EXHIBIT-Q WAS MARKED.)

22 JUDGE FARRAR: Go ahead, Mr. Turk.

23 MR. TURK: I need to find a way to

24 address all of you collectively so I may just refer

25 to you as Members of the Panel. And if I do that,

1 I'm addressing all three of you collectively.

2 Members of the Panel, do you recognize

3 this document marked as Staff Exhibit Q?

4 PANEL: Yes.

5 Q. And it's the document you prepared, as

6 indicated on the cover page?

7 PANEL: Yes.

8 Q. Dr. Stamatakos, by way of background,

9 could you explain what that document is?

10 DR. STAMATAKOS: This is a report that

11 we prepared in response to the exemptions request,

12 in our evaluation of the exemptions request to, in

13 the larger sense, document a summary of our review

14 in 1999 of the PFS application in the of seismic

15 hazard assessment.

16 Q. And is this document also referenced in

17 the Staff's SER which has been admitted, your

18 Honors, as Staff Exhibit C in this proceeding?

19 DR. STAMATAKOS: Yes.

20 MR. TURK: Your Honor, at this time I'd

21 like to request that this document, identified as

22 Staff Exhibit Q, be admitted into evidence.

23 JUDGE FARRAR: Any objection?

24 MR. GAUKLER: No objection.

25 MS. CHANCELLOR: No objection.

1 JUDGE FARRAR: Then Staff Q will be
2 admitted?
3 (STAFF EXHIBIT-Q WAS ADMITTED.)
4 MR. TURK: At this time we are
5 distributing the next Staff exhibit, Staff Exhibit
6 R.
7 (STAFF EXHIBIT-R WAS MARKED.)
8 Q. This is a document entitled Comparison
9 of Western U.S. Hazard Curves. And I would ask the
10 members of the panel if they recognize this
11 document.
12 PANEL: Yes.
13 Q. And Dr. Stamatakos, is this a document
14 that you prepared?
15 DR. STAMATAKOS: Yes.
16 Q. Could you explain what this is?
17 DR. STAMATAKOS: This is a document that
18 we prepared during our review in the Supplemental
19 Safety Evaluation Report preparation, and it was --
20 it's a plot that tries to capture the range of
21 seismic hazard curves for various nuclear
22 facilities in the Western United States. And then
23 included on there is also a seismic hazard curve
24 that I took from a 1997 United States Geologic
25 Survey paper for Salt Lake City.

1 Q. And each of the curves are shown in
2 color with corresponding labels in the same color
3 indicating what the curve is for?
4 DR. STAMATAKOS: That's correct.
5 MR. TURK: Your Honor, we would offer
6 Staff Exhibit R into evidence at this time.
7 JUDGE FARRAR: Before I ask for
8 objections, could you explain it to us in a little
9 more detail what the two axes represent?
10 DR. STAMATAKOS: Certainly. The X axis,
11 the horizontal axis, is ground motion; in this case
12 the part of ground motion is the peak ground
13 acceleration. This time it is plotted in
14 centimeters per second squared, which is roughly
15 equivalent to about a 1000 times values of g. The
16 vertical axes or the Y axes are exceedance
17 probabilities in log space for between ten to the
18 minus one and ten to the minus six.
19 JUDGE FARRAR: So, for example, the
20 Yucca Mountain curve horizontally across from ten
21 to the minus four, tell me what that represents.
22 DR. STAMATAKOS: If you go horizontally
23 across from an exceedance probability at ten to the
24 minus four, annual exceedance probability, the
25 curve would intersect at a ground motion level at

1 approximately 600 centimeters per second squared.
2 Q. And for clarification, what would that
3 be in terms of the standard way of describing PGA
4 in terms of gravity?
5 DR. STAMATAKOS: That would be
6 approximately .6 g.
7 JUDGE FARRAR: So the centimeters per
8 second per second happens to correspond to g just
9 by coincidence?
10 DR. STAMATAKOS: You have to multiply it
11 by that gravitational constant line, .8.
12 JUDGE FARRAR: Right. But 600 is.6?
13 DR. STAMATAKOS: That's correct.
14 JUDGE FARRAR: For eyeball purposes.
15 DR. STAMATAKOS: That's correct.
16 JUDGE FARRAR: And would the Bay Bridge
17 line, San Francisco Bay Bridge line be linear if it
18 were extended, or why is it not extended?
19 DR. STAMATAKOS: I'm assuming it is not
20 extended because whoever originally compiled and
21 prepared that data only evaluated to a probability
22 of ten to the minus four, and I don't know whether
23 it would be linear beyond that or not.
24 JUDGE FARRAR: So this is not a
25 calculation you did; this is something you pulled

1 out of a text somewhere?

2 DR. STAMATAKOS: Text or data that I

3 have accumulated from various sources.

4 JUDGE FARRAR: Okay. Thank you for that

5 explanation. Mr. Gaukler?

6 MR. GAUKLER: No objection.

7 JUDGE FARRAR: Ms. Chancellor?

8 MS. CHANCELLOR: Objection, you Honor.

9 JUDGE FARRAR: Okay.

10 MS. CHANCELLOR: First of all, I don't

11 see one reference in the testimony to Staff's

12 Exhibit R.

13 Second, it's a nice, colorful map but it

14 has absolutely not one reference as to where any

15 one of these lines came from. Salt Lake City is a

16 nice red line, Skull Valley Soil, Skull Valley

17 Rock. There's absolutely no -- if it came from

18 some publication, there's no reference data. I

19 think that -- two reasons. It is not cited in the

20 testimony, and it is -- this exhibit could be

21 extremely misleading if there is no reference data

22 with respect to where these numbers came from.

23 MR. TURK: Your Honor, I hope you'll

24 hear from us before you rule.

25 (The Board confers off the record.)

1 JUDGE FARRAR: Mr. Turk, Ms. Chancellor
2 has two objections; that there's no reference to
3 this exhibit in the testimony and there's no
4 indication of where the curves came from.
5 MR. TURK: They are easy objections to
6 solve, your Honor. I direct your attention to Page
7 16 at the bottom.
8 JUDGE FARRAR: Page 16 of the testimony?
9 MR. TURK: Of the prefiled testimony,
10 yes. There is a discussion by the witnesses as to
11 the conservative nature of the PSHA that was
12 conducted by the Applicant here, and discussing the
13 fact that the conservativism existed, at the bottom
14 of the page, starting the last few words, they
15 state, "This is shown in a figure entitled --"
16 JUDGE FARRAR: Wait a minute. I was on
17 the wrong page here. Go ahead.
18 MR. TURK: The statement here is in the
19 testimony that, "This," meaning the conservatism,
20 "is shown in a Figure entitled Comparison of
21 Western U.S. Hazard Curves, which the Staff intends
22 to submit as an Exhibit in this proceeding." Well,
23 this is the exhibit. And, in fact, it was prefiled
24 along with the testimony, so the State has been
25 aware of this since April 1 or 2 when they received

1 the testimony.

2 JUDGE FARRAR: But usually the testimony

3 refers explicitly to exhibit numbers. And so we

4 are --

5 MR. TURK: The testimony was completed

6 before the exhibits were assembled and numbered.

7 And due to the filing deadline and need to get

8 everything out, it went out without a precise

9 exhibit number in the testimony. But we certainly

10 pre-produced with the exhibit number because we

11 were able to do that after the testimony was typed.

12 JUDGE FARRAR: I do recall that April 1

13 was a confusing time for everyone.

14 MR. TURK: Very busy period.

15 JUDGE LAM: And Mr. Turk, do you mean to

16 say this exhibit, Staff Exhibit R, is compiled as a

17 result of the program, the United States Geological

18 Survey National Earthquake Hazard Reduction

19 Program, exhibit 2?

20 MR. TURK: I think the witness can

21 identify what that statement means. What we

22 indicated is it was compiled by the witness, as he

23 indicated himself, in order to show how the

24 different mean annual probability of exceedances

25 compare at different Western United States sites.

1 JUDGE LAM: So this exhibit is compiled
2 by the witness?
3 MR. TURK: Yes.
4 JUDGE FARRAR: How about the second
5 objection that --
6 MR. TURK: The second is easy to cure
7 through cross-examination of the witness. If
8 there's any question about the sources, they can
9 inquire into that.
10 JUDGE FARRAR: Well, then, why don't we
11 withhold admission of the exhibit pending that
12 cross-examination. So we will take the State's
13 objection under advisement at this point on Exhibit
14 R.
15 You have more exhibits, Mr. Turk?
16 MR. TURK: Your Honor, at this point we
17 would pass out Staff Exhibit S.
18 (STAFF EXHIBIT-S WAS MARKED.)
19 JUDGE FARRAR: The reporter has marked
20 this as Staff S for identification.
21 MR. TURK: And your Honor, for the
22 record let me identify what this document is.
23 Actually is an exhibit comprised of several related
24 documents. First, at the top is a document labeled
25 SECY-98-071 dated April 8, 1998. It is a

1 memorandum from L. Joseph Callan, Executive
2 Director for Operations at the NRC, to the
3 Commissioners. Subject, Exemptions to 10 CFR
4 72.102(f)(1), Seismic Design Requirement for Three
5 Mile Island Unit 2, Independent Spent Fuel Storage
6 Installation. That document consists of four
7 numbered pages. It's followed by a draft letter
8 under the name of Charles J. Haughney to a Mr.
9 Wilcynski at the Idaho Operations Office at the
10 Department of Energy. And following that is a
11 draft SER consisting of four pages. That document
12 in its entirety is SECY 98.071, and that's the
13 memorandum with the attached draft letter and draft
14 SER.
15 Following that document is a one-page
16 document dated May 20, 1998. And this is a Staff
17 requirement memorandum, from John C. Hoyle to L.
18 Joseph Callan, Subject, Staff Requirements: SECY
19 98-071 - Exemption to 10 CFR 72.102(f)(1) Seismic
20 Design Requirement for Three Mile Island Unit 2
21 Independent Spent Fuel Storage Installation. And
22 if I didn't mention before, that document is dated
23 May 20, 1998.
24 And finally, the last document in this
25 three-part exhibit is a letter signed by Charles

1 Haughney, Acting Director of the Spent Fuel Storage
2 Office, to Mr. J. M. Wilcynski dated May 28, 1998,
3 responding to the Department of Energy's request
4 for exemptions from the requirements of 10 CFR
5 72.102(f)(1). And that cover letter is followed by
6 an SER and a service list of persons who received
7 copies of the document.
8 JUDGE FARRAR: And what's the purpose
9 for which you offer this?
10 MR. TURK: In the Staff's SER, and in
11 the witnesses' testimony, the Staff explained that
12 part of its basis for deciding that a 2000 year
13 return period ground motion would be appropriate
14 was looking back at past precedent. And one of the
15 examples drawn upon was the issuance of an
16 exemption for the TMI2 ISFSI. And this is the
17 document that comprises the official record of the
18 granting of that exemptions request.
19 JUDGE FARRAR: Mr. Gaukler, any
20 objection?
21 MR. GAUKLER: No objection.
22 JUDGE FARRAR: Ms. Chancellor?
23 MS. CHANCELLOR: None, your Honor.
24 JUDGE FARRAR: The Staff S will be
25 admitted. Go ahead, Mr. Turk.

1 (STAFF EXHIBIT-S WAS ADMITTED.)

2 MR. TURK: At this time we pass out

3 Staff Exhibit T.

4 (STAFF EXHIBIT-T WAS MARKED.)

5 MR. TURK: Staff Exhibit T consists of

6 two documents. First, the cover page is actually

7 one document by itself. It is a Staff requirement

8 memorandum entitled SECY 98-126 Rulemaking Plan:

9 Geological and Seismological Characteristics for

10 Siting and Design of Dry Cask Independent Spent

11 Fuel Storage Installations, 10 CFR Part 72. And

12 this is a memorandum from John C. Hoyle, secretary

13 to L. Joseph Callan, Executive Director of

14 Operations, dated June 24, 1998. That one-page

15 document is followed in this exhibit by a second

16 document which is, in fact, SECY 98-126, entitled

17 Rulemaking Plan, Geological and Seismological

18 Characteristics for Siting and Design of Dry Cask

19 Independent Spent Fuel Storage Installations 10 CFR

20 Part 72. It is a memorandum from L. Joseph Callan

21 to the Commissioners dated June 4, 1998.

22 JUDGE FARRAR: And this deals with an

23 earlier version of the rulemaking plan we had

24 discussed earlier today?

25 MR. TURK: Yes. This, in fact, is the

1 rulemaking plan which I believe serves as the
2 premise for the State's initial filing of the
3 seismic exemptions contention as referenced in the
4 contention.
5 JUDGE FARRAR: Mr. Gaukler?
6 MR. GAUKLER: No objection.
7 JUDGE FARRAR: Ms. Chancellor?
8 MS. CHANCELLOR: No objection, you
9 Honor.
10 JUDGE FARRAR: All right. This will be
11 admitted.
12 (STAFF EXHIBIT-T WAS ADMITTED.)
13 MR. TURK: Your Honor, at this time
14 Staff will distribute copies of Staff Exhibit U.
15 JUDGE FARRAR: And the reporter will
16 mark this for identification, as she has done with
17 all the previous ones.
18 (STAFF EXHIBIT-U WAS MARKED.)
19 JUDGE FARRAR: All right. Exhibit U has
20 been marked.
21 MR. TURK: Your Honor, let me describe
22 this for the record. This is actually a composite
23 exhibit again. The very first document is a letter
24 dated November 27, 2001 from Richard A. Meserve,
25 Chairman of the Commission, to Dianne R. Nielson,

1 Ph.D., Executive Director of State of Utah
2 Department of Environmental Quality, and Mr. Jay
3 Silberg of the Shah Pittman law firm. That is a
4 two-page letter with enclosures. The first
5 enclosure actually could stand as a separate
6 document or exhibit itself, but we thought it might
7 be appropriate just to attach them all here as they
8 were included as enclosures to the letter.
9 The second document included in this
10 exhibit is labeled SECY 01-0178 and it is dated
11 September 26, 2001. It is a memorandum from
12 William D. Travers, Executive Director of
13 operations to the Commissioners. Subject:
14 Modified Rulemaking Plan, 10 CFR Part 72,
15 Geological and Seismological Characteristics for
16 Siting and Design of Dry Cask Independent Spent
17 Fuel Storage Installations. And that is, at the
18 bottom, indicated to be Enclosure 1 to the
19 Chairman's letter.
20 And following along behind that
21 document, the very last page is Enclosure 2 to the
22 Chairman's letter. And that document is dated
23 November 19, 2001. It is a Staff Requirement
24 memorandum from Annette L. Vietti-Cook, secretary
25 to William D. Travers, Executive Director for

1 Operations. Subject: Staff Requirements SECY
2 01-0178, Modified Rulemaking Plan, 10 CFR Part 72,
3 Geological and Seismological Characteristics for
4 Siting and Design of Dry Cask Independent Spent
5 Fuel Storage Installations. And that is, in fact,
6 the SRM that responds to SECY 01-0178 which is the
7 Modified Rulemaking Plan.
8 JUDGE FARRAR: And I take it that SECY
9 01-0178 supersedes 98-126? Is that how the system
10 works?
11 MR. TURK: Yes, your Honor. It
12 supersedes and modifies. It doesn't entirely do
13 away with the original one, but it modifies it.
14 JUDGE FARRAR: Right. And that just
15 means that every time you all go up to the
16 Commission with a new version, it gets a new docket
17 number, as it were?
18 MR. TURK: A new SECY paper number, and
19 it would mean in hearings I would have to read a
20 very long title.
21 JUDGE FARRAR: Mr. Gaukler?
22 MR. GAUKLER: No objection.
23 JUDGE FARRAR: Ms. Chancellor?
24 MS. CHANCELLOR: No objection, your
25 Honor.

1 JUDGE FARRAR: All right. Then Staff
2 Exhibit U will also be admitted.
3 (STAFF EXHIBIT-U WAS ADMITTED.)
4 MR. TURK: Your Honor, may I take a
5 moment to confer with the witnesses?
6 JUDGE FARRAR: Yes.
7 (Discussion off the record.)
8 MR. TURK: That completes the Staff's
9 direct examination and offer of exhibits, and we
10 understand the ruling on admissibility of R has
11 been deferred so we will rest there.
12 JUDGE FARRAR: Okay. Mr. Gaukler, you
13 are going to do the cross for the Applicant?
14 MR. GAUKLER: Yes, I am.
15 JUDGE FARRAR: How much time do you
16 think you will need?
17 MR. GAUKLER: Ten minutes, at most.
18 JUDGE FARRAR: Okay. Ms. Chancellor,
19 are you doing this for the State or Ms. Nakahara.
20 MS. CHANCELLOR: I'm doing it, your
21 Honor.
22 JUDGE FARRAR: How long do you think you
23 will need?
24 MS. CHANCELLOR: It will go until
25 tomorrow.

JUDGE FARRAR: Okay.

MS. CHANCELLOR: I beg your pardon. Until Monday.

JUDGE FARRAR: Fortunately we are in Salt Lake City. In D. C. you might have meant that. And your plan is to finish by Monday noon.

MS. CHANCELLOR: That's the plan, but it's not the guarantee.

JUDGE FARRAR: Okay. And then -- well, we will do this at the end of the day. Go ahead, Mr. Gaukler.

CROSS-EXAMINATION

BY MR. GAUKLER:

Q. Good afternoon. My name is Paul Gaukler appearing for the Applicant, Private Fuel Storage. I have very few questions and I'm going to focus my questions on your Question and Answer 13. There you make reference to the acceptability of a design basis earthquake of five times ten to the minus four for the PFS facility for the mean return period earthquake. My first question is I'd just like to have you elaborate on the reason for using the mean return period as the basis for establishing the design basis earthquake for the

1 PFS as opposed to the median.

2 DR. STAMATAKOS: I think I'd ask

3 Dr. McCann to answer that. He is probably better

4 qualified than I am.

5 DR. McCANN: In our view, the use of the

6 mean hazard, the use of the estimate of the mean

7 hazard is more appropriate in a number of respects.

8 One is, as Dr. Cornell discussed this morning, the

9 mean does include, at least implicitly, the

10 uncertainty that has been considered explicitly in

11 the hazard analysis. So we have a representation

12 of uncertainty in the mean.

13 Secondly, in the context of generally

14 considering risk and making risk-informed

15 decisions, it is typical within the context of risk

16 analyses to want to make mean estimates of risk,

17 and to do that one would use the mean hazard curve.

18 So that the mean offers a parameter that has a

19 number of attributes that it carries with it that,

20 in our view, provides a better characterization of

21 the hazard, it's uncertainties, and a subsequent

22 application of that product as it is handed off, in

23 the context of the design.

24 Q. I also notice in your answer to question

25 13 that you adopt a risk layers approach in

1 determining the appropriate design basis earthquake
2 for the Private Fuel Storage facility in the sense
3 that you compare it to the hazards that would be
4 associated with a design basis earthquake for a
5 nuclear power plant?
6 DR. STAMATAKOS: That's correct.
7 DR. McCANN: Correct.
8 Q. And because the risk for an ISFSI is
9 less than that for a nuclear power plant, you agree
10 that the design basis earthquake for the PFSF may
11 be less than that for a nuclear power plant? I
12 mean, have a higher probability than that for a
13 nuclear power plant?
14 DR. STAMATAKOS: I agree.
15 Q. Now, when you are comparing the mean,
16 say the 2000 mean return period earthquake for the
17 PFS, what would be -- when you are comparing it to
18 the earthquake hazard for a nuclear power plant,
19 what would be the appropriate comparison between
20 the 2000 mean return period earthquake for the PFSF
21 with that for a nuclear power plant? Would it be
22 to the mean of some group of nuclear power plants,
23 their mean earthquake design basis, or would it be
24 to the median of some group of nuclear power
25 plants?

1 DR. STAMATAKOS: I would say you want to
2 stay in the same statistic and look at mean
3 compared to mean.
4 Q. Okay. Do you have anything to elaborate
5 on that, Dr. McCann, beyond that?
6 DR. McCANN: Well, your question
7 addresses, really, a broad range of issues that
8 don't originate with us in the context of our
9 review. In other words, your reference to the
10 hazard posed by an ISFSI versus an operating
11 nuclear power plant, that notion and the fact that
12 an ISFSI represents a lower hazard was made by the
13 Commission. And that represented one of our
14 starting points with regard to our consideration,
15 as you put it, of a graded approach. There was
16 also a statement in the SECY, I forget the number
17 right now, in which it was stated that the design
18 for an ISFSI need not be as stringent, meaning the
19 ground motion basis need not be as stringent as
20 that for a nuclear power plant. So that
21 represented two, if you will, qualitative
22 directions for us in the context of establishing
23 what an appropriate design basis ought to be for
24 the PFS.
25 Q. And I guess my question was going

1 towards when you are trying to compare the relative
2 hazards, is it appropriate to express the design
3 basis earthquake for a nuclear power plant as a
4 mean-based annual average or a median-based
5 average?
6 DR. McCANN: In my opinion, in terms of
7 a mean.
8 Q. Now, there's been reference to
9 Regulatory Guide 1.165 making reference to a median
10 of ten to the minus five. You heard Dr. Cornell
11 explain his beliefs that that was, in part, due to
12 historically a difference between two different
13 studies, the results from two different studies.
14 Do you have an opinion on that?
15 DR. McCANN: Yes. My recollection of
16 that process is a little bit different than
17 Dr. Cornell's, because at the time, as I recall, a
18 lot of the differences between the two studies were
19 either resolved or nearly resolved, although they
20 weren't, obviously, exact. So the median, however,
21 as Dr. Cornell said, more so than the mean, over
22 time represented a more stable comparison between
23 the two studies, even when they were so
24 dramatically different in the mean. So there was
25 some reluctance to use the mean, I believe, at that

1 time, even though the issues were either resolved
2 or nearly resolved.
3 There were also, as I recall, based on
4 the extensive studies done by the Staff's
5 contractor, Lawrence Livermore, and the Electric
6 Power research Institute which was doing work on
7 behalf of the nuclear industry while this
8 Regulatory Guide was being developed, there were
9 various studies being done in which the mean and
10 the median were both looked at. And despite the
11 favorable problemistic or statical attributes of
12 the mean, the median brought some other attributes
13 to the table that offered a sense of, I'll say
14 stability, as one made comparisons. And I think
15 that went into the eventual decision to use the
16 median. The near term reluctance based on the big
17 differences between EPRI and Livermore to pursue
18 the mean, and the fact that the median did have
19 some positive attributes that it brought to the
20 table, albeit, it is not a parameter that is
21 carried forth in probabilistic risk studies.
22 Q. So for those reasons you believe it's
23 appropriate to use a mean base in this case?
24 DR. McCANN: I did then, and I do now.
25 Q. Okay. I have no further questions.

1 JUDGE FARRAR: Thank you, Mr. Gaukler.
2 Ms. Chancellor?
3
4 CROSS-EXAMINATION
5 BY MS. CHANCELLOR:
6 Q. Good afternoon. My name is Denise
7 Chancellor, representing the State of Utah. I will
8 direct my question either to a person specifically
9 or to the panel in general. What I would ask is
10 that you do not confer amongst each other prior to
11 answering the question.
12 In general, your testimony discusses the
13 acceptability of PFS's seismic exemptions request.
14 Is that right?
15 DR. McCANN: Yes.
16 DR. STAMATAKOS: Yes.
17 DR. CHEN: Yes.
18 Q. And you are not testifying about dose
19 consequences; is that correct?
20 DR. McCANN: Yes.
21 Q. And you are relying on Michael Waters
22 for anything that you raise in your testimony with
23 respect to dose consequences; is that correct?
24 MR. TURK: I would ask for
25 clarification. Is there some part of the testimony

1 that refers to dose consequences?

2 MS. CHANCELLOR: I believe on Answer 21

3 it refers to dose limits specified in 72.106(a),

4 and it talks about testimony by Dr. Waters and

5 release of radiological materials. In is Answer 21

6 on Page 26.

7 MR. TURK: Thank you.

8 Q. (By Ms. Chancellor) And to all the

9 panel members?

10 DR. McCANN: Could you restate your

11 statement before you were questioned?

12 Q. That you are not or to the extent that

13 you address radiation doses in your testimony, you

14 are relying on Michael Waters's testimony for

15 statements in your testimony?

16 DR. McCANN: That is true. But we also

17 spoke just a moment ago of relying on Commission

18 statements about the radiological hazards

19 associated with nuclear power plants and ISFSIs,

20 the fact that they are different. So to the extent

21 that radiological doses are part of the

22 Commission's statement, we do rely on that.

23 Q. Okay. Thank you for that clarification,

24 Dr. McCann. And also, looking at Answer 21, you

25 are not testifying about cask performance; is that

1 correct?

2 DR. STAMATAKOS: That's correct.

3 Q. And to the extent that there's anything

4 in your testimony about cask performance, do you

5 rely on, I can't remember if it is Mr. Or

6 Dr. Pomerening and Dr. Luk?

7 MR. TURK: Your Honor, I would object.

8 I can't tell you at this time, I don't know if Ms.

9 Chancellor can, exactly what statements she may be

10 referring to in this 35-page piece of testimony.

11 If she has a question about a particular statement

12 in the testimony she can ask if they rely on

13 someone else or their own view. But it unfair to

14 ask the witnesses to try to recall, or to

15 characterize if for all of their testimony there is

16 something they are relying on someone else for --

17 MS. CHANCELLOR: I'm trying to establish

18 the area of expertise.

19 MR. TURK: We would stipulate that they

20 are not being provided to talk about cask

21 performance or radiation doses.

22 JUDGE FARRAR: I think that was the

23 purpose of the questions, was to exclude rather

24 than to include areas as not within their

25 testimonial capability here. And that's how I took

1 the question, rather than having them thinking they
2 were supposed to review their entire testimony.
3 MS. CHANCELLOR: That's precisely it.
4 MR. TURK: I think we were fairly
5 careful in framing their testimony to reference
6 other sources where we say, when we talk about
7 someone's statement about their consequences we
8 indicate it is the statement of so and so.
9 JUDGE FARRAR: I think Ms. Chancellor
10 was trying to pin that down. Let's let her
11 continue. Although, if there's a whole lot more
12 questions of that nature, maybe a stipulation would
13 save us some time.
14 MS. CHANCELLOR: That was it. I just
15 wanted to establish the ground rules, and I'll move
16 on.
17 JUDGE FARRAR: Okay.
18 Q. (By Ms. Chancellor) Is it true that you
19 would have no personal knowledge of whether PFS
20 complies with NUREG 0800 Seismic Design parameters
21 Section 3.7.1?
22 DR. STAMATAKOS: Can you define what you
23 mean by "no personal knowledge"?
24 Q. Do you have --
25 JUDGE FARRAR: That's more, I think, for

1 you to define.

2 DR. STAMATAKOS: Well, we certainly know

3 what the evaluations have been in the context of

4 other parts of the review in the SER.

5 Q. Did you conduct or was any of your

6 review for the seismic exemptions request based on

7 your personal review of whether PFS complied with

8 NUREG 0800 Section 3.7.1 Seismic Design Parameters?

9 DR. STAMATAKOS: No.

10 Q. Was any of your review of PFS's seismic

11 exemptions request conducted based on your review

12 of whether PFS complied with NUREG 0800 3.8.5,

13 Foundations? Staff's Exhibit EE.

14 DR. STAMATAKOS: We did not personally

15 review those, no.

16 Q. Okay. Thank you.

17 MR. TURK: Your Honor, may I interject a

18 background point? The witnesses' testimony

19 indicates that they were partially responsible for

20 preparation of the Staff's SER and they indicate

21 the sections of the SER that they were involved in

22 drafting. I think that might be a handy point to

23 turn to if there's any question about what they

24 used in their analysis or what they are applying.

25 MS. CHANCELLOR: Was that an objection

1 or a suggestion?

2 MR. TURK: That's a continuing objection

3 to asking the witnesses to characterize all of

4 their testimony, all of their study, with respect

5 to either a standard or a subject matter. The

6 subject matter is explained there and I think

7 trying to characterize it in a single sentence may

8 do harm to the record and to the nature of their

9 testimony.

10 JUDGE FARRAR: This is cross-

11 examination, Mr. Turk. And we have just got

12 started. I haven't seen anything irregular or

13 excessive yet. So I will overrule that objection.

14 MR. TURK: Thank you, your Honor.

15 Q. (By Ms. Chancellor) What is the basis

16 of A21. Who answered that? Dr. Stamatakos, do you

17 have a basis for your opinion that the regulatory

18 standard that applies to dose limits is 72.106(b)?

19 DR. STAMATAKOS: Yes. As we said in the

20 testimony, the dose limits that are specified in 10

21 CFR 72.106(b) are for design basis events and the

22 dose limits specified in 10 CFR 104(a) are for

23 anticipated events.

24 Q. And when you say "design basis events",

25 are you talking about a design basis with a mean

1 annual return period of 2000 years?

2 DR. STAMATAKOS: The 2000 year mean

3 annual return period you refer to is part of the

4 exemptions request for the seismic hazard

5 assessment at the site. Reg 72, as you know, the

6 requirements in that regulation as they are now

7 written is for deterministic analysis for seismic

8 valuation.

9 Q. Would you agree that the design basis

10 earthquake that you are rearing to in Answer 21 of

11 your testimony refers to a 2000 year mean annual

12 return period?

13 DR. STAMATAKOS: Yes.

14 Q. Thank you. Is it correct that if PFS is

15 not granted the exemptions request and has to

16 comply with a 5000 year mean annual return period

17 earthquake, that the design basis earthquake that

18 you referred to with respect to dose limits in

19 72.106(b) would be based on a 5000 year mean annual

20 return period earthquake?

21 DR. STAMATAKOS: I would presume so,

22 yes. Although I will qualify my answers here by

23 saying that in our evaluations of these parts of

24 the regulations, we would certainly confer with

25 members of NRC Staff who are more familiar with

1 dose requirements, dose limits, who are experts in
2 those areas.
3 Q. And who would you confer with?
4 DR. STAMATAKOS: Well, in this
5 particular case, certainly Mike Waters, as he has
6 indicated that he is testifying on these. But
7 others of the NRC Staff who would be involved in
8 the project.
9 Q. Okay. Now, Dr. Stamatakos, were you
10 responsible for reviewing PFS's site
11 characterization?
12 DR. STAMATAKOS: Yes. Among other
13 things, yes.
14 Q. In the SER, on consolidated SER on Page
15 236, you state, "The Staff found no evidence of
16 historic seismicity in the vicinity of the site."
17 Page 236.
18 MR. TURK: Do you have a copy of the
19 consolidated SER?
20 Can we go off the record for a moment?
21 (Discussion off the record.)
22 JUDGE FARRAR: Back on the record. Let
23 me ask the parties a question on this difference in
24 and which section of the regulation provides the
25 dose limit. Is that something you all expect to

1 establish through the different experts or is that
2 a legal matter to argue? Ms. Chancellor?
3 MS. CHANCELLOR: I think it is both,
4 your Honor. I think that will come out during the
5 radiation consequences part of the hearing.
6 JUDGE FARRAR: Okay.
7 MR. GAUKLER: We believe it is a legal
8 matter, your Honor. We have said it before.
9 MR. TURK: In our view it is entirely a
10 legal matter except that the witnesses are now
11 stating their opinion with respect to whether or
12 not a certain regulatory requirement is satisfied,
13 so they refer to that standard as they understand
14 it will be apply.
15 JUDGE FARRAR: Okay. So we can get
16 their opinion on whether something is satisfied
17 without deciding at that point what the proper
18 standard is?
19 MR. TURK: They may also characterize it
20 as they believe it applies, but you would not have
21 to listen to them for that. You would make your
22 own legal determination.
23 JUDGE FARRAR: Okay.
24 Q. (By Ms. Chancellor) Dr. Stamatakos,
25 Page 236 of the SER states that the Staff reviewed

1 information provided by the Applicant and evaluated
2 the Applicant's analyses of historic seismicity.
3 The Staff found no evidence of historic seismicity
4 in the vicinity of the site. Is that correct?
5 DR. STAMATAKOS: That's correct.
6 Q. And you conducted that review?
7 DR. STAMATAKOS: Yes.
8 Q. I'd like to hand out State's Exhibit
9 183, which is SAR Chapter 2, Revision 9, Page
10 2.6-89. And also second page 2.6-4, Page 2 of 14,
11 SAR Chapter 2, Revision 0.
12 JUDGE FARRAR: Is this going to be an
13 exhibit?
14 MS. CHANCELLOR: Yes. 183, your Honor.
15 (STATE EXHIBIT-183 AS MARKED.)
16 Q. (By Ms. Chancellor) Do you have the
17 exhibit in front of you, Dr. Stamatakos?
18 DR. STAMATAKOS: Yes.
19 Q. If you look at Paragraph 2, the second
20 sentence says, "Table 2.6-4 is a chronological
21 listing and description of those events." And
22 those events are earthquakes within 100 miles of
23 the PFS site with a magnitude of 3.0 or greater.
24 DR. STAMATAKOS: That's correct.
25 Q. And it describes, "Only one earthquake

1 greater than magnitude 3.0 has been reported within
2 50 kilometers of the PFSF site."
3 DR. STAMATAKOS: That's correct.
4 Q. And that event occurred August 11, 1915.
5 DR. STAMATAKOS: That's correct.
6 Q. And then the last sentence of that
7 paragraph states, "The earthquake was not reported
8 in Tooele, less than 20 miles from Iosepa. And
9 then if you look on Table 2.6-4, second entry,
10 1915, date August 11. You see that?
11 DR. STAMATAKOS: Yes.
12 Q. You're probably not familiar with the
13 latitude and longitude of the PFS site, are you?
14 DR. STAMATAKOS: Not without looking at
15 a map.
16 Q. It's at the top of the table. Would you
17 take my representation that the earthquake that
18 occurred in 1915 was about 10 kilometers or 16
19 kilometers from the site?
20 MR. TURK: Ten miles?
21 Q. Ten miles or 16 kilometers.
22 MR. TURK: May I ask if the witness
23 needs time to review his own report?
24 DR. STAMATAKOS: Well, I would note in
25 the table the longitudes are recorded only in

1 degrees without -- excuse me. I just have to
2 characterize those. I could probably calculate it
3 but hypothetically, for the moment, I will take
4 your word for it.
5 Q. Does this suggest that there is evidence
6 of historic seismicity in the vicinity of the site?
7 DR. STAMATAKOS: Well, I would still
8 argue on two points; that, one, it's a quite small
9 magnitude earthquake, and two, that the distance,
10 if it truly is ten miles or slightly more than ten
11 miles, is not right on the site.
12 Q. What is your definition of vicinity of
13 the site with respect to site characterization?
14 DR. STAMATAKOS: I'd have to go back in
15 my memory quite a way to remember what we did in
16 this particular part. This was done in the 1999
17 review. I don't remember, offhand, without
18 checking back in my notes, what I would have looked
19 at for vicinity of the site. So I can't answer
20 your question exactly.
21 MR. GAUKLER: Your Honor, I'd like to
22 raise a general point at this point in time. All
23 of this is going to the site investigation, which
24 was really Basis 1 or Basis A of the Unified
25 Contention, and Basis 1 of Utah L. At least that's

1 the way I interpret it. And I'm just raising the
2 question of relevance at this point in time as to
3 understand exactly what we are looking at.
4 MS. CHANCELLOR: Your Honor, the
5 testimony at questions 8, 9, 12, pages
6 approximately 12 through 18, address PFS's PHSA
7 methodology, including site characterization. If
8 the witnesses address site characterization I think
9 it is fair game to point out where there may be
10 some errors in their site characterization.
11 JUDGE FARRAR: Mr. Gaukler?
12 MS. CHANCELLOR: I only have a couple
13 questions in this area.
14 MR. GAUKLER: Well, if she is not going
15 to pursue it much farther --
16 JUDGE FARRAR: Yeah. Rather than try to
17 find where that line is, if we were talking about a
18 lot of questions we would find the line, but let's
19 go ahead.
20 Q. (By Ms. Chancellor) On pages -- on
21 Answer 12, Pages 14 through 16 of your testimony,
22 you discuss the results of a slip tendency analysis
23 of faults in the vicinity of the proposed PFS site.
24 DR. STAMATAKOS: What page of the
25 testimony?

1 Q. Pages 14 through 16.

2 DR. STAMATAKOS: Okay. Thank you.

3 That's correct.

4 Q. And do --

5 JUDGE FARRAR: Did we ever get an

6 answer -- Mr. Gaukler, did you object after an

7 answer?

8 MR. GAUKLER: I don't recall.

9 JUDGE FARRAR: This is why we don't go

10 too late in the day.

11 JUDGE FARRAR: Would the reporter check

12 and see if we got an answer to the question that I

13 thought was pending before the objection?

14 (Discussion off the record.)

15 JUDGE FARRAR: The answer was given, but

16 it was that he couldn't answer it exactly, which is

17 why I think we were confused.

18 Go ahead, Ms. Chancellor. Sorry to have

19 interrupted you.

20 MS. CHANCELLOR: That's fine, your

21 Honor. Before I forget, I'd like to move for

22 State's Exhibit 183 to be entered. That was the

23 SAR sections we handed out.

24 JUDGE FARRAR: I take it there would be

25 no objection to that?

1 MR. TURK: I don't have the SAR with me.
2 Are these the most recent two page?
3 MS. CHANCELLOR: Yes. Even though it is
4 Revision 0, it is the most recent.
5 MR. GAUKLER: On that representation, I
6 have no objection.
7 MR. TURK: Same, your Honor.
8 JUDGE FARRAR: State 183 will be
9 admitted
10 (STATE EXHIBIT-183 WAS ADMITTED.)
11 Q. Getting back to Answer 12 on Pages 14
12 through 16, you discussed the results of slip
13 tendency analysis of faults in the vicinity of the
14 proposed PFS site.
15 DR. STAMATAKOS: Yes.
16 Q. In this analysis you assumed a stress
17 field with a horizontal minimum principal stress
18 Sigma 3 with an azimuth of 85 degrees, and
19 particular ratios among principal stress
20 magnitudes. Correct?
21 DR. STAMATAKOS: That's correct.
22 Q. On Page 15, you conclude, "Fault
23 segments with approximately North-South strikes
24 (azimuth = 175 degrees) are optimally oriented for
25 future fault slip. Faults with north northwest

1 (sic) -south southwest strikes have high slip
2 tendency values. In contrast, fault segments with
3 northwest-southwest (sic) strikes, such as the East
4 fault near the proposed PFS Facility site and the
5 southern segments of the East Cedar Mountain fault
6 also near the proposed PFS Facility site, have
7 relatively low slip tendency values. Therefore,
8 these fault segments are less likely to slip in the
9 future than fault segments further from the site."
10 Is that correct?
11 MR. TURK: Objection, your Honor. I
12 would just note that there were two readings that
13 were incorrect, but we will let the testimony stand
14 for itself.
15 MS. CHANCELLOR: Fine. This is like
16 reading Chinese. That's fine.
17 MR. TURK: We may be able to help you
18 with that, too.
19 JUDGE LAM: Dr. Chen can help you.
20 JUDGE FARRAR: All right. This
21 testimony will stand. The reading, we had a couple
22 of inadvertent misstatements, but we all have the
23 testimony in front of us. So the question is?
24 Q. (By Ms. Chancellor) The question is are
25 you saying that northwest/southwest striking faults

1 near the PFS site can't slip at all and therefore
2 don't need to be considered in seismic hazard
3 analysis?
4 JUDGE FARRAR: Let me correct. If it is
5 northwest it has to be southeast.
6 Q. Northwest/southeast. Right. Are you
7 saying that the northwest/southeast striking faults
8 near the PFS site can't slip at all and therefore
9 don't need to be considered in the seismic hazard
10 analysis?
11 DR. STAMATAKOS: No. Let me elaborate.
12 The slip tendency analysis, which is a fairly
13 simple analysis, although the computer code is
14 fairly complicated, was performed on our behalf and
15 I was involved in it with others at Southwest
16 Research Institute to try to get a sense for which
17 parts of the faults might be the most active in the
18 region, to help us understand where there may be
19 potential conservatisms in the seismic source
20 characterization.
21 The intent here was to try to limit
22 those parts of the fault segments which, given our
23 understanding of the stress stated in this part of
24 the crust, would have the highest slip tendency
25 values. And let me explain about what slip

1 tendency is. It's a ratio that looks at the shear
2 stress divided by the normal stress. And the shear
3 stress is that stress that would act on a fault
4 surface to initiate stress, and the normal stress
5 would be perpendicular and try to limit stress. So
6 as the shear stress, as the slip tendency value
7 goes up, that ratio gets larger, the shear stress
8 is larger than the normal stress and there's a
9 higher, more likely that the faults would slip.
10 We did not try to recharacterize the
11 Applicant's seismic hazard characterization. If an
12 Applicant comes to us where a characterization that
13 we deem adequate or we deem conservative, it is
14 generally accepted and it is not our job to try to
15 redo a characterization that we may deem
16 conservative. But we can do some simple analyses
17 to give us sort of first order understanding of
18 what the seismic hazard assessment, what those
19 results mean to us. So in this case, we have done
20 a number of other kinds of independent analyses to
21 try to demonstrate to ourselves in our review the
22 probability of the Applicant's seismic hazard
23 assessment. And it is up to the Applicant to come
24 forth with the results and what they proposal.
25 Q. And then the slip tendency analysis or

1 review that you did, have you examined the
2 sensitivity of your conclusions about slip tendency
3 and your assumptions about the stress field?
4 DR. STAMATAKOS: To some degree. We
5 looked at variations in the stress field but we
6 tuned the stress field in this particular analysis,
7 as it is described here, to try to get maximum slip
8 tendency values on parts of fault surfaces in the
9 region that have known paleoseismic or seismically
10 active, like the Wasatch Fault.
11 Q. And you base your analysis, in part, on
12 a paper by Martinez, et al, 1998?
13 DR. STAMATAKOS: Only in the sense that
14 that gives us information about what the regional
15 stress conditions, some of the regional stress
16 conditions might be, yes.
17 MS. CHANCELLOR: I'd like to have marked
18 and hand out Utah Exhibit 184. Exhibit 184 is a
19 Geophysical Research Letters, Volume 25, Number 4,
20 Pages 567 through 570, February, 1998. And the
21 title is, "Rapid deformation rates along the
22 Wasatch fault zone, Utah, from first GPS
23 measurements with implications for earthquake
24 hazard," offered by Linda J. Martinez, Charles M.
25 Meertens, and Robert B. Smith.

1 JUDGE FARRAR: We will have the reporter
2 mark this as State's 184.
3 (STATE EXHIBIT-184 WAS MARKED.)
4 JUDGE FARRAR: Go ahead.
5 Q. Is this the paper from which,
6 Dr. Stamatakos, you obtained the Sigma 3 azimuth of
7 85 degrees?
8 DR. STAMATAKOS: Not entirely. We
9 relied on some of the information in this paper
10 and, as I said, we also looked at requirements that
11 faults that are known to slip should have slip
12 tendency values well above .65. So we tuned our
13 slip tendency magnitudes and directions with those
14 principles in mind.
15 Q. If you look at the table on Page 569,
16 Table 1, Wasatch Front Strain Rates from Geodetic,
17 Seismic, and Geologic Determinations.
18 DR. STAMATAKOS: Yes.
19 Q. In this table the 85 degrees doesn't
20 appear on this table; is that correct?
21 DR. STAMATAKOS: That's correct. But
22 what is shown here on this table are principal
23 strain rates, horizontal displacement, and slip
24 rates and orientations of the least principal
25 strain rate.

1 Q. Would you agree that the most reliable
2 Sigma 3 azimuth in the Table is 73 degrees plus or
3 minus 7 degrees?
4 DR. STAMATAKOS: No. Because what is
5 shown there is an orientation for strain, not an
6 orientation of stress. And the two are not
7 necessarily the same.
8 Q. Is it a reasonable assumption that the
9 stress and the strain were oriented in same
10 direction?
11 DR. STAMATAKOS: That is one assumption
12 you would make and test. It depends. Again, as I
13 said, and even if we used -- and I think we
14 actually looked at a range of orientations of the
15 principal stress. That small difference between 73
16 and 85 degrees that we used, 12 degrees would not
17 make a large or have a large impact on the slip
18 tendency analysis results.
19 Q. So you believe this wouldn't affect your
20 conclusion?
21 DR. STAMATAKOS: No, I don't think it
22 would affect my conclusion.
23 Q. Could changes in other parameters
24 assumed in your calculation affect your conclusion
25 if the changes are within the uncertainty limits of

1 these parameters?

2 DR. STAMATAKOS: You'll have to clarify

3 which parameters, which uncertainty limits.

4 Q. Well, let's take an example. Are you

5 aware that some active sections of the Provo

6 section of the Wasatch fault strike northwest?

7 DR. STAMATAKOS: I have to go back and

8 look at a pattern of the parts of the Wasatch fault

9 to remind myself what the Provo segment looks like.

10 Q. If this is correct, would this

11 observation change your opinion about the

12 reliability of the slip tendency analysis for

13 determining whether or not a fault is active?

14 DR. STAMATAKOS: No. Because again, I'd

15 want to know the specifics of what the Provo

16 segment was. One of the clear assumptions that I

17 state in this is that we are assuming a regional

18 stress and that along active faults, especially

19 normal faults which tend to be segmented, there are

20 portions of the faults especially in overlap zones,

21 what we call relay ramps, that may also be active

22 at different orientations and they are responding

23 to the local stress pervasions produced by the

24 overlapping fault tips as opposed to the regional

25 stress. So we clearly made a statement that our

1 assumptions were based on what we interpreted as a
2 reasonable representation of the regional stress.
3 JUDGE FARRAR: When you hear Ms.
4 Chancellor use the word "active", what do you infer
5 from that? And how do you use it yourself?
6 DR. STAMATAKOS: I infer active to
7 indicate faults that have demonstrated geologically
8 relatively recent earthquake activity, either from
9 historic seismicity or from paleoseismic. I think
10 the general --
11 JUDGE FARRAR: When you say "relatively
12 recently", is that tied in with the Commission's
13 definitions when things were done deterministically
14 about movement in the last 35,000 years or repeated
15 movement in the last 500,000 years ago?
16 DR. STAMATAKOS: You stole my thunder.
17 I wrote this down in anticipation that you would
18 bring that up. I think we would probably extend
19 the 35,000 now. It is probably extended so we are
20 looking at, for example, in the Yucca Mountain PHSA
21 which I know Dr. Arabasz was a member of that
22 expert elicitation, the limits go beyond 35,000
23 years for what are considered active faults in that
24 analysis. And there's evidence that goes into
25 the -- I don't remember the exact years. I'm

1 trying to think of some of the most recent slip and
2 some of the less active faults. But 500,000 years
3 is maybe a more appropriate metric than 35,000 for
4 what we consider active. So they don't neatly fit
5 into the old definition of "capable".
6 Q. (By Ms. Chancellor) Dr. Stamatakos,
7 would you agree the answers to Questions 8, 9, and
8 12 of the testimony address PFS's PHSA methodology,
9 if you take a moment to review that?
10 JUDGE FARRAR: What answers were those?
11 Q. Answers 8, 9, and 12. Approximately
12 Pages 12 through 18.
13 DR. STAMATAKOS: You said Page 12, and
14 if you are on Question 8 it starts on Page 8 on my
15 copy.
16 Q. You are right. I did this at ten
17 o'clock last night. Yes, Page 8, Question 8. If
18 you look at Answer 8, in general doesn't this
19 address PFS's PHSA methodology and site
20 characterization?
21 MR. TURK: I would object, your Honor.
22 It's a two and a half page long answer. Trying to
23 characterize it in a phrase may do injustice to it.
24 JUDGE FARRAR: We will let the witness
25 decide that.

1 DR. STAMATAKOS: The end information in
2 here was provided as background information to
3 answer the question about the appropriateness of
4 using a PSHA or DSHA and it is a summary of the
5 Applicant's PSHA, to some extent, and a brief
6 summary of our evaluation of that. But it is meant
7 to try to introduce, I believe, the sort of
8 background information about the exemptions itself.
9 And as we stated, there are two questions that we
10 had to answer in those regards. One is, is the
11 PSHA appropriate; and if the PSHA is appropriate,
12 what is the appropriate exceedance probability,
13 annual exceedance probability to use in determining
14 the design basis ground motions?
15 Q. Okay. And in Question 8, basically it
16 addresses is the PSHA methodology appropriate, not
17 whether you should use a 2000 year design basis
18 earthquake; correct?
19 DR. STAMATAKOS: That's correct.
20 Q. And in question 9?
21 DR. STAMATAKOS: Question 9 also is an
22 answer that goes to the heart of whether or not
23 PSHA may be used in a deterministic hazard
24 assessment.
25 Q. And with the exception of the first

1 paragraph of Paragraph 12 -- I beg your pardon.
2 With the exception of the first paragraph of Answer
3 12, is it correct that the remainder of Answer 12
4 deals with, and this is where we went over the slip
5 tendency, deals with the Applicant's source
6 characterization and conducting a PSHA?
7 DR. STAMATAKOS: Well, one of the
8 "pillars", I guess, is probably too strong of a
9 term. But in support of the 2000 year return
10 period ground motion that we approved in the
11 exemptions request was an analysis to demonstrate
12 that we considered the ground motion, the
13 problemistic ground motion hazard assessment
14 performed by the Applicants, be conservative, and
15 to provide a conservative estimate of what the
16 actual 2000 ground motion values would be for the
17 site.
18 Also the point of that comparative graph
19 that's Exhibit R is to demonstrate in a first order
20 sense to ourselves that there's additional, if you
21 will, margins of safety. And using the 2000 year
22 ground motions as defined by the Applicant in their
23 probabilistic seismic hazard assessment. So we
24 wanted to assure ourselves in the analysis that
25 there were appropriate margins in the problemistic

1 source characterization and ground motion model.
2 So these answers speak to some of the types of the
3 sort of first order tests that we performed to show
4 that our conclusion, or to support our conclusion
5 that the PSHA performed by the Applicant is
6 conservative.
7 Q. So Questions 8, 9 and 12 go to the
8 appropriate use of PSHA and the way in which PFS
9 has conducted the PSHA. All these acronyms.
10 MR. TURK: Your Honor, again, a standing
11 objection to the characterization of testimony. It
12 says what it says. I don't mind if she asks us to
13 help her understand the major thrust of each answer
14 and question. But --
15 MS. CHANCELLOR: I was trying to move it
16 along.
17 MR. TURK: I hope she was trying not
18 trying to exclude anything from the answer that
19 doesn't fit within the narrow limit she was
20 defining.
21 Q. That's final. I will start at Question
22 8 Paragraph 1.
23 JUDGE FARRAR: Mr. Gaukler?
24 MR. GAUKLER: We are getting -- I think
25 this is background in large part and we seem to be

1 getting into a lot of issues that really require
2 the site investigation of Part 1 of Utah L or Part
3 A of Unified Contention. And I'm just concerned we
4 are going to end up far afield of the real issues
5 left for litigation in this unified contention, in
6 C, D, and E.
7 JUDGE FARRAR: So far, and my
8 understanding is she has been asking them about
9 testimony they presented, which she is free to do.
10 It is cross-examination. I think she is free to
11 ask them, "Isn't this what you are saying?" Or,
12 "Isn't this all that you are saying?" And they can
13 answer, "That's true," or, "That's not true." And
14 they can say, "No, it's not what they are saying.
15 Here is what we are really saying." I'm speaking
16 very generally here. But it is cross-examination.
17 So the objections are overruled.
18 Q. So Dr. Stamatakos, I think we
19 established that in Answer 8, that this basically
20 deals with the way in which PFS conducted its
21 probabilistic seismic hazard analysis. Correct?
22 MR. TURK: That's a mischaracterization
23 of the answer that they gave her a few minutes ago.
24 Q. We will go over every single question --
25 JUDGE FARRAR: Wait a minute.

1 MR. TURK: He gave her an answer with
2 many components and she is trying to distill that
3 into a further crystal.
4 JUDGE FARRAR: These are expert
5 witnesses. They are highly competent people. They
6 know what they think. And very few of them so far
7 have been bashful about expressing their opinions
8 even in the face of vigorous cross-examination. If
9 I see that they appear to think they are being
10 harassed or not able to take care of themselves, we
11 will step in. But I haven't seen that yet.
12 DR. STAMATAKOS: Can you restate your
13 question?
14 Q. (By Ms. Chancellor) Let me give you a
15 choice: I can go through Answer 8 paragraph by
16 paragraph or we can agree that Answer 8 deals with
17 the way in which PFS conducted its probabilistic
18 PSHA.
19 JUDGE FARRAR: Or you could assume that
20 that's what it deals with and ask them a question
21 that challenges what they said.
22 MR. TURK: Your Honor, I know you don't
23 want to hear from me on this.
24 JUDGE FARRAR: You're learning.
25 MR. TURK: There's a famous lawyer in

1 Washington who came up with an analogy that he was
2 not a potted plant when his client was being
3 examined.
4 JUDGE FARRAR: That was Brendon Soloman
5 and Holly North, I believe.
6 MR. TURK: It was Soloman who decided he
7 wasn't a plant.
8 JUDGE FARRAR: And Holly North knew he
9 wasn't a plant.
10 MR. TURK: But again, it is an attempt
11 to characterize the testimony. The testimony
12 indicates it is a description of what the Applicant
13 did, as well as what they did in their evaluation.
14 Now, I don't know whether my witnesses are attuned
15 to the question or not. But I don't understand why
16 we have to characterize the testimony. It says
17 what it says. If she has a question about it, let
18 her ask the question. And I would also have to
19 observe, your Honor, --
20 JUDGE FARRAR: Why don't you quit while
21 you are ahead.
22 MR. TURK: Okay.
23 JUDGE FARRAR: Ms. Chancellor, I will --
24 you can ask these questions if you want. But I
25 don't know that getting the witnesses to

1 characterize their testimony advances the ball.
2 I'd rather hear you attempt to challenge their
3 testimony and see what they say.
4 MS. CHANCELLOR: I'd like to -- I'll get
5 to it this way.
6 MR. TURK: One other objection.
7 MS. CHANCELLOR: I haven't started and
8 he is objecting.
9 JUDGE FARRAR: One at a time. Mr. Turk?
10 MR. TURK: She basically said, "I can do
11 it the hard way or the easy way. I can make it
12 question by question or get an easy answer," and I
13 think that is unfair. If she feels she has --
14 MS. CHANCELLOR: I'm taking a different
15 approach, your Honor. I'm moving on.
16 JUDGE FARRAR: We have an understanding.
17 You may not all realize it. We have an
18 understanding on how we are going to proceed.
19 JUDGE FARRAR: Go ahead, Ms. Chancellor.
20 Q. (By Ms. Chancellor) I'd like to hand
21 out two documents. They don't need to be marked.
22 They are legal documents. Joint Submittal of
23 Unified Geotechnical Contention, Utah L and Utah
24 QQ, dated January 16, 2000 consisting of a cover
25 page followed by seven pages which is entitled

1 Unified Consolidated Contentions Utah L/QQ. The
2 second document is dated January 31, 2002, entitled
3 Joint Stipulation of Facts and Issues Not in
4 Dispute with Respect to Unified Contention Utah
5 L/QQ, consisting of three pages. Do you have those
6 two documents in front of you?
7 DR. STAMATAKOS: No. I only have the
8 first one.
9 JUDGE FARRAR: We only got one. We have
10 the stipulation but not the -- which was the second
11 document you referred to? Dr. Kline has the joint
12 submittal and I have the joint stipulation but we
13 don't have both of them. Just make sure the
14 witnesses have them both. We will share up here
15 for now.
16 (Discussion off the record.)
17 Q. If you would look first at Joint
18 Submittal of Unified Geotechnical Contention Utah L
19 and Utah QQ dated January 16, 2002. If you would
20 turn to the second page of the document that was
21 handed out to you and look at Unified Consolidated
22 Contention Utah L and Utah QQ Geotechnical, Section
23 A, Surface Faulting. Do you see that?
24 DR. STAMATAKOS: Yes.
25 Q. And do you see Section B, Ground

1 Motions?

2 DR. STAMATAKOS: Yes.

3 Q. Does Surface Faulting and Ground

4 Motions, does that deal with site characterization?

5 DR. STAMATAKOS: Yes.

6 Q. Would you please look at the stipulation

7 on the second document, January 31, 2002? First of

8 all, have you reviewed the Unified Consolidated

9 Contention before?

10 DR. STAMATAKOS: Yes, I have seen it.

11 Q. Including parts A, B, C, D, and E?

12 DR. STAMATAKOS: Yes.

13 Q. Now, would you look at the joint

14 stipulation, please?

15 DR. STAMATAKOS: Okay.

16 Q. Are you aware that PFS, the State and

17 the Staff have entered into a stipulation with

18 respect to Section A of the Unified Contention,

19 Surface Faulting, and also Section B of the Unified

20 Contention, Ground motions?

21 DR. STAMATAKOS: That's correct. I see

22 that.

23 Q. Isn't it true that the answers in your

24 testimony that relate to site characterization do

25 not relate to the items at issue in this

1 proceeding?

2 MR. TURK: Objection, your Honor. She

3 is asking for a legal conclusion. I don't mind if

4 she asks him how he understands his testimony

5 relates to Section E of the contention.

6 JUDGE FARRAR: Let's get the facts

7 rather than a legal conclusion. I take it you are

8 asking if their testimony relates to B of the

9 stipulation?

10 MS. CHANCELLOR: Of the Unified

11 Contention.

12 JUDGE FARRAR: No. We were just talking

13 about the --

14 MS. CHANCELLOR: Let's do it that way.

15 JUDGE FARRAR: We were just talking

16 about the stipulation and I thought you were asking

17 them if their testimony, prefiled testimony,

18 relates to B of the stipulation.

19 MS. CHANCELLOR: Let's do it that way,

20 yes. Either A or B.

21 DR. STAMATAKOS: The answer that is

22 provided in the testimony answers the question that

23 was put forth in the testimony about what two parts

24 of the exemption request need to be addressed in

25 order to evaluate that exemption through the PSHA?

1 Those two parts, as I said before, are the choice
2 of using a methodology probabilistic versus
3 deterministic. And then if the probabilistic
4 methodology is acceptable what's the appropriate
5 exceedance level return period, if you will, that
6 would be applicable or adequate for design.
7 So the answers that we provided in the
8 testimony were set forth to answer those two
9 questions. And in reviewing my answers provided in
10 testimony, what I see is a discussion of how we
11 conducted our analysis in support of answering the
12 questions specific to Part E of this contention,
13 whether or not an exemption should be granted from
14 the deterministic regulations in 72.
15 Q. Does your Answer 8 relate to Parts A or
16 B of the stipulation?
17 MR. TURK: Again, that is not asking for
18 a legal conclusion or his understanding of what his
19 testimony relates to?
20 MS. CHANCELLOR: That's correct.
21 JUDGE FARRAR: Right.
22 DR. STAMATAKOS: As I look at
23 Stipulation A, it is specific to the issues related
24 to surface faulting and the fault displacement
25 hazard at the site. There are some specific

1 statements in there about characterization issues.
2 But in general, Stipulation A had to do with or has
3 to do with the issue that was raised in regard to
4 the actual surface displacement, I believe, of the
5 small faults that are found right underneath the
6 site.
7 Q. What part of Part E of the Unified
8 Contention does Answer 8 relate to? And Answer 8
9 is on pages 8 through 10.
10 DR. STAMATAKOS: Well, certainly in the
11 very first sentence, the introduction, you state,
12 "Request for exemptions from the requirements of 10
13 CFR 72.102(f) to allow PFS to employ a
14 probabilistic rather than a deterministic seismic
15 hazards analysis, PFS should be required either to
16 use a probabilistic methodology with a 10,000 year
17 return period or comply with the existing
18 deterministic analysis requirement of section
19 72.102(f), or, alternatively, use a return period
20 significantly greater than 2000 years." That's the
21 introduction to Part E. And I believe that the
22 answer that we are giving you in Answer A to
23 Question 8 goes to the heart of that part. Is a
24 deterministic or probabilistic the appropriate
25 method to use in this case?

1 Q. Okay. Moving on to another topic, on
2 Page 16, which is part of Answer 12 again, you
3 state, last paragraph on Page 16, towards the end
4 you state, "For example, the results of the
5 Applicant's PSHA for Skull Valley (Geomatrix
6 Consultants, Inc. 2001a) suggest that it is 1.5
7 times more likely that a ground motion of 0.5g
8 horizontal peak ground acceleration or greater will
9 be exceeded at the PFS site (assuming hard rock
10 site conditions), than at Salt Lake City, based on
11 the USGS National Earthquake Hazard Reduction
12 Program." That's correct, right?
13 DR. STAMATAKOS: That's correct.
14 Q. And the National Earthquake Hazard
15 Reduction Program is a regional assessment; is that
16 correct?
17 DR. STAMATAKOS: The comparison that I
18 made goes back to the Staff Exhibit R. And the
19 curve that was published in the Frankle paper for
20 Salt Lake City is the curve that is represented as
21 the red line labeled "Salt Lake City" in Exhibit R.
22 And that comparison is made with the Skull Valley
23 rock hazard curve, which is the hazard curve
24 provided by the Applicant in the SAR. So that
25 comparison with the 1.5 times more likely comes

1 from comparison of those two particular hazard
2 curves.
3 Q. That's not my question. My question is,
4 is the USGS National Earthquake Hazard Reduction
5 Program map that you reference, is that a regional
6 assessment of earthquake hazards?
7 DR. STAMATAKOS: I'm assuming that is an
8 assessment of earthquake hazards for the city of
9 Salt Lake City.
10 Q. You are assuming?
11 DR. STAMATAKOS: That's correct.
12 Q. You don't know what that --
13 DR. STAMATAKOS: Well, it said it was a
14 comparison of hazard curves for, if you look at
15 that paper by Frankle et al, it's a comparison of
16 hazard curves for a number of U.S. cities. That's
17 where I derived that data.
18 Q. And it's based on major active faults,
19 right? It doesn't identify every specific fault in
20 Salt Lake City, for example.
21 DR. STAMATAKOS: Well, I'm assuming its
22 based on the USGS evaluation. It's a probabilistic
23 analysis based on faults in the vicinity of Salt
24 Lake City. And I'm presuming, not knowing
25 everything that the GS did in this analysis, but

1 it's a first principle that the Wasatch fault
2 probably controls a lot of what is in that hazard.
3 Q. But this USGS National Earthquake Hazard
4 Reduction Program doesn't deal with -- it deals
5 with soft rock sites. Correct?
6 DR. STAMATAKOS: Well, I'm sure it deals
7 with a variety of sites. In this case I made the
8 comparison to the rock curve to Skull Valley, not
9 taking account of soil conditions in Skull Valley
10 which, in PGA, anyway, increase the hazard. As you
11 can see in Exhibit R.
12 Q. Would you use the USGS National
13 Earthquake Hazard Reduction map to establish the
14 design basis ground motions for the PFS site?
15 DR. STAMATAKOS: No.
16 Q. That would not be acceptable for the
17 SAR?
18 DR. STAMATAKOS: That's correct. Again,
19 I would elaborate on that. The intent here was to
20 provide a sort of first order or first principle,
21 to use Judge Lam's terminology --
22 Q. I don't know what first order or first
23 principle are. Can you explain that?
24 DR. STAMATAKOS: At the most fundamental
25 level of our understanding of phenomenon. And in

1 this particular case, what we wanted to show was
2 that, in fact, the Applicant had produced a hazard
3 for the site, either raw hazard that's for the rock
4 site, or if you add on what amplification they have
5 predicted for the soil, that in comparison to many
6 other hazard curves for the Western United States,
7 including the one that was derived by the USGS for
8 Salt Lake City, that those hazards are large
9 compared to many of those other sites. In fact,
10 even large compared to hazard curves for
11 California, for example Diablo Canyon and the San
12 Francisco Bay Bridge.
13 And what is surprising about the
14 Applicant's results in this kind of comparison is
15 that there aren't faults at the site that appear to
16 be as large or as active as the faults that
17 contribute to the hazards in Salt Lake City, as an
18 example, or Diablo Canyon or in San Francisco Bay
19 bridge. So this gave us a sense of a conservatism
20 in the Applicant's PSHA analysis. And as I said
21 before, working for the regulator, if an Applicant
22 chooses to provide something that is conservative
23 or very conservative, it's hard for us to go back
24 and ask him to do something less conservative. I'm
25 sure you'd jump all over us if we asked an

1 Applicant to do something less than what they were
2 willing to provide. Something less conservative.
3 But it does demonstrate that in this particular
4 instance we view the results of the Applicant's
5 PSHA analysis as being quite conservative, and we
6 have stated that. In the Stamatakos et al report
7 that is stated, and we did some analysis there to
8 support this conclusion. It is stated in the SER,
9 it is stated in the consolidated SER, and we said
10 it in our testimony.
11 Q. I'm still back at the rock site. You
12 mentioned something about you obtained this rock
13 site conditions at PFS from a raw hazard. Can you
14 explain how the hard rock site conditions at PFS,
15 how did you obtain those?
16 DR. STAMATAKOS: Well, that was provided
17 in the SAR. And that is the hazard that the
18 Applicant calculated without consideration of
19 amplification of effects of the overlying soil
20 column, as if PFS was at a bedrock site or as if
21 you could strip away the soil and calculate the
22 hazard at depth.
23 Q. And that's in the Geomatrix report?
24 DR. STAMATAKOS: Which Geomatrix report?
25 Q. Well, one of the many Geomatrix reports.

1 It comes from Geomatrix?

2 DR. STAMATAKOS: That was provided in

3 the updated information that Geomatrix gave us last

4 spring. That's where I derived this data.

5 Q. Well, how can you compare the hard rock

6 site -- let me back up. With respect to the

7 National Earthquake Hazard Reduction Program, you

8 prefaced a lot of your testimony with presuming

9 what USGS had done. And what I'm trying to get at

10 is how can you compare anything that is

11 site-specific with a regional analysis?

12 MR. TURK: I have to object to the

13 characterization. He indicated his understanding

14 of the USGS report is that it considered several

15 different cities. He didn't say he presumed it.

16 He gave her a direct answer.

17 Q. Okay. Tell me again about the USGS

18 National Earthquake Hazard Reduction Program map

19 for Salt Lake City.

20 DR. STAMATAKOS: The curve -- it's a

21 published hazard curve in the Frankle et al, 1997

22 paper. That paper looked at hazard curves for a

23 number of cities in the United States. It compared

24 earthquake hazards for a number of cities in the

25 United States. So I simply used that curve as a

1 reference point to the city of Salt Lake City.

2 Q. And what was that that hazard curve,

3 other than it being in the USGS publication, was it

4 based on soft rock site, a hard rock site, a soil

5 site? What was the published hazard curve based

6 upon?

7 DR. STAMATAKOS: I'd have to go back and

8 check the Frankle paper. My recollection is that

9 this was a rock site. And if it is not a rock

10 site, then that curve would be higher, if you

11 incorporated soil factors. But you can also make

12 this comparison with what was done for the I-15

13 project in the analysis, the problemistic seismic

14 analysis, that was performed by I believe Dames and

15 Moore. And again, if you make comparisons, what

16 you see is that the hazards at the PFS site are

17 larger than the ground motions that are predicted

18 along the I-15 corridor for that construction

19 project. And again, that's despite the fact that

20 faulting along the Wasatch Front is of larger

21 magnitude and occurs much more frequently than

22 faults in Skull Valley.

23 Q. What were the ground accelerations at

24 PFS assuming hard rock site conditions?

25 DR. STAMATAKOS: For what probability of

1 exceedance?

2 Q. I don't know. Whatever you are

3 comparing here.

4 DR. STAMATAKOS: I compared the 2000

5 year return period, if you will, ground motions for

6 the PFS site with, I believe the Dames and Moore

7 report looked at nine or ten sites and published

8 ground motion values for 2500 years return period.

9 And I looked at PGA, made comparisons with PGA.

10 Q. That was the PGA at the PFS site for

11 hard rock soil conditions?

12 MR. TURK: At a 2000 year return period?

13 Q. Sure.

14 DR. STAMATAKOS: In this particular

15 comparison, I believe I used the soil. They did a

16 soil. And I believe the Dames and Moore --

17 Q. Sticking with the PFS site. I'm trying

18 to understand what you are comparing, what site

19 specific peak ground acceleration at the PFS site

20 for hard rock soil conditions based on a 2000 year

21 ground motions, what is the PGA that you used for

22 making these comparisons with other studies?

23 DR. STAMATAKOS: I didn't make the

24 numerical comparison in that way. When I used the

25 rock site against the Salt Lake City curve, I just

1 selected 500 centimeters per second squared, or
2 approximately .5 G, and looked at what the
3 exceedance probabilities and read off the
4 exceedance probabilities for those two values. And
5 as you can see, the exceedance probabilities for
6 the Skull Valley site is about 1.5 times higher
7 than what you would get --
8 Q. Just stick with what you did for the PFS
9 site. I'm not -- at the moment I'm trying to
10 figure out what other ground motions at the PFS
11 site are you looking at a PGA of .5 g in doing this
12 comparison at the PFS site assuming hard rock soil
13 conditions?
14 DR. STAMATAKOS: I looked at, if you go
15 to Staff Exhibit R --
16 Q. I'm not interested in Staff Exhibit R.
17 DR. STAMATAKOS: Well that's the way I
18 did the comparison.
19 MR. TURK: Your Honor, I object to the
20 interruption of the witness. He is explaining how
21 to get the answer she wants, and I think if she
22 would have a little patience he can explain it to
23 her. I think he is trying to answer her question.
24 JUDGE FARRAR: Ms. Chancellor, whether
25 or not you agree Exhibit R should be admitted, it

1 seems to illustrate how the comparison was made.
2 Let me ask a question about Exhibit R, again
3 without prejudicing the State's right to object to
4 its eventual admission.
5 Are these various colored curves you
6 have on here, were they created continuously or do
7 you graph certain places on them and then just fit
8 a curve to it?
9 DR. STAMATAKOS: That's correct. You
10 fit a curve to a number of -- different parts of
11 the data, different data sets have different
12 numbers. And while you are on that, I would point
13 out, in the answer before, I would point out that
14 we did provide in Discovery a complete referencing
15 of all the hazard curves that are provided in this
16 figure.
17 JUDGE FARRAR: Okay. But getting back
18 to the Skull Valley rock situation, I presume one
19 of the points on the curve is that point at the
20 2000 year interval, that's one of your points?
21 DR. STAMATAKOS: If that was one of the
22 probability points in those data sets, that would
23 be an absolute point; that's correct.
24 JUDGE FARRAR: And whatever else may be
25 said about this exhibit, the Skull Valley rock and

1 Skull Valley soil curves came from data supplied by
2 PFS?
3 DR. STAMATAKOS: That's correct.
4 JUDGE FARRAR: It may or may not be too
5 conservative or not conservative enough, but you
6 plotted here what they gave you?
7 DR. STAMATAKOS: I plotted exactly what
8 was provided to us. That's right.
9 JUDGE FARRAR: Does that help, Ms.
10 Chancellor?
11 MS. CHANCELLOR: I'm trying to
12 understand what the PGA is for the Skull Valley
13 rock site for 2000 year return period earthquake.
14 JUDGE FARRAR: That's 550. Isn't it?
15 Isn't it.
16 DR. STAMATAKOS: Roughly.
17 Q. (By Ms. Chancellor) So .55g,
18 approximately?
19 DR. STAMATAKOS: Approximately, yes.
20 Q. And Geomatrix, is this data based on the
21 Geomatrix evaluation where there was a 35 percent
22 increase in the ground motions, or is it from the
23 earlier study?
24 DR. STAMATAKOS: No. It's after their
25 revisions.

1 JUDGE FARRAR: I thought it was -- I
2 thought they came up with higher than .55g.
3 DR. STAMATAKOS: That's the main -- if
4 you look at the soil --
5 JUDGE FARRAR: The soil. Okay.
6 DR. STAMATAKOS: The soil is .71.
7 MR. TURK: Your Honor, I'm not sure if
8 Ms. Chancellor would request it or you would, but
9 we would offer, if you request an explanation from
10 Dr. Stamatakos as to how he prepared the chart, we
11 would have no problem with that if it helps move
12 things along. If no one needs it, that's fine. It
13 may be on the record already.
14 JUDGE LAM: I think this is, without
15 prejudicing the State's claim on admissibility, I
16 think this can be a useful piece of document for
17 this Board to look at, assuming it's done, the
18 plotting of it is done in a reliable fashion. And
19 Dr. Stamatakos just mentioned that references were
20 provided in Discovery.
21 DR. STAMATAKOS: That's correct.
22 JUDGE LAM: Do we have a record of all
23 the references?
24 DR. STAMATAKOS: I don't know. All I
25 know is that in December Discovery I was asked to

1 provide all the supplemental information, and I
2 provided all of the excerpts outs of my scientific
3 notebook that talked about the preparation of how
4 this plot was prepared, where the data came from,
5 and the three distress analysis, the slip tendency
6 analysis that we did, as part of our additional
7 information in the supplemental SER. So that was
8 provided, I believe, as part of the Discovery.
9 MS. CHANCELLOR: Your Honor, I think we
10 could move this along if, over the weekend, we look
11 through our Discovery file and see if we can find
12 the relevant information. And if we can't, then we
13 will need to establish on the record how each and
14 every curve was derived.
15 MR. TURK: For clarification, the
16 witness mentioned he believed he produced it in
17 December. I have a copy of a document production
18 list dated February 1, 2002. I think if you look
19 at that date you will see it. The very first item
20 says, "In response state of Utah 17th set of
21 Discovery includes the following." The first entry
22 was scientific notebook of 353 by Dr. John
23 Stamatakos and I would simply ask the witness if
24 that's the reference.
25 DR. STAMATAKOS: I believe that is

1 correct.

2 MR. TURK: And there's a further set of

3 documents that may be responsive, as well. You may

4 want to look at this document production.

5 MS. CHANCELLOR: And you haven't

6 withheld any of those as privileged?

7 MR. TURK: They are listed as documents

8 produced. On the second page there's a list of

9 documents withheld. Those are not the ones we are

10 talking about here.

11 MS. CHANCELLOR: I think if we review

12 that, it would help move things along.

13 JUDGE FARRAR: Does this provide us a

14 good breaking point --

15 MS. CHANCELLOR: It sure does.

16 JUDGE FARRAR: -- for the evening? It

17 is 5:30 on a Saturday so we have put in a good day.

18 Assuming we finish these witnesses at a reasonable

19 hour on midday Monday, then we are bringing Colonel

20 Horstman back?

21 MR. GAUKLER: Yes. And our people are

22 flying in Sunday evening and Monday morning. They

23 will be here by Monday noon.

24 JUDGE FARRAR: And refresh me where we

25 were with them. The State was in the middle of its

1 cross?

2 MR. GAUKLER: I was in the middle of my

3 cross of Lieutenant Colonel Horstman and then the

4 State has redirect and we talked about doing, then,

5 rebuttal that we would have to lieutenant Colonel

6 Horstman. And then Lieutenant Colonel Horstman

7 would do the rebuttal he had to our rebuttal and

8 evidence.

9 JUDGE FARRAR: When you say rebuttal,

10 with a different witness?

11 MR. GAUKLER: No. And then we would

12 move on to Dr. Marvin Resnikoff.

13 JUDGE FARRAR: Who will be here -- when

14 does he get here?

15 MS. NAKAHARA: He will be here Monday,

16 your Honor.

17 JUDGE FARRAR: So we will get to him.

18 And are we going to just take his aircraft

19 testimony or are we going to then switch and do his

20 seismic testimony, also?

21 MR. GAUKLER: The idea is to do seismic

22 testimony on Friday.

23 JUDGE FARRAR: Of Resnikoff?

24 MR. GAUKLER: No.

25 JUDGE FARRAR: So we are not going to

1 have a Resnikoff day where he does aircraft and
2 seismic?
3 MR. GAUKLER: No.
4 MR. TURK: I'm shaking my head. I
5 remember he stayed for that entire last set of
6 hearings and didn't get a chance to take the
7 witness stand. I hope he doesn't have to do that
8 again. That would be unfair.
9 JUDGE FARRAR: Are we finishing aircraft
10 next week?
11 MR. GAUKLER: That's the desire, the
12 object, yes.
13 JUDGE FARRAR: By Friday.
14 MR. GAUKLER: The schedule constraint is
15 getting through with all the material that
16 Lieutenant Colonel Horstman is involved with by
17 Wednesday noon, roughly. That's when he has to
18 take off. We are getting concerned about getting
19 to the Staff panel by Monday noon because, by my
20 estimate, it is going to take two days to go
21 through the issues; my remaining cross, redirect,
22 recross.
23 JUDGE FARRAR: With Colonel Horstman?
24 It can't be.
25 MR. GAUKLER: I have about a half day of

1 cross and I have been told the State has a half day
2 of redirect at this point in time.
3 JUDGE FARRAR: That can't be. Wait a
4 minute.
5 (Board confers off the record.)
6 JUDGE FARRAR: Here's the deal on
7 Colonel Horstman. We will review his testimony,
8 and depending on what we think about it and how it
9 fit into the case, we may give you some time limits
10 on him. We have been together a long time here.
11 In a sense we have bonded with each other, sad as
12 that seems. You all know how we rule on things.
13 You all know how we think records should be
14 developed. I would encourage you to use the
15 weekend, or the one day that is left of it, to
16 focus all parties on how we can best get through
17 Colonel Horstman's testimony. And remember, we
18 don't need a lot of background. We understand the
19 issues. Ask him questions. Mr. Gaukler, if you
20 are going to challenge him, challenge him. Ask him
21 a question and see what he says. No background.
22 No reading stuff. Just ask him questions. Ms.
23 Chancellor, or Ms. Nakahara or Mr. Soper, who is
24 doing it?
25 MS. NAKAHARA: It will be Mr. Soper, but

1 I will be assisting him.

2 JUDGE FARRAR: Just ask him the

3 questions and get the answer. We found at the

4 beginning of seismic we had to stop and these

5 gentlemen were kind enough to give us a tutorial.

6 But we certainly don't need a lot of back and forth

7 on aircraft. Everybody understands what that is

8 about. So I would say get to the point. And we

9 will do him shorter rather than longer. Anything

10 else we need to do?

11 MR. GAUKLER: I just wanted to bring up

12 we had a couple of exhibits pending on which we

13 gave the State background information in terms of,

14 first of all, the simulation, Exhibit OOO. We have

15 provided the State the input data for it and the

16 results of Cask 1, as we agreed. And also with

17 respect to Utah WW, which was the Applicant's

18 one-page of Paul Trudeau's testimony on --

19 MR. TRAVIESO-DIAZ: If I may, Exhibit

20 QQ, you recall, was a set of time histories that

21 were provided to Mr. Trudeau by Holtec. The State

22 requested copies of the time histories and we

23 provided them. That was over a week ago.

24 MR. GAUKLER: Exhibit WW was based on

25 the time histories we provided to the State.

1 JUDGE FARRAR: All right.

2 MR. GAUKLER: I would move my request to

3 admit them.

4 JUDGE FARRAR: We like to get those

5 loose ends taken care, of but whether something is

6 admitted today or tomorrow is not the most pressing

7 matter we have. Ms. Chancellor, are you ready to

8 address that yet?

9 MS. CHANCELLOR: I believe our experts

10 still were doing the time histories, your Honor.

11 JUDGE FARRAR: Tell them to get busy.

12 MS. CHANCELLOR: They have been busy.

13 They didn't have time to do it on the stand, your

14 Honor.

15 JUDGE FARRAR: All right. Let's keep

16 pressing ahead. It's now 5:40 on Saturday. Time

17 to go home. Thank you all. See you at nine

18 o'clock Monday.

19

20 (The proceeding was concluded

21 for the day at 5:40 p.m.)

22

23

24

25

CERTIFICATE

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

Name of Proceeding: Private Fuel Storage, LLC

Docket Number: Docket No. 72-22-ISFSI

ASLBP No. 97-732-02-ISFSI

Location: Salt Lake City, Utah

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.

/s/ Diana Kent

Diana Kent
Official Reporter
Neal R. Gross & Co., Inc.