

ORIGINAL
UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

In the matter of:

PHILADELPHIA ELECTRIC COMPANY

(Limerick Generating Station,
Units 1 & 2)

Docket No. 50-352
50-353

Location: Philadelphia, Pa.

Pages: 11,223-11,433

Date: Wednesday, May 23, 1984

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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

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In the Matter of:      :
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PHILADELPHIA ELECTRIC COMPANY :      Docket Nos. 50-352
:                               :      50-353
(Limerick Generating Station :
Units 1 and 2.)          :
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U.S. Customs House
Old Customs Courtroom No. 300
Second and Chestnut Streets
Philadelphia, Pennsylvania 19106

Wednesday, May 23, 1984

The hearing in the above-entitled matter reconvened
at 9:00 a.m., pursuant to recess.

BEFORE:

LAWRENCE BRENNER, ESQ., Chairman
Atomic Safety and Licensing Board

RICHARD F. COLE, Member
Atomic Safety and Licensing Board

PETER A. MORRIS, Member
Atomic Safety and Licensing Board

1 APPEARANCES:

2 On behalf of the Applicant:

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8 On behalf of the NRC Staff:

9 BENJAMIN VOGLER, ESQ.
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11 JOSEPH RUTBERG, ESQ.
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13 U.S. Nuclear Regulatory Commission
14 Washington, D.C. 2055515 On behalf of the Commonwealth of Pennsylvania,
16 Governor's Energy Council:17 ZORI FERKIN, ESQ.
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22 On behalf of the City of Philadelphia:

23 MARTHA W. BUSH, ESQ.
24 Deputy City Solicitor
25 1500 Municipal Service Building
Philadelphia, Pennsylvania 19102On behalf of Friends of the Earth of the
Delaware Valley:ROBERT ANTHONY, pro se
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Moylan, Pennsylvania, 19065

On behalf of Limerick Ecology Action:

CHARLES W. ELLIOTT, ESQ.
1101 Building, 11th and Northampton Streets
Easton, Pennsylvania 18042

C O N T E N T S

	<u>WITNESSES:</u>	<u>Direct</u>	<u>Cross</u>	<u>Red.</u>	<u>Rec.</u>	<u>Board Exam</u>
1						
2						
3	Brian Richter)					
4	Lewis G. Hulman)					
5	Sarbeswar Acharya)					
6	Edward Branagan)					
7	By Mr. Elliott		11,238			
8	By Mr. Wetterhahn		11,272			
9	By Ms. Ferkin		11,277			
10	By Ms. Hodgdon			11,284		
11	By Mr. Elliott				11,295	
12	By Ms. Bush				11,300	
13	By the Board					11,300
14	By Ms. Hodgdon			11,304		
15	G. Kaiser)					
16	E. Schmidt)					
17	S. Levine)					
18	G. Daebeler)					
19	By Mr. Elliott		11,309			
20	By Ms. Hodgdon		11,326			
21	By the Board					11,327
22	By Mr. Wetterhahn			11,334		
23	By the Board					11,342
24	By Mr. Elliott				11,345	
25	By Ms. Bush				11,351	
26	By Mr. Wetterhahn			11,353		
27	B. Richter)					
28	L. Hulman)					
29	S. Acharya)					
30	E. Branagan)					
31	W. Pratt)					
32	G. Kaiser)					
33	E. Schmidt)					
34	S. Levine)					
35	G. Daebeler)					
36	By Ms. Hodgdon	11,358				
37	By Mr. Elliott		11,370			

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L A Y - I N S

Prof. Quals. of Dr. Branagan	11,237
Prof. Quals. of Dr. Pratt	11,358
Staff Exhibit No. 30	11,360
Summary of the atmospheric release specifications used in consequence analysis for Limerick Units 1 and 2	

E X H I B I T S

	<u>Identified</u>	<u>Received</u>
Staff Exhibit No. 30 (described in lay-ins)	11,360	11,368

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25P R O C E E D I N G S

Whereupon,

BRIAN J. RICHTER

LEWIS G. HULMAN

SARBESWAR ACHARYA

resumed the stand and, having been previously duly sworn were examined and testified further as follows:

JUDGE BRENNER: All right, good morning. I guess our first inquiry is how we're going to proceed in light of the discussion at the end of the day yesterday.

MR. WETTERHAHN: The parties have reached agreement with regard to the order for this particular contention. And that is, the completion of the Staff witnesses on Contention 4-A-1, which relates to the health consequences. After which the Staff panel or the Applicant's panel would be substituted, including Dr. Goldman.

We would complete the Applicant's panel on the health effects and then proceed back to the Staff in the same order as we have agreed on for the remainder of this contention, and then for the other contentions.

JUDGE BRENNER: That is acceptable to us. Just to finish out that sequence, Mr. Wetterhahn, then after 4-A-1 was completed with respect to all witnesses, and we go back to the Staff for the remainder of 4, I imagine we would then go to the Applicant's witnesses for 4 and then

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1 back to the Staff for 3 and so on.

2 MR. WETTERHAHN: We really did not discuss any
3 order beyond 3.

4 JUDGE BRENNER: Well, we can do it that way. As
5 you know, beyond 3 we want the panels combined unless there's
6 a strong showing to the contrary. And we would not mind
7 starting the combined panel approach with 3 and the parties
8 can think about that and let us know, because we're losing
9 efficiency here. We can see that already.

10 MR. WETTERHAHN: Applicant has no objection to
11 starting the panel approach on the remainder of 4 either.

12 JUDGE BRENNER: Well, we won't do it on 4. We've
13 been over that ground already.

14 Mr. Elliott, you're going to have to make a showing
15 as to why you're prejudiced if we combine them on 3.

16 MR. ELLIOTT: I would have no objection to
17 combining the panels on 3.

18 JUDGE BRENNER: Staff what about you? Can we
19 combine the panels on 3, or do you have a particular reason
20 as to why you would be prejudiced?

21 MS. HODGDON: We stated our reasons that we would
22 prefer it the other way.

23 JUDGE BRENNER: Well, we didn't see that reason
24 going to any legal prejudice and we will combine them. We
25 think it will innure to the Staff's benefit also frankly,

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1 if we saw any prejudice we wouldn't do it. If something
2 arises in the course of events that the Staff or any party
3 wants to point to, you're certainly free to do that and we'll
4 consider being flexible in adjusting it because we do want
5 to avoid any prejudice to any party. But so long as things
6 are moving more efficiently and there's no prejudice, we'll
7 give it a try.

8 But we'll be flexible, Ms. Hodgdon, and if you
9 show us something we'll certainly be willing to adjust. Just
10 because we start that way doesn't mean we'll stay that way
11 no matter what. If unforeseen things occur, you can feel
12 free to raise them to our attention.

13 MS. HODGDON: Certainly. We did not wish to
14 appear inflexible because we stated our position. Should
15 things go worse rather than better, I would assume we would
16 return to -- we would devise some other order of proceeding.

17 JUDGE BRENNER: All right. Part of the problem
18 was it came up with no notice and the message there is for
19 the parties to communicate with each other. And that message
20 was directed to you, Mr. Elliott, in yesterday's context.
21 In general, it was directed to all parties.

22 All right, I see an additional witness on the
23 Staff panel.

24 MR. WETTERHAHN: I have one preliminary matter.
25 When we were last in session, the Board, I believe stated

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1 it was considering oral argument with regard to Mr. Romano's
2 pleadings and our responses which were due next Tuesday.
3 Could the Board set a schedule so that we could notify
4 Mr. Romano if it still deems it appropriate, or will it not
5 make a decision until we see the responses?

6 JUDGE BRENNER: We won't see a decision until we
7 see the responses. You phrased it correctly. We were
8 considering oral argument, we did not necessarily decide that
9 oral argument would be necessary. It may be prudent however
10 to schedule a potential time for oral argument so that
11 Mr. Romano and other interested parties can be prepared to
12 be here at that time with the knowledge also that we might
13 deem unnecessary. And if so, he and everybody else would be
14 told in advance.

15 It will have to be next week sometime, and I would
16 not like it scheduled as late as Friday. So I presume next
17 Thursday might be an appropriate time. Perhaps Thursday
18 morning, and then we could adjust that if we're on the verge
19 of finishing something else up. We would finish the other
20 thing up and take it up. But see if Mr. Romano could be
21 here on Thursday morning at 9:00, with the knowledge that
22 we'd get to it some time that day. Perhaps Thursday morning,
23 perhaps later that day.

24 And we'll let you know at the end of the day --
25 by the end of the day Wednesday if we deem it unnecessary

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1 to have oral argument.

2 MS. BUSH: In that regard --

3 JUDGE BRENNER: You're going to have to come to
4 a microphone.

5 MS. BUSH: Your Honor, in that regard, our experts
6 have requested that we be able to schedule my cross-examination
7 in one time frame so that we could have one day that they
8 would be here. So I'd request if you could keep that in mind
9 for asking when Mr. Romano comes.

10 JUDGE BRENNER: You've caught me cold and I don't
11 know how to work that into the schedule of proceedings. We're
12 going to proceed the way we stated. And to the way you can
13 work your cross-examination in, that's up to you.

14 MS. BUSH: I brought it up because you were
15 scheduling Mr. Romano would be here. And if that would be
16 in the middle of my cross-examination, I'd ask you to defer.

17 JUDGE BRENNER: I've just stated how we'll do
18 it, and we'll be flexible. But we're not going to put it
19 off another day, once we tell him to be here. We might
20 not even have oral argument. It's difficult to discuss many
21 of these schedule concerns you have well in advance of the
22 time.

23 MS. BUSH: I don't want to be inconsiderate of
24 the Board and be informed that I haven't told you in advance
25 of my needs and my concerns. You've just raised for the

lpb6

1 first time that Mr. Romano might be told of the expectation
2 that he might have oral argument, and I knew something you
3 didn't know before, and that is it would help my California
4 experts if they could be here just for one day.

5 JUDGE BRENNER: I can't promise that, and it's
6 that simple.

7 MS. BUSH: I'm just asking for you to consider
8 that and to be aware of that.

9 JUDGE BRENNER: All right. Why aren't you at the
10 counsel table?

11 MS. BUSH: I have a lot of papers I need to spread
12 out. I have work I need to do and there's just no room up
13 here.

14 JUDGE BRENNER: All right, fine. Well, Ms. Bush,
15 since you raised the point of your experts, have you
16 considered when we can find out whether the -- have you
17 considered when we can get a statement as to just what
18 remains in contention in the severe accident contentions
19 between the city, the Applicant and the Staff?

20 MS. BUSH: I have been considering that, Your
21 Honor. If we go through to the end of the day Thursday here,
22 then I have requested of the Staff that we have a telephone
23 conference with my experts and their experts between 11:00
24 and 12:00 on Friday. I would have that telephone conference
25 with them, talk with my expert after that, write something

lpb7

1 up, and telefax it up to you in Bethesda that Friday,
2 according to your request yesterday.

3 JUDGE BRENNER: It's getting very late, if you
4 wait until that point on Friday to put the parties together.

5 MS. BUSH: Well, as I understand it, the hearings
6 will go until the end of the day Thursday, and we're talking
7 to somebody in California. If the Staff were willing, we
8 could do it after the hearing Thursday night.

9 JUDGE BRENNER: What if we give you a little
10 extra time on lunch time Thursday and set something up then,
11 and that may give you the opportunity to be able to come back
12 and tell us on the record what the situation is. And maybe
13 we can save you having to make a written filing, if you
14 can give us a good specification on the transcript; well
15 thought through, specific issue would be in writing, have
16 your notes, but you could read it into the record.

17 MS. BUSH: That might be good. I'm definitely
18 having a conference with my experts tonight. So whatever
19 comes out of that, I certainly will be prepared to do it
20 on the record Thursday. We might need to talk to the Staff
21 to specify it even more intelligently.

22 JUDGE BRENNER: Set it up with the parties and
23 tell us how much time you need on Thursday. Our normal
24 break is approximately 11:30 to 1:00, and we'll extend that
25 so you can accomplish what you need to accomplish and still

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eat lunch. And you tell us what times we should set, and we'll set those times.

1 Tell us whether you want us to start the break
2 earlier. We'd prefer, I think, to start it earlier because
3 I'm concerned that Friday is pushing things a little late.

4 MS. BUSH: I was, too.

5 JUDGE BRENNER: All right. Maybe we can help you
6 out that way. Okay, Staff.

7 MS. HODGDON: Yes, Dr. Branagan has joined the
8 Staff's panel of witnesses to answer certain questions that
9 were raised yesterday, regarding health effects. If Dr.
10 Branagan -- his professional qualifications have been
11 distributed to the Board and the parties, and if he could
12 be sworn at this time, he could make a statement regarding
13 those questions, or we can do it in any way that the Board
14 sees appropriate.

15 JUDGE BRENNER: Let's make Mr. Elliott reask the
16 questions, if he wants to.

17 MS. HODGDON: If Mr. Elliott doesn't have a
18 transcript, we can let him borrow it. It starts at 11,209.

19 JUDGE BRENNER: We'll do what you requested in a
20 moment, swear Dr. Branagan in, if there are no objections to
21 that. Mr. Elliott, does that conform to your desires?

22 MR. ELLIOTT: Yes.

23 MS. HODGDON: Yes, regarding Mr. Pratt?

24 JUDGE BRENNER: Yes.

25 MS. HODGDON: We would prefer to have Dr. Branagan

1 answer the questions that were raised yesterday, at this
2 time. And perhaps after the lunch break we could clear up the
3 problem that was mentioned yesterday by Mr. Hulman, regarding
4 Mr. Pratt's table. I could represent that the Staff and Mr.
5 Pratt met about that last night and feel that the correction
6 to be made doesn't significantly change the risk, so that
7 anything that might transpire -- I was just trying to save
8 that time, so as not to have to go through all of this.

9 JUDGE BRENNER: All right, if you're confident
10 that it won't affect the testimony we're going to go through
11 this morning, that would be acceptable.

12 MS. HODGDON: I am as confident as I can be that it
13 won't affect the testimony that will be -- which will be given
14 this morning.

15 JUDGE BRENNER: Okay.

16 MR. ELLIOTT: Will we be apprised, at some point,
17 of what the actual change is?

18 JUDGE BRENNER: That's a good point. Since we're
19 going to do it the way you just requested, Ms. Hodgdon, I think
20 you should make sure to inform the other parties what the
21 changes are before we go back on the record this afternoon.
22 And more than just a few minutes before, so that the other
23 parties have a chance to contemplate them.

24 MS. HODGDON: Yes, I should have said that. That
25 was one of the reasons we wanted to do it later, so we could

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1 tell the parties what's involved or show them, before we go
2 back on the record.

3 JUDGE BRENNER: All right. Dr. Branagan, could
4 you stand and raise your right hand, please?

5 Whereupon,

6 EDWARD F. BRANAGAN, JR.

7 took the stand and, having been duly sworn, was examined and
8 testified further as follows:

9 JUDGE BRENNER: Ms. Hodgdon, do you want to ask
10 him about his statement?

11 MS. HODGDON: Statement of professional qualifica-
12 tions? I didn't understand you.

13 JUDGE BRENNER: Yes.

14 MS. HODGDON: The reason I was standing up is I
15 thought perhaps I didn't give to the reporter his professional
16 qualifications, and it should be bound in. You have it,
17 thank you.

18 No, I have no questions for Dr. Branagan.

19 JUDGE BRENNER: Dr. Branagan, I have in front of
20 me a one page statement entitled "Edward F. Branagan, Jr.,
21 Office of Nuclear Reactor Regulation, Professional Qualifica-
22 tions." Do you have that in front of you, sir?

23 WITNESS BRANAGAN: I do not have that in front of
24 me.

25 JUDGE BRENNER: Applicant's counsel is lending you

1 a copy.

2 WITNESS BRANAGAN: Yes, I do.

3 JUDGE BRENNER: Is that true and correct?

4 WITNESS BRANAGAN: Yes, it is.

5 JUDGE BRENNER: All right. And would you adopt that
6 as the statement of your professional qualifications, to put
7 into evidence in this proceeding?

8 WITNESS BRANAGAN: Yes, I do.

9 JUDGE BRENNER: With that, we will admit his
10 statement of professional qualifications into evidence and
11 bind it in the transcript at this point, as if read. And that
12 includes the handwritten, typographical change, also.

13 (The document referred to follows:)

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EDWARD F. BRANAGAN, JR.
OFFICE OF NUCLEAR REACTOR REGULATION

PROFESSIONAL QUALIFICATIONS

From April 1979 to present, I have been employed in the Radiological Assessment Branch in the Office of Nuclear Reactor Regulation of the U.S. Nuclear Regulatory Commission (NRC). As a Senior Radiobiologist with the Radiological Assessment Branch, I am responsible for evaluating the environmental radiological impacts resulting from the operation of nuclear power reactors. In particular, I am responsible for evaluating radioecological models and health effect models for use in reactor licensing.

In addition to my duties involving the evaluation of radiological impacts from nuclear reactors, my duties in the Radiological Assessment Branch have included the following: (1) I managed and was the principal author of a report entitled "Staff Review of 'Radioecological Assessment of the Wyhl Nuclear Power Plant'" (NUREG-0668); (2) I served as a technical contact on an NRC contract with Argonne National Laboratory involving development of a computer program to calculate health effects from radiation; (3) I served as the project manager on an NRC contract with Idaho National Engineering Laboratory involving estimated and measured concentrations of radionuclides in the environment; (4) I served as the project manager on an NRC contract with Lawrence Livermore Laboratory concerning a literature review of values for parameters in terrestrial radionuclide transport models; and (5) I served as the project manager on an NRC contract with Oak Ridge National Laboratory concerning a statistical analysis of dose estimates via food pathways.

From 1976 to April 1979, I was employed by the NRC's Office of Nuclear Materials Safety and Safeguards, where I was involved in project management and technical work. I served as the project manager for the NRC in connection with the NRC's estimation of radiation doses from radon-222 and radium-226 releases from uranium mills, in coordination with Oak Ridge National Laboratory which served as the NRC contractor. As part of my work on NRC's Generic Environmental Impact Statement on Uranium Milling (GEIS), I estimated health effects from uranium mill tailings. Upon publication of the GEIS, I presented a paper entitled "Health Effects of Uranium Mining and Milling for Commercial Nuclear Power" at a Conference on Health Implications of New Energy Technologies.

I received a B.A. in Physics from Catholic University in 1969, an M.A. in Science Teaching from Catholic University in 1970, and a Ph.D. in Radiation Biophysics from Kansas University in 1976. While completing my course work for my Ph.D., I was an instructor of Radiation Technology at Haskell Junior College in Lawrence, Kansas. My doctoral research work was in the area of DNA base damage, and was supported by a U.S. Public Health Service traineeship; my doctoral dissertation was entitled "Nuclear Magnetic Resonance Spectroscopy of Gamma-Irradiated DNA Bases."

I am a member of the Health Physics Society.

21b5

1 MS. HODGDON: Thank you.

2 JUDGE BRENNER: All right. You said you had
3 nothing further, Ms. Hodgdon?

4 MS. HODGDON: I have no questions for Dr. Branagan.
5 He's being offered to answer the questions which were asked
6 yesterday.

7 JUDGE BRENNER: Okay, Mr. Elliott, you're on for
8 cross examination. You can follow whatever order you want in
9 completing DES-4-A-1. That is, you can back up and ask
10 Dr. Branagan some questions you asked yesterday. Or, upon
11 reflection, if you want to change the questions, you can do
12 that. It's totally up to you. Or you can pursue the questions
13 you were in the midst of pursuing with the other witnesses.
14 Whatever your desires are.

15 CROSS EXAMINATION (Continued)

16 BY MR. ELLIOTT:

17 Q Mr. Hulman, I believe -- if my recollection is
18 correct -- that yesterday there was testimony that a
19 contribution to system failure, due to human error of
20 commission, during transient mitigation, was considered in the
21 treatment of accident probabilities in the FES. Is that
22 statement correct?

23 A (Witness Hulman) That's my understanding.

24 Q Do you know how it was considered?

25 MR. WETTERHAHN: Objection. I believe the Board

1 specifically denied the contention at the pre-hearing
2 conference related to this particular subject of sabotage
3 and human acts of commission. And therefore, it goes beyond
4 the scope of contentions, ad admitted by this Board.

5 JUDGE BRENNER: I thought I was going to hear that
6 objection at some point yesterday. Mr. Elliott?

7 MR. ELLIOTT: Each of the health effects calculated
8 in the FES depend upon an accurate treatment of accident
9 probabilities. I am simply looking for an admission as to
10 whether or not the treatment was complete or not. It's not
11 my intention to explore, in detail, the validity of that
12 approach.

13 JUDGE BRENNER: Well, the contention to which
14 Mr. Wetterhan refers was DES-6, which we did deny. We didn't
15 interject on our own yesterday because part of what you were
16 asking got an explanation from the Staff witnesses as to how
17 they considered human errors and because of the terminology
18 problem, among other things, in talking about human errors
19 of commission versus omission, which terminology Judge
20 Morris discussed and which we took into account in our ruling
21 on admissibility of the contentions.

22 We thought it was appropriate to allow it to go
23 as far as it did yesterday. But now, given the statement of
24 your purpose just now, we will sustain the objection. In
25 denying the admission of DES-6, we found there was no basis

21b7

1 to require full consideration of sabotage and human errors
2 of commission, as LEA was using it in the contention. And as
3 I said, we spent a bit of time getting the specification of
4 what it was that LEA intended. I don't know if the witnesses
5 are keyed into that or not, but we are, so we'll sustain the
6 objection.

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1 MR. ELLIOTT: May I ask one clarifying question
2 about what the witnesses meant when they testified that
3 it was included?

4 JUDGE BRENNER: All right. I think we had it
5 yesterday, but we'll certainly allow that question.

6 BY MR. ELLIOTT:

7 Q Mr. Hulman, what did you mean when you said that
8 human errors of commission during transient mitigation were
9 considered? What types of errors were you referring to?

10 A (Witness Hulman) Observed failure rates of
11 systems, the availability of systems were considered in what
12 we call the front end or the probability assessment. They
13 were considered, insofar as there was data.

14 Q Insofar as there was data? There is data on
15 system failure due to human error of commission?

16 MR. WETTERHAHN: Objection, same objection.

17 JUDGE BRENNER: We'll let him pursue it a little
18 bit, just for purposes of clarifying the record. I think the
19 basis of our exclusion of DES-6 was clear on the transcript
20 of our oral ruling, which we have referenced in the written
21 order, in the transcript would be pages 8,778 to 81. I
22 don't have it in front of me right now, but in sum it is the
23 fact that while we understand that the modeling may include
24 as it could be construed encompassing or being related to
25 sabotage and human errors of commission, it was acceptable and

31b2

1 sufficient to include those to these current state feasible,
2 in the state of the art of that type of modeling.

3 But given what the contention was calling for, of
4 the kind of rigorous methodological approach to these two
5 areas, much as the same as applied to other areas of the
6 probabilistic modeling. There is no basis for requiring
7 that much, given the state of the art, among other things.

8 That is the main thrust of our ruling, including
9 the contention, so it is consistent with that ruling that the
10 modeling -- to the extent that it could -- did include certain
11 things, and we understand that. But nevertheless, we have
12 excluded the contention, which excludes an inquiry into whether
13 or not the modeling, as to those two items, is adequate or
14 inadequate or should require more or not.

15 And so, I'm not sure how far you intend to pursue it,
16 but we'll allow this one more question and then we'll judge
17 from there.

18 MR. ELLIOTT: I think I'm at the outward bounds of
19 my inquiry.

20 JUDGE BRENNER: Do you remember the question, after
21 all that?

22 (Panel conferring.)

23 JUDGE BRENNER: Why don't you repeat it, Mr. Elliott?

24 BY MR. ELLIOTT:

25 Q What data are you referring to?

1 A (Witness Hulman) The historical data on system
2 failure rates, equipment failure rates, includes errors by
3 operators.

4 Q During transient mitigation?

5 A In several cases, yes.

6 Q Okay. Would it be possible for a reader of the
7 FES to determine how many early fatalities, latent cancers,
8 and genetic effects together would result from any particular
9 accident sequence, identified in the FES Table 5.11(c)?

10 (Pause.)

11 Excuse me, when I said accident sequence, I meant
12 release category.

13 A As I understand your question, you want to know
14 whether a reader could find estimates of early fatalities,
15 latent cancers, and genetic effects from any one of the
16 particular release categories identified in Table 5.11(c)? Is
17 that --

18 Q I want to know if he can determine how many of
19 those kinds of health effects would occur together?

20 A No.

21 Q Would it be possible for a reader of the FES to
22 determine how many early fatalities, latent cancers, and
23 genetic effects together would result from any combination
24 of those release categories?

25 A I believe the answer is one can have a fair

1 estimate.

2 Q How would one derive the estimate?

3 A (Witness Acharya) Would you please repeat the
4 question?

5 Q Pardon?

6 A I don't understand the question. This one
7 in particular, and also that one well before it.

8 A (Witness Hulman) For a particular probability
9 level, one can get an estimate of the three kinds of health
10 effects that you've identified by using the CCDFs for a
11 particular probability level. But one cannot necessarily
12 attach that to a particular sequence.

13 Q Or any combination of sequences?

14 A That's correct.

15 Q There was testimony yesterday that in the calcula-
16 tion of health effects or genetic effects in the FES, that
17 five generations were considered. Is that correct?

18 Mr. Branagan?

19 JUDGE MORRIS: Would you turn on the microphone,
20 please?

21 WITNESS BRANAGAN: The number of genetic effects
22 on the genetic effects risk estimator integrated the number
23 of effects over all succeeding generations. The mean
24 persistence of genetic effects, depending upon the particular
25 category, would be five generations or ten generations

31b5

1 according to the BEIR-III Report by the National Academy
2 of Sciences.

3 BY MR. ELLIOTT:

4 Q In fact, the elimination rate for multi-factorial
5 effects is ten percent per generation, isn't that correct?
6 As used in BEIR-III?

7 A (Witness Branagan) For ten generations mean
8 persistence, yes, it would be about that.

9 Q Therefore, did the FES health effects modeling
10 limit the calculation of genetic effects to those that would
11 persist through five generations?

12 A The genetic effects estimates that were estimated
13 in response to question number 12 integrated over all
14 generations.

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1 Q In what context was the limitation to five
2 generations?

3 A My understanding is that the question would be
4 what elimination rate would occur to remove the genetic
5 effects and the mean persistence would be five generations
6 for diseases and abnormalities caused by dominant mutations.
7 And for those that are more irregularly inherited, the
8 mean persistence would be ten generations, according to the
9 National Academy of Sciences, BEIR-III report.

10 Q A calculation of total number of genetic effects
11 through all succeeding generations, which would be limited
12 to five generations would omit some contribution from
13 multi-factorial effects past the fifth generation; isn't
14 that correct?

15 MR. WETTERHAHN: Objection, he just answered
16 that question.

17 JUDGE BRENNER: I think it's the same question
18 also, Mr. Elliott.

19 MR. ELLIOTT: I didn't understand the answer to
20 his question. I didn't fully understand the previous answer.

21 WITNESS BRANAGAN: The question is the calculation
22 itself. For all generations that would be limited to five
23 generations. The value that was used in response to question
24 number 12 in the prefiled testimony included genetic
25 effects over all future generations of the population.

4pb2

1 BY MR. ELLIOTT:

2 Q And that was up to ten generations; is that correct?

3 A (Witness Branagan) Pardon?

4 Q And that was up to ten generations for multi-factorial
5 effects; is that correct?

6 A The value was for all future generations.

7 Q How many generations was that?

8 A According to the National Academy of Sciences
9 BEIR-III report, the expression rate of these would depend
10 upon the particular types of genetic defects. Some of the
11 genetic defects would be expressed with a mean value of
12 five generations. Others within a mean value of ten generations

13 JUDGE BRENNER: Mr. Elliott, could you bring your
14 microphone just a little closer to you, please? With the
15 windows open we get some outside noise.

16 BY MR. ELLIOTT:

17 Q The Staff testimony in paragraph 15 states that
18 10 percent of cancer is thyroid nodules may be fatal, 90
19 percent non-fatal. And thus the number of non-fatal thyroid
20 nodules can be derived by scaling the consequences axis to
21 the thyroid cancer fatality CCDF in Figure 5.4(d) by a
22 factor of nine.

23 Can the reader of the FES do this without resort
24 to reading this testimony or relying upon information outside
25 of the FES?

4pb3

1 A (Witness Acharya) I would say yes.

2 Q How can he do this?

3 A (Witness Hulman) On page 5-73 of the FES, the
4 last sentence of the first paragraph, and I quote, "The
5 health risk to an individual receiving such a thyroid
6 exposure is the potential appearance of benign or malignant
7 thyroid nodules in about one out of ten cases in the
8 development of a fatal cancer. And in about four out of
9 1,000 cases."

10 I submit that is sufficient.

11 Q Is that the only basis upon which a reader of
12 the FES could derive the estimate?

13 A That plus all the references that have been
14 provided. They provide the bases, including the BEIR report
15 that we've talked about.

16 Q Expressed in terms of a per reactor year risk,
17 the risk of genetic effects is greater than any other health
18 effect analyzed in the FES; isn't that correct?

19 JUDGE BRENNER: He said the risk of genetic effects?

20 MR. ELLIOTT: I'm sorry, non-fatal cancers.

21 WITNESS HULMAN: The answer to your question, I
22 think is yes, it is the highest.

23 BY MR. ELLIOTT:

24 Q Staff's testimony, paragraph 15, paragraph 2
25 with respect to the estimate for the risk of non-fatal

4pb4
1 thyroid nodules, is that non-fatal cancerous nodules, or does
2 it also include benign nodules induced by radiation?

3 A (Witness Acharya) This is cancerous. The answer
4 is that the cancer nodules that are talked about in this
5 paragraph that -- excuse me. The type of nodules that are
6 talked about in this paragraph are the cancerous type nodules.

7 Q Benign nodules are not included; is that correct?

8 A That's correct. The information about benign
9 nodules is provided downstream somewhere in the testimony.

10 JUDGE BRENNER: I'm sorry. I didn't get that.
11 Dr. Acharya, could you bring the microphone closer to you
12 also, and give me that answer again?

13 WITNESS ACHARYA: The estimate of benign type
14 nodules is provided in the response -- let me identify it.
15 Just a minute please -- it begins on page 12. Page 12,
16 the first full paragraph where we say, "On the basis of
17 WASH-1400 model, the risk of benign type nodules would be
18 about 15 times higher than that of cancer fatality."

19 JUDGE BRENNER: Thyroid cancer fatality?

20 WITNESS ACHARYA: That's right.
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1 BY MR. ELLIOTT:

2 Q The risk of benign thyroid nodules is not
3 disclosed in the FES, is it?

4 A (Witness Acharya) No, it is not.

5 A (Witness Hulman) Not directly. But I again point
6 out, indirectly, that the references to the FES provide that
7 level of information.

8 Q Is the reader of the FES told even that he may look
9 to BEIR-III to know that there is a risk of benign thyroid
10 nodules?

11 A I can't debate the answer. In my judgment, the
12 informed reader of the FES should also consult the references.

13 Q He would have to consult the references even to
14 know that there was a risk of benign thyroid nodules, wouldn't
15 he?

16 A I -- I think I cannot make a judgment.

17 Q Well, if he knows nothing more than what's in the
18 FES, he wouldn't know that there is a risk of benign thyroid
19 nodules, would he?

20 A Not explicitly, he wouldn't.

21 Q Mr. Richter, the HECOM model assumes that the
22 period of risk for most types of cancer, after irradiation,
23 is lifetime, or with respect to some cancers, 30 years. Is
24 that correct?

25 A (Witness Richter) Yes, I believe that's right.

1 Q Do you believe those latency periods to be
2 accurate?

3 A I'm not an expert in the cancer incidence field,
4 but from my limited knowledge, I believe that's a good
5 assumption.

6 Q Mr. Hulman, doesn't the CRAC health effects model
7 assume a latency period with only ten years for cancer
8 induced in children after radiation?

9 A (Witness Acharya) No. As stated in -- let me
10 identify a page in the FES where the statement about the
11 latency period for exposure for uterine exposures. In page
12 5-66 of the FES it is stated that -- the last full paragraph
13 on the page, somewhere in the middle "Occurrence of cancer in
14 the exposed population may begin to develop only after
15 a lapse of one to 15 years." That's what the latency field
16 is from the time of exposures, in the case of -- and then
17 continue over a period of about 30 years. That is a period.

18 However, in the case of exposure to fetuses in
19 utero, occurrence of cancer may begin to double up at birth --
20 may begin to develop at birth. That is no latent period.
21 And in that, this --

22 JUDGE BRENNER: Why don't we just leave it, that
23 it's in page 5-66 of the FES. In fact, I think you misread
24 one of the numbers, Dr. Acharya. I think you said over 20
25 years and the text says over 30 years. But it's in evidence

51b3

1 and it's that paragraph that Dr. Acharya referenced on 5-66
2 of the FES. Did you want to add something to the text,
3 Mr. Hulman?

4 WITNESS HULMAN: No, I was just going to reread it.

5 JUDGE BRENNER: Mr. Elliott?

6 BY MR. ELLIOTT:

7 Q The assumption that occurrences of cancer in the
8 case of exposure to fetuses ends at age 10 assumes that the
9 period of risk ends with age 10, isn't that correct?

10 A (Witness Acharya) That's right.

bu2

11 Q Spontaneous abortions in women who are in the
12 population exposed to radiation is a possible risk of severe
13 accidents at Limerick, isn't that correct?

14 A (Witness Hulman) Of severe accidents, yes.

15 Q The FES risk contributor -- I'm sorry, risk
16 estimator of genetic effects did not include this contribution,
17 did it?

18 A (Witness Acharya) It did not include that.

19 Q Staff's testimony at paragraph 17 says the
20 majority of such effects would lead to early spontaneous
21 abortions, loss of the fetus during the first trimester.
22 What is the majority?

23 A The majority is quantified later.

24 Q Is what? I'm sorry.

25 A Is quantified in the next paragraph. That is 15

1 percent in the estimate for the spontaneous abortion to 15
2 percent of the total genetic effects for which the estimate
3 has been already provided earlier.

4 Q The figure that's in that paragraph you just
5 referred to refers to the entirety of spontaneous abortions,
6 doesn't it? It is not limited to early spontaneous abortions,
7 is it?

8 A (Witness Hulman) We don't understand your question.
9 Would you please repeat it?

10 Q My question is, the Staff testified that the
11 majority of such effects, genetic effects, would lead to
12 early spontaneous abortions. What is the majority?

13 A (Witness Acharya) Well, if I would interpret what
14 is stated in WASH-1400, that would mean most.

15 Q It could be anything in excess of 50 percent, right?

16 A My impression is it is much more than 50 percent.
17 I don't have the number exactly, but it would mean most. And
18 the most would be much higher than 50 percent.

19 Q Did WASH-1400 use most, or did it use majority?

20 A See here --

21 (Panel conferring.)

22 A Whatever is stated in WASH-1400, I guess, my
23 statement here --

24 JUDGE BRENNER: Dr. Acharya, let's wait a minute.

25 (Pause.)

(Discussion off the record.)

6pbl

1 WITNESS ACHARYA: I would like to explain here
2 something that in the assessment of genetic effect, the
3 complete account is provided as I have described now. Now
4 the genetic effect will be expressed either amongst the
5 live birth, or it could have been expressed by spontaneous
6 abortion.

7 Now the genetic effects expressed among the live
8 births is already expressed, and the balance of the genetic
9 effect, which the society would not notice, if associated
10 with the spontaneous abortion. Now, we have already provided
11 an estimate of the genetic effects in the live birth in
12 the succeeding generations, and here we are providing the
13 estimate of the spontaneous abortions which would not be
14 noticed.

15 Now, whether the majority or most -- a precise
16 knowledge as to what majority meant, whether it is 70
17 percent, 90 percent or just more than 50 percent, I cannot
18 provide the precise definition of that. That complete
19 accounting is provided by providing the estimates of these
20 two forms of genetic effects.

21 BY MR. ELLIOTT:

22 Q With respect to the manner in which genetic effects
23 are expressed in live births, how are those genetic effects
24 physically expressed?

25 A (Witness Acharya) That is what Dr. Branagan will

6pb2

1 respond to.

2 A (Witness Branagan) By genetic effects estimates
3 that were included in the value of 260 potential genetic
4 defects per million person-rem, that included all disorders
5 that could cause some serious handicap during the lifetime
6 of an individual. Examples of genetic effects that are
7 included in the risk estimator are diseases and abnormalities
8 caused by a dominant mutation. For example, extra fingers,
9 extra toes. Diseases caused by recessive mutations. For
10 example, sickle cell anemia. Abnormalities caused by
11 chromosomal aberration. For example, Downs syndrome,
12 congenital anomalies, anemia, diabetes, and schizophrenia.

13 Those are examples of the types of things that
14 are included.

15 Q There is not a single sentence in the FES which
16 tells the reader what a genetic effect is and how it is
17 physically expressed; isn't that correct?

18 A There are many references in the FES to the
19 publications of the major radiation protection organizations
20 that give that type of information. We tried to give a
21 simplified presentation of genetic effects that includes
22 a whole spectrum of things.

23 Q Back to Staff's testimony in paragraph 17 about
24 spontaneous abortions. It is stated in the first paragraph
25 that these spontaneous abortions would likely occur so early

6pb3

1 in pregnancies as to be undetectable. What is likely?

2 A (Witness Acharya) Well, that's what the word
3 says, likely.

4 A (Witness Hulman) No numerical estimate.

5 Q Is probably another word for likely?

6 A (Witness Acharya) That's right.

7 Q For each pregnancy that is detected, its abortion
8 would also necessarily be detected, wouldn't it?

9 A (Witness Hulman) Please repeat your question.

10 Q For each pregnancy that is detected, its
11 abortion would also necessarily be detected, wouldn't it?

12 A I don't understand the question.

13 Q For each pregnancy that is detected, that is, that
14 a woman knows about, its abortion would necessarily be
15 detected, wouldn't it?

16 A Not necessarily.

17 Q How would a woman not know, if she knows that she's
18 pregnant -- not know that she has aborted? I mean after nine
19 months go by, she has a problem right?

20 A (Witness Acharya) Let me respond to this. It
21 is stated here that about spontaneous abortion, that either
22 a person or pregnancy would not be known to the individual
23 concerned. And also have stated the page on BEIR-I where it
24 is so stated.

25 Q There is some abortions which would be detected;

6pb4

1 isn't that correct?

2 A (Witness Hulman) If the woman knew she was
3 pregnant, and she did not have a child, one possibility is
4 abortion.

5 Q Is there another possibility?

6 A Yes, she could be carrying a dead fetus.

7 Q All right. Is a recognized human abortion
8 difficult to assess from the standpoint from societal impact?

9 A (Witness Acharya) Well, this is a statement which
10 we took out from WASH-1400, I believe. The basis for this
11 statement in WASH-1400 is that, there's a normal occurrence
12 of spontaneous abortion. The rate is quite high, very high,
13 about which most of the individuals concerned are not aware.

14 Q I'm not talking about the case in which it is
15 not recognized. I'm talking about the case in which it is
16 recognized.

17 The statement of the Staff is that an unrecognized
18 human abortion is difficult to quantify, and even more
19 difficult to assess from the standpoint of societal impact.
20 Where the cases of abortion have been detected, is that
21 difficult to assess from the standpoint of societal impact?

22 A Our estimate that is provided here that includes
23 all of the spontaneous abortions, whether they're recognized
24 or not recognized.

25 A (Witness Hulman) But I think the uncertainty would

6pb5

1 be in whether they were caused by a reactor accident.

2 Q That's true of all health effects induced by a
3 reactor accident, except perhaps for prompt fatalities;
4 isn't that correct?

5 A (Witness Acharya) That's correct.

6 Q The Staff's estimate per reactor year of spontaneous
7 abortions is 1.5×10^{-1} per reactor year. That risk estimate
8 is higher than any health effect risk estimated in the FES;
9 isn't that correct?

10 A Yes, it is, but as you pointed out earlier the
11 risk of the genetic effects, based on the live births, that
12 number is perhaps higher than this. It's 2.6 minus 1.

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1 Q The Staff's testimony, at paragraph 19, with respect
2 to sterility. Where reference is made to cases of temporary
3 sterility, how long is temporary?

4 A It is stated in a sentence which has been now
5 made from the middle of the paragraph to the end of the
6 paragraph.

7 Q What is temporary? What's the time period being
8 referred to?

9 A Dr. Branagan will respond to that.

10 A (Witness Branagan) My recollection is it would
11 be less than a half year. Definitely less than a half a
12 year.

13 Q Doesn't BEIR III say that it could be up to one
14 year for doses of 100 rads?

15 A I haven't seen that. I don't recall that.

16 Q Dr. Branagan, let me read you the sentence.

17 JUDGE BRENNER: Give him a page reference, too.

18 BY MR. ELLIOTT:

19 Q BEIR III, page 498.

20 A (Witness Branagan) Excuse me, could you hold up
21 the copy you have? I think we have different copies.

22 Q Well, this is a photocopy. I'll show you the copy
23 I have, if you want.

24 A Page 498?

25 Q Yes.

1 MR. WETTERHAHN: Could you give us the section?

2 MR. ELLIOTT: Second to the last paragraph on the
3 page.

4 MR. WETTERHAHN: No, no. The section. We have
5 a different version.

6 MR. ELLIOTT: This is Chapter 6.

7 JUDGE BRENNER: Apparently, he's having difficulty
8 finding it, Mr. Elliott. Maybe it would be more efficient
9 to show it to him. Show him the cover also, so you can figure
10 out the two editions.

11 MR. WETTERHAHN: For anyone trying to follow, we
12 have the typescript edition and it's on page 599 of that
13 edition.

14 JUDGE BRENNER: But the printed edition is the
15 smaller version, and it's on 498?

16 MR. WETTERHAHN: Yes, sir.

17 JUDGE BRENNER: So am I correct that Dr. Branagan
18 and Mr. Elliott, at least, have the same edition?

19 WITNESS BRANAGAN: Yes, I do.

20 BY MR. ELLIOTT:

21 Q That reference indicates the normal sperm counts
22 can return in a period of about one year after doses of
23 100 rads. And apparently up to about three years after
24 exposures in the near lethal range. Is that correct?

25 A (Witness Branagan) That is correct. However, the

71b3

1 testimony that was indicated on page 10 death with a range
2 of those estimates, not just the 100 rads range.

3 Q Okay. The per reactor year risk estimate provided
4 by the testimony of 1.6×10^{-1} for males for temporary
5 sterility is higher than the risk of any category of health
6 effects analyzed in the FES. Isn't that correct?

7 A (Witness Acharya) Well, the answer is yes, but
8 as we have said earlier, the genetic effects -- the risk of
9 that is higher than this.

10 Q Yes. Staff's testimony at paragraph 20, last
11 paragraph, with respect to benign thyroid nodules. The
12 testimony is that the risk is 15 times higher than that of
13 thyroid cancer fatalities. Does that mean that I could derive
14 a per reactor year risk estimate by multiplying the per
15 year reactor year value for thyroid cancer fatality
16 by 15?

17 A That's correct.

18 Q If that were done, that would make this risk
19 per reactor year higher than any other health effect analyzed
20 in the FES, isn't that correct?

21 A I have to check it. The number now would be --
22 if you look at the Table 5.11(h), the total cancer fatality
23 reported there is 1×10^{-2} . And if you multiply that
24 by 15, it would be 1.5×10^{-1} .

25 Q And that's higher than any other number on that

1 table, right?

2 A (Witness Hulman) That's correct.

3 Q The Staff testimony mentions hypothyroidism. What
4 is that?

5 A (Witness Branagan) That would be a decrease in
6 activity of the thyroid.

7 Q What physical impact does that have on a person
8 who suffers from that disease?

9 A (Witness Acharya) As stated in WASH-1400, the
10 hypothyroidism is not seen as an impediment in the sense
11 that it is easily and inexpensively treatable by administration
12 of thyroid hormones.

13 Q Why does it require medical treatment?

14 A Well, I cannot quote about the treatment, as I
15 said, this is treated by the administration of thyroid
16 hormones which are distributed, are available, in the form of
17 tablets. And the person affected by hypothyroidism will be
18 on that medication. For many individuals the thyroid
19 glands could be removed -- the persons will have undergone
20 the removal of the thyroid gland.

21 Their activities in normal life is not affected
22 by using the thyroid hormones. The same kind of treatment
23 will be provided here and that would not impair the activity
24 of the person in any measured way.

25 Q That assumes he gets medical treatment, right?

A That's correct.

8pbl

1 Q In Staff's testimony, paragraph 20 there's a
2 reference to other types of health effects. In addition to
3 the ones considered, and in addition to the benign thyroid
4 nodules and hypo thyroidism, what other health effects did
5 the Staff consider?

6 A The -- according to the description provided in
7 WASH-1400 Appendix 6, the other forms of health consequences
8 that is not already accounted for the in FES or in this
9 contention could be the early fatality due to the exposure
10 of the embryo and in utero exposures. The early fatality
11 of such exposure, as stated in WASH-1400 from serious reactor
12 accident could be within 5 to 10 percent of the early fatality
13 that's already reported.

14 So those are the two types of early fatality.
15 That's what we're referring to here.

16 Q Any other health effect considered?

17 A That could be an early health effect due to
18 excessive exposure of the thyroid organ, what is ablation.
19 In which case the thyroid could be destroyed.

20 But again, the number of such is very sma!''
21 compared to the early fatality. That will not result in
22 fatality, the complete destruction of the thyroid. But
23 however, there is associated with it -- it is small compared
24 to what is already reported.

25 Q Anything else considered?

8pb2

1 A I am not aware of anything else.

2 Q Pardon?

3 A I am not aware of anything else that could happen
4 from reporting that.

5 JUDGE BRENNER: I didn't get the last health
6 effect you were discussing thyroid --

7 WITNESS ACHARYA: Thyroid ablation, a-b-l-a-t-i-o-n.

8 JUDGE BRENNER: Okay, thank you.

9 BY MR. ELLIOTT:

10 Q Dr. Branagan, did not BEIR-III also address at
11 length the effect of radiation on early development of
12 children?

13 A (Witness Branagan) BEIR-III contains information
14 on the effects of radiation on children.

15 Q Is not impairment of or defects in the development
16 of children due to in utero exposure of embryos and fetuses,
17 a health effect of -- a health risk of severe accidents at
18 Limerick?

19 A In utero exposure was included in the somatics
20 risk estimator that was used in WASH-1400.

21 Q Risk estimator for which category of consequence?

22 A That would include all fatal cancers.

23 Q I'm not talking about fatalities now. I'm talking
24 about impairment of development of children. I'm talking
25 about microcephaly, mental retardation, growth retardation,

8pb3
1 blindness, cleft palate, spina bifida. Were those considered?

2 A I would have to check on that to see.

3 JUDGE BRENNER: Just so I understand your question,
4 Mr. Elliott, when you say were those considered -- where?

5 BY MR. ELLIOTT:

6 Q In the FES.

7 A (Witness Hulman) The Staff will check at the
8 break and respond afterwards.

9 MR. ELLIOTT: That concludes my cross-examination
10 on 4-A-1 of this panel.

11 JUDGE BRENNER: Maybe I misunderstood your estimate
12 yesterday. I thought you said 4-A-1 would be extensive.
13 Maybe you meant all of 4 yesterday.

14 MR. ELLIOTT: Oh, yes. I think I did.

15 JUDGE BRENNER: All right. We can go to the
16 Applicant's questions at this point of the Staff's witnesses
17 on this subject.

18 MR. WETTERHAHN: Would it be helpful to take a
19 break now, so they can get the answers to the last question
20 so we can proceed in order?

21 JUDGE BRENNER: Okay, but then the problem is we'll
22 need another break when we switch witnesses.

23 MR. WETTERHAHN: Okay, I'll proceed.

24 JUDGE BRENNER: How much do you have of these
25 witnesses?

8pb4

1 MR. WETTERHAHN: Five or ten minutes I would say.

2 JUDGE BRENNER: All right, you want to take a
3 break now. Okay, we'll come back at 10:30.

4 (Recess.)

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1 JUDGE BRENNER: Mr. Wetterhahn, you may proceed.

2 MR. WETTERHAHN: I believe there was an answer
3 that was going to be checked as to Mr. Elliott's last
4 question. Perhaps we can get that answer on that record
5 before I begin.

6 Can any member of the Panel respond to Mr.
7 Elliott's question? Do you recall it?

8 WITNESS ACHARYA: I would like the question to be
9 repeated.

10 JUDGE BRENNER: Do you have that, Mr. Elliott?

11 MR. ELLIOTT: Let me ask two questions.

12 BY MR. ELLIOTT:

13 Q Is not impairment of or defects in the development
14 of children due to in utero exposure of embryos and fetuses
15 a health risk of severe accidents at Limerick?

16 A (Witness Acharya) Well, that could be a health
17 risk from the Limerick accident, but, however, though we
18 have not explicitly calculated some of these impairments
19 and written them down by the types of impairments, the early
20 injury estimates that's provided in the Staff's FES has
21 used the basis which is more conservative compared to
22 WASH 1400 basis, and that would provide the envelope, the
23 bounding type of estimates. And in that bounding, all other
24 small impairment risks would be included, or is already
25 included.

1 Q Staff did not analyze the contribution to early
2 injuries of these developmental defects, did it?

3 A Explicitly, no. But the early injury estimates
4 that is provided in the FES would include that. In other
5 words, the estimates that are -- the estimates that are
6 not provided would be small fraction of the estimates that
7 are already provided, and since that allows uncertainty
8 in the estimates in general, a small fraction change would
9 not be -- the small change to the risk estimates such as
10 a few percent would not be very much material.

11 Q Was the reason for the Staff's use of what you
12 call conservative risk estimator for early injuries to
13 include the contribution to early injuries of these
14 developmental defects in children?

15 A (Witness Hulman) I don't understand the question.

16 Q Was the purpose in choosing a risk estimator
17 that the Staff did for early injuries to accommodate the
18 contribution of developmental defects?

19 A (Witness Acharya) In the WASH 1400 model for the
20 estimate of early injuries, the exposure to three organs --
21 of the three organs were identified. They are the principal
22 organs; namely, the whole body, the lungs and the GI tract.
23 The threshold for the whole body was 55 rems, and that was
24 for the abdominal vomiting and the 100 percent occurrence
25 was something like -- I don't remember exactly from the CRAC

1 runs, maybe something like 400 or so.

2 But Staff modified that and by it attaining the
3 other two organs, namely the lungs and GI tract, we
4 substituted the whole body by total marrow. That is
5 exposure to the total marrow we adopted as a basis for
6 calculating the morbidity, and the threshold for that was
7 55 rems, but, however, we assumed that at 200 rems to the
8 total bone marrow, that would be indicative of 100 percent,
9 of injury to 100 percent of the people so exposed.

10 Now this is very conservative compared to the
11 WASH 1400 assumption, that 100 percent of the impairment
12 from the whole body exposure would be somewhere around 400
13 rems. So this is the reason why -- the reason that we used
14 total bone marrow of 200 rems to mean injury to all people
15 so exposed, is that that might be indicative of hospitalization.
16 And that includes everybody. All age groups.

17 Q The developmental defects I have just been
18 referring to are associated with dose threshold levels much
19 lower than 55 rems whole body to the embryo or fetus, aren't
20 they?

21 A (Witness Branagan) They can be associated with
22 lower doses, that is correct.

23 Q They could be associated with doses down to 10
24 rems to the fetus and embryo; isn't that correct?

25 A In some cases, yes. But that's not in all cases.

1 Q I understand.

2 Establishing a dose threshold of 55 rems for
3 early injuries would not pick up the contribution to early
4 injuries associated with dose threshold level of down to 10
5 rems for early injuries in fetuses and embryos; isn't that
6 correct?

7 A (Witness Acharya) Well, it is -- we can use
8 the comparison that we had provided earlier; namely the
9 fatality resulting from embryonic in utero exposure is
10 something like 5 or 10 percent of the fatalities estimated
11 for the -- estimated for all people. And that is supported
12 here in the FES. A similar relationship between the
13 impairment between the low dose thresholds such as in utero
14 exposure or exposure to the age groups for low age groups.
15 The risk of impairment that would be calculated would be
16 very small, perhaps the risk that is already calculated,
17 assuming 55 rem threshold.

18 JUDGE BRENNER: I'm sorry, I just did not under-
19 stand the last part of that. Just repeat it, if you could.

20 WITNESS ACHARYA: Let me refer to a statement
21 that is made here --

22 JUDGE BRENNER: Well, wait. Let me make sure
23 you have repeated what you said, and then you can add it.
24 Could you repeat essentially what you said?

25 WITNESS ACHARYA: The estimate of risk by assuming

1 a low threshold for the low age groups would be a small
2 fraction of the estimate of the risk of impairment that is
3 already reported.

4 (Discussion off the record.)

5 BY MR. ELLIOTT:

6 Q With respect to the population of concern here,
7 that is fetuses and embryos, the impact could be very large,
8 could it not?

9 A (Witness Acharya) Would you repeat the first
10 part of the question?

11 Q With respect to the population of concern here,
12 which is embryos and fetuses, the impact could be very large,
13 could it not?

14 A We have not provided the risks broken down in
15 terms of risks to the different age groups. We have -- our
16 estimates include all age groups.

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1 Q So you don't know what the impact on that
2 population is, then?

3 A We didn't calculate that for the small fraction
4 of the risk that is already reported.

5 MR. ELLIOTT: I have nothing else.

6 JUDGE BRENNER: Mr. Wetterhahn?

7 CROSS EXAMINATION

8 BY MR. WETTERHAHN:

9 Q I'll address all question to the panel. Any
10 member may feel free to respond.

11 JUDGE BRENNER: I should have done this earlier,
12 The rules here are, in addition to somebody responding first,
13 if anybody wants to add -- and particularly if they have a
14 different view, they're under an obligation to add an answer
15 to the question.

16 Go ahead, Mr. Wetterhahn.

17 BY MR. WETTERHAHN:

18 Q The NRC Staff, in preparing its FES, decided
19 as you stated here to include certain health effects and
20 certain consequences of reactor accidents and exclude others.
21 Was there a value judgment made, as to which effects to
22 include and which to include? And if so, can you state
23 the basis of that judgment?

24 A (Witness Hulman) Mr. Wetterhahn, I think your
25 question said which to include and which to include.

1 Q Exclude.

2 A Oh, I'm sorry. Yes. The answer is yes.

3 Q Could you describe the judgmental process and
4 the basis for process for deciding which consequences to
5 include and which to discuss generally, by words rather than
6 specific numbers which you felt were not necessary to
7 include?

8 A The judgmental process went something as follows:
9 confronted with a very long list of potential health
10 effects, as well as other effects of reactor accidents, the
11 Staff went through all the literature and decided to select
12 a representative sample of the more important effects. The
13 FES reflects that judgment.

14 As your question indicated, the Staff tried to
15 indicate there were a number of other effects and discussed
16 them in general. The Staff also believed that by providing
17 references and appropriate references on health effects, that
18 a reader that wished more information would be able to use
19 those references and identify the specific effects that are
20 only discussed in general.

21 So, in our view, not only the written words in the
22 FES constitute an assessment, but the use of the references
23 as well.

24 Q You stated that you used a representative sample
25 of more important effects. Then, in making this decision, did

1 you consider the importance of the various health risks
2 involved in determining which should be discussed explicitly,
3 quantitatively, in the FES?

4 A (Witness Acharya) Let me respond to that. The
5 health effects that we decided to include in the FES were
6 largely -- were the serious types that may result in fatality
7 or in injury. The health effects that would not result in
8 -- would not result in fatality are health effects that are
9 not -- would not affect the individuals concerned to the
10 extent -- namely benign thyroid nodules, hyperthyroidism, such
11 effects. We talked that they are not as important for putting
12 -- making estimates of.

13 So that was the principal reason that we did not
14 include them. And many of the health effects that have been
15 omitted or developed from the information that's already
16 provided in the FES. Many of them are based on the basis
17 of personrems. That's the population exposure that's provided.
18 Some of the nonfatal effects are also developed from the
19 estimates of the fatal effects.

20 A (Witness Hulman) I would like to add to that. It's
21 not that we didn't think that all of the health impacts that
22 could be associated with reactor accidents were not important.
23 My God, they were very important. But we did not feel that
24 in the FES it was necessary to describe, in great detail,
25 every single one of them. We thought what we did was an adequate
representation of the types and the more important types.

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1 Q Thank you. I believe this is probably directed to
2 Dr. Branagan. You described your 260 genetic effects per
3 million manrem as those which would cause serious defects.
4 Is that the term you used?

5 A (Witness Branagan) That is correct.

6 Q How many of these would be expressed in the first
7 generation?

8 A Approximately -- the 260 genetic defects per million
9 person-rem, approximately 1/5th of those would be in the
10 first generation. And I did make a comparison, Dr. Shearon,
11 in response to question number 12 stated it would be about
12 .26 genetic defects per reactor year.

13 If you assume that 1/5th of those would be in
14 the first generation, that would equate to about .05 genetic
15 effects in the first generation per reactor year. And you
16 can compare that value for some perspective with the natural
17 incidence of genetic effects of about 11 percent. So this
18 means that for the year 2000 population of approximately
19 8.1 million people, you would expect approximately 880,000
20 genetic effects in the first generation, due to natural
21 causes.

22 Q And that number will be comparable to the .05
23 genetic effects to the same population as the risk on an
24 annualized basis.

25 A Yes, as the risk per reactor year, that's correct.

11pb2

1 Q These -- considering the health and other impacts
2 that are discussed in the FES, also those that were discussed
3 in your testimony, and also the ones that were brought up
4 on cross-examination by LEA's counsel, if the panel would
5 consider all those health impacts, do you believe that a
6 consideration of all these explicitly or as stated by you
7 on the panel would change your conclusions in any way in
8 the final environmental impact statement?

9 A (Witness Hulman) Not in mine, but I think you
10 asked an individual question, and the rest of the panel has
11 to respond I think.

12 A (Witness Richter) No.

13 A (Witness Branagan) No.

14 A (Witness Acharya) No. And we have so stated in
15 page 15 in response to the question that we posed here,
16 question and answer 26.

17 Q But your answer, Dr. Acharya, considers also
18 not only your testimony, but considers your testimony -- I'm
19 sorry, your written testimony, but your oral testimony and
20 your responses to question.

21 A That's correct.

22 MR. WETTERHAHN: Thank you, I have no further
23 questions.

24 JUDGE BRENNER: Does the Commonwealth have any
25 followup?

11pb3

1 MS. FERKIN: I have one question.

2 CROSS-EXAMINATION

3 BY MS. FERKIN:

4 Q Staff testimony paragraph 20 mentions other types
5 of health effects not specifically discussed in the FES.
6 LEA asked the panel to describe what those other health
7 effects would be. I believe Dr. Acharya made an answer
8 concerning early fatality effects. And he named two types.

9 Can you repeat those for me, please?

10 A (Witness Acharya) The risk of early fatality
11 resulting from exposure to the embryo and fetus.

12 MS. FERKIN: All right, I have no further questions.

13 JUDGE BRENNER: Ms. Bush, I infer from the fact
14 that you did not come up to the table that you have no
15 questions; is that correct?

16 MS. BUSH: That's correct.

17 BOARD EXAMINATION

18 BY JUDGE COLE:

19 Q Dr. Branagan, you indicated that the risk of
20 genetic effects per reactor year was .26 divided by 5. Do
21 you recall that, sir?

22 A (Witness Branagan) That's correct.

23 Q And you compared that with 800,000 genetic effects
24 caused by non-nuclear, or not caused by the plant -- natural
25 causes. I guess I don't understand the origin of the 800,000

11pb4

1 and how you justify comparing it with the .05 value per
2 reactor year.

3 A Okay, the point -- the origin of the question was
4 response to question number 12 in the prefiled testimony.
5 And on page 6, the ninth line down, the value of .26 cases
6 of genetic effects per reactor year is given as the risk
7 of genetic effects from the reactor's operation. That would
8 be the risk of genetic effects over all succeeding generations.
9 Approximately 1/5th of those would occur in the first
10 generation. These wouldn't occur to those people that are
11 irradiated, but rather to the first generation, the descendants
12 of those people that would be irradiated.

13 So to put this number in perspective, I compared
14 it with the natural incidence of genetic effects in the
15 first generation of the population of 3.1 million people.
16 And the natural incidence of genetic effects as given in
17 the BEIR, 10.7 percent, I have rounded that off to 11 percent.
18 And so that would be compared with approximately 880,000
19 genetic effects in the first generation.

20 Q I guess I'm still confused, because when I
21 consider a generation, I consider a time period of say,
22 20 years or something. And if we've got .05 per reactor
23 year, why don't I just multiply that .05 by 20 and compare
24 that to the 800,000 in that generation?

25 A Well, a generation is considered in the BEIR-III

11pb5

1 report to replace itself within a period of about 30 years,
2 approximately that. Another way to look at this would be
3 the risk would be .05 genetic effects in the first generation
4 per reactor year times the number of years the reactor
5 operates, and that way you could get a value integrated over
6 the lifetime of the plant, and compare that with the 380,000.
7 That would be another perspective.

8 Q Or integrated over a generation.

9 A Well, my understanding, the reactor would operate
10 for 40 years. That's a typical value. And so the risk would
11 be limited to the number of reactor years.

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1 Q Well, if the risk of genetic effects is .05
2 per reactor year and it's going to operate for 30 years, the
3 same 30 years that a generation is counted, your 800,000 figure,
4 why wouldn't .05 times 30 be compared to the 800,000? Is
5 that not a --

6 A Excuse me. I don't have all the operating license
7 -- how long it's proposed. I assume it's 30. Okay, you could
8 compare the value of .05 times 30 reactor years. That would
9 give you a value of 1.5 genetic effects in the first
10 generation. That's over -- for all -- 30 years of reactor
11 operations. You could compare that with the value of 800,000
12 genetic effects in the first generation.

13 Q Okay, is that a more valid comparison than the value
14 of .05 to 800 and some thousand?

15 A It's another perspective. It's another way to look
16 at it. I wouldn't say one is necessarily more valid than the
17 other. Myself, I prefer to use a per reactor basis. I find
18 that the simplifying factor.

19 Q Okay. I understand your position now. Thank you.

20 BY JUDGE MORRIS:

21 Q Dr. Branagan, I want to see if I understand your
22 use of mean values of generations for genetic effects. Is
23 it correct you did use mean values?

24 A (Witness Branagan) Actually, the mean values
25 did not really enter into the calculations. The BEIR report

1 gives a risk estimate are integrated over all future genera-
2 tions. And in the discussion on that, there is a question
3 when do you expect these effects to be expressed? And they
4 gave mean values of five generations and ten generations for
5 the respective categories.

6 Q So just quoting those mean values is of interest,
7 but it was not used in the calculation?

8 A That's correct.

9 Q Thank you. Again, for my understanding, in a
10 general way, it's clear that some health effects have been
11 neglected explicitly at least. And I've heard some numbers
12 like they might be five to ten percent of the more dominant
13 health effects.

14 In your final judgment, were those things left
15 out, factored back in, or did you simply say that the
16 uncertainties already from the dominant health effects are
17 large enough so that it wouldn't make any difference whether
18 you added in those that were neglected, or left them out?

19 A (Witness Hulman) I think the answer to your
20 question is both. They were factored into our final
21 judgments on whether the risks were low. There was also a
22 consideration of the fact that they were a small percentage
23 of the kinds of risks that we've described. So the answer to
24 your question is both.

25 Q Thank you.

1 BY JUDGE BRENNER:

2 Q On that last theme, Mr. Hulman, I think in answer
3 to one of Mr. Wetterhan's questions, you explained your
4 judgment and said you didn't deem it necessary to consider
5 some of these other health effects in great detail in the FES,
6 correct?

7 A (Witness Hulman) I did not say -- if I did, I
8 will correct the record. I did not mean to say we did not
9 consider. I did not report. I distinguish between the two.
10 All of the kinds of health effects that have been described
11 were considered.

12 Q Upon reflection now, why would it not be appropriate
13 to at least list the other health effects and indicate,
14 in a paragraph or so, what you've told us here? That is
15 that these health effects could occur but you consider them
16 subsumed for the reasons you have expressed by the others
17 that you have analyzed in some detail?

18 A It could be done?

19 Q If we did that, would it change any of the numbers
20 in the CCDFs or the table expressions of risk that are presented
21 in the FES?

22 A No, sir.

23 BY JUDGE COLE:

24 Q Dr. Branagan, one question. The 880,000 figure
25 for the population surrounding Limerick?

1 A (Witness Branagan) Yes.

2 Q That's for a generation and you indicated a
3 generation is considered to be about 30 years, right sir?

4 A That's correct.

5 Q Getting back to the comparison to .05, working the
6 other way, could we justify the 880,000 by the 30 year
7 generation and get the number of genetic effects actually
8 caused per year, and compare that?

9 A Yes, one could do that. That would be another --
10 comparison -- I wouldn't do that, for this reason --

11 Q Okay, tell me why you wouldn't do that.

12 A The .05 genetic effects would be the number of
13 genetic effects that would occur in the first generation. They
14 wouldn't necessarily occur in the first year after the
15 accident, but they would occur in the first generation because
16 the population of 8.1 million people wouldn't reproduce itself
17 instantaneously. And so, in that way, the comparison is more
18 valid with the 880,000 value.

19 BY JUDGE BRENNER:

20 Q The .05 is the result of one reactor year. It
21 isn't expressed in the one year, is that what you're saying?

22 A (Witness Branagan) That's correct. It's not
23 expressed in one year. It would be expressed in the first
24 generation, and it's the risk for one reactor year of operation.

25 A (Witness Hulman) May I add to the answer, please?

1 It's an average value. It's not necessarily associated with
2 the first or the last year.

3 Q Okay, thank you.

4 MS. BUSH: Judge Brenner, I had a question about
5 the .05 number that Judge Cole raised.

6 JUDGE BRENNER: Well, wait, let's keep things in
7 sequence. Let me go back to Mr. Elliott for follow up.

8 All right, let's go to redirect.

9 REDIPECT EXAMINATION

10 BY MS. HODGDON:

11 Q The panel was asked a question earlier about whether
12 -- as I heard it, it was whether the reader of the FES could
13 find the health effect risk associated with a particular
14 release category by use of Table 5.11(c) I believe and the
15 Staff said -- the panel said no.

16 I direct you to Table K.1. Can you find that,
17 Dr. Acharya?

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1 Is it possible for the reader of the FES to find
2 the health effects associated with the particular release
3 category? The health effect risk associated with a
4 particular risk category by the use of that table? And could
5 you tell us, if so, how?

6 A (Witness Acharya) Yes, one can use the results
7 provided in Table K.1 to determine the risks of the particular
8 types that result from any of the release categories listed
9 in the text, that is Table 5.11(c) by the following
10 procedure. In Table K.1, the various health effect estimates
11 or cost or whatever other items that are provided -- they are
12 the conditional mean values.

13 That means it presupposes the occurrence of the
14 accident in the first place. And the results obtained are
15 average values of different meteorological conditions that
16 were assembled. In order to obtain the risk of any
17 particular type for any particular release category, all that
18 one has to do is refer to the Table 5.11(d), where we have
19 the probabilities of the individual release categories, and
20 pick up the probability from that table and multiply that by
21 the conditional mean value of the particular effect from the
22 Table K.1.

23 Q Thank you.

24 MS. HODGDON: May I have a moment, please?

25 (Counsel conferring.)

1 BY MS. HODGDON:

2 Q Dr. Acharya, yesterday you made a statement
3 regarding the estimates of uncertainty for the numbers in the
4 risk assessment. Can you state the basis for the numbers that
5 you gave, which I believe was from four to 400 -- excuse me,
6 40 to 400?

7 A (Witness Acharya) Well, as I stated yesterday, or
8 also as it is stated in the FES, that the risk that we have
9 estimated could be low by a factor of about 40. The risk
10 could be higher by a factor of 40, but also it could be that
11 the risk that we have estimated could be high by a factor of
12 400.

13 In other words, the risk may be 400 times lower than
14 the risks that are put in the FES. I also said yesterday
15 that the state of the art for the precise quantification of
16 the uncertainty is not well developed. So a lot of personal
17 judgment has gone into this, in attempting to provide whatever
18 quantification we have done.

19 The various elements of the personal judgment that
20 were used along the way are as follows. I'm going to state
21 the -- now the risk of any kind that is estimated, that is
22 the result of the multiplication of the probability of the
23 severe accident as the conditional mean value that one would
24 get under the hypothesis of occurrence of the accident. The
25 judgment of the Staff is that the probability of severe

1 accidents that could result in large consequence could be
2 higher by about a factor of 30 or it could be lower also by
3 a factor of 30. Now this number 30 expressed as the power
4 of 10 is 10 is to the power plus or minus 1.5. It is
5 10 -- if it is 10 raised to the power of +1.5, that's 30.
6 And it can raise to the power -1.5 is 1/30.

7 Now keep aside this factor for a while. Also, it
8 is the consensus of the Staff that the fractions of the
9 radionuclides that are associated with the release categories,
10 namely the magnitudes of the radionuclides that would come
11 to the environment could be higher than what we have assumed,
12 by a factor of 3. It could also be lower than what we have
13 assumed by a about a factor of 30.

14 So this factor of 3 on the high side, and the
15 factor of 30 to the low side, can be mathematically put in the
16 form as 10 -- I'm repeating, 10 raised to the power of -.5
17 plus or minus 1. Now keep this factor aside.

18 JUDGE BRENNER: Dr. Acharya, let me interrupt.
19 Although maybe your counsel wanted the mathematical expression,
20 I think it might be good at the outset to get a direct answer
21 to the question, which was the basis for the estimates of
22 40 to 400, as I recall the question.

23 WITNESS ACHARYA: That's what I'm trying to keep
24 the final mathematical expression which would result in a
25 factor of 40 and a factor of 400.

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1 JUDGE BRENNER: I know, you were getting there, but
2 I wasn't sure that you were getting there in the most
3 efficient way.

4 MR. ACHARYA: It is also the concensus that the
5 conditional estimates of the consequences, conditional
6 mean values of the most severe accidents could be up or down
7 by a factor of 10. So this is put in the perspective -- in
8 the mathematical form -- as 10 plus or minus 1.

9 So when you combine all these factors, it
10 translates to or it results in 10^{-5} and plus or minus 1.5
11 plus -1 and plus -1.

12 Now since the uncertainty arising in various
13 elements here are uncorrelated with one another and can
14 be treated as independent, the uncertainty that would arise
15 in the overall result is described as 10^{-5} because -5 was
16 not associated with any alternative -- it was associated only
17 with the negative side. Then plus or minus the square root
18 of 1.5 square plus one square plus another one square.

19 So the net result is the net uncertainty would be
20 10 to the square -5 plus minus square root of 4.25 and finally
21 it all translates to 10 squared 1.6 or 10 square -2.6.

22 The 10 square 1.6 is 40 and 10 square -2.6 is
23 1/40.

24 WITNESS HULMAN: Let me see if I can summarize
25 because it was very lengthy and detailed.

1 JUDGE BRENNER: Well, wait for one second. What
2 did you say the -2.6 is? One over what?

3 WITNESS ACHARAY: It's 1/400, excuse me.

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1 WITNESS HULMAN: Let me just summarize. The
2 uncertainty assessment is based on three components,
3 probability, source term and consequences. The uncertainty
4 associated with each one was evaluated in using the square
5 root of the sum of the squares, the estimate was 40 up to
6 400 down.

7 MS. HODGDON: I believe that answers my question.

8 JUDGE BRENNER: I hope so.

9 (Laughter.)

10 MS. HODGDON: I have another question.

11 BY MS. HODGDON:

12 Q Mr. Hulman, LEA has asked questions regarding
13 severe accidents. Would you comment on the probability of
14 the occurrence of a severe accident of the relationship
15 that that has to the numbers in the overall accident
16 evaluation in the FES?

17 A (Witness Hulman) The FES estimates risks on
18 a reactor year basis. The FES also indicates that the risk
19 of any of these accidents occurring have probabilities
20 individually less than 10^{-4} per year. Less than one in
21 10,000 per year.

22 Collectively, the risk of all of the accidents
23 we have looked at is less than one in 10,000 per year.
24 Therefore we conclude that even though some of the relative
25 risk categories may be high on a per reactor year basis, the

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1 probability of occurrence is low.

2 And in comparison to other risks to which the
3 public is exposed, is also low.

4 Q Thank you. Dr. Branagan, in response to a question
5 about sterility you gave a response regarding the effect of
6 100 rads, and the effect that would have on the incidence
7 of sterility. What would be the normal incidence without
8 the reactor?

9 A (Witness Branagan) Let me try to respond to the
10 question. I think the question concerned with how long
11 sterility might last. And there's a very relevant passage
12 from WASH-1400, Appendix 6, page F-15, and I'd like to read
13 a couple of sentences there to put things a little better
14 in perspective. That's page F-15, WASH-1400, Appendix 6.

15 Q If you could read that, I don't think that
16 everybody has that reference available.

17 A The last paragraph, "To summarize, in the human
18 male, radiation doses beginning above 10 rads and extending
19 to 600 produce a decrease or absence of sperm beginning at
20 least six to seven weeks after exposure and continuing for
21 a few months to several years.

22 "The subsequent recovery ensuing within this dose
23 range. The magnitude of the depression and the rate of
24 return of sperm count are related to the magnitude of the
25 exposure.

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1 "It is noteworthy, however that even the dose at
2 the high end of the range, which would in the potentially
3 lethal area, if administered to the whole body is not
4 sufficient to produce permanent sterility."

5 Q Thank you.

6 JUDGE BRENNER: Did you want an answer to the
7 question you asked also?

8 BY MS. HODGDON:

9 Q Yes, the question asked was a different question,
10 and that was --

11 A (Witness Branagan) Excuse me.

12 Q I think, although your response was very interesting.

13 (Laughter.)

14 Q The question was, you traced earlier, I thought,
15 the effect of 100 rads, which you took for a number. I
16 wanted to know how that related to -- whether that wasn't
17 high. And I wanted to know something about the causation,
18 if you know, of other incidents of sterility. I wanted to
19 know 100 rads related to sterility of other incidents that
20 was not so long lasting.

21 A The value of 100 rads that was referenced in
22 the BEIR-III report, was one of the higher dose estimates.
23 And if you had a lower dose estimate, then the period of
24 sterility would not as long as a year. It could be less
25 than a year, and that was the reason I read the passage from

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1 Appendix F of WASH-1400.

2 Q And what is the effect of 100 rads then, in terms
3 of sterility?

4 A 100 rads in terms of sterility -- I would just
5 reference the passage from the BEIR-III report.

6 JUDGE BRENNER: That's the question you did just
7 answer before.

8 WITNESS BRANAGAN: Yes.

9 JUDGE BRENNER: Ms. Hodgdon, I didn't understand
10 your question when you rephrased it. I'm sorry, I thought
11 your question was -- and I'll ask it -- what's the natural
12 incidence of sterility, if you could break it down, either
13 temporary or permanent in the population so that we could
14 have a basis for comparison between the estimates you've
15 given for different dose rates caused by reactor operation,
16 if you know?

17 WITNESS BRANAGAN: I don't have that information.

18 JUDGE BRENNER: Okay. Wasn't that your question,
19 Ms. Hodgdon?

20 MS. HODGDON: That was my question, but I related
21 the 100 rads --

22 JUDGE BRENNER: That's enough. You answered my
23 question.

24 MS. HODGDON: Yes, that was my question.

25 JUDGE BRENNER: Okay. If you have other questions.

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BY MS. HODGDON:

Q To elaborate on that question, my question was with regard to --

JUDGE BRENNER: No, do you have other questions?

MS. HODGDON: No, I have no further questions for the panel.

JUDGE BRENNER: Thank you. Any followup, Mr. Elliott?

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1 RECROSS EXAMINATION

2 BY MR. ELLIOTT:

3 Q Mr. Hulman, in response to a question Mr.
4 Wetterhahn you compared the discussion in detail in the FES
5 of some effects with the generalized discussion of other
6 effects in the FES. There were some effects that you've
7 testified today, and in your prefiled testimony that are
8 not discussed at all in the FES; isn't that correct?

9 A (Witness Hulman) Yes.

10 Q You mentioned that some effects are derivable from
11 the person-rem figures in the FES. But some are not
12 derivable from that figure; isn't that correct?

13 A Yes.

14 Q The multiplication factors that you have relied
15 upon in the prefiled testimony, except with respect to
16 genetic effects are not found in the FES; isn't that correct?

17 A My understanding of the FES is that it includes
18 not only the material that is written, but its references.
19 And in my context, the references do include it.

20 Q Are you suggesting that the FES incorporates the
21 entirety of every single reference that it makes?

22 A It utilizes every one of those references.

23 Q Right. But it doesn't disclose the multiplication
24 factors that are found in some other document, does it?

25 A No.

15pb2

1 Q You said that you chose a representative sampling
2 of some of the more important health effects. How are the
3 health effects that are disclosed in the FES representative
4 in any sense of sterility or spontaneous abortion?

5 A I didn't say they were.

6 Q Well, you said representative sampling. Representa-
7 tive of what?

8 A Of the types of health impacts and other impacts.

9 Q How is the health effects that are disclosed
10 representative in any way of health effects such as sterility,
11 spontaneous abortions, or in utero injuries?

12 A They are not, but the health impacts that were
13 used are representative of the range of health impacts, in
14 our judgment that would occur. They did not include specific
15 reference to the ones you have listed.

16 Q When you said range, are you referring to range
17 of numbers?

18 A Type.

19 Q In response to Staff counsel's question you made
20 a reference to Table K.1. Table K.1 omits genetic effects;
21 isn't that correct?

22 A It does not explicitly list them.

23 Q Where does it include them?

24 A I've answered your question.

25 JUDGE BRENNER: I was going to ask the same

15pb3

1 question, for what it's worth, Mr. Hulman, after your
2 previous answer.

3 WITNESS HULMAN: I don't understand the question.
4 I thought I answered them.

5 JUDGE BRENNER: You said it does not explicitly
6 list them. So the natural followup question is, where
7 does it include them.

8 WITNESS HULMAN: It's typical of the type. It
9 does not explicitly include them. It does not explicitly
10 list them.

11 JUDGE BRENNER: Where does it include them in
12 any sense?

13 WITNESS ACHARYA: Let me respond to that. Though
14 the genetic effect is not listed in Table K.1, as I pointed
15 out yesterday, that is a table in the FES that's -- I believe
16 it was Table 5.11(g). It is stated at the bottom as a
17 footnote about --

18 JUDGE BRENNER: What table is that, (g) or (d)?

19 WITNESS ACHARYA: It's page number 5-90 in the
20 FES.

21 JUDGE BRENNER: 5.11(g)?

22 WITNESS ACHARYA: That's correct.

23 JUDGE BRENNER: So, Mr. Hulman, the answer to
24 Mr. Elliott's question about Table K.1 is they are not
25 included.

;5pb4

1 WITNESS HULMAN: That's correct.

2 JUDGE BRENNER: That wasn't the way you phrased
3 your answer originally, which is why you got the followup
4 question that you got. Mr. Elliott.

5 BY MR. ELLIOTT:

6 Q You've testified that the probability of a severe
7 accident at Limerick is approximately one in 10,000 per
8 reactor year. What is the -- excuse me, do I have that
9 wrong?

10 A (Witness Hulman) I said it was less than. And
11 the accumulated total is estimated to be from all types of
12 severe accidents. Individually it's less for any individual
13 kind of an accident.

14 Q I understand. Is it approximately one in 10,000?

15 A Or less.

16 Q What would the probability be at Limerick over
17 its entire period of operation?

18 A One in 10,000 in any reactor year.

19 Q I'm asking you what it would be over its entire
20 operational period.

21 (Panel conferring.)

22 A (Witness Acharya) That number is an annual
23 frequency. If you are looking for the frequency of the
24 entire plant life, you have to multiply that by the number
25 of plants -- the number of years the plant operates.

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Q So that I can determine the probability of a severe accident at Limerick over the period of its operational life by multiplying one over 10,000 by 30 assuming a 30-year operational period.

A (Witness Hulman) Yes.

JUDGE BRENNER: That also would assume 100 percent capacity factor, wouldn't it, Mr. Hulman?

WITNESS HULMAN: 100 percent capacity factor and 30 years of continual operation, right.

MR. ELLIOTT: No further followup.

1 FURTHER BOARD EXAMINATION

2 BY JUDGE MORRIS:

3 Q Mr. Hulman, are you sure about that 100 percent
4 capacity factor?5 A (Witness Hulman) We used something like 100 percent
6 in our estimate of fission products. As I remember, the number
7 is 105 percent. We've done that part of the analysis
8 conservatively. If the reactor does operate at less than
9 100 percent, our assumptions on fission product and energy
10 are conservative. Our risk estimates, therefore, tend to
11 be conservative.

12 Q And by about how much?

13 A Well, my recollection of the plant capacity factors
14 or contemporary BWRs is they tend to be operating at about
15 85 percent roughly or less. So we're perhaps 20 percent too
16 high.

17 JUDGE MORRIS: Thank you.

18 JUDGE BRENNER: Ms. Bush, you said you had a
19 follow up question.

20 RECROSS EXAMINATION

21 BY MS. BUSH:

22 Q On the .05 figure for the genetic effects in the
23 first generation, is that a number that has the probability
24 of the accident included in it?

25 A (Witness Branagan) Yes, it does.

1 Q So to get the number that would be conditional
2 -- a conditional value, you would divide it by the total
3 probability of a core melt -- that is the nine over --
4 9×10^{-5} -- 9×10^{-5} ?

5 A (Witness Acharya) Well, to get the number, it would
6 be -- you might get the number. It would be difficult to
7 interpret the number.

8 Q It would be difficult to what?

9 A It would be difficult to get the meaning of that
10 number because the .05, the risk of genetic effect in the
11 first generation, is the weighted average number in which
12 the weighting factors were individualized category proba-
13 bilities.

14 Now the sum of the individualized category probabilities
15 you can see from 5.11(d) is 9×10^{-5} . And you're saying
16 if we divide this .05 by 10^{-5} , well, that would not result
17 in the conditional mean value of genetic effect per reactor
18 year -- excuse me, would not be equal to the conditional mean
19 value of the genetic effect of the first generation because
20 you have the sum of these probabilities.

21 The first two -- the conditional mean value to be
22 associated with only one risk category. So if you divide that
23 by the total probability of all the risk category, what you
24 would be getting is a conditional value of genetic effect
25 for the first generation resulting from a hybridized or

1 synthetic accident, which is out of all the risk categories
2 which weighting factors as given by the individual
3 probabilities.

4 So that's why I say if the result would be
5 difficult to interpret or give the meaning of.

6 Q Are you saying then it's methodologically incorrect
7 to test the total probability of a severe core melt and
8 separate that out of the .05 genetic effects in order to get
9 a determination of what the genetic effects would be
10 conditional upon a core melt?

11 A That's correct. It would be inappropriate because
12 all core melt accidents will not result in the same mean
13 value of the -- the same conditional mean value of an effect.

14 Q Now you have the table in Appendix K that you have
15 genetic -- not the genetic, but the other health effects for
16 each of all of the source terms? Is that correct?

17 A Right.

18 Q And on each of those accidents, you said before,
19 it had a different probability?

20 A That's right.

21 Q And so we don't have a value equivalent to
22 Appendix K for the genetic effects?

23 A You can immediately get that by doing a simple
24 multiplication. It would have the personrem for each of the
25 individual release categories in Table K.1, then multiply that

1 personrem value by 260 and divide that by one million?

2 Q One million?

3 A That's right because 260 cases per million
4 personrem.

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1 (Counsel conferring.)

2 MS. BUSH: I have no further questions.

3 JUDGE BRENNER: I changed the sequence because
4 Ms. Bush had said she had some follow up. Mr. Wetterhahn, do
5 you have any follow up?

6 MR. WETTERHAHN: No, sir.

7 JUDGE BRENNER: Commonwealth?

8 MS. FERKIN: No further questions.

9 JUDGE BRENNER: Staff?

10 MS. HODGDON: Possibly. I'm not sure whether it's
11 proper follow up or not, but I'll ask the question anyway.

12 FURTHER REDIRECT EXAMINATION

13 BY MS. HODGDON:

14 Q Dr. Acharya, I directed your attention to Table
15 K.1 and asked you questions about that before. And then you
16 were asked further questions by counsel for LEA and the
17 City. I now direct you to Appendix K on page K-1 and ask
18 you to look that over. Don't those two paragraphs there,
19 entitled Conditional Mean Values of Accident Consequences,
20 direct the reader of the FES regarding how to derive the
21 numbers of interest for consequences and risks?

22 A (Witness Acharya) Yes, it does.

23 MS. HODGDON: Thank you. I have no further
24 questions.

25 JUDGE BRENNER: We have no further questions

171b2

1 either, on the health effects. So we're going to, in a
2 moment, be breaking for lunch, since we'll have to shuffle
3 the panels anyway. We might as well break early.

4 We, at this time, potentially have questions on
5 the code qualification type questions which Mr. Elliott did
6 touch on, but we're adjusting to the sequence the parties,
7 announced that they prefer this morning. So we recognize
8 that Mr. Elliott has asked questions on cross examination
9 which neither the Board or the other parties has had a
10 chance to follow up on yet.

11 I guess Mr. Elliott would call those general
12 background type questions. And one area in which the Board
13 may have follow up questions may be the code qualification
14 area, so I want to make that clear.

15 Mr. Vogler, did you have something?

16 MS. HODGDON: The Board directed us earlier to
17 advise the other parties of the circumstances or of the
18 numbers involved, the changes that would be made to this table.
19 And we could do that now and then Mr. Pratt could answer
20 questions about it after lunch, when we resume.

21 JUDGE BRENNER: I didn't mean to say that you had
22 to do it on the record, so you can do it off the record. Then
23 when you come back, I'll just confirm it. That way, if there
24 is any confusion, it will be efficient. And if you could just
25 give us a little interim change, when we come back from lunch

171b3

1 we'll look for it on our desk.

2 MS. HODGDON: Yes, we could do that. Are there
3 other questions for Dr. Branagan?

4 JUDGE BRENNER: No, we don't have any?

5 MS. HODGDON: Could he be excused?

6 JUDGE BRENNER: Well, we're going to dismiss this
7 panel temporarily, in terms of -- with the exception of
8 subject matter that they're still here for. And you make
9 your own determination as to whether you want him here, given
10 the fact that there's going to be cross examination on the
11 same subject of Applicant's witness.

12 It's your business. If you want to fly witnesses
13 in and out and then be left high and dry if something comes
14 up.

15 MS. HODGDON: Thank you.

16 JUDGE BRENNER: All right, this panel is excused
17 temporarily and we will return to whichever witnesses the
18 Staff still deems it appropriate to put forward for the other
19 contentions, which includes at least Messers. Richter,
20 Hulman, and Acharya, and the Staff can determine who else
21 they want.

22 We will break for lunch at this time and we will
23 be back at 1:15.

24 (Whereupon, Witnesses Richter, Hulman, Acharya, and
Branagan were temporarily excused.)

Whereupon, at 11:45 a.m. the hearing was recessed, to
resume at 1:15 p.m. this same day.)

18pbl

AFTERNOON SESSION

(1:15 p.m.)

Whereupon,

G.F. DAEBELER

S. LEVINE

M.I. GOLDMAN

E.R. SCHMIDT

G.D. KAISER

resumed the stand and, having been previously duly sworn were examined and testified further as follows:

JUDGE BRENNER: All right, the witnesses have already been sworn as we all know. Mr. Elliott, you may begin. You're going to restrict your questions to your contention on health effects DES-4(A)1, correct?

MR. ELLIOTT: Correct. May I just raise one other brief matter?

JUDGE BRENNER: I can't hear you, sir.

MR. ELLIOTT: May I also raise one brief matter?

JUDGE BRENNER: If you speak louder you can.

MR. ELLIOTT: A corrected table has been provided by Mr. Pratt. I just wonder whether I will have an opportunity to direct one or two questions to Mr. Pratt at some point.

JUDGE BRENNER: Why don't you discuss it with the Staff as to what they intend to do with their witness panel, and if there's a problem you can make a motion and

18pb2

1 we'll rule on it.

2 MR. ELLIOTT: My understanding is that they did
3 not intend, on their own, to present Mr. Pratt.

4 JUDGE BRENNER: Is that right?

5 MS. HODGDON: We weren't clear because we couldn't
6 hear as to whether the Board had indicated that they would
7 not want to hear from Mr. Pratt except if the parties were
8 interested in asking questions. On our own, we were not going
9 to offer Mr. Pratt.

10 JUDGE BRENNER: We haven't gotten as far as the
11 Board's desires here. Right now Mr. Elliott has made a
12 request that Mr. Pratt be included in the panel, given what
13 has occurred so far this week. So what is the Staff's
14 answer to that?

15 MS. HODGDON: We have no objection to including
16 Mr. Pratt with the panel for answering questions about this
17 chart.

18 JUDGE BRENNER: All right.

19 MS. HODGDON: The next time the Staff takes the
20 stand.

21 JUDGE BRENNER: I didn't hear you, I'm sorry.

22 MS. HODGDON: Yes, the Staff will offer Mr. Pratt
23 the next time the Staff takes the stand.

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CROSS-EXAMINATION

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BY MR. ELLIOTT:

Q Gentlemen, in Applicant panel testimony, first paragraph, it is stated that the potential accident risks from LGS are expected to be a small fraction of the risks the general public incurs from other sources. What other sources are included in that opinion?

A (Witness Levine) Well, there are a whole series of accidents to which the public is exposed. There are accidents involving automobiles, involving airplane crashes, lightning, drowning, falling from ladders, et cetera.

Q Is it fair to say that the opinion -- that the opinion is referenced to other sources and limited to other sources of accident risk as opposed to other types of risk?

A The statement applies to other sources of accident risk and cancer risk.

Q So it's the risk of both accidents and disease, at least cancer -- disease of cancer.

A Yes, that's correct.

Q The risk of the public incurring cancer arises from both accidental and nonaccidental sources; isn't that correct?

A I think that's true, yes. Although I think mostly it's from routine exposures to all kinds of things.

Q What is the basis for that choice of comparison?

18pb4

1 A Well, it's meant to generally characterize what
2 has been found in almost every risk assessment I'm familiar
3 with. That when you calculate -- when you predict the
4 potential principal risk from reactor accidents, you find that
5 they are a small fraction of the risk to which the public
6 is already exposed from other sources.

7 Q When you refer to the risk that the general public
8 incurs, what do you mean by the general public?

9 A People who live in the United States.

10 A (Witness Goldman) I think there might be a
11 distinction between those who may be, in the course of
12 their occupation exposed to somewhat greater risk than the
13 public at large.

14 Q So you were drawing a distinction both between
15 the general public risks and occupational risks, correct?

16 A Yes, that's correct.

17 Q The reference to general public that's used in
18 this paragraph, then refers to the entire United States
19 population; is that correct?

20 A (Witness Levine) Yes.

21 A (Witness Kaiser) Could I add something?

22 A (Witness Levine) They're related to fraction of
23 the people in this region.

24 Q Well, now that's what I want to clarify. Does
25 it refer to the whole United States population?

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A No.

A (Witness Goldman) I think there may still be some clarification required, insofar as the risks incurred by the general population, based on vital statistics, the normal incidence of genetic defects, the normal incidence of various kinds of cancer, those are based on U.S. vital statistics, not on the particular statistics to the greater Philadelphia area, let's say.

In the context of the risks that are developed for the -- as a result of the accident sequences, those risks are specific to the population within given distances of the plant.

Q When you rely upon information and vital statistics, are you referring to the incident rate of those diseases, or are you talking about total numbers of diseases?

A Well, generally they are the rates, the incidence per 100,000 or per million of population.

1 Q When you say in the area around Limerick, at
2 least one person made a qualification or definition, the
3 general public is used in this opinion to some limitation
4 in the area around Limerick. Do you have a specific radius
5 in mind, as a basis for comparison?

6 A (Witness Kaiser) In the context of DES-4(a)
7 the distance is 50 miles.

8 Q Do you know whether the accident risk to the
9 general public, from Limerick, are small compared to the
10 risks the general public incurs from any other industrial
11 accident risk?

12 A (Witness Goldman) I'm aware of only one other
13 quantitative study that has been done on an industrial non-
14 nuclear complex. I don't have the specific numbers at hand.
15 There was a study of a British industrial complex, Canby
16 Island, and my recollection is that the risks to the
17 surrounding population there were several -- I don't know
18 how to quantify that -- two to three orders of magnitude
19 greater than those from any nuclear reactor risk assessment
20 that I have ever seen.

21 A (Witness Levine) In fact, the Canby Island
22 results were approximately that there was a 10^{-4} probability
23 per year of 20,000 early fatalities occurring.

24 Q What were the sources of risk at that industrial
25 facility?

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1 A Various petrochemical plants.

2 Q Is there a similar facility within 50 miles of
3 Limerick?

4 A (Witness Goldman) I can't be too specific, but
5 in the taxi coming from the airport I passed a rather large
6 petrochemical -- excuse me. I'll correct that. It looked
7 like a refinery with a possible petrochemical plant
8 associated with it, but I can't be certain as to what it does
9 for a living.

10 Q The panel has no idea as to the actual risk from
11 any other industrial facility within 50 miles of Limerick
12 is, do you?

13 A (Witness Levine) No, we have not studied that.

14 A (Witness Schmidt) No.

15 Q Part of the basis for the comparison of the opinion
16 was the incidence of cancer in the population. Cancer is
17 among the leading causes of death in the United States, isn't
18 that correct?

19 A (Witness Levine) Yes, it is.

20 Q Do you know how it ranks, in terms of other
21 sources of --

22 A I think heart disease is first and cancer is second.

23 (Discussion off the record.)

24 BY MR. ELLIOTT:

25 Q Applicant used CRAC 2 in making its consequence

1 analysis. Are the predictions of consequences from CRAC 2 --
2 do they conform well to the predictions of the original
3 CRAC code?

4 A (Witness Kaiser) Yes, they do.

5 Q Is that based upon the international benchmark
6 studies?

7 A In part.

8 Q What else is it based on?

9 A It's based on my conversations with the code
10 originators.

11 Q In paragraph 12 of Applicant's testimony, about
12 two-thirds of the way down, it is stated that because of
13 these and other uncertainties, SARA presents results not as
14 a single CCDF but as a family of CCDFs. A range of
15 results including a lower and an upper estimate are
16 presented.

17 Is it your opinion that presentation of the
18 family of CCDFs presents an adequate picture of the range
19 of uncertainties?

20 A (Witness Levine) Yes, it is. Yes, I believe that.
21 We made a series of sensitivity studies to define by varying
22 important parameters to risk, to define what a reasonable
23 upper bound might be. It's possible to generate larger
24 estimates. These estimates, in our view, would be
25 unrealistic in terms of rationality.

1 Q Would a single CCDF, without any upper or lower
2 bound curve, display the range of uncertainty?

3 A A single curve would not, but the way in which
4 we generate our median estimate in the SARA report. We
5 generate our median estimate by first determining the upper
6 and lower estimates and calculating the median from those.

7 Q I understand knowing the median will not tell you
8 how far up, how far above, or how far below the range may
9 lie. Isn't that correct?

10 A If you just know the median, it will not tell
11 you -- if you just present the median, it will not tell you.
12 But to generate a median, you need to know those upper and
13 lower estimates.

14 Q Right. It is also stated that the lower and
15 upper estimates are not absolute bounds but define the range
16 in which there is a large degree of assurance that the actual
17 result would lie. What is a large degree of assurance?

18 A The upper estimates represents the 95th percentile
19 and the lower estimate represents the 5th percentile.

20 Q So that with respect to an upper bound curve, if
21 the upper bound curve is at a 95 percent confidence level --
22 and I guess that's another way of putting it --

23 A Yes.

24 Q -- there is a five percent chance that the actual
25 result may lie outside even that limit, isn't that correct?

201b2

1 A Yes.

2 A (Witness Kaiser) Yes.

3 Q Earlier, in response to a question, you made a
4 reference to something being unrealistic in terms of -- I'm
5 not sure I caught the last part of it -- unrealistic in terms
6 of reality or in --

7 A (Witness Levine) That would be not rational not
8 to assume some of the values of parameters that would give
9 you higher numbers than our upper estimate or lower estimate.

10 Q If the models are accurate and the calculations
11 have been carried out correctly, why are the projections
12 that lie outside those limits deemed to be not rationale?

13 A There's a very low likelihood of their occurrence.

14 Q So what you really mean is that the probability
15 figure is so low that it's literally out of the world?

16 A That's one way to think of it, yes.

17 Q Applicant's testimony, paragraph 39, states that
18 estimates of the public risk of latent health effects -- other
19 than those resulting in fatalities -- can readily be obtained
20 from estimates of risk that are already presented in SARA or
21 the FES by the use of simple multiplication factors. Are
22 the simple multiplication factors disclosed in SARA or the FES?

23 A They are partly -- at least partly disclosed in
24 the FES. The number of 260 genetic effects per million manrem,
25 which covers many of these specific effects you listed in one

1 of your questions. That is, they are essentially all genetic
2 effects. There may be others I can't think of at the moment.

3 Q Well, my next question was going to be are there
4 any others?

5 A That's all I can recall from the FFS.

6 JUDGE BRENNER: Mr. Elliott, your questioning
7 included a reference to SARA. Do you want an answer to that
8 part of your multipart question, also?

9 BY MR. ELLIOTT:

10 Q Yes, if SARA discloses something in addition than
11 what the FES discloses?

12 A (Witness Kaiser) It does not.

13 Q Because I'm on paragraph 39, which makes reference
14 to a number of other areas -- I'll save it.

15 In Applicant's testimony, paragraph 40, the last
16 sentence states "These health effects include non-fatal
17 cancers, genetic effects, spontaneous abortions, and temporary
18 or permanent sterility. Are not in utero radiation injuries,
19 resulting in impairment of development, also another health
20 effect from population exposures to radiation?"

21 A (Witness Goldman) Yes, they are but they are
22 almost a trivial fraction of the consequences to the
23 remainder of the population. And therefore, were not
24 included.

25 Q They're a small fraction in the sense that the

201b4

1 number of fetuses and embryos present in the population, at
2 any given time, is relatively small. Is that what you're
3 saying?

4 A In comparison to the population at large, yes.
5 For example, the typical current birth rate -- again, not for
6 the Philadelphia area but for the U.S. as a whole -- is about
7 16 per thousand population per year. If one assumes the
8 period of special risk is the first trimester, that puts
9 at risk 48 fetus months, if you will, per thousand population
10 per year.

11 Now that thousand population is exposed to 12,000
12 person months of exposure compared to 48 fetus months of
13 exposure. So the fetus population dose, if you will, is less
14 than a half of one percent of the adult population, even
15 considering what other special sensitivity there may be to
16 the fetus. It still is an insignificant fraction of the
17 population exposure and consequences.

18 Q Has Applicant determined the risk impact of severe
19 accidents on that particular population of concern, i.e.
20 fetuses and embryos in the population?

21 A No, for the reasons I have just stated.

22 Q Is there a present controversy about whether
23 premature aging is a health effect of radiation exposures
24 to populations?

25 A Yes, there is a controversy.

201b5

1 Q What is the present status of the controversy?

2 A It's controversial. It's unresolved.

3 Q So the best one can say about it is that premature
4 aging may or may not be caused by radiation exposures to
5 populations?

6 A That is in the same category as -- I'll say yes
7 and then, in the same category, as to whether or not very
8 low levels of radiation are, in fact, harmful or not.

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1 Q With respect to Applicant's testimony, paragraph
2 41, and with respect to the mortality rate or cancers, the
3 malignancy rate of thyroid cancers is about 33-1/3rd percent;
4 isn't that correct?

5 A No, it's not correct.

6 Q What is the correct rate?

7 A The malignancy rate for thyroid cancers is
8 approximately 3 percent, according to the most recent
9 estimates. That is, of those cancers -- malignancies that
10 develop -- approximately 3 percent end in mortality over
11 a period of about 25 years.

12 Q My question is not limited to mortality. I'm
13 talking about malignancy rates. The malignancy rate of
14 thyroid cancers is about 33-1/3rd percent; isn't that
15 correct?

16 MR. WETTERHAHN: Objection. I don't think that
17 question is comprehensible.

18 JUDGE BRENNER: It sounds tautological to me.

19 BY MR. ELLIOTT:

20 Q The percentage of thyroid cancers, which are
21 malignant cancers, is about 33-1/3rd percent; isn't that
22 correct?

23 JUDGE BRENNER: I've got the same problem. Maybe
24 I'm ignorant, but I thought a cancer is a malignancy.

25 WITNESS GOLDMAN: By definition.

21pb2

1 BY MR. ELLIOTT:

2 Q Let me rephrase it. The malignancy rate of thyroid
3 tumors is about 33-1/3rd percent; isn't that correct?

4 A (Witness Goldman) No, I don't think it's that
5 high. If in the definition you include benign tumors, nodules
6 and other things, it's substantially lower than 33 percent.

7 Q WASH-1400 assumed that 10 percent are malignant;
8 isn't that correct?

9 A WASH-1400 assumed, from my recollection, that 10
10 percent of the cancers were fatal. There was substantially
11 more abnormalities, which were benign. But of the cancers,
12 10 percent were fatal.

13 Q Are you aware of any U.S. reactor risk assessment
14 which has used a 5 percent fatality rate for thyroid cancers?

15 A I am not aware of any, no.

16 Q The Applicant's reference to the UNSCEAR Report,
17 in paragraph 41 of its testimony refers to a fatality rate
18 of 3 percent.

19 A Yes.

20 Q With respect to the studies upon which that
21 fatality rate is based, at least some of those patients
22 who had thyroid malignancies in the studies were killed by
23 other metastasizing cancers first; isn't that correct?

24 A I don't think I understand the question. The
25 report -- the UNSCEAR Report indicates that there were about

21pb3

1 four deaths that were attributable to thyroid cancer in about
2 142 patients over that period -- average period of 24 years
3 that would not indicate to me that there were deaths from
4 causes other than that, other than thyroid cancer included
5 in the four deaths which made up the roughly 3 percent.
6 There may have been deaths in other of the 142 subjects which
7 were due to other causes.

8 Q Are you saying that in no case in the other 142
9 that you mentioned that none of the other 142 patients had
10 thyroid malignancies and who also had bone or other
11 metastasizing cancers which in fact was the cause of death?

12 A I'm saying those that died of lung or bone
13 cancers are not included in the 3 percent. In other words,
14 the thyroid cancer mortality rate was 3 percent. The mortality
15 rate overall in the group was substantially greater from
16 cancer, but not thyroid cancer.

17 Q Right. But among the 142 cases of thyroid
18 malignancy considered, there were some of these people who
19 also had other sources of cancer who were killed by those
20 cancers.

21 A That is correct.

22 Q So that the fatality rate of those thyroid cancers
23 upon which that 3 percent is based is polluted by the fatality
24 rate of other types of cancers; isn't that correct?

25 MR. WETTERHAHN: Objection. Asked and answered.

21pb4

1 JUDGE BRENNER: Mr. Elliott, I thought it was, too.
2 If you changed the question, I missed the change.

3 MR. ELLIOTT: I may have gotten the answer that
4 I was looking for.

5 JUDGE BRENNER: Well, if you can show me there's
6 something different, I'll allow it. The words weren't
7 exactly the same, but as I said, I did not detect a difference
8 in the real meaning between the two questions.

9 Let me put it this way. If there's something
10 else you still need, ask it a little differently.

11 BY MR. ELLIOTT:

12 Q It is possible that among the 142 cases considered
13 that had it not been for the intervention of the other
14 sources of metastasizing cancer that the cause of death
15 might have been thyroid cancer; isn't that correct?

16 A (Witness Goldman) That was not the judgment of
17 the people who ran those studies, no, that's not correct.

18 Q How could they know?

19 A They were there. I was not. The reports, as
20 indicated in the cited reference, indicate that in the
21 judgment of the United Nations Scientific Committee on
22 Effects of Atomic Radiation, that the fatality rate based
23 on those data indicate -- those and other data, I should
24 say -- indicate the appropriate fatality risk is about 1
25 percent over a 25-year period.

21pb5

1 That includes more than just the 142 that were --
2 you are referring to. The judgment as to the proximate
3 cause of death is best made by those proximate, not those
4 at a distance.

5 Q With respect to the proximate cause of death, I
6 don't think I'm questioning that. My question is, inasmuch
7 as thyroid cancer is a slow-growing cancer as the testimony
8 indicates, would not a faster growing cancer supercede and
9 take over with a higher contribution to mortality than a
10 thyroid cancer?

11 A I think that is already a matter of record. Other
12 cancers do have higher fatality risks than do thyroid cancer.
13 People rarely die of thyroid cancer.

14 Q There is no explicit finding in the studies upon
15 which the UNSCEAR Report is based, that had it not been for
16 the intervention of the other sources of cancer that the
17 thyroid cancer would not have been the cause of death; isn't
18 that correct?

19 A There is not explicit finding in that particular
20 section. There is explicit reference to other cancer
21 incidents and mortality rates which indicates that very few
22 people die of thyroid cancer, and relatively more people die
23 of other kinds of cancer.

24 Q Are those other sources of data the same type of
25 data that you have just referred to with the four cases out

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1 of the 1427

2 A They refer to all of the radiological database
3 that has gone to make up not only the United Nations but
4 the BEIR and ICRP and other risk estimates that have been
5 made by knowledgeable scientific organizations around the
6 world.

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1 Q At paragraph 44 of the Applicant's testimony, it is
2 stated that spontaneous abortion estimates can be derived
3 from Tables VI.9-11 and 9-12 of the RSS. Can those estimates
4 be derived from information in SARA or the FES?

5 A (Witness Kaiser) They cannot be derived from the
6 estimates in SARA.

7 Q I'm sorry, I didn't hear you.

8 A They cannot be derived from SARA?

9 Q How about the FES, the extent of your knowledge
10 about the FES?

11 A I don't know.

12 MR. ELLIOTT: I have concluded on 4-A(1)

13 JUDGE BRENNER: Commonwealth.

14 MS. FERKIN: I don't have any questions.

15 JUDGE BRENNER: City?

16 MS. BUSH: No.

17 JUDGE BRENNER: Staff?

18 CROSS EXAMINATION

19 BY MS. HODGDON:

20 Q Would you please describe how you estimated a
21 95 percent confidence interval for your upper bound CCDFs?

22 A (Witness Levine) We examined all the parameters
23 beyond core melt, probability prediction that could have large
24 effects on the outcome of the CRAC model. And we put in
25 appropriately remote value into the CRAC model. We sometimes

1 combined two parameters at once, in making these
2 calculations. And after examining the calculations,
3 judgmentally determined a point at which we felt represented
4 a reasonable 95 percent confidence bound. That's a typical
5 way in which sensitivity studies are made.

6 MS. HODGDON: Thank you. I have no further
7 questions.

8 JUDGE BRENNER: Give us a moment.

9 (Board conferring.)

10 BOARD EXAMINATION

11 BY JUDGE MORRIS.

12 Q Mr. Levine, following up on your last answer,
13 it wasn't quite clear the extent to which you did a semi-
14 mathematical approach or a judgment approach to determining
15 the five percent to 95 percentile figures. Could you expand
16 on that a little bit? Maybe you could even give an example.

17 A (Witness Levine) Well, one thing I can add is we
18 did, in fact, include the uncertainty in the estimates of the
19 frequency of the releases, which I did not mention before.
20 I think beyond this point, you'd have to ask Mr. Kaiser to
21 answer.

22 Q Fine.

23 A (Witness Kaiser) We carried out a number of
24 sensitivity studies. This was the kind of foundation of our
25 uncertainty analysis in the consequence modeling area. We

1 varied parameters that we judged to be those that were
2 likely to give us the biggest ranges of uncertainty. Mr.
3 Levine has already mentioned the core melt frequency, but in
4 addition to that we looked specifically at the variations
5 possible in the source term, variations in possible evacuation
6 procedures and variations in possible modeling of health
7 effects.

8 When we had done those sensitivity studies, the
9 result was that we found a bound, if you will, within which
10 the true results might lie.

11 Q Did you, in fact, for at least some instances,
12 draw a distribution curve from which you could look at the
13 area under the curve and arrive at these five percent and
14 95 percent numbers?

15 A That was -- no, not the way that we did it.
16 From the panel that we established, we derived a judgment on
17 what might be an upper estimate, which we then called our
18 95th percentile. And a similar judgment on what might be
19 a lower estimate. And then, at each fixed level of consequence
20 -- as example, say ten latent cancer fatalities if we were
21 looking at CCDFs for latent cancer fatalities. We fit
22 between the 95th and the 5th percentiles what the standard
23 log normal distribution and the 5th and 95th bounds are
24 sufficient to determine the mathematical parameters in that
25 model. And that log normal distribution was then combined

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1 with the uncertainty distribution and the frequency, which
2 is being derived more or less independently through the
3 systems analysis to give us an overall uncertainty pattern.

4 Q Was the original judgment, or whatever it was, of
5 the five percent and 95 percent levels sort of a Delphic
6 judgment?

7 A Yes, it was.

8 Q In other words, it was sort of a concensus of
9 experts?

10 A Yes, I believe that's correct.

11 Q Thank you.

12 Switching to another subject, I guess in SARA -- as
13 in the FES -- there are some health effects which are not
14 explicitly discussed. Is that correct?

15 A That's correct.

16 Q And you heard my questions of Mr. Hulman. I have
17 the same thought in my mind, with respect to SARA. What was
18 the rationale for not including those health effects?

19 A (Witness Levine) I think there has been a consensus
20 developing in the risk assessment community, if you will, in
21 the people who work on safety goals, that one can characterize
22 for public consumption reactor accident risks very well by
23 talking about early fatalities, latent cancer fatalities,
24 manrem, and economic damage, economic cost.

25 The other risks seem to be much smaller than these

1 risks. I have been at safety goal workshops where these
2 matters were discussed explicitly and that conclusion was
3 reached.

4 The NRC, in its proposed published safety goals,
5 talks about qualitative safety goals first of all and then
6 talks about numerical guidelines. The numerical guidelines
7 address, aside from core melt -- which is sort of an engineering
8 guideline -- they talk about the probability of early
9 fatalities and the probability of cancer fatalities from
10 reactor accidents and talk about a number for cost benefit
11 analysis.

12 So there seems to be a consensus developing that
13 these kinds of things we showed in SARA characterized the
14 risk very well, although they are not complete.

15 Q Is there a parallel here between the completeness
16 concept and the accident probabilities where perhaps not all
17 sequences have been treated, but you feel that you have
18 covered all dominant sequences?

19 A Yes, it's a parallel. For instance, let's talk
20 about sabotage for a moment. PRA cannot treat sabotage, but
21 that doesn't -- quantitatively, but that doesn't mean sabotage
22 is not being handled as a matter of reactor safety. There
23 are deterministic rules, regulations, which are followed in
24 the design of reactors to give adequate protection against
25 sabotage.

221b6

1 The fact that one can't quantify this
2 contribution to risk doesn't mean that it's not well
3 characterized, in terms of the safety of reactors.

4 Q In SARA, with respect to what I'll characterize
5 as the residual risk -- which is not explicitly treated --
6 is it your view that it is so small that you just don't add
7 10 percent or something to the result that you have
8 calculated?

9 A I think it's much smaller. It's hard to answer
10 that question with precision. Is it a question of numbers
11 of health effects versus impact of the kind of health effect.
12 And so it's hard to answer that explicitly, but I would
13 just say that in terms of both numbers and impact on people,
14 I would certainly say there are small fraction of the
15 uncertainties which have already been estimated for the
16 major contributors to risk.

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1 Q So even if they added up to 10 percent, that
2 would be a small fraction of the error band on your estimate.

3 A Yes. Our 95th and 5th percentiles on early
4 fatalities generally are a factor of 100 or 200 apart, and
5 that would be a very small part of that.

6 JUDGE MORRIS: Thank you.

7 (Board conferring.)

8 BY JUDGE MORRIS:

9 Q The Board would like to pursue the Delphic judgment
10 a little bit just so it's not misinterpreted on the record.
11 The reason you use what I've introduced as the Delphic
12 approach is that it's the best approach you have at the
13 present time; is that correct?

14 A (Witness Kaiser) Yes.

15 Q What would you need to do something else?

16 A We would need a better handle on some of the
17 parameters that go into the model. For example, the source
18 term is at present a subject of intense research and where
19 the source terms will eventually end up is still not
20 determined. So that what one is forced to make judgments,
21 if you like -- I'm trying to give one specific example.

22 I would need for example a much better handle on
23 the source term than we have at the moment.

24 Q Can you generalize from that and say, generally
25 you would need a much better database, and it just simply

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1 doesn't exist; is that true?

2 A Yes. I think as a general comment that would be
3 fair to say.

4 A (Witness Levine) If I could amplify on that
5 for a moment. There are uncertainties in the understanding
6 of the physical phenomena. There are uncertainties, therefore
7 in the models one makes to describe the physical phenomena.
8 So one needs data that affect your ability to construct the
9 model that is realistically representative of real world
10 reality for things that have never occurred.

11 And I should say, by the way, that all modeling
12 suffers from this deficiency. All models do not represent
13 reality very well. There are varying degrees of uncertainty.
14 But research data, for instance, can help you develop a
15 better model and can in some cases help you determine which
16 parameters should go into that model with greater confidence.

17 Q So it's not a weakness in the methodology per se,
18 but rather the database and the phenomenology that leads to
19 this approach.

20 A I think that's correct. And I think that's correct
21 in many fields, in many areas of many fields.

22 JUDGE MORRIS: Thank you.

23 BY JUDGE COLE:

24 Q Pursuing that a little, how do you know you don't
25 have the one in 99 percent levels, rather than the five in

23pb3

1 95?

2 A (Witness Levine) That's the matter of the
3 Delphic judgment, I believe. It's hard to know whether you're
4 exactly at 95, but you're not -- you're not at 99.9 for
5 instance.

6 Q The ranges that you put on this and then assigned
7 your judgment of 95 percent and 5 percent -- is there any
8 data that you collected from your runs that was outside the
9 range that you indicated? Or did you include all data within
10 the range and said that's probably 5 and 95?

11 A Some of it's outside.

12 Q So you actually looked at the data and said that's
13 probably outside the one chance in 20 of being outside --

14 A But I would not describe this process as involving
15 a large number of datapoints.

16 JUDGE COLE: All right, sir. Thank you.

17 JUDGE BRENNER: Redirect.

18 REDIRECT EXAMINATION

19 BY MR. WETTERHAHN:

20 Q A number of your answers indicated that you used
21 the CRAC 2 code in order to produce your results. What
22 theoretical and experimental results or other data support
23 the use of the consequence model -- consequence code, CRAC 2
24 to model the physical phenomena which are being examined?

25 A (Witness Levine) There are, of course, many

23pb4

1 phenomena involved in the CRAC code, and I will talk about
2 just two areas for the moment. I think that's sufficient
3 to make the example.

4 You have to predict the dispersion of airborne
5 radioactivity in the environment after an accident. And one
6 uses an atmospheric dispersion model. It's the Gaussian
7 dispersion model developed by Pasquill and Gifford. It's a
8 very well known model.

9 It's been developed. There's been data collected
10 on atmospheric dispersion for decades now. It's a generally
11 accepted model. The only thing that was done to that model
12 in CRAC was to modify the input so you could put in a
13 probable distribution of weather conditions and the like.

14 So that's a very well validated model based on
15 theory, data and judgment of many experts, as is any model.
16 The health effects model is less well founded than the
17 dispersion model. It is based on data, theory and judgment
18 of many experts. The data comes from experiments conducted
19 with animals subjected to radioactivity, several different
20 kinds of animals.

21 The data also comes from studies of human beings
22 who have been exposed to radioactivity, either by medical
23 treatment or from the bombs dropped in Japan. And the
24 principal task we had was to take the judgment of the many
25 experts in this country who have been studying those matters

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1 for many years and describe that judgment mathematically,
2 based on the data, the theory that was available.

3 And this is all documented extensively in Appendix
4 6 to WASH-1400. The model was written. The model was fed
5 back to the people who contributed to it, and we have a
6 statement from each of the members of this group, about 40
7 people, saying they agreed with the model. And in fact,
8 the model anticipated some of the developments in BEIR-III.

9 When we made the model, BEIR-II was the report
10 out that was in existence, and it had proposed a linear
11 hypothesis for the prediction of latent cancer effects. And
12 we departed slightly from that in a more realistic direction.
13 And the BEIR-III report confirms that departure.

14 So again, I think the preponderance of scientific
15 evidence supports the validity of that model.

16 Q Were similar procedures, either data or experimental,
17 theoretical concepts used to check all parts of the model
18 before it was incorporated?

19 A Yes.

20 Q With regard to physically running the code, can
21 the panel answer how you assured yourself that the code that
22 you put on your computer was correct, and how you confirmed
23 the input and the output data that you utilized in running
24 the code?

25 A (Witness Kaiser) Yes, I think two important stages

23pb6

1 in this process: the first is when you receive such a
2 code from the code originators. The tape contained the code
3 and came along with a number of sample runs. And the first
4 thing you have to do is to put the code up on your own
5 computer and reproduce the sample runs, which exercise
6 various parts of the code.

7 And then process was done by the person who works
8 for me and was checked by someone else who works in another
9 department in NUS, so that we could satisfy ourselves that
10 the code was working as the originators intended it to work.

11 Once you have done that, then you go on to use
12 the code to run specific cases. And the -- I think the really
13 important thing there, to ensure that you've got quality
14 answers, is to make sure that the input data are correct.

15 Again, generally a member of my department was
16 responsible for putting the -- or combining the input to the
17 code. And then I would go over those inputs after that to
18 make sure that what he had put in was, in fact, doing what
19 I had intended him to do when I gave him direction.

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1 Q Does that complete your answer?

2 A It does, yes, sir.

3 Q Dr. Goldman, I believe that there was testimony
4 earlier, by the Staff, with regard to the comparison of
5 genetic risk due to a hypothetical severe accident, to that
6 which may be normally be expected to be incident in the
7 population. Can you comment on that testimony?

8 A (Witness Goldman) I think there was some degree
9 of confusion that had to do with the frequency per reactor
10 year and genetic effects per generation -- intergenerational
11 transfer that might be somewhat clarified. At the outset,
12 I think my prepared testimony may have contributed somewhat
13 to it. In reviewing it, I noticed that in two locations --
14 in paragraph 42 on page 32, line 4, one word was left out,
15 although I think it is perhaps understood. And that is the
16 sentence should most correctly read, on line 4 "Together
17 with the 0.04 fatalities per reactor year." Rather than "per
18 year" as stated.

19 And the same omission on the following page,
20 paragraph 43, line 7 should read "About 0.13 genetic defects
21 per reactor year in the population."

22 If one looks at the BEIR-III report, Applicant's
23 Exhibit 147, which indicates the normal incidence of genetic
24 defects, the rate indicated in that table is 10.7 percent per
25 million births. I think the Staff witness probably misstated

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1 per million population. It is, in fact, per million live
2 births.

3 If one goes back with that 10 percent per million
4 births -- and the number I had used in response to an earlier
5 question of population birthrate of 16 per thousand per
6 year, one can calculate that in a population of 8 million within
7 50 miles of the station, one would calculate about 384,000
8 genetically defective births per generation.

9 By the same token, the Staff estimate for the
10 first generation predicted there -- predicted genetic effects
11 were, I believe, 0.05 per reactor year of operation. To
12 include the total risk say over the 30 year operating lifetime,
13 one would come up with about 1 1/2 genetically defective births
14 per generation from the complete period of operation of the
15 Limerick Station.

16 That 1 1/2 genetically defective births should be
17 compared with the estimate of 384,000 per generation and
18 the 8 million population, assuming that stays the same.

19 Q Let me make sure I understood you. You stated the
20 Staff used 0.05?

21 A My recollection of the Staff answer was that the
22 total genetic defect attributable to the station would be
23 .26, of which they said about 20 percent -- or .05 -- would
24 be expressed in the first generation.

25 Q Do you then believe that this result is still

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1 insignificant, as testified to by the Staff?

2 A Yes. It's 1 1/2 in 400,000 which, in my judgment,
3 is insignificant.

4 Q Dr. Kaiser, I believe a Staff witness indicated
5 that you were a member on the committee on the safety
6 of nuclear installations international benchmark comparison
7 of consequence modeling codes, as indicated on page 3 of your
8 statement of professional qualifications?

9 A (Witness Kaiser) I was.

10 Q Can you recall the codes that you compared in
11 that benchmark comparison?

12 A I have a list of these codes here.

13 Q Please read them into the record.

14 JUDGE MORRIS: You probably better spell the
15 acronyms, so we get them correct.

16 MR. ELLIOTT: Mr. Chairman, I don't really mind
17 on this question, but it seems as if it was beginning to get
18 beyond the scope of any questioning --

19 JUDGE BRENNER: Well I have the same question. Part
20 of the reason is we're trying to accomodate you, Mr. Elliott.
21 But I felt we were going to stay with the health effects.
22 We held off on our code qualification questions.

23 MR. WETTERHAHN: I can do it later.

24 JUDGE BRENNER: It's up to you. You're the one
25 who had a witness you wanted to get out of here.

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1 MR. WETTERHAHN: Let's answer this question. I
2 have two more questions. We might as well do it now.

3 JUDGE BRENNER: Okay, but the subject matter is
4 getting disbursed than I would like.

5 MR. WETTERHAHN: I'll recall the question and we'll
6 do it later. It makes no difference.

7 MR. ELLIOTT: I don't mind if he stays with an
8 area of code validation, if he wants to pursue that topic
9 now. It's fine with me. I just wanted to raise the caveat
10 because he was getting further and further away.

11 JUDGE BRENNER: Let's stay with whatever you need
12 Dr. Goldman for and related subjects, so we can try to
13 accomodate his schedule.

14 MR. WETTERHAHN: I have one more question of
15 Dr. Goldman.

16 BY MR. WETTERHAHN:

17 Q Dr. Goldman, you indicated earlier, in response
18 to a question, that there was a controversy regarding whether
19 radiation causes premature aging.

20 A (Witness Goldman) That's correct.

21 Q Is there any concensus such that discussing this
22 matter in a document such as the FES here would provide any
23 substantial additional information for a member of the
24 population reading it, or is the matter entirely too specula-
25 tive?

1 A My judgment is that it would be too speculative
2 at the moment to provide any generally useful information.

3 MR. WETTERHAHN: I have no further questions with
4 regard to Dr. Goldman.

5 JUDGE BRENNER: Now if we had Dr. Branagan up there
6 combined, the way I wanted to do it, we could have turned
7 it back and got it all neatly tied up, or neatly in disarray,
8 depending on what the views of the witnesses were. But we
9 would have had it together. And that's why I think we have
10 made a mistake here, accomodating the Staff. You're going
11 to need Dr. Branagan on the panel when he comes back, now.

12 FURTHER BOARD EXAMINATION

13 BY JUDGE COLE:

14 Q The origin of that 394,000, could you explain that
15 to me?

16 A (Witness Goldman) Yes. The arithmetic was -- with
17 8 million -- let me go back. There are an average of 16 births
18 per thousand, or 16,000 births per million per year of
19 which roughly 10 percent or 1600 would be genetically disordered.
20 If there are 8 million people, then 8 times 1600 would give
21 about 12,800 per year in the population at risk, the 8
22 million population. Multiplying the 12,800 per year in an
23 8 million population group by 30 years per generation, which
24 is the value that the BEIR Committee and most others used,
25 you come up with 384,000.

1 JUDGE COLE: All right, sir. Thank you.

2 BY JUDGE MORRIS:

3 Q Dr. Goldman, with respect to the controversy on
4 the premature aging, is that controversy confined within some
5 band, some saying zero effect and some saying say a maximum
6 of X effect?

7 A (Witness Goldman) The controversy has developed to
8 some extent because there has been a tendency to use a
9 measure of the loss of life span as a measure of radiation
10 effect. That has, in many of the discussions in the papers
11 and meetings I'm familiar with, been confused with premature
12 aging, as such, as a physiological phenomena. An example
13 that's probably well understood is that most people who are
14 exposed to an excess of sunlight on a continuing basis, tend
15 to have their skin age rather rapidly.

16 People who live in tropical climates, or beach
17 boys in Miami, have a tendency to have prematurely aged
18 skin, because of the excessive radiation exposure or solar
19 radiation. There is a predisposition, in that same population,
20 to develop cancer of the skin. Now whether the death of the
21 skin, you might say, is due to a premature aging process or
22 whether it results from melanoma skin cancer is something
23 that's been an argument, just in that one area.

24 If you look at the body as a whole and say are there
25 organs in the body, or systems in the body, that slow down

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1 faster than they otherwise would as a result of radiation
2 exposure, or do people develop radiation induced diseases
3 which cause them to slow down sooner, so to speak, sooner
4 than they otherwise would. There is not an agreement as to
5 whether radiation exposure, as such, causes premature aging
6 in the general sense, that somebody who is 40 years old looks
7 60 years old. That is the kind of thing to which there is
8 generally attributed radiation aging, so to speak, which
9 most people do not believe occurs.

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1 So there is no consensus whatsoever on whether
2 there is or is not a radiation aging phenomena. And even less
3 consensus over whether there's any kind of risk that can
4 be put with that kind of radiation response.

5 Q And what would be your professional judgment as
6 to what the outer limits of the impact of such a risk, if
7 it were real, might be?

8 A Miniscule. I would hesitate to be any more
9 quantitative than that. But it would be an extraordinarily
10 small effect. Most of the effects of loss of life, lifespan
11 are attributable to the occurrence of specific radiation
12 induced diseases, cancers of various kinds. Any contribution
13 to that from the so-called aging process would, in my
14 judgment, not change it one iota.

15 JUDGE MORRIS: Thank you.

16 JUDGE BRENNER: Mr. Elliott, do you have any
17 followup based on questions and answers since your last
18 opportunity?

19 MR. ELLIOTT: Maybe just one.

20 RE CROSS EXAMINATION

21 BY MR. ELLIOTT:

22 Q Forgive me if I don't have the figure right, but
23 my recollection is that a comparison was made between 1.5
24 genetic effects that may be expected over the 30-year
25 operating life of the Limerick plant. That was compared

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1 against the background of some -- was it 384,000?

2 A (Witness Goldman) Yes.

3 Q That 384,000 is a number within the population at
4 risk?

5 A That is correct.

6 Q Within a 50-mile radius?

7 A Yes.

8 Q Those 384,000 genetic effects are effects which
9 occur over that period of time. They're known to occur;
10 isn't that correct?

11 A Those are the numbers that would be predicted to
12 occur, assuming that they occur at the incidence of these
13 kinds of effects has continued to be expressed in this
14 population over that period of time. These are averages
15 for the country as a whole again, but yes.

16 Q These effects occur year after year; isn't that
17 correct?

18 A These effects would occur -- the 384,000 would
19 occur over a 30-year period.

20 Q It would be divided by 30 years to get the year
21 after year incidence?

22 A That's right, 12,800.

23 Q The 1.5 effect is not the effect that is expected
24 to occur over the 30-year period, is it?

25 A Yes, it is. That is the -- from the full operation

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1 of the Limerick plant, 30-year operation.

2 Q Isn't that simply the product of 30 times the
3 per reactor year figure?

4 A Yes.

5 Q The 384,000 figure is not a risk figure, it is
6 an incidence figure; isn't that correct?

7 A It is an incidence figure. People who suffer or
8 at risk at that risk.

9 Q The 1.5 figure is a risk figure, not an incidence
10 figure.

11 A It would be an expected incidence figure.

12 Q When you say expected, you mean it is the product
13 of the sum of the probabilities over the 30-year period
14 times the number of genetic effects which may be expected.

15 A Yes. That's a mathematical average.

16 Q That's something different than a 384,000 which
17 is expected in the population over that 30 years; isn't it?

18 A The -- I think there is perhaps a semantic problem.
19 If there is a risk of any individual in that 8 million over
20 the 30-year period of having genetic defects resulting from
21 natural causes, it is expressed as an incidence. But it is
22 in fact a risk of any particular individual having that
23 defect or having those defects.

24 So risk and incidence -- you have a chance of
25 getting ill or being hit by a car or being born with a

25pb4

1 genetic defect. The expression of that, after the fact is
2 the incidence. The risk of your getting it or any number
3 getting it in a population is it's risk.

4 Q The 1.5 genetic effect is not expected to occur
5 in the absence of a severe accident; isn't that correct?

6 A I think that is not correct. The expected value
7 is literally that. It's probability-weighted, so that it
8 is the value that would be expected, considering both
9 high probability, low consequence accidents, and low
10 probability, high consequence accidents.

11 Q In the absence of a severe accident, there will
12 not be the 1.5 genetic effect, will there?

13 A I guess it depends upon how you consider the range
14 of severe accidents.

15 A (Witness Levine) If I may add something. The
16 term expected value is a mathematical definition of the
17 area under the CCDF curve. If you take the area under the
18 CCDF curve, you get what could loosely be called an average.
19 But when you're dealing with very low probability events,
20 you cannot call it an average because an average is sort of
21 statistical. That is, it's an average of many events that
22 have occurred, and you're talking about events that have not
23 yet happened, and may not occur in the lifetime of the
24 reactor industry in fact.

25 So we call that an expected value to describe the

25pb5

1 area under the curve.

2 Q Then expected value is the mathematical term at
3 work?

4 A Yes, it is exactly.

5 Q That is something different than the word expected
6 in reference to the 384,000 genetic effects, which we may
7 expect in experience.

8 A I would call that a prediction based on a
9 statistical background. You take statistics that exist, you
10 make a prediction, and you expect that prediction to come
11 true. As opposed to being a mathematical expected value.

12 Q The two concepts are different, aren't they?

13 A Yes.

14 Q Applicant has estimated the probability of a
15 severe accident at Limerick, hasn't it?

16 A I couldn't hear you.

17 Q Applicant's panel has calculated the probability
18 per reactor year of a severe accident at Limerick, hasn't it?

19 A Yes, we have.

20 Q And what is that probability per reactor year?

21 A Well, there's a spectrum of accidents, ranging
22 from rather modest to very severe. And they have different
23 frequencies. And they're indicated in our tables in SARA,
24 and the tables in the FES.

25 One way to think about this is that as a prerequisite

25pb6

1 to a severe accident, you must have a core melt accident first
2 of all. And there, there is a number predicted for that
3 core melt accident. But the consequences of most core melt
4 accidents are not severe. There have to be other things to
5 happen to make the accident severe.

6 Q Is it possible to derive a conditional mean value
7 or genetic effects, given a severe accident at Limerick?

8 A Yes, it is.

9 Q Has Applicant calculated that value?

10 A We calculate conditional CCDFs for various
11 consequences. We did not do it for genetic effects. We
12 do it for personrem and we then modify that CCDF to account
13 for the probability of the occurrence of the accidents, so
14 to get an absolute probability for the CCDF.

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1 JUDGE BRENNER: Mr. Elliott, are we still in the
2 realm of follow up, because I don't want to go through three
3 rounds again. The idea of follow up is to narrow what has
4 already been asked about, not to have a whole new area on
5 realms.

6 MR. ELLIOTT: I'm finished, thank you.

7 JUDGE BRENNER: Commonwealth, City?

8 MS. BUSH: Yes, I have a follow up on the
9 redirect question about the .05 per reactor year and the
10 1.5.

11 JUDGE BRENNER: Okay.

12 RE CROSS EXAMINATION

13 BY MS. BUSH:

14 Q I think this was just now being discussed by
15 either Dr. Levine or Goldstein -- is it -- Goldman, excuse
16 me. I'm sorry. I believe we previously discussed that the
17 1.5 genetic defects was a number that included both the
18 consequence of an accident and the probability of an accident.
19 Was that a correct summary of what you just stated?

20 A (Witness Goldman) I think the basis for my
21 derivation of that number really was just taken from the Staff
22 testimony this morning. My recollection is the Staff witness
23 indicated that in the first generation the genetic effects
24 attributable to reactor accidents at Limerick would be
25 approximately 1/5th of those over all future generations. And

261b2

1 that would be about .05 per reactor year. I multiplied that
2 .05 per reactor year by the 30 years of expected reactor
3 operating lifetime and came up with a value of 1 1/2 for the
4 first generation over a 30 year period.

5 Q With regard to the .05 per reactor year number that
6 you just described, in your resource for that -- or your
7 source for that -- to your knowledge, does that number
8 include both the consequence of an accident and the probabi-
9 lities of the accident?

10 MR. WETTERHAHN: Objection. The same question was
11 asked by LEA's counsel and it was answered.

12 MS. BUSH: I was asking was it my correct
13 understanding of what he just said, and I got the previous
14 answer. I just want to make sure that's what he said.

15 JUDGE BRENNER: Where are you going to go from
16 that? You understand they had .26 and then they divided it,
17 which is in the Staff testimony. And you have places you
18 need to go with that?

19 MS. BUSH: Yes, I have one specific question I
20 want to ask, but that was the basic question and I didn't get
21 a yes answer to that when I asked it first, so it might not
22 be so clear.

23 JUDGE BRENNER: All right. We'll give you a little
24 bit of leeway, but not much more, because I want to stay with
25 new ground and not old ground. Dr. Goldman?

1 BY MS. BUSH:

2 Q Was that understanding correct?

3 A (Witness Kaiser) That number does contain
4 considerations of both probability and magnitude of
5 consequence.

6 Q Now focusing on the probability aspect of that
7 number, would it be a reasonable approximation of the
8 consequences of the magnitude of the consequences to make
9 a calculation such that you take the total probability
10 of a core melt accident out of the .05 and the remaining
11 number? Would that represent the magnitude of consequences,
12 in your opinion?

13 A The -- by take out, do you mean divide by?

14 Q Yes.

15 A The result that you would get by doing that
16 calculation would be the average number of -- in this case
17 we're talking about genetic defects, given that a core
18 melt accident had occurred.

19 MS. BUSH: Thank you. I have no further questions.

20 JUDGE BRENNER: Staff, any follow up?

21 MS. HODGDON: No.

22 FURTHER REDIRECT EXAMINATION

23 BY MR. WETTERHAHN:

24 Q In response to the last question, does that number
25 -- if you divide it by some further given core melt probability

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1 have any physical meaning, as far as any accident at the
2 Limerick generating station?

3 A (Witness Levine) Yes, it would. It would be
4 the equivalent of calculating a conditional -- a CCDF of
5 genetic effects conditional upon core melt and taking the
6 area under that curve.

7 MR. WETTERHAHN: Thank you. No further questions.

8 JUDGE BRENNER: All right. I take it we're going
9 to go back to the Staff's panel now, for the rest of DES-4?

10 MR. WETTERHAHN: I again would suggest that the
11 panel is here and I would think it would be more efficient
12 just to add the Staff panel to the four members of the
13 Applicant's panel that remain.

14 JUDGE BRENNER: I would like to do that, but
15 since I have already told the Staff I wouldn't do it for this
16 DES-4, I won't reverse myself, unless the Staff wants to do
17 it. But we've already seen one example where it would have
18 been efficient to do it.

19 In the meantime, I take it you want to dismiss
20 Dr. Goldman, or is that wrong?

21 MR. WETTERHAHN: Yes, sir. I would ask that he
22 be dismissed.

23 JUDGE BRENNER: He's going to let you know that I
24 had to keep reminding you.

25 (Laughter.)

1 JUDGE BRENNER: I'm glad we were able to
2 accomodate your schedule, Dr. Goldman, given the amount of
3 time the parties spent with you. In a perfect world, we
4 could have scheduled differently, but the Board is in the
5 dark and the parties have to do better about working together
6 about working together on this type of thing. And I think
7 you could have taken him yesterday, Mr. Elliott, as things
8 turned out.

9 I was also beginning to worry -- and I expect
10 the Staff to be thinking while I'm talking about the other
11 question -- I was beginning to worry, due to your eagerness
12 to leave, that there was something I should know about too
13 many days in the courtroom leading to premature aging.

14 WITNESS GOLDMAN: I expect that the radiation in
15 the courtroom is rather high due to the prolonged period of time.

16 JUDGE BRENNER: Well, hopefully the lack of
17 exposure to the sun will offset that.

18 You are dismissed at this time, Dr. Goldman.
19 Dr. Goldman, thank you.

20 MS. HODGDON: The Staff does not object to having
21 its panel join the Applicant's panel when we resume.

22 JUDGE BRENNER: Good, I think that will work
23 better. You still have the safety valve I gave you before.
24 I haven't forgotten it. If something surprising comes up,
25 feel free to let us hear about it.

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1 For example, if you need to confer with an
2 expert whom you would have had at your side, had they not
3 been on the combined panel, just tell us and we'll give you
4 the opportunity to confer. That's the one thing that occurs
5 to me, as a potential prejudice, but you have a large number
6 of people and maybe that won't arise.

7 (Witness Goldman excused.)

8 JUDGE BRENNER: Now we're going to take a break,
9 so you can physically do all this. So you're going to start
10 out with Dr. Pratt. Maybe you can work it so that whatever
11 needs to be done with Dr. Pratt can be done early, so he
12 doesn't have to stay here as many days as the whole panel is
13 going to be here.

14 Why don't we try to take him first, but I'll let
15 the parties work it out.

16 Let's take a break until three o'clock.

17 (Recess.)

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Whereupon,

- E. BRANAGAN
- B. RICHTER
- S. ACHARYA
- L. HULMAN
- G. KAISER
- E. SCHMIDT
- S. LEVINE
- G. DAEBELER

called jointly on behalf of the Staff and the Applicant, resumed the stand and, having been previously duly sworn, were examined and testified further as follows:

JUDGE BRENNER: All right. Let's go back on the record. We have the Staff and Applicant's panel combined, and it may be the reporter for the transcript should list each name. One witness has not previously been sworn and we'll take care of that right now.

I take it that's Mr. Pratt over that. Dr. Pratt would you please stand and raise your right hand.

Whereupon,

WILLIAM T. PRATT

called on behalf of the Staff, took the stand and, having been first duly sworn, was examined and testified as follows:

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DIRECT EXAMINATION

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BY MS. HODGDON:

Q Mr. Pratt, do you have a document with you consisting of six pages entitled professional qualifications of William Trevor Pratt, August, 1983?

A (Witness Pratt) I do.

Q Have you prepared the statement of professional qualifications?

A Yes, I have.

Q It's dated August, 1983. Do you have any changes to make to it?

A Not significant.

Q Does it constitute your testimony in this proceeding and is it true and correct to the best of your knowledge and belief?

A Yes, it is.

MS. HODGDON: Judge Brenner, the Staff moves that Mr. Pratt's professional qualifications consisting of six pages be bound into the record as if read.

JUDGE BRENNER: All right. In the absence of any objections we will admit the document into evidence and bind it into the transcript at this point.

(The document referred to follows:)

PROFESSIONAL QUALIFICATIONS OF

WILLIAM TREVOR PRATT

AUGUST 1983

EXPERIENCE

September 1976 - Present:

I am presently Group Leader (Principal Investigator) of the Accident Analysis Group, Division of Engineering and Risk Assessment, Brookhaven National Laboratory. As Group Leader, my primary duties are to provide technical management over BNL staff and provide technical assistance to the Office of Nuclear Reactor Regulation (NRR), U.S. Nuclear Regulatory Commission (NRC). Other duties involve the safety review of specific reactor plants and the preparation and coordination of Technical Evaluation Reports, which contain a description of the work accomplished.

At present, I am primarily involved in assessing core meltdown accidents in LWRs. In particular this involves evaluations of core meltdown phenomena, containment failure modes, fission product release and site consequence modeling. The group has performed extensive assessments in these areas particularly related to the Zion and Indian Point (Z/IP) facilities. I gave direct testimony with J.F. Meyer (NRC staff) at the IP hearings and other group members acted as expert witnesses. The group also performed extensive CRAC analysis in support of the direct testimony of Dr. Acharya (AEB/DSI/NRC) at the Indian Point Hearings.

I have directed the BNL reviews (in the above areas) of the Zion Probabilistic Safety Study (ZPSS), Indian Point Probabilistic Safety Study (IPPSS), Big Rock Point PRA, and the Limerick PRA. I am currently directing reviews of the Limerick Severe Accident Assessment (SARA) and the GESSAR-II PRA.

I have also worked on severe accident assessments for LMFBRs (namely FFTF and CRBR) and the group maintains a current involvement in NRC activities related to CRBR.

I was involved in an evaluation of a proposed core ladle to be installed in floating nuclear power plants (FNPs). I gave testimony before the Atomic Safety and Licensing Board related to the manufacturing license for the FNPs.

1975 - 1976:

Gibbs & Hill, Inc., New York, NY 10001, U.S.A. Mechanical Engineer - Nuclear Member of Development Group: preparation of Standard BOPSAR based on 3800 Mwt PWR Reactor Island. Responsible for analysis of PWR water systems (Component Cooling Water, Containment Spray, Auxiliary Feedwater, spent fuel pool cooling and service water systems). Worked on analysis of suppression pool loadings due to BWR safety relief blowdown.

1973:

United Kingdom Atomic Energy Authority Reactor Group, Dounreay, Scotland - Professional and Technical Officer, Grade II: Member of technical section of the Dounreay Fast Reactor (DFR); technical appraisals in the areas of core thermal hydraulics and reactor containment. Preparation of safety working party report on an appraisal of the DFR containment leakage test program.

1966 - 1967:

Whessoe, Ltd., Teesside, England - Design Engineer: Thermal and mechanical design, selection of materials of construction, preparation of technical reports and specifications for shell and tube heat exchangers.

1959 - 1966:

Head Wrightson Ltd., Teesside, England: Engineering Training.

EDUCATION

I obtained a Doctor of Philosophy Degree in Mechanical Engineering from the University of Strathclyde, Glasgow, Scotland. The graduate work was done during the period of September, 1969 through December, 1972 under the direction of Prof. Simpson, Head of the Department of Thermodynamics and Fluid Mechanics. I also obtained a Bachelor of Science in Mechanical Engineering from the University of Strathclyde. The undergraduate studies were done during September, 1967 through July, 1969. I attended Teesside Polytechnic, England from September, 1961 through April, 1965 and obtained a Higher National Diploma in Mechanical Engineering.

HONORS AND PUBLICATIONS

I was awarded the Prescott Scholarship by the Institution of Mechanical Engineers, London in 1968. A list of publications I have authored or co-authored is attached.

PUBLICATIONS (Open Literature)

W.T. Pratt, et al, "An Assessment of Uncertainties in Core Melt Phenomenology and Their Impact on Risk at the Z/IP Facilities," accepted for presentation at the International Meeting on Light-Water Reactor Severe Accident Evaluation, to be held in Boston on August 28 - September 1, 1983.

H. Ludewig, W.T. Pratt, R. Karol, and R.A. Bari, "An Assessment of Core Melt Accidents in the Limerick Facility," *ibid.*

J.W. Yang and W.T. Pratt, "Hydrogen Production from Oxidation of a Debris Bed During Severe Accidents in LWRs," *ibid.*

R.D. Gasser and W.T. Pratt, "COPTER, An LWR Containment Response Code," *ibid.*

R. Jaung, A.L. Berlad, W.T. Pratt, "Detonability of Containment Building Atmosphere During Core-Meltdown Accidents," Proc. Second International Meeting on Nuclear Reactor Thermal-Hydraulics, Santa Barbara, January 11-14, 1983.

J.W. Yang and W.T. Pratt, "Characteristics of PWR Ice Condenser Containments During Degraded Core and Fuel Core Meltdown Accidents," *ibid.*

A.L. Berlad, R. Jaung, and W.T. Pratt, "Mitigation Effects of Continuously Pressurized, Partially Inerted Containment Building Atmospheres," presented at the Second International Workshop on the Impact of H₂ on Water Reactor Safety, Albuquerque, October 1982.

A.L. Berlad, R. Jaung, and W.T. Pratt, "Electric Cable Insulation Pyrolysis and Ignition Resulting from Hypothetical Hydrogen Burn Scenarios for Nuclear Containment Buildings," *ibid.*

W.S. Yu and W.T. Pratt, "Hydrogen Production from the Steel-Steam Reactor During a Postulated Core Meltdown Accident," *ibid.*

J.W. Yang and W.T. Pratt, "H₂ Combustion During Degraded Core Accidents in PWR Ice Condenser Plants," *Trans. Am. Nucl. Soc.*, 41, 399 (1982).

A.L. Berlad, R. Jaung, and W.T. Pratt, "Electric Cable Insulation Ignition During Potential Nuclear Containment Hydrogen Burns," *Trans. Am. Nucl. Soc.*, 41, 401(1982).

W.T. Pratt, et al, "Potential Influence of Core-Concrete Interactions on PWR Containment Pressurization," *Trans. Am. Nucl. Soc.*, 39, 609(1981).

R. Jaung, R.A. Bari, and W.T. Pratt, "Carbon Monoxide Burning During Core Meltdown Events in a PWR," *Trans. Am. Nucl. Soc.*, 39, 606(1981).

W.S. Yue and W.T. Pratt, "Effects of Steel-Water Reaction During a Postulated Core Meltdown Event," *Trans. Am. Nucl. Soc.*, 39, 604(1981).

W.T. Pratt and R.A. Bari, "Impact of H₂ Combustion on Degraded Core Accidents in PWR Containments," presented at a Workshop on the Impact of Hydrogen on Water Reactor Safety, Albuquerque, January 1981.

W.T. Pratt and R.A. Bari, "PWR Containment Response During a Postulated Core Meltdown Event," *Trans. Am. Nucl. Soc.*, 38, 460(1981).

W.T. Pratt and R.D. Gasser, "Analysis of a Passive Ex-vessel Core Retention Device During a Postulated Core Melt Event," Proceedings of the ANS/ENS Topical Meeting on Thermal Reactor Safety, Vol. 1, pp. 218-225, April, 1980.

W.T. Pratt and R.D. Gasser, "Effects of Steel on a Core Meltdown in a Sacrificial Bed," Trans. Am. Nucl. Soc. 34, 492(1980).

R.D. Gasser and W.T. Pratt, "Thermal Response of a Molten Pool with Stefan Type Boundary Conditions," ASME Paper, #80-HT-9, July 1980.

R.D. Gasser and W.T. Pratt, "Containment Response to Postulated Core Meltdown Accidents in the Fast Flux Test Facility," Nuclear Technology, Vol. 47, pp. 2820307, February 1980.

J.K. Long, A.Q. Marchese and T.P. Speis (NRC), R.D. Gasser and W.T. Pratt (BNL), "Radiological and Containment Analysis for a Postulated Fast Reactor Melt-through Accident with Containment Venting," Proceedings of the International Meeting on Fast Reactor Safety Technology, Vol. III, pp. 1251-1260, August 1979.

R.D. Gasser and W.T. Pratt, "Analysis of LMFBR Containment Response to a Core-Disruptive Accident," Trans. Am. Nucl. Soc. 28, 460(1978).

J.J. Pyun, R.D. Gasser, W.T. Pratt and R.A. Bari, "Ex-vessel Containment Response to a Core Meltdown," Proceedings of the 3rd PAHR Information Exchange. ANL-78-10, pp. 327-334, November, 1977.

K.R. Perkins, R.A. Bari and W.T. Pratt, "In-Vessel Natural Circulation During a Hypothetical Loss-of-Heat-Sink Accident in the Fast Flux Test Facility," ASME Paper, #79-WA/HT-66, December 1979.

R.A. Bari, W.T. Pratt and K.R. Perkins, "Phenomena and Scenarios Related to a Loss-of-Heat-Sink Accident (with Scram) in a LMFBR," Proceedings of the International Meeting on Fast Reactor Safety Technology, Vol. II, pp. 665-674, August 1979.

R.A. Bari, H. Ludewig, W.T. Pratt and Y.H. Sun, "Accident Progression for a Loss-of-Heat-Sink with Scram in an LMFBR," Nuclear Technology, Vol. 44, pp. 357-380, August 1979.

R.A. Bari, H. Ludewig, W.T. Pratt and Y.H. Sun, "An Assessment of the Loss-of-Heat-Sink Accident with Scram in the LMFBR," Presented at the International Meeting on Nuclear Power Reactor Safety, Brussels, October 1978.

R.A. Bari, H. Ludewig, W.T. Pratt, Y.H. Sun, "Recriticality Considerations for the Loss-of-Heat-Sink Accident with Scram," Trans. Am. Nucl. Soc. 28, 471(1978).

R.A. Bari, M.A. Klenin, W.T. Pratt and Y.H. Sun, "Meltdown Phase for an LMFBR Loss-of-Heat-Sink During Shutdown," Trans. Am. Nucl. Soc. 26, 347(1977).

PUBLICATIONS (Laboratory Reports)

W.T. Pratt, et al, "Review and Evaluation of the ZPSS, Vol. 2; Containment and Site Consequence Analysis," NUREG/CR-3300, draft completed July 1983.

"Review and Evaluation of the GESSAR-II Probabilistic Risk Assessment - Containment Failure Modes and Fission Product Release," draft completed July 1983.

I.A. Papazoglou, et al, "A Review of the Limerick Generating Station Probabilistic Risk Assessment," NUREG/CR-3028, February 1983.

J.W. Yang and W.T. Pratt, "A Study of H₂ Combustion During Degraded Core Accidents in PWR Ice Condenser Plants, BNL Report, February 1982.

R.D. Gasser, H. Ludewig, and W.T. Pratt, "A Review of the Containment Failure Mode and Consequence Analyses Used in the Big Rock Point PRA," published as Appendix A in EGG-EA-5765, January 1982.

R. Jaung, A.L. Berlad and W.T. Pratt, "A Review of Combustion Processes Related to Detonations," BNL Report, January 1982.

W.T. Pratt and R.A. Bari, "Containment Response During Degraded Core Accidents initiated by Transients and Small Break LOCA in the Zion/Indian Point Reactor Plants," NUREG/CR-2228, July 1981.

W.T. Pratt and R.D. Gasser, "Thermal Analysis of a Floating Nuclear Power Plant Core Ladle," BNL-NUREG-27037, December 1979.

S.S. Tsai, R.D. Gasser and W.T. Pratt, "Sodium Fires Evaluation for the Fast Flux Test Facility," BNL-NUREG-24635, August 1978.

R.D. Gasser and W.T. Pratt, "Containment Response to Postulated Core Meltdown Accidents in the Fast Flux Test Facility," BNL-NUREG-24141-R, August 1978.

S.S. Tsai, R.D. Gasser, and W.T. Pratt, "Containment Design Basis Accident for LMFBRs: Review of Methods," BNL-NUREG-23221, September 1977.

R.D. Gasser, S.S. Tsai, D.C. Albright and W.T. Pratt, "Containment Design Basis Accident Analysis for the Clinch River Breeder Reactor, BNL-NUREG-25561, July 1977.

K.R. Perkins, W.T. Pratt and R.A. Bari, "Evaluation of In-vessel Natural Circulation During a Hypothetical Loss-of-Heat Sink Accident in the Fast Flux Test Facility," BNL-NUREG-26565, August 1979.

R.A. Bari, H. Ludewig, W.T. Pratt and Y.H. Sun, "Accident Progression for a Loss-of-Heat-Sink with Scram in an LMFBR," NUREG/CR-0427, BNL-NUREG-50910, October 1978.

R.A. Bari, H. Ludewig, W.T. Pratt and Y.H. Sun, "Material Relocation and Recriticality Assessment for the Loss-of-Heat-Sink Accident in the LMFBR," BNL-NUREG-23432, November 1977.

R.A. Bari, M.A. Klenin, W.T. Pratt, and Y.H. Sun, "Preliminary Assessment of the Meltdown Progression of the Loss-of-Heat-Sink Accident with Scram in the LMFBR," BNL-NUREG-23137, August 1977.

W.T. Pratt, "A Critical Appraisal of the DFR Containment Leakage Test Programme," DFR/SWP/P212, May, 1973.

W.T. Pratt, "Flash Evaporation in the Downcomer of a Natural Circulation Loop," Ph.D. Thesis, University of Strathclyde, Glasgow, 1974.

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1 MS. HODGDON: I have no questions for Mr. Pratt
2 at this time.

3 JUDGE BRENNER: Don't you want to get the
4 corrections in the record?

5 MS. HODGDON: Yes.

6 BY MS. HODGDON:

7 Q Yes, Mr. Pratt, do you have also with you a single
8 page document entitled Table 5.11(c), Summary of the Atmospheric
9 Release Specifications Used in Consequence Analysis for
10 Limerick Units 1 and 2?

11 A (Witness Pratt) Yes, I do.

12 Q Which is page 5-76 of the Limerick FES.

13 A Yes.

14 Q Have you corrections to make to that table?

15 A Yes, I have.

16 Q Would you care to -- well, the table has been
17 provided to all parties and the Board and the reporter. We
18 could bind it in as Staff Exhibit or --

19 JUDGE BRENNER: All right, we can do that. A
20 minor concern is that some of the numbers are not very
21 legible on my copy, although I can make them out. And I
22 would like to get a very legible copy for the official
23 exhibits. Can we do that?

24 MS. HODGDON: Yes. My copy is legible to me.

25 JUDGE BRENNER: Well, the handwriting on some of

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1 the numbers is difficult.

2 MS. HODGDON: Yes, would you like to have them
3 read in?

4 JUDGE BRENNER: Perhaps we should do that. But
5 we will mark it as Staff Exhibit 30. We could do that for
6 identification at this point.

7 (The document referred to
8 as Staff Exhibit 30
9 was marked for identification.)

10 JUDGE BRENNER: And in addition, since it is
11 just a one-page loose document, besides being an exhibit,
12 let's bind a copy into the transcript at this point also.
13 And perhaps we could have Dr. Pratt go through the changes.

14 (The document referred to follows:)

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Staff Ex. 30

Table 5.11c Summary of the atmospheric release specifications used in consequence analysis for Limerick Units 1 and 2^a

Release category ^b	Release time (hr)	Release duration (hr)	Warning time for evacuation (hr)	Energy release (10 ⁶ Btu/hr)	Release height (m)	Fractions of Core Inventory Released							
						Xe-Kr	Organic I ^c	Inorganic I	Cs-Rb	Te-Sb	Ba-Sr	Ru ^d	La ^e
I-T/DW(22)*	5	0.5	4	100	30	1	7(-3)**	2(-3)	2(-2)	8(-2)	1(-3)	5(-3)	1(-3)
I-T/WW(25)	5	0.5	4	100	30	1	7(-3)	1(-4)	3(-4)	1(-3)	2(-5)	7(-5)	1(-5)
I-T/WW(24)	5	0.5	4	100	30	1	7(-3)	2(-4)	9(-4)	2(-3)	8(-5)	1(-4)	3(-5)
I-T/SE(14)	2	0.5	1	100	30	1	--	1(-1)	1(-1)	4(-1)	1(-2)	4(-1)	2(-3)
I-T/HE(20)	2	0.5	1	100	30	1	--	2(-1)	6(-2)	1(-1)	7(-3)	8(-2)	1(-5)
I-T/LGT(26)***	2	3	0	1	30	0.7	--	3(-3)	1(-4)	5(-4)	2(-5)	3(-5)	6(-6)
I-T/LGT(18)	2	3	0	1	30	0.7	--	2(-2)	1(-1)	5(-2)	2(-3)	3(-3)	6(-4)
II-T/WW(8)	20	4	5	1	30	1	7(-3)	7(-1)	3(-1)	2(-1)	4(-2)	4(-2)	3(-3)
II-T/SE(14)	30	0.5	7	100	30	1	--	1(-1)	1(-1)	4(-1)	1(-2)	4(-1)	2(-3)
III-T/WW(10)	3	1	2	100	30	1	7(-3)	8(-2)	2(-1)	6(-1)	2(-2)	4(-2)	7(-1)
III-T/SE(5)	2	0.5	1	100	30	1	--	4(-1)	5(-1)	5(-1)	5(-2)	5(-1)	3(-3)
III-T/HE(20)	2	0.5	1	100	30	1	--	2(-1)	6(-2)	1(-1)	7(-3)	8(-2)	1(-5)
III-T/LGT(26)	0.5	4	0	1	30	0.7	--	3(-3)	1(-4)	5(-4)	2(-5)	3(-5)	6(-6)
III-T/LGT(18)	0.5	4	0	1	30	0.7	--	2(-2)	1(-1)	5(-2)	2(-3)	3(-3)	6(-4)
IV-T/LW(2)	1	3	0.5	1	30	1	7(-3)	5(-1)	5(-1)	5(-1)	6(-2)	9(-2)	7(-3)
IV-T/WW(4)	1	3	0.5	1	30	1	7(-3)	5(-1)	5(-1)	5(-1)	6(-2)	8(-2)	6(-3)
IV-T/WW(3)	1	3	0.5	1	30	1	7(-3)	5(-1)	5(-1)	5(-1)	6(-2)	9(-2)	7(-3)
IV-T/SE(5)	2	0.5	2	100	30	1	--	4(-1)	4(-1)	5(-1)	5(-2)	5(-1)	3(-3)
I-S/DW(23)	5	0.5	4	100	30	1	7(-3)	3(-3)	5(-3)	3(-3)	6(-4)	3(-4)	4(-4)
IV-A/LW(1)	1	3	0.5	1	30	1	7(-3)	5(-1)	5(-1)	5(-1)	6(-2)	9(-2)	7(-3)
IS-C/DW(13)	0	3	0.5	1	30	1	7(-3)	8(-2)	1(-1)	6(-1)	7(-3)	8(-2)	7(-3)
IS-C/SE(14)	1	0.5	1	100	30	1	--	1(-1)	1(-1)	4(-1)	1(-2)	4(-1)	2(-3)
IS-C/DW(12)	1	3	1	1	30	1	7(-3)	8(-2)	1(-1)	6(-1)	8(-3)	1(-1)	7(-3)
IS-C/SE(14)	2	0.5	2	100	30	1	--	1(-1)	1(-1)	4(-1)	1(-2)	4(-1)	2(-3)
S-H2O/WW(11)	2.5	0.5	2.5	1	30	1	7(-3)	1(-1) 2(-1)	2(-1) 4(-1)	3(-1)	1(-2) 4(-2)	5(-2)	4(-3)
S-H2O/SE(5)	2.5	0.5	2.5	100	30	1	--	4(-1)	4(-1)	5(-1)	5(-2)	5(-1)	3(-3)
S-H2O/WW(9)	2.5	0.5	2.5	1	30	1	7(-3)	3(-1) 5(-2)	3(-1) 4(-1)	4(-1)	3(-2)	4(-2) 7(-2)	5(-3) 6(-3)

^aSee Section 5.9.4.5(7) for discussion of uncertainties. Estimated numbers were rounded to one significant digit only for the purpose of this table.

^bSee Appendix H for designations and descriptions of the release categories.

^cOrganic iodine is added to inorganic iodine for consequence calculations because organic iodine is likely to be converted to inorganic or particulate forms during environmental transport.

^dIncludes Ru, Rh, Co, Mo, Tc.

^eIncludes Y, La, Zr, Nb, Ce, Pr, Nd, NP, Pu, Am, Cm.

^fNumber in parentheses indicates relative ranking of the release category according to cesium fraction.

**7(-3) = 7 x 10⁻³ = 0.007.

***This release category is combined with III-T/LGT in consequence analysis.

Limerick FES

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27pb5

1 JUDGE BRENNER: At least one of them does not
2 appear to be a change to me, so I don't understand it. But
3 when he goes through each of them, perhaps we can get them.

4 Would you please do that, Dr. Pratt?

5 WITNESS PRATT: Yes, indeed. The change that's
6 applied to the last three release categories in the table,
7 and starting with S-H20(11) under the heading release time the original
8 value was three hours. It now goes to .5 hours. Under release
9 duration it was 3 hours. I'm not sure -- some of these have
10 been crossed out. The new number is four hours. Under
11 warning time goes to .5 of an hour.

12 Under the column inorganic iodine, the number is
13 now 2(-1). Under the cesium-rabidium group the new number
14 is 4(-1). Under the berium-strontium group the number is
15 4(-2). There are no other changes in that column -- in that
16 row, I should say.

17 If I go to the next one down, which is an SE
18 sequence, S-H20/SE sequence, the release time is .5. The
19 release duration remains the same at .5.

20 JUDGE BRENNER: All right. So that is not really
21 a change on that one.

22 WITNESS PRATT: It's whoever copied this. Warning
23 time, .5. Nothing else in the row would change.

24 For the last column, for the last row, the release
25 time is now .5. The duration goes to three hours. The

27pb6

1 warning time is .5. Under inorganic iodine, the new number
2 is 5(-2). There is only changes in ruthinium and lanthium.
3 The new numbers are 7(-2) and 6(-3).

4 JUDGE BRENNER: Does that complete the changes?

5 WITNESS PRATT: Yes, I was requested, if other
6 tables in the report would change, it was my opinion and the
7 Staff have come to their own independent opinion. These
8 are calculations that I did. The only impact in the main
9 text of the report would be Table 5.11(h), page 5-99.

10 This was really the estimate of societal risk,
11 and the changes in this table might have influenced the
12 numbers in this particular table. It was my opinion that
13 the changes would have been in the round-off of the numbers.

14 I checked two numbers only, under number two,
15 early fatalities and under number four, latent cancer
16 fatalities and found that there would be no -- I wouldn't
17 make a change to the table.

18 JUDGE BRENNER: Is there a reason why you didn't
19 check the other lines in that Table 5.11(h)?

20 WITNESS PRATT: I checked these two in the time
21 I had available as being representative as early -- as being
22 representative of those two groups of damage and disease.

23 JUDGE BRENNER: Can you conclude that because any
24 changes would be lost in the round-off, as to the two you
25 checked the same would be true as to the others, given the

27pb7

1 nature of the two you checked?

2 WITNESS PRATT: In my opinion, yes.

3 JUDGE BRENNER: So far we've got change to
4 Table 5.11(c) marked only for identification. And the reason
5 for that is I wanted to get some foundation, and I can do
6 it now as to what your involvement was in the preparation
7 of Table 5.11(c), and how these changes came about. If you
8 could enlighten us on that.

9 WITNESS PRATT: Yes, certainly. We have produced --
10 I'm not sure whether this is in evidence -- this document --
11 the BNL document.

12 JUDGE BRENNER: It doesn't matter, you can just
13 tell us what you did in the context of your personal
14 involvement in the preparation of the original 5.11(c). And
15 if you need to relate to other work to do that, that's okay,
16 and then to explain how the changes came about.

17 WITNESS PRATT: What we did at Brookhaven was to
18 calculate a series of potential release categories of
19 failure modes for Limerick. And it was my particular group
20 that was involved in this calculation. And two people in
21 my group, Dr. Ludwig and Dr. Yang who specifically did the
22 calculations.

23 We submitted to the NRC a table of about 27
24 potential failure modes which have been reproduced in the
25 RES, and were also reproduced in the DES. The NRC Staff

27pb8

1 selected 20 of those release categories for use in outside
2 consequence analysis. When we looked over the release
3 categories, we determined -- perhaps I should go back and
4 explain how we would do a calculation.

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1 There are many accident sequences that could occur
2 and there are a number of potential failure modes. For a
3 given accident class, what we tried to do is group together
4 those accident sequences that have commonalities that are
5 similar in their response. We tried to put into those
6 various accident sequences those that are representative
7 of the particular accident class that we're looking at.

8 In this particular case, we looked at this
9 accident sequence which was a Class S as identified in the
10 Limerick SARA. Most of that is coming from an external
11 event. The assumption made there was there would be a
12 failure of the primary system as a result of the seismic
13 event coupled with the failure of the containment building.

14 We analyzed several calculations at Brookhaven,
15 assuming various sizes of break. Those calculations, in
16 themselves, were correct given the input assumptions that one
17 would make. We then looked at those accident sequences
18 and decided which one would represent this family of accident
19 classes, the S class.

20 There were two assumptions, one in which the
21 break would be sufficient as to result into all of it being
22 expelled from the vessel. That was the Case S-H₂O bar. The
23 implication there is there is no water in the bottom of the
24 vessel.

25 The other case was an S-H₂O in which there was

1 water available at the bottom of the vessel and the core
2 fell into it. We made various assumptions about core
3 locations and failure size.

4 The decision was made, by the authors of the
5 report, to use as a representative accident sequence for
6 this class a large break LOCA. This assumption is consistent
7 with the assumption made with the Applicant. That was a
8 calculation that resulted in very rapid times to core melt,
9 about half an hour. Unfortunately, the engineer -- Dr. Yang
10 -- copied in his small break calculations, rather than the
11 large break calculations.

12 So both calculations are correct. We wanted that
13 to represent this particular class with what we considered
14 to be the most limited accident sequence. And we put it into
15 the table, the changes indicated in terms of some of the
16 release fractions.

17 Now this is, I guess, a kind of a good indication
18 of how the QA, which is a long discussion that went on
19 yesterday, could come into the sequence. If you do a
20 calculation, you make assumptions, these codes will not tell
21 you what a core melt accident will look like. You have to
22 make assumptions to decide how it will go. Once you make
23 those assumptions, there is QA to see if the assumptions have
24 been put into the code correctly, and the results are consistent.

25 That was done. It's the next step, where you use

281b3

1 judgment to represent a wide range of accident sequence
2 for a particular class. We should have used the more limiting
3 calculation for this particular case. Its influence in risk
4 was not large. Therefore, when we looked at the overall
5 risk perspective that we calculated or the NRC calculated
6 against that calculated by the Applicant, we didn't see large
7 differences because these particular sequences, as far as
8 we were concerned, were not large contributors.

9 So this gives you an idea of how you can compare
10 your results with somebody else and you tend to focus on those
11 areas that are important risk contributors, rather than
12 those that do not affect things very much.

13 When I saw the mistake, I went through and did
14 some rather limiting calculations of what the maximum effect
15 would be on risk. This was my opinion and the NRC Staff
16 was not able to testify yesterday until they had done the
17 calculations themselves and convinced themselves that this
18 was indeed true. My calculations were for early fatalities.
19 They would be less than a two percent influence on overall
20 risk and for long term damage, to see if it would be less
21 than one percent.

22 Again, I think this confirms really the relative
23 importance of this particular sequence to the overall risk
24 perspective.

25 JUDGE BRENNER: Thank you. I take it that Staff

1 would like to move Exhibit 30 into evidence?

2 MS. HODGDON: Yes, the Staff would move Exhibit
3 30 into evidence.

4 JUDGE BRENNER: In the absence of any objections
5 and hearing none, we will admit it, Staff Exhibit 30, into
6 evidence.

7 (The document previously marked
8 for identification as Staff
9 Exhibit 30 was received
10 into evidence.)

11 JUDGE BRENNER: I just have one question, Dr. Pratt,
12 since you raised the QA point, how did you discover the
13 error? I'm not sure I got that in your information.

14 WITNESS PRATT: I think this is again a
15 rather interesting point. The people at NUS are involved
16 in doing calculations, I believe, for the ACRS related
17 to reactor pressure vessel failure. And one of the people
18 called me at Brookhaven and inquired why there was a
19 difference in timing for the particular accident sequence that
20 they are interested in.

21 It was at that point that I went back and checked
22 Dr. Yang's log and realized that he'd entered the calculations
23 for the small break LOCA rather than the large break LOCA.
24 So it was academic interest on how one would analyze a sequence,
25 rather than its impact on overall risk.

1 As soon as I found the difference, I reported the
2 fact to the NRC. Oh yes, of course, once I did find that
3 one I spent most of the weekend and evenings checking all the
4 rest of them to make damn sure that the rest were fine.

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1 But again, I think if there had been errors of
2 this nature -- or should I say errors -- is perhaps a
3 misrepresentation of the accident classes, it would have
4 become rather obvious when we compared our calculations
5 against those performed by the utility, if there had been
6 important risk contributors.

7 JUDGE BRENNER: All right. Mr. Elliott, you may
8 cross examine on all subjects related to DES-4, rather than
9 A(1), which we have completed. And I think our goal is to
10 see if you can ask questions related to these changes first,
11 since that may alleviate the necessity to keep Dr. Pratt up
12 there. And that might include questions of other Staff
13 witnesses, as to their agreement or lack thereof. I don't
14 want to pursue it, in advance of your cross examination, so
15 I'll go to you at this point.

16 CROSS EXAMINATION

17 BY MR. ELLIOTT:

18 Q I think I only have two questions. Depending upon
19 the accident sequence, and depending upon the release
20 category, a difference in warning time for evacuation can
21 potentially have a large impact on early fatalities. Is that
22 correct?

23 A (Witness Pratt) Yes, it is.

24 Q The reason it did not, in this case, as I understand
25 it -- based on our conversation off the record -- was that

1 the three sequences involved are all earthquake initiated
2 release categories.

3 A The largest contributor to those was from
4 earthquake. If you go to Table 11 -- 5-11(d) on page
5 5-77, you will see the frequency there for the three
6 releases subdivided into internally initiated events and into
7 externally initiated events of such impact to impact

8 So that the one minus eight and one minus
9 eight are really coming from the random reactor pressure
10 vessel failure initiator for the internal events. And the
11 other frequencies are coming largely from the seismic
12 event. So the seismic event probability would not be
13 affected by the changes in warning time. The internal event
14 would be, and in the calculations that I gave, I took that
15 into account.

16 Q The reason that warning time is not significant,
17 with respect to these sequences, is because people are not
18 modeled to move out within a rapid period of time in any
19 event, is that correct?

20 A Again, for the frequencies that are under the
21 probability of the release category initiated by severe
22 earthquakes, that's true. For the other category, that isn't.

23 Q Okay, I understand.

24 JUDGE BRENNER: Let me correct one thing I said.

25 When I said questions other than 4-A(1) the one exception would

1 be if you want to come back to Dr. Branagan what he thinks
2 about Dr. Goldman's explanation, if it's important to you, you
3 can.

4 MR. ELLIOTT: It's been so long.

5 (Laughter.)

6 No, I don't revisit it.

7 JUDGE BRENNER: Okay.

8 Well, I'd like to ask him if he agrees, if I
9 could interrupt your examination, and I did only because
10 that may allow us to totally leave that health effect subject
11 finally.

12 Dr. Branagan, do you agree with -- you were here
13 when Dr. Goldman clarified, as he put it, the comparison that
14 you'd previously given for genetic effects occurring due
15 to reactor operation, as compared to those effects that might
16 be expected to occur in a population?

17 WITNESS BRANAGAN: Well, the number of effects
18 that would be expected to occur in the population -- I
19 would stick with the values that I have before. And I can
20 elaborate a little on that. I assumed an equilibrium popula-
21 tion. The population essentially would reproduce itself.

22 JUDGE BRENNER: Well, we'll let you pursue it in a
23 moment. You might want to include in the explanation of
24 Dr. Goldman's point -- and it's been so long I'm not sure I
25 have it straight -- but that one of the values was births that

1 may be expected in a population, in a generation, rather than
2 per total population.

3 WITNESS BRANAGAN: Yes, the estimates in the BEIR
4 Report are given per million live births. And we have made
5 the assumption that there would be a stable population. The
6 population would reproduce itself. And that is a
7 clarification, the per million live births. I don't think
8 it really affects our estimates at all.

9 JUDGE BRENNER: All right. Well, Dr. Goldman,
10 however, adjusted for -- I guess he used the United States
11 average. But using that average, he adjusted for the expected
12 live births, given some eight million in the population within
13 50 miles of Limerick, which adjustment you did not make.
14 At least I don't recall it.

15 WITNESS BRANAGAN: I would like to see the
16 transcript on that, to go over that. I was taking my own
17 notes, but the way I have calculated it there is roughly
18 8.1 million persons within the 50 mile population and for
19 an equilibrium population to reproduce itself I'm assuming
20 about 11 percent of those -- of the reproduced population --
21 would have genetic defects. You would get approximately
22 890,000 genetic defects in the first generation.

23 JUDGE BRENNER: Okay, I think I understand how
24 you did it on that point, now, and I think we've got the
25 transcript on what Dr. Goldman did.

1 JUDGE COLE: But it reproduced itself in 30 years?
2 That was your basis?

3 WITNESS BRANAGAN: The mean reproductive age would
4 be 30 years for the parents. The difficulty I had with
5 Dr. Goldman did, he used a rate of 16 births per thousand
6 persons and then multiplied that by 30 years, as a mean
7 reproductive age, and that gives you 480 persons per thousand
8 persons, and it doesn't seem like you're at an equilibrium
9 population. I did assume an equilibrium population.

10 JUDGE BRENNER: Okay, we know where you got your
11 numbers.

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1 Are there any follow up questions, based on that?
2 If not, I think we could dismiss Dr. Branagan and have
3 one clean break, at least, in this proceeding and put aside
4 any further questions on DES 4-A(1).

5 All right, thank you, Dr. Branagan. We can dismiss
6 you at this point.

7 (Witness Branagan dismissed.)

8 JUDGE BRENNER: Okay. I'm sorry for the
9 interruption, Mr. Elliott.

10 MR. ELLIOTT: In fact, I was wondering if perhaps
11 the Board had questions on the code validation matter, whether
12 it might want to take up those questions at this point, if
13 the Board chooses.

14 (Board conferring.)

15 JUDGE BRENNER: I think we'll pick it up in the
16 normal sequence. We stopped the Applicant from asking
17 those kinds of questions, also. Why don't we just go through
18 the remainder of DES-4, rather than trying to simply that one
19 further.

20 MR. WETTERHAHN: Did counsel mean questions for
21 Dr. Pratt, only? I don't understand.

22 JUDGE BRENNER: No, we had told him that the
23 Board, at that point in time, had questions about the code
24 qualifications, is the way I phrased it -- rather than
25 validation -- but in any event, that's what he referred to.

1 And I recall, from Mr. Elliott, that I had stopped you from
2 asking some questions on that subject. So we'll wait until
3 we all come back again.

4 Why don't you just proceed with your cross
5 examination?

6 BY MR. ELLIOTT:

7 Q I'd like to move now to DES 4-A(2) and (3). With
8 respect to the Staff's testimony at paragraph 22, it has
9 stated that if an accident were to occur during the crop
10 and pasture growing season, then crop and milk affected by
11 high levels of radioactive contamination during only that
12 particular season would be interdicted.

13 First of all, in this context, what is a high level
14 of contamination?

15 A (Witness Acharya) The limits of interdiction for
16 milk and crops, they are developed in the WASH-1400, Appendix
17 6. There's a pretty good table there, I think, that was --

18 A (Witness Hulman) Could we have Appendix 6, please?

19 MR. WETTERHAHN: Mr. Chairman, for ease, that's
20 in Applicant's testimony, Table 4.

21 JUDGE BRENNER: Dr. Acharya, were you saying
22 interdiction? I didn't quite understand you. When you said
23 particular something.

24 WITNESS ACHARYA: Well, I said the levels of
25 contamination, above which the interdiction of milk or crops

1 would be required -- these levels are provided -- well, the
2 basis for these levels are provided in Appendix 6 of
3 WASH-1400. I was looking for a particular table where the
4 guidelines are provided.

5 It's in Appendix 6 --

6 JUDGE BRENNER: Mr. Wetterhahn believes the table
7 you may be thinking of may be reproduced as Table 4 in
8 Applicant's testimony.

9 JUDGE MORRIS: Where the reference is given to
10 Table VI-11-6 of the Reactor Safety Study.

11 JUDGE BRENNER: And if you could, I'd like you to
12 look at that table, so I can get your opinion, rather than
13 just Mr. Wetterhahn's as to whether or not that's what you
14 want to use.

15 WITNESS ACHARYA: This is in page --

16 JUDGE BRENNER: Look at Table 4. Does that
17 serve your purpose?

18 WITNESS ACHARYA: That's right. This is the same
19 table.

20 JUDGE BRENNER: All right.

21 Go ahead. I'm sorry for the interruption.

22 WITNESS ACHARYA: Well, the Table 4 that is in the
23 Applicant's testimony somewhere is identical to the WASH-1400
24 table that I was citing, except for one line in that table
25 which, of course, was neither used by the Staff -- and I

1 understand it was also not used by the Applicant -- namely
2 the allowable level of dose that is factored into our
3 calculations in that the low population density area --
4 ten rem for the whole body in 30 years. That is in the
5 original WASH-1400 table. That was not used.

6 In our CRAC analysis, we used the criterion
7 that nobody would receive 35 rem to the whole body in
8 30 years, which is stated to be applicable to the urban areas,
9 which also we used for the rural areas, as well.

10 So the particular item in the WASH-1400 table,
11 which is not transferred to the Table 4, doesn't matter.

12 BY MR. ELLIOTT:

13 Q Staying with Table 4, there are doses stated for
14 cesium and iodine by the ingestion pathway, via milk. Over
15 what time periods are those two doses projected?

16 A (Witness Acharya) It says here that ingestion
17 by milk, the strontium does -- as stated in the table, the
18 dose from strontium -- the milke ingestion should be no higher
19 than 3.3 rem to the bone marrow in the first year. Then for
20 the cesium, it is 3.3 rem to the whole body for all times.
21 And for iodine, it is 10.0 rem to the thyroid over all times.

22 Q Do you know whether these dose criteria are more
23 restrictive or less restrictive than the EPA protective
24 action guidelines?

25 A Well, I have not read the comparison with the EPA

1 guidelines. For one thing, the EPA guidelines -- or I guess
2 the HUD guidelines -- the EPA guidelines in particular,
3 they are proposed guidelines and we have stated, in the
4 DES, or the FES that we have used this WASH-1400 recommended
5 levels for interdiction and if you wanted to go to more
6 restrictive levels, as the criteria for interdiction, then it
7 would add to the economic cost. But however, it would
8 reduce the associated health effects and the converse would
9 also be true.

10 If one raised this, then one would get higher
11 health effects, but reduced cost.

12 Q Can Applicant's panel assist me.

13 A (Witness Kaiser) Would you repeat the question?

14 Q Can you tell me whether the dose criteria, that
15 are used in Table 4, is more restrictive or less restrictive
16 than the EPA protective action guidelines, or indeed if a
17 comparison can be made at all.

18 A The protective action guidelines, that have
19 sprung to my mind at the moment, are those which for example
20 give you five rem whole body over the acute period of ingestion,
21 say the first 24 hours. And it's clear that the restrictions
22 apply here are more restrictive, since they're smaller doses
23 by and large, over a longer period of time.

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1 Q Thank you. With respect to the statement that
2 crop and milk affected by high levels of radioactive contamina-
3 tion only during that particular season would be interdicted;
4 isn't that statement true only with respect to areas 3 and
5 4 in that pictorial figure reproduced from WASH-1400?

6 A (Witness Acharya) That's correct.

7 Q With respect to areas 1 and 2, there may be
8 crop and milk destroyed subsequent to the first year; isn't
9 that correct?

10 A Well, the areas identified as 1 and 2, they would
11 be interdicted from use for several years. And when they
12 are interdicted for use, they will also be denied for
13 growing any crops.

14 Q The CRAC code breaks land area interdiction into
15 two categories, right? One greater than 30 years and the
16 other less than 30 years.

17 A That's correct.

18 Q Is the land area in that pictorial figure, area
19 number 1, is that land that's interdicted for more than
20 30 years?

21 A That's correct.

22 Q And land area 2 is interdicted for less than
23 30 years.

24 A That's correct.

25 Q The actual length of time of interdiction depends

31pb2

1 upon how long the process of decontamination takes place;
2 isn't that correct?

3 A It depends upon the process of the removal of
4 the radionuclide by the decay, and the weathering from the
5 contaminated ground, until such time when the level would be
6 such that the decontamination can be effectively carried out,
7 to such level that it can be opened for rehabilitation.

8 Q With respect to the land area over which milk
9 will be impounded, as I read Table 2, at least with respect
10 to severe accidents initiated by causes other than severe
11 earthquakes, the chance that one square meter will be so
12 contaminated that milk from that area will be impounded is
13 only about six times the chance that about 30 million square
14 meters of land will be so contaminated; is that correct?

15 A You have to repeat your question.

16 Q Looking at column 4 of Table 2.

17 A Okay.

18 Q Is it a correct statement that the chance that
19 one square meter of land will be so contaminated that milk
20 from the area will be impounded is only about six times the
21 chance that 30 square million meters of land will be so
22 contaminated?

23 A The statement is not entirely true, because you
24 notice that for each of these columns, 1, 2, 3, 4, that is
25 a multiplier of 1×10^3 just below the printout of the

31pb3

1 title. What it's supposed to mean is that whatever is the
2 magnitude of the consequences printed out in the first column,
3 that has to be multiplied by 1,000. That is here in this
4 table, the minimum magnitude that is to be read is 1,000
5 square meters.

6 Q I understand that. So that with respect to the
7 magnitude of 30 million square meters --

8 A Let me see that. You are using 30 million square
9 meters. Then that should be 3 X 4 in the magnitude column,
10 because you have already the factor of 10 X 3 for each of
11 them.

12 Q Including magnitude, the magnitude figures being
13 multiplied by --

14 A 1,000. So the first number in the magnitude
15 column where it says 1 is actually 1,000.

16 Q Are the figures in Table 2 expressed in the per
17 reactor year estimate?

18 A That's right.

19 Q If we look at the very first figure in column 4,
20 8.52E minus 05.

21 A That's right.

22 Q Scaling that would be 8.52E minus 2 then.

23 A No.

24 Q Okay, well then tell me.

25 A How it should be read is that 1,000 that is at the

31pb4

1 top of the column, that is to multiply the magnitude column.
2 So in order to read this, please do the following. That is
3 the probability that the contamination area will exceed
4 1,000 square meters is equivalent to 8.52×10^{-5} per reactor
5 year.

6 Q So the scaling only applies to the consequence --

7 A Magnitude.

8 Q Okay. Can a reader of the FES without resort to
9 this testimony derive these figures?

10 A Well, we have one CCDF in the main part of our
11 FES that is land area for interdiction. Let me identify the
12 figure where the minimum time there is 1,000. Therefore,
13 for the land interdiction area, if it does indicate that the
14 numbers are in thousands.

15 JUDGE BRENNER: Wait, were you going to give us
16 the figure you said? While he's doing that, Mr. Elliott,
17 maybe I misinterpreted your question. I didn't realize you
18 were asking him about the multiple of 1,000. I thought you
19 were asking him as to the data in Table 2 itself.

20 MR. ELLIOTT: My first question went to understanding
21 what the data represented. It looked to me as though the
22 multiplier applied to both probability and consequence.
23 That's been clarified for me.

24 WITNESS ACHARYA: It's the table on page 5-95.
25 Excuse me, not table, the figures. The figures on page 5.95.

321b1

1 JUDGE BRENNER: Dr. Acharya, looking at Table 2,
2 why does it have the multiplier at the top of each column,
3 then, if it only applies to the magnitude?

4 WITNESS ACHARYA: Let me explain that. In the
5 background, we have 39 different kinds of results that are
6 printed out. And the CCDF for all of them are also printed
7 out. In any one given case of the printout, you'd have some
8 items selected. And also you may have items like the area
9 for contamination. Now for all these items, there is really
10 column, called the magnitude column, that is provided for the
11 entire page.

12 So since all the -- all the magnitudes of all the
13 items that are printed on the same page are not counted, in
14 terms of thousands, some are counted in the normal way and
15 some -- which are a large number, like the areas -- they are
16 counted in multiples of 1000. It would have been inappropriate
17 to stick in the factor of 1000 on the top of the magnitude
18 because that magnitude column applies to a lot of consequences.

19 So the factor of 1000 is just shown underneath the
20 particular consequence item.

21 WITNESS HULMAN: Another way to state it is that
22 it was a computational convenience, in doing the calculation.

23 JUDGE MORRIS: Mr. Elliott, could I jump in for a
24 moment? Would you focus on Figure 5.4(h) of the FES? I
25 thought your original question was going to the point that the

1 curve here is flat for a long distance, and that the
2 probability of like 10 million square miles is about the
3 same as it is for 1000 square miles. Wasn't that your
4 original question?

5 MR. ELLIOTT: That was part of it. This table
6 I think applies -- and that's the next point I was going
7 to inquire into -- this figure 5.4(h) applies to a different
8 land area than the land area over which milk is interdicted,
9 I believe. But --

10 JUDGE MORRIS: Why don't we get to that kind of
11 question, whether it's milk or for whatever reason, without
12 going through all the rest of it?

13 MR. WETTERHAHN: Judge Morris, for the sake of
14 the record, I think this is an area in square meters not
15 square miles.

16 JUDGE MORRIS: You're correct, sir, thank you.

17 BY MR. ELLIOTT:

18 Q Figure 5.4(h), is a CCDF curve for land area
19 interdiction. Now if we take a look again at that pictorial
20 figure reproduced in WASH-1400, does this curve correlate to
21 area number 1 in that --

22 A (Witness Acharya) That's correct.

23 Q It does not relate to areas 2, 3, or 4?

24 A No.

25 Q So that from the FES, one cannot determine the land

321b3

1 area over which crops will be interdicted, isn't that correct?

2 A That's correct.

3 Q And the same thing, with respect to milk, correct?

4 A That's correct. However, the cost associated
5 with the milk interdiction or the crop interdiction were
6 included in the curve that is provided in the FES and also
7 earlier in the FES it is stated what are the items from which
8 the cost is calculated. And that's included in the CCDF.
9 That includes the cost of the milk interdiction, as well as
10 the crop interdiction.

11 Q Going back to Table 3 -- I'm sorry, Table 2, again,
12 last column, the column for milk again. This column would
13 show that the CCDF is approximately flat, within a factor of
14 10, between one square meter of land being interdicted and
15 700 million square meters, isn't that correct?

16 MR. WETTERHAHN: Objection. This table doesn't
17 show one square meter, so there's no foundation.

18 MR. ELLIOTT: You're right, 1000 square meters.

19 MR. WETTERHAHN: I'm sorry. Could you --
20 1000 square meters, and what's the next value, upper value?

21 MR. ELLIOTT: If my quick math is correct, it's
22 700 million.

23 WITNESS ACHARYA: That's correct.

24 JUDGE BRENNER: I guess I missed -- 700 million
25 square meters, is that what we're talked about now?

1 MR. ELLIOTT: (Nodding affirmatively.)

2 WITNESS HULMAN: If one looks at Figure 5.4(h),
3 the probability is approximately the same between 1000 and
4 10 million square meters. From there the probability
5 decreases. What is flat is shown by the figure.

6 BY MR. ELLIOTT:

7 Q Right. Well, that's with respect to land area
8 interdiction, which we've already gone over, as corresponding
9 only to area 1 of that pictorial figure. With respect to the
10 land area for milk interdiction, it's flat out to about
11 700 million. Isn't that correct?

12 A (Witness Acharya) Now it's much simpler if you
13 tell me which -- in column 4 -- which probabilities that
14 you are interested to have the magnitudes.

15 Q Between the topmost figure, 8.52 minus 5 and
16 7.74(e) minus 5.

17 A 7.4(e) minus 5?

18 Q Right. The difference between those two probabili-
19 ties is not very significant, is it?

20 A It is not significant and the consequence magnitude
21 corresponding to the second probability, just below the
22 two, is 700 million square meters.

23 Q Right. Thank you.

24 A And 2.6 million square meters equals one square
25 mile.

1 Q Thank you. Going to Applicant's panel, with
2 respect to paragraph 46.

3 JUDGE BRENNER: What's the question, Mr. Elliott?

4 BY MR. ELLIOTT:

5 Q There's a reference to unacceptable levels of
6 contamination in milk. What is unacceptable?

7 A (Witness Kaiser) Those are the levels defined
8 in our Table 4, which are the same as were just discussed
9 by the Staff.

10 Q Unacceptable is a value judgment, is it not?

11 A As I understand it, these values are based on
12 recommendations by the Federal Radiation Council and the
13 British Medical Research Council.

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1 Q Line 4 of that paragraph refers to excessive
2 radiation doses delivered to people. What are excessive
3 radiation doses?

4 A This refers to the 25 rem delivered in 30 years
5 as stated in Table 4.

6 Q Excessive is a value judgment also, is it not?

7 A I would -- yes, I think I'd agree with you on
8 that. That is a value judgment. It was arrived at by the
9 team that put together WASH-1400. Perhaps Mr. Levine may
10 have more recollection of the reasoning that went into it,
11 I don't.

12 A (Witness Levine) I have only the most general
13 of recollections. It's almost 10 years. But I think there
14 were recommendations by various international bodies addressing
15 the subject matter.

16 Q It is not meant to imply that a dose delivered
17 below that level would not have a health effect.

18 A (Witness Kaiser) No, it's not.

19 Q Staying with paragraph 46, but to the next page,
20 down to line 5, the testimony states that the contaminated
21 areas could be easily identified by emergency response
22 personnel after the accident and controls on both of the
23 ingestion pathways and access to highly contaminated areas
24 could be put into effect. What would be necessary to identify
25 those areas?

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1 A Simply measurements of the levels of radioactive
2 contamination. For example, gamma counts and so on.

3 Q The measurements would have to take place over
4 an area much wider than the area that is actually to be
5 interdicted; isn't that correct?

6 A You would have to establish what are the areas
7 of the boundary, yes.

8 A (Witness Levine) I don't think that implies a
9 survey that is much wider than the actual area, but it would
10 be somewhat wider.

11 Q It would have to be surveyed within the entire
12 area over which the plume passes, wouldn't it?

13 A Yes, that's correct.

14 Q Has Applicant determined over what area that
15 might encompass?

16 A (Witness Kaiser) Yes, if we could turn to our
17 tables, Tables 5 and 6 give estimates of the areas that would
18 be contaminated with the associated frequencies.

19 Q Those areas set forth in the table are limited
20 to areas in which in fact the dose level exceeds the
21 threshold; isn't that right?

22 A That is how they're calculated, yes.

23 Q That is not the entire area over which the plume
24 passes, is it?

25 A Correct.

33pb3

1 Q So that the area required to be surveyed is in
2 excess of the area that is set forth in Tables 5 and 6, correct?

3 A Somewhat, yes.

4 Q Has Applicant determined over what area surveys
5 would have to be taken to determine the levels -- dose levels
6 requiring interdiction?

7 A (Witness Levine) No, we have not, but you should
8 recognize that in addition to land surveys, there are planes
9 available from the Department of Energy which have very
10 sensitive measuring instruments, which can measure rather
11 large areas of contamination very quickly.

12 A (Witness Hulman) There's also instrumentation
13 available through state agencies, through NRC, through EPA,
14 through the Air Force and the Army and a number of other
15 federal and state agencies.

16 Q You do not know whether the off-site surveying
17 arrangements for the Limerick site include access to Army
18 and Air Force survey equipment, do you?

19 A No, nor do I know of any requirement for such
20 an arrangement.

21 Q In fact those sources may not be utilized; is
22 that right?

23 A No.

24 Q Are you saying those resources will necessarily
25 be utilized?

33pb4

1 A In my judgment, yes.

2 Q But you do not know whether the actual arrangements
3 are in place for utilization of those resources, or whether
4 Applicant or the state are relying upon them, do you?

5 A I'd like to provide an answer and then Dr.
6 Acharya will add. To my knowledge, there are no arrangements,
7 formal arrangements for Limerick. There are national
8 radiation plans. There are emergency plans within NRC and
9 DOE that would call for this kind of survey.

10 Dr. Acharya wants to add.

11 A (Witness Acharya) I would like to add that it
12 is this kind in NUREG 0654 which is regarding the emergency
13 planning in which several federal agencies are identified
14 to take part in the environmental monitoring, such as FEMA,
15 EPA, DOE, Department of Health and Human Services. And
16 that measurements could -- the measurements could take place
17 as far as beyond the 50 miles procedures for accidents.

18 Such considerations are also concluded. I can
19 cite you the page in the document where it is stated. For
20 instance, in the same document, NUREG 0654 on page 11, Item
21 D, and on page 12 also. And page 27, 28 the item called
22 federal response and also it is addressed in emergency
23 support evaluation criteria on page 40 of the same document,
24 from the reading of which the scope and extent of the
25 involvement of federal agencies in the association can be

33pb5

1 figured out.

2 Q Applicant refers to controls on ingestion pathways
3 and access to highly contaminated areas. What controls does
4 that paragraph contemplate? What controls are contemplated
5 by that paragraph 46?

6 A (Witness Levine) I think these would be provided
7 for by the emergency response plans being developed by
8 federal agencies and states.

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1 Q Well, irrespective of how they may be carried out,
2 what kind of controls are you contemplating?

3 A (Witness Kaiser) The impoundment of crops and
4 milk in the more severely contaminated areas, now allowing
5 people access to those areas.

6 Q That might include residential areas, correct?

7 A Yes.

8 Q For land calculated to be interdicted in excess
9 of 30 years, what would those patrols consist of?

10 A (Witness Levine) It would be a permanent interdic-
11 tion to access of that land.

12 Q Would ownership remain with the residents?

13 A We don't know about that. I should say that
14 in our economic consequence model, we assumed the total value
15 of that land and appurtenances as a loss.

16 Q Would the areas have to be guarded?

17 A I suspect that's possible. I don't know.

18 JUDGE BRENNER: Mr. Elliott, can you enlighten
19 me as to how your last several questions relate to the
20 contention, which I thought went to a dispute that LEA had
21 with the disclosure as to the total land area in which these
22 interdictions would take place. Two being with respect to
23 crops, three being respect to milk, subpart A being with
24 respect to population.

25 MR. ELLIOTT: In response to it, Applicant has

1 testified it's a very simple matter to employ control
2 to limit the access of those areas, and it doesn't seem to
3 be a very simple matter to me.

4 JUDGE BRENNER: The contention wasn't whether
5 they could do it or not. The contention was whether the
6 potential area that would be affected is adequately disclosed.
7 Which relates a little bit, tangentially, I'll admit, to
8 a discussion we had at the admission stage to that
9 unfortunately not very bright line, to getting into emergency
10 planning details, as opposed to getting into environmental
11 assessment of the effects of impacts of postulated or
12 probabilistically weighted accidents, not postulated.

13 MR. ELLIOTT: Well, the contention did not merely
14 call for an estimate of the land area.

15 JUDGE BRENNER: I can tell you when we admitted
16 it, what we admitted was the contention that DES supplement
17 fails to adequately disclose or consider the total land area
18 in which crops will be interdicted, for example. So I think
19 we've gone beyond that already. I don't know whether you
20 plan to follow up on that, but I interjected when I did in
21 case you did. I want to stay with the contention.

22 I only have so many bins in my mind. And this
23 here, I'm here in my severe accident bin. And we can do the
24 severe accident planning some other time.

25 MR. ELLIOTT: Well, the difficulty that I have

1 is in response to the contention. Applicant has offered
2 all manner of other opinions in paragraph 47, including
3 what contribution the economic risk is, and so on. I think
4 it was fair for them to do that, because the contention did
5 not specifically address merely providing a numerical estimate
6 of the land areas involved, but I would like the opportunity
7 to explore the bases for the opinions that were expressed.

8 JUDGE BRENNER: They've got the -- as I understand
9 paragraph 47, they have expressed their estimates of the
10 land area that would be affected -- well, on one case for
11 crops; in your other subpart of the contention for milk;
12 and in the other subpart for population. They've taken those
13 estimates, probabilistically weighed, and then expressed
14 them in economic terms. That's not the same as your delving
15 into the details as to how they would guard the land, to
16 assure that interdiction was effective.

17 It's a whole different matter. I can tell you,
18 if you had a contention that proper plans have not been
19 arranged and letters of agreement have not been obtained,
20 as to how the National Guard or other police agencies are
21 going to keep people out of the land area that should be
22 interdicted, we would have rejected that as being a speculative
23 detail of an already way out there probabilistic assessment.

24 MR. ELLIOTT: Well, I would not have been
25 interested in pursuing that.

1 JUDGE BRENNER: That's the question that stimulated
2 my involvement a few moments ago, so apparently you were
3 interested then.

4 MR. ELLIOTT: Well, the reason --

5 JUDGE BRENNER: I don't want to prolong the debate.
6 If you want to question them as to how their expressions
7 in a cost benefit analysis of the estimates of the total land
8 area, which the risk of having those land areas subject to
9 interdiction, with respect to those three subjects in your
10 subparts 2, 3, and 8 of Contention DES-4 -- you can cross
11 examine that, as to how they got to those economic terms.

12 But I did not perceive that you were doing that.
13 You may recall that when I did interrupt you, I asked you to
14 enlighten me. That was not your initial point of enlightenment.
15 I've discussed it enough.

16 Go ahead and ask some questions, but keep in mind
17 the contention when you ask them. As you know, I cannot tell
18 from your cross plan what your questions are going to be,
19 unfortunately. It's quite a general plan.

20 BY MR. ELLIOTT:

21 Q With respect to the Applicant's opinion that it
22 should be stressed, the principal impact of these kinds of
23 contamination is economic, was the full socio-economic impact
24 examined or analyzed?

25 A (Witness Levine) No, PRAs generally do not evaluate

1 social impacts. In fact, if you look in compilations of
2 all kinds of accidents, including very large damage, these
3 are generally reported in fatalities, injuries, and dollars
4 in all fields. And I don't know -- I have not seen any models
5 to evaluate the sociological impacts of large impacts.

6 Q Just one question on a detail. Paragraph 49, with
7 respect to the fraction of farmland in Pennsylvania that was
8 used, has the basis for estimating the actual area of farmland,
9 and which crops may have to be interdicted, has the area
10 within the 50 mile radius of Limerick been evaluated to
11 determine whether the percentage of farmland may be greater
12 or less than the Pennsylvania average?

13 A (Witness Kaiser) Within 50 miles, we broke down the
14 figures on a county by county basis.

15 JUDGE COLE: I didn't hear that answer.

16 WITNESS KAISER: Within 50 miles, we broke down
17 the estimates of farmland fraction on a county by county basis.

18 JUDGE COLE: And where is that presented, sir?

19 WITNESS KAISER: That's presented in SARA, in
20 Chapter 10. It's in Table 10.11

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1 MR. WETTERHAHN: Which has been moved into evidence
2 and provided to the Board and the parties.

3 JUDGE BRENNER: It's part of Exhibit 152?

4 MR. WETTERHAHN: Yes, sir.

5 MR. ELLIOTT: I don't know that we have to address
6 it directly, but let me just ask Mr. Kaiser.

7 BY MR. ELLIOTT:

8 Q That data from that table is actually the data
9 used in your CRAC runs?

10 A (Witness Kaiser) Yes, it was.

11 Q As opposed to the .28.

12 A The .28 was also used for any parts of Pennsylvania
13 that were more than 50 miles from the site. Let me add that
14 we only used the .28 as an example.

15 Q Thank you.

16 MR. ELLIOTT: That's all I have on 2 and 3.

17 JUDGE BRENNER: I didn't see anything in your
18 cross plan on (a), and I thought it was naturally related
19 to 2 and 3.

20 MR. ELLIOTT: I'm not going to have any
21 cross-examination on (a) as an entity.

22 JUDGE BRENNER: So the only thing left on 4 is --

23 MR. ELLIOTT: Is 6 I believe.

24 JUDGE BRENNER: You also have (b). Where you
25 termed them general background questions, were those your

35pb2

1 questions on (b)?

2 MR. ELLIOTT: I'm not going to have any specific
3 cross-examination as a separate item.

4 JUDGE BRENNER: I'm trying to figure out how to
5 best proceed. Maybe you ought to just finish up with the
6 rest of your questions on 4, unless the parties would object.
7 How much do you have, if we would let you do that?

8 MR. ELLIOTT: I have a fair amount on (a)6, and
9 then what I would like to do, is to kind of tie it together
10 with some more general questions about what the Staff and
11 Applicant mean when they say the risks are small and that
12 they're not significant.

13 JUDGE BRENNER: I think we'd better let you finish
14 then, if you're going to come back to tie up those questions
15 at the end.

16 BY MR. ELLIOTT:

17 Q I have a series of questions for Mr. Richter on
18 DES page 6. Is it your opinion that the estimates provided
19 in your testimony are the best available data at the present
20 time?

21 A (Witness Richter) Yes.

22 Q The accident probabilities on which the health
23 cost are calculated are Limerick specific; isn't that correct?

24 A That's correct.

25 Q The health effects data upon which the health

35pb3

1 costs are based are also either Limerick specific or they
2 don't change from site to site; isn't that correct.

3 A They're national data.

4 Q Am I correct in saying that only the actual cost
5 factors that were used are not Limerick specific?

6 A I think that's right.

7 Q And the cost factors are national data averages;
8 is that correct?

9 A Yes, sometimes for example on the national cancer
10 survey, the cost data were taken from different areas of
11 the country. But in general the cost data represent a
12 national figure.

13 Q Do you have any reason to believe that the
14 Limerick area specific cost factors are likely to be
15 significantly different than the national data averages?

16 A No, I don't.

17 Q On what do you base that opinion?

18 A I was not -- I didn't look into that specifically,
19 but given the general knowledge and background I have, I have
20 no reason to believe that the Limerick area would be a higher
21 cost -- significantly higher cost than average.

22 Q In your testimony at paragraph 4, it is stated that
23 direct costs are all the costs associated with the treatment
24 of the patient, e.g., physician fees, hospital charges,
25 cost of medicines, et cetera. What is the "et cetera"? What

35pb4

1 else was considered?

2 A I could get that out of the HECOM publication.

3 Q Well, maybe we'll come back to it.

4 JUDGE BRENNER: Let's do it now.

5 WITNESS RICHTER: Drugs, nursing, special
6 equipment, radiation treatments, chemotherapy, and et cetera.

7 (Laughter.)

8 WITNESS RICHTER: These estimates are again based
9 on national averages from the third national cancer survey.
10 And the standard is to include the direct and indirect cost
11 in that composition.

12 BY MR. ELLIOTT:

13 Q Do you know whether the listing of items that
14 were calculated in determining the direct cost are complete?

15 A (Witness Richter) In HECOM or direct cost in
16 general?

17 Q In HECOM.

18 A No. As I mentioned in my testimony, transportation
19 cost were not included, and whether screening cost would be
20 a direct cost might be debatable. But as I said, those two
21 costs were not included in HECOM.

22 Q Your testimony also says that indirect costs are
23 the losses due to reduced productivity caused by disability
24 or premature death. Are any losses other than loss of
25 productivity considered?

35pb5

1 A No.

2 Q At page 4, last sentence, it is
3 stated that since the direct cost and the value of lost
4 labor occur over a number of years, the cost are discounted
5 to a base year and expressed in 1980 dollars. What was the
6 discount rate applied?

7 A Let me check on that. I believe that's a typo.
8 I should be '81 dollars, I'm sorry, having missed that before.
9 I believe it's a 10 percent discount rate. I'd have to check
10 it to be sure.

11 Q Is the base here 1981 then?

12 A No the base here is whatever year you might want
13 it to be. However it's expressed in 1981 dollars.

14 Q Are you verifying your 10 percent discount rate?

15 A Yes, I'll try to.

16 (Pause.)

17 A I'm sorry, no, that was 4 percent.

18 JUDGE BRENNER: What did you say it was?

19 WITNESS RICHTER: 4 percent. As I recall now,
20 originally when we received the model they had 10 percent
21 and we lowered it somewhat to 4 percent. I believe, however,
22 that OMB recommends 10 percent to be used, but we stuck with
23 4.

24 JUDGE BRENNER: A discount rate of 4 percent?

25 WITNESS RICHTER: Yes.

35pb6

1 JUDGE BRENNER: Could you explain to me how you
2 chose 4 percent?

3 WITNESS RICHTER: Given the slowdown in the rate
4 of inflation we thought 4 percent was more realistic.

5 JUDGE BRENNER: Did you have a base range or
6 moving averages upon which to select the 4 percent from?

7 WITNESS RICHTER: No, we were just working with
8 constant dollars in assuming a real rate, a real inflation
9 rate of 4 percent -- or a discount rate, excuse me.

10 BY MR. ELLIOTT:

11 Q So that is not the same discount rate that is
12 used for other economic analyses.

13 A (Witness Richter) Could you be more particular,
14 more specific on that?

15 Q Well, you say OMB recommends 10.

16 A Yes.

17 Q And what was the basis again for 4 rather than
18 10?

19 A The rate of inflation had not been as great
20 recently. And with the higher discount rate, the future
21 value of the projected cost would diminish more quickly
22 with the higher rate.

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1 JUDGE BRENNER: Let me see if I can put this
2 in simple terms, because it's been a while since I got
3 the degree in that subject. You would be willing to lend
4 me money at four percent today?

5 WITNESS RICHTER: Real rate discounting inflation.

6 JUDGE BRENNER: But did you have a series of years
7 upon which to base the discount rate, or did you just take
8 what you saw as the current state of affairs at this snapshot
9 point in time?

10 WITNESS RICHTER: We did the snapshot point in time.

11 JUDGE BRENNER: Was that the usual way to project
12 a discount rate?

13 WITNESS RICHTER: The way rates have been going,
14 over this past several years, it's anyone's guess. We thought
15 it was a more conservative approach. As I have said, the
16 higher the discount rate, the quicker the cost would be
17 discounted in the future. So we didn't want to go overboard
18 on that.

19 JUDGE BRENNER: Mr. Elliott, I'm sorry for the
20 interruption.

21 BY MR. ELLIOTT:

22 Q Why were costs expressed in 1981 dollars?

23 A (Witness Richter) Just to have a constant fixture
24 to discount the effects of inflation.

25 Q Would it be possible to apply a historical

1 inflation rate to arrive at 1984 dollars?

2 A Yes, there is a consumer price index breakdown
3 of the medical -- cost of medical care, et cetera, although
4 the data for 1984 probably wouldn't be available till next
5 year.

6 Q Do you know what it was broken out for medical
7 cost for 1983?

8 A No, I don't. I know roughly between '80 and '81
9 -- depending upon the subcategory -- it was in the two to
10 three percent range.

11 Q Per year?

12 A Yes.

13 Q Because you have applied a discount rate, the
14 figures do not reflect what, in fact, would be spent in the
15 future but rather the present value of those future
16 expenditures, isn't that correct?

17 A This is assuming the accident would happen now and
18 discounting the future cost, as well as providing a value for
19 the cost occurring this year. So if the cost occurred -- if
20 the accident occurred mid-life of the plant, looking from this
21 point in time forward, those costs would be much less. That's
22 why I said it's discounted to a base year. You can adjust
23 for the base year.

24 So while the cost might be more, I think our dollar
25 value expressed in the '81 dollars is a representative one.

361b3

1 Q But the actual dollars spent will be higher than
2 the dollar figures that are reported in this document, isn't
3 that correct?

4 A If inflation continues to grow, although discounted,
5 they would be less if an accident occurred.

6 Q Has any count been taken of the likely increase
7 in the rate of treatment cost in the next 20, 30 years?

8 A Yes.

9 Q How is it taken into account?

10 A We --

11 (Pause.)

12 Now there's a rate of growth, both for income and
13 health cost, and we have both of those at one percent. That's
14 in real terms.

15 Q That is in comparison to the two to three percent
16 that you had mentioned earlier, with respect to 1980 and 1981?

17 A Those were not in real terms. Those were in
18 current terms.

19 Q How much difference is there between the two?

20 A I don't know right off. I'd have to check. PNL
21 did a sensitivity analysis of treatment cost and they estimated
22 the range of uncertainty and treatment cost is estimated
23 to be 30 percent. Varying treatment costs by 30 percent
24 results in an identical percentage change in direct cost and
25 a 15.2 variation in total health effects cost.

361b4

1 Q Do you have the --

2 A Page 7.19 and I'm sorry. I actually should have
3 been referring to Section 7.4.3, sensitivity to treatment
4 cost escalation.

5 Q Doesn't that table show that the HECOM cost
6 estimates are extremely sensitive to treatment cost
7 escalation assumptions?

8 A Yes.

9 Q That sensitivity showed that if a five percent
10 rate of treatment cost were assumed, the direct cost would
11 increase over 1400 percent? Isn't that correct?

12 A Over 300 years, I guess that is. The elasticity
13 turns out to be about 3.62.

14 Q The 300 years is because it is necessary to model
15 the cost of the genetic effects over that period of time,
16 correct?

17 A That's correct. However, we did not include
18 genetic cost in our runs of HECOM.

19 Q You did not?

20 A No, we didn't.

21 Q What is the relative contribution to cost of the
22 genetic effects, as opposed to the other health effects?

23 A Relatively small. One reason is because of the
24 genetic effects occurring on future generations. That's the
25 main reason.

1 JUDGE BRENNER: Dr. Richter, I'm not sure I
2 understand. Maybe you didn't expressly complete your
3 thought. The health effects would be small, in your view,
4 with respect to genetic effects, because they would occur
5 over succeeding generations?

6 WITNESS RICHTER: That's right. The cost would be
7 discounted.

8 BY MR. ELLIOTT:

9 Q What would be the relative contribution if the
10 costs were not discounted?

11 A (Witness Richter) Right off, I don't know, but I
12 don't -- that wouldn't be standard economic practice.

bul0 13 Q Paragraph 8 makes reference to screening and
14 transportation cost?

15 A Yes.

16 Q It makes reference to surveillance of people who
17 could have been exposed to radiation. What testing or
18 surveillance is contemplated by that paragraph?

19 A Perhaps --

20 A (Witness Hulman) Following a severe reactor
21 accident, it is anticipated that a number of people would
22 consult their physicians and seek diagnosis, as to whether they
23 had received doses of radioactivity requiring medical treatment.
24 Physicians, medical teams, and hospitals, and in private
25 service and in public service would be anticipated to

1 participate. Those costs of diagnosis and testing, the
2 cost of potential repeat visits on the part of people, are
3 all in that general category. There are a number of tests
4 and there are a number of different types of surveillance.

5 Q Such as?

6 A In which category?

7 Q Either one, testing or surveillance. What are
8 you talking about?

9 A Under testing, if there is reason to believe
10 that a patient has received doses of radioactivity that
11 could be indicative of early health effects, lymphatic --
12 lymphocyte counts, blood counts involving lymphocytes would
13 be undertaken to see whether the blood structure had been
14 modified by radiation.

15 end36
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1 Q Anything else?

2 A There are a number of tests that have been
3 described. I don't remember the others at this point.

4 Q What about surveillance?

5 A Surveillance. If a patient exhibited some of
6 the early health effects -- vomiting and the like --
7 physicians have said that they would put that patient
8 under surveillance to determine whether it was due to
9 actually radiation or whether it was due to just the fear
10 of radiation.

11 Q What would the surveillance consist of?

12 A Watching the patient.

13 Q In the hospital?

14 A It could either be in the hospital, it could be
15 at home, it could be in the doctor's office. If there was
16 no evidence of radioactivity on the person's body, there
17 was no evidence of any -- there was no evidence that the
18 individual had been in the plume or close to the plume,
19 or in any area after the plume had passed, but still
20 evidenced symptoms of early health effects, the doctor
21 would want to make certain, in our opinion, that that
22 patient had not indeed for some reason or other unknown to
23 him received a dose.

24 Q How about latent health effects? What kind of
25 testing and surveillance is contemplated for that category?

1 A Surveillance for and testing of latent health
2 effects would go on for the entire period for which those
3 effects could be predicted.

4 Q The entire period of time that the person is at
5 risk; is that it?

6 A Yes.

7 Q That's the whole lifetime; right?

8 A Yes, I think that's evidenced by what has happened
9 after the weapons in Japan. Those tests and surveillance
10 are still going on.

11 Q The numbers of people involved could be quite
12 large, could they not?

13 A Depending upon the particular accident, they
14 could be large, they could be small.

15 Q What is the basis for the 1 percent figure in
16 paragraph 9?

17 A (Witness Richter) As I stated, I just checked
18 a round-trip flight to Chicago, for no better reason than
19 to come up with sort of a midpoint estimate, I thought,
20 back-of-the-envelope only, and added the \$250 cost to the
21 other costs incurred per patient.

22 Q Is that a 1981 airfare?

23 (Laughter.)

24 A No, I'm afraid I missed it there. It's 1984.

25 Q That seems cheap to me.

1 JUDGE COLE: The government has to fly tourist
2 class.

3 (Laughter.)

4 BY MR. ELLIOTT:

5 Q Do we have any idea at all what the cost increase
6 if the screening and surveillance and the testing is taken
7 into account, do we have any idea at all what it might be?

8 A (Witness Richter) No, especially not on the
9 screening. As I said, I think transportation costs would
10 increase the estimate perhaps 1 percent, but screening -- I
11 don't believe there are any good numbers available -- any
12 estimates available for that.

13 Q With respect to the work loss component of those
14 costs, as I understand it, the work loss calculations with
15 respect to radiation injuries is limited to a one-year
16 period; is that right?

17 A I believe that is correct.

18 Q That's because the patient is assumed either to
19 live or if he doesn't, to die within that first year?

20 A That's correct, for the injuries.

21 Q How about with respect to cancers?

22 A Cancers are treated differently. My testimony
23 answer in 7, I mentioned the value of lost labor. It is
24 based on weeks of work missed for each type of illness,
25 and the expected income for individuals of a given age and

1 sex. The model takes into account the probability of death
2 in the time period since exposure.

3 Q Does that model assume as the period of risk
4 an entire lifetime?

5 A Depending upon the period of latency, yes. I
6 think it might differ as to the particular types of cancers.

7 Q These cost estimates do depend upon the CRAC2
8 health effects output run by the Staff and the probabilities
9 associated with the various release categories in your
10 Attachment 1 and 2; is that right?

11 A I had a hard time hearing. I think you said
12 CRAC2, and these were based on CRAC1, or CRAC, just regular
13 CRAC.

14 Q With that correction, the costs depend upon the
15 CRAC runs made by the Staff?

16 A That is correct.

17 Q And they depend upon the probabilities of the
18 various release fractions that are set forth in your Table 1?

19 A That is correct.

20 Q Could one construct a crude graph similar to a
21 CCDF curve by applying the average cost values on an axis
22 as against the assigned probabilities of these release
23 categories?

24 A One could do it. Right off, I'm not sure if it's
25 mathematically or statistically correct. The average value

1 that we worked with is based on 91 simulations times the
2 16 wind directions for each accident sequence, so we
3 wouldn't have as many data points, obviously.

4 Q Has Staff calculated a per reactor year risk
5 estimate for these costs?

6 A Yes. They are given in Tables 1 and 2.

7 Q So in a summary, in Attachment 1, page 2 of 2,
8 the line total risks, the last column, total costs (risk),
9 that is a per reactor year cost estimate?

10 A Yes. I think Table 3 gives the complete risk
11 for both the early and late evacuation scenarios.

12 Q At paragraph 11, Staff says that with respect to
13 impacts, the absolute costs are large. Compared to what?

14 A I think in absolute terms the hundreds of millions
15 of dollars is at large. That might occur under some
16 sequences.

17 Q For some sequences, is in excess of a billion;
18 correct?

19 A Yes.

20 Q In fact, as I look at it now, in excess of 2
21 billion on Table 2.

22 A There are several, yes.

23 Q When you say --

24 A However, those with the 2 billion total cost
25 on a risk basis are \$111, \$105, \$110, on a per reactor year

1 basis.

2 Q That's because of the low probability?

3 A Exactly.

4 Q Health costs can be a substantial portion of
5 the total economic impact of a reactor accident; isn't
6 that correct?

7 A It could be.

8 Q It is not so in the case of Limerick; is that
9 your opinion?

10 A Yes.

11 Q What is the basis of that opinion?

12 A Looking at the risks of the other costs estimated.

13 Q So your opinion is based on the fact that with
14 respect to other types of costs at Limerick, the other types
15 of costs are extremely high?

16 A I didn't say extremely high. Again, they are
17 relatively greater than the health care costs. I should
18 say health costs.

19 Q So the opinion with respect to relative
20 insignificance is a comparison between the health costs and
21 the other types of economic costs associated with severe
22 accidents at Limerick?

23 A You are referring to A-11 again?

24 Q Yes.

25 A I think on a dollar value of risk, the relatively

1 small risks values stand on their own, as well as in
2 comparison with the other risk dollar values.

end 37

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38pbl

1 Q Going back now to Staff's testimony page 15,
2 paragraph 26, that opinion is expressed I assume with respect
3 to the testimony in that section was Mr. Richter's analysis
4 factored in?

5 A I have to check that. Hold on, please.

6 Yes. Are you asking if I agree with that conclusion?

7 Q I'm asking if Mr. Richter's costs were considered
8 when the opinion in paragraph 26 was made.

9 A (Witness Hulman) Yes.

10 Q How was it considered?

11 A In the manner in which he described in terms of
12 the relative contribution to risk, plus the understanding
13 that the likelihood of accidents that would contribute such
14 risks were low.

15 Q Compared to what?

16 A Compared to other kinds of accidental risks that
17 the public is generally exposed to, and to the background
18 cancer risk.

19 Q What criteria were used in making a judgment that
20 a risk is small, or that it is not significant?

21 A Small fractions.

22 Q Was any numerical criteria applied?

23 A Small fractions and it's described in the FES in
24 terms of what the comparison was. If you'd like the exact
25 reference I can give it to you.

38pb2

1 Q I'm asking whether there is a numerical criteria
2 against which one measures the standard of significance or
3 insignificance.

4 A I answered that as small fraction. That's the
5 criteria we have used.

6 Q What is a small fraction?

7 A A number less than 50 percent. In this particular
8 case, it is substantially less than that.

9 Q Is it your opinion that any fraction which is
10 less than 50 percent is not significant?

11 A No.

12 Q So then the 50 percent criteria is not the one
13 you actually use; isn't that correct?

14 A No.

15 Q What numerical criterion do you use?

16 A We use -- we made a comparison. The comparison
17 is identified in the FES. Let me see if I can find it.

18 (Witness Hulman examining document.)

19 A If I understand your question correctly, you
20 wanted to know what criteria we used.

21 Q I want to know what numerical criteria were used,
22 if any.

23 A Numerical criteria were not used directly. What
24 was used was a comparison of the estimated risks to the
25 ratio -- to late cancer fatality risks, in the bottom paragraph

38pb3

1 on page 5-99 of the FES, and to the risks an individual
2 would see from accidental death from other causes.

3 In the middle paragraph of page 5-100 there is
4 further information in the intervening paragraphs, but the
5 conclusion that we came to is that the ratios were small
6 numbers, small fractions. And a specific numerical criteria
7 of how small was not established. It's the fact that the
8 ratio was so small that we concluded that the risks were not
9 significant. No criteria was established other than a
10 judgment, small.

11 Q What is a fraction that is not small?

12 A One.

13 Q What is a fraction that is not small. One is a
14 unity.

15 A It's a fraction. It's one divided by one.

16 Q Isn't one divided by one, unity?

17 A Yes, that's what I just said.

18 Q What is a small fraction?

19 A Something less than 50 percent.

20 Q That's your definition?

21 MR. WETTERHAHN: Objection. Asked and answered.

22 He has asked the same question four times.

23 JUDGE BRENNER: I think we've got it many times
24 already.

25 MR. ELLIOTT: I don't think we have.

38pb4

1 I'm asking for definition.

2 JUDGE BRENNER: You asked for definition of a
3 small fraction, and he kept telling you 50 percent or less.

4 MR. ELLIOTT: Okay, that's the definition.

5 JUDGE BRENNER: That's his definition.

6 BY MR. ELLIOTT:

7 Q So that the risk posed by the Limerick facility
8 could be upwards up to 50 percent of the risk posed by all
9 other sources, and still be considered insignificant; is
10 that correct?

11 MR. WETTERHAHN: Objection. That's the same
12 question rephrased.

13 JUDGE BRENNER: No, he's entitled to pursue this
14 line. It's not the same question rephrased. It's the
15 natural followup of Mr. Hulman's definition.

16 WITNESS HULMAN: No, sir.

17 BY MR. ELLIOTT:

18 Q Why not?

19 A (Witness Hulman) Because the actual computation
20 showed much smaller fractions.

21 Q So it would have to be somewhat less than 50
22 percent for you to reach the conclusion that it's not
23 significant; isn't that correct?

24 A I can't make that judgment. I don't know. If
25 the computations had come up differently, we may have come

38pb5

1 to a different conclusion.

2 Q Whose judgment was it? Was it your judgment?

3 A It was a judgment of a number of people.

4 Q Made by who?

5 A Dr. Acharya participated. His supervisor
6 participated.

7 Q Who is?

8 A Jaques Reed. J-a-q-u-e-s. I participated. My
9 assistant director, Daniel Muller participated. Our division
10 director, Roger Mattson participated. And Mr. Denton
11 participated.

12 Q Were these discussions held simultaneously in
13 conference?

14 A No. Some of them were simultaneous and some of
15 them were serial.

16 Q When did they take place?

17 A I don't remember the dates specifically, but
18 prior to publication of the FES.

19 Q Are these discussions documented somewhere?
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1 A The discussions themselves, I think one or more
2 may be. But I am not certain. Many of them are not.

3 JUDGE BRENNER: Mr. Elliott, I'm lost on the
4 materiality of this last series of questions. I mean, I don't
5 care if they had 2,000 staff members who concurred on that
6 decision. We've got the numbers before us, and we've got
7 to decide the case.

8 MR. ELLIOTT: I'm trying to find out what the
9 process was, what was the actual decision-making process.

10 JUDGE BRENNER: To some extent, that may be fair
11 game, although I'm not sure to what extent. But I think it's
12 fair to say that you went into unnecessary detail to establish
13 that in some of your recent questions.

14 WITNESS ACHARYA: I can provide some --

15 JUDGE BRENNER: Wait for the questions. Talk to
16 your own counsel, if there are things you want to say on
17 redirect.

18 BY MR. ELLIOTT:

19 Q If we assume that the actual risk is at the upper
20 bound of the uncertainty range, that is 40 times higher than
21 these estimates, what impact on significance would that make?

22 A (Witness Hulman) We believe we've considered that
23 and would have the same judgment. I believe we've considered
24 the uncertainties.

25 Q How were they considered?

391b2

1 A As described in the FES.

2 Q At the probability levels involved here, are there
3 any consequences which would be considered significant?

4 MR. WETTERHAHN: Objection, that question is not
5 comprehensible.

6 JUDGE BRENNER: All right. Why don't you ask it
7 again, Mr. Elliott?

8 MR. ELLIOTT: Okay.

9 BY MR. ELLIOTT:

10 Q In making an assessment of significance, attention
11 is to be paid to both probability and consequences, is that
12 correct?

13 A (Witness Hulman) Yes.

14 Q As the probability levels rise, so does the
15 significance, isn't that correct?

16 A It depends on the magnitude of the consequences.

17 Q In relative terms, purely relative terms, as
18 probability of any given consequence rises, does not the
19 significance of that consequence increase, also?

20 A The consequence stays the same, yes. If the
21 consequence varies, I don't know the answer. And certainly,
22 consequences is a very large variable.

23 Q I understand. Assuming we look at an axis with
24 probabilities on the left hand side and consequences on the
25 other axis, assuming a given probability level, as the

1 consequences increase at that level, does not the significance
2 of those consequences increase also?

3 A I don't know what -- I don't understand the
4 question. Would you please rephrase it?

5 JUDGE BRENNER: I don't understand that one either,
6 Mr. Elliott. I'm sorry.

7 JUDGE MORRIS: It sounded to me like you were
8 saying that the probability was constant, but you were
9 increasing the magnitude of the consequences so the CCDF
10 would have a larger area under the curve. Is that what you
11 meant?

12 MR. ELLIOTT: Yes.

13 BY MR. ELLIOTT:

14 Q And in that event, would not the significance
15 one attributes to the consequences increase?

16 A (Witness Hulman) As described by Dr. Morris, yes.

17 JUDGE BRENNER: Mr. Elliott, I don't know where
18 we're going. You've assumed all the variables in your
19 question.

20 MR. ELLIOTT: The only point I'm trying to make
21 is that significance is a relative term that increases and
22 decreases with either one of the two axes.

23 JUDGE BRENNER: I think we understand what the
24 definition of risk is.

25 MR. ELLIOTT: Well, I'm trying to get the
definition of significance.

1 Okay. That's all. That's all I have.

2 JUDGE BRENNER: Let me get time estimates on what
3 the other parties have on DES-4. Is there going to be
4 any follow-up by the City? No?

5 Commonwealth?

6 Applicant?

7 MR. WETTERHAHN: Yes, about a half hour at the
8 most.

9 JUDGE BRENNER: Staff?

10 For the Applicant and Staff in each case, it is a
11 combination of follow-up and redirect.

12 Staff?

13 MS. HODGDON: I can't say definitely, but we
14 don't have very much.

15 JUDGE BRENNER: We don't have very much, either,
16 in terms of Board questions. After 4, we will go immediately
17 to DES-3 with I guess essentially the same panel. You
18 can talk among yourselves and decide whether some of the
19 additional witnesses need be there, such as Dr. Pratt. But
20 talk to the other parties about it first.

21 MR. WETTERHAHN: I have one question concerning
22 Dr. Pratt, and as far as I'm concerned, he can leave
23 tonight, unless someone else has a question.

24 JUDGE BRENNER: I don't know if the Staff is
25 going to have questions for him also. Is he going to be

1 here tomorrow, in any event, Ms. Hodgdon?

2 MS. HODGDON: Yes, but Mr. Richter would not be
3 required tomorrow, so --

4 JUDGE BRENNER: We just had a whole round of
5 his questions for which we have not yet gotten to the
6 follow-up.

7 MS. HODGDON: Okay.

8 JUDGE BRENNER: We can't isolate it that quickly.

9 MS. HODGDON: Okay, that's true.

10 JUDGE BRENNER: Maybe we can find out in a hurry.
11 I don't know.

12 Do you have any questions of Mr. Richter?

13 MR. WETTERHAHN: I do want to consult with my
14 panel first.

15 MS. HODGDON: Mr. Richter can stay.

16 JUDGE BRENNER: All right. I'm sure he will
17 appreciate your offer on his behalf.

18 WITNESS RICHTER: I don't have any problems
19 with that.

20 JUDGE BRENNER: Thank you. We have been
21 searching through this whole hearing for a witness who
22 didn't have any problems. So we appreciate that, seriously.
23 Just for that, we won't ask you what airport in Chicago you
24 assumed for your value.

25 (Laughter.)

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I think it was the "Midway Special."

We would recommend -- but if any party has a problem we won't do it -- we would recommend starting at 8:30 tomorrow, to compensate for taking a two-hour lunch break. Does anybody have a problem with that? If you have a problem, let me know. I am really anxious to finish as much as we can this week and although Ms. Bush keeps pushing for a Friday session, I had told the parties that we would not have a Friday session and I am not going to. If any party has an objection to a Friday session, as far as the Board is concerned, we could be here half a day on Friday, but --

MS. BUSH: I wasn't pushing for a Friday session. I was saying next week.

JUDGE BRENNER: Yes, I know. I told you I don't want to lose half a day willy-nilly because of what happens at these proceedings.

MS. BUSH: I wasn't pushing for Friday this week.

JUDGE BRENNER: We are going to have to know a whole lot more about the timing for next week before we start next week, and it may be that the Friday morning session was the only way I would have been willing to trade it off, because I am not going to give up the option of finishing all these issues, plus accommodating anything else we have to do on the welding issue by the time of completion

1 of next week. That has been long scheduled, and I have
2 said that already, but we will revisit it at the end of
3 tomorrow.

4 All right. So we will start at 8:30 tomorrow.

5 Ms. Bush, do you want to give us that one sentence?

6 MS. BUSH: Yes. For the City's revised
7 emergency planning document, page 10, issue No. 9,
8 between the words "emergency measures to be," after "to be"
9 insert "provided and the," and then "mutually" follows
10 after that. So it reads, "The emergency measures to be
11 provided and the mutually acceptable criteria for the
12 implementation," and the reference for that is --

13 JUDGE BRENNER: That's a direct quote?

14 MS. BUSH: Yes. NUREG 0651, Section 2-A-3, page
15 32.

16 JUDGE BRENNER: Let me make one point. I don't
17 need any debate on it with respect to the City's issues. I
18 know the parties are under a tight time frame and will be
19 getting the answers under the schedule we had established.
20 Mr. Smollen is handling this for the City, so presumably
21 counsel for the other parties working on this can be in
22 communication with Mr. Smollen for the preparation of their
23 answers.

24 We have a problem pulling out what the words of
25 the contention are, as opposed to the other verbiage in this

1 filing. It is just not clear, and we are going to have to
2 resolve that sooner or later and it is better to resolve it
3 sooner.

4 One way to do it is for the parties to be in
5 communication and when they file their answers, to in the
6 answers reflect the fact that they havemet with counsel
7 for the City and have identified which portions of this
8 rather lengthy filing is the actual wording of the
9 contention. Because sometimes I think I have the wording
10 of the contention at the beginning of the subject, and
11 then two pages later it says "and also," and I don't know
12 what to do with that sometimes.

13 So we should get that clarified at the time of
14 the filing of the parties' answers, and the parties can
15 include that understanding in their answers, and perhaps
16 it would help if the City, on the same date as the parties'
17 answers, refiled just a separate listing of the issues,
18 which is what we had asked for. And I suspect we will have
19 to schedule some sort of argument on these issues if it is
20 not otherwise settled, and I know negotiations are hopefully
21 still going on. If they are not otherwise settled, we will
22 have to pick up for some time that one week in June when
23 we will be back on the water issues of City 15, anyway.

24 MS. BUSH: June 19, that would be.

25 JUDGE BRENNER: Yes. So be alert for the fact

1 that some time that week we will have the schedule
2 discussion or argument, label it what you will, on the
3 admissibility of these issues.

4 I am hoping that some of them go away by then,
5 but maybe they won't. But, in any event, we need to know
6 what the issue is.

7 MS. BUSH: Yes, sir. I'll tell Mr. Smollen.

8 JUDGE BRENNER: Okay. We'll adjourn for the day
9 and be back at 8:30 tomorrow morning.

10 (Whereupon, at 5:17 p.m., the hearing
11 was recessed, to reconvene at 8:30 a.m.,
12 Thursday, May 24, 1984.)

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CERTIFICATE OF PROCEEDINGS

1
2
3 This is to certify that the attached proceedings before the
4 NRC COMMISSION

5 In the matter of: PHILADELPHIA ELECTRIC COMPANY

6 Date of Proceeding: Wednesday, May 23, 1984

7 Place of Proceeding: Philadelphia, Pennsylvania

8 were held as herein appears, and that this is the original
9 transcript for the file of the Commission.

10
11 Ann Riley

12 Official Reporter - Typed

13 *Ann Riley*

14 Official Reporter - Signature