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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

In the matter of:

CAROLINA POWER & LIGHT COMPANY
and NORTH CAROLINA EASTERN
MUNICIPAL POWER AGENCY

Docket No. 50-400 OL
50-401 OL

(Shearon Harris Nuclear Power Plant,
Units 1 & 2)

Location: Raleigh, North Carolina Pages: 1861-2163

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of:	:	
CAROLINA POWER & LIGHT COMPANY	:	Docket Nos.
and NORTH CAROLINA EASTERN	:	50-400 OL
MUNICIPAL POWER AGENCY	:	50-401 OL
Shearon Harris Nuclear Power Plant, Units 1 and 2	:	

Old Post Office Building
Courtroom 205
300 Fayetteville Street
Raleigh, North Carolina

Tuesday, June 19, 1984

The hearing in the above-entitled matter convened, pursuant to recess, at 8:40 a.m.

BEFORE:

JAMES L. KELLEY, ESQUIRE, Chairman
Atomic Safety and Licensing Board
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

DR. JAMES H. CARPENTER, Member
Atomic Safety and Licensing Board
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

DR. GLENN O. BRIGHT, Member
Atomic Safety and Licensing Board
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

DR. HARRY FOREMAN
Technical Interrogator

mgc 2

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I N D E X

EXHIBITS

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PROCEEDINGS

JUDGE KELLEY: On the record. Good morning. Last evening we finished up with the Applicant's panel on Contention II(e) and that brings up this morning to the Staff's witness. Let me ask first if there's anything to be taken up before we hear from Dr. Branagan?

(No response.)

JUDGE KELLEY: Ms. Moore?

MS. MOORE: Your Honor, the Staff calls Dr. Edward F. Branagan, Jr. and asks that the witness be sworn. Whereupon,

EDWARD F. BRANAGAN, JR.

a witness, called for examination and, having been first duly sworn was examined and testified as follows:

DIRECT EXAMINATION

BY MS. MOORE:

Q Dr. Branagan, would you please state your name and business address for the record?

A My name is Edward F. Branagan, Jr. I am with the U.S. Nuclear Regulatory Commission in Washington, D.C.

Q Would you please identify your position with the NRC?

A I am a senior radiobiologist in the radiological assessment branch.

Q Do you have before you a document entitled NRC

Staff testimony of Edward F. Branagan, Jr. on Joint Contention II (e)?

A Yes, I do.

Q Was this testimony prepared by you, or did you participate in its preparation?

A Yes, I did.

Q Is this testimony true and correct to the best of your knowledge, information and belief?

A Yes, it is.

Q Do you adopt this as your testimony in this proceeding?

A Yes, I do.

MS. MOORE: Your Honor, copies of this testimony have been delivered to the Board, parties and the court reporter. I ask that the testimony and the attached professional qualifications be admitted into evidence and bound into the record as if read.

JUDGE KELLEY: Dr. Branagan's testimony will be admitted and bound as requested.

(The prepared testimony of Edward F. Branagan, Jr. follows:)

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NUCLEAR REGULATORY COMMISSION

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CAROLINA POWER AND LIGHT COMPANY AND	)	Docket Nos. 50-400-OL
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POWER AGENCY	)	
	)	
(Shearon Harris Nuclear Power Station,	)	
Units 1 and 2)	)	

NRC STAFF TESTIMONY OF
EDWARD F. BRANAGAN, JR. ON JOINT CONTENTION II (c)

Q.1. Dr. Branagan, please state your name and affiliation.

A.1. My name is Edward F. Branagan, Jr. I am a Senior Radiobiologist in the Radiological Assessment Branch, Division of Systems Integration within the Office of Nuclear Reactor Regulation. A copy of my professional qualifications is attached.

Q.2. Dr. Branagan, what is the purpose of this testimony?

A.2. The purpose of this testimony is to address Joint Contention II subpart (c). Joint Contention II (c) as originally admitted states:

Joint Contention II

The long term somatic and genetic health effects of radiation releases from the facility during normal operations even where such releases are within existing guidelines, have been seriously underestimated for the following reasons: (c) the work of Gofman and Caldicott shows that the NRC has erroneously estimated the health effects of low-level radiation by examining effects over an arbitrarily short period of time compared to the length of time the radionuclides actually will be causing health and genetic damage.

The Board modified this contention in it's Order of January 27, 1984 (pp 39-41). This modification focused on the following issues:

(1) Whether the environmental impact statement should provide the total risk associated with exposure to radioactive effluents from normal operations for the 40-year life of the plant; and (2) whether the environmental impact statement should take into account the incremental impact on people who live near the plant for many years.

Q.3. Over what time period did the Staff estimate radiological impacts from exposure to effluents released from Shearon Harris during normal operation?

A.3. The time period for evaluating doses is described in the FES, page 5-26, as follows:[1/]

> When an individual is exposed through one of these pathways, the dose is determined in part by the amount of time he/she is in the vicinity of the source, or the amount of time the radioactivity inhaled or ingested is retained in his/her body. The actual effect of the radiation or radioactivity is determined by calculating the dose commitment. The annual dose commitment is calculated to be the total dose that would be received over a 50-year period, following the intake of radioactivity for 1 year under the conditions existing 20 years after the station begins operation. (Calculation for the 20th year, or midpoint of station operation, represents an average exposure over the life of the plant.) However, with few exceptions, most of the internal dose commitment for each nuclide is given during the first few years after exposure because of the turnover of the nuclide by physiological processes and radioactive decay.

1/ As utilized in this testimony, "dose" refers to the "dose equivalent" for an individual and the "collective dose-equivalent commitment" for a population.

Q.4. Did the staff present "the total risk represented by the life of the plant" in the FES?

A.4. No. Radiological impacts from exposure to effluents released from Shearon Harris during normal operations were presented on an annual basis in Section 5.9.3 and Appendix D of the FES.

Q.5. Why were radiological impacts presented on an annual basis, rather than summed over the life of the plant?

A.5. There are several reasons. First, applicable regulations (i.e., 10 CFR 20; and 10 CFR 50, Appendix I) contain annual limits or design objectives, rather than cumulative limits or design objectives. Second, the benefits from operating the plant were expressed on an annual basis in the FES. Integrating the impacts over the lifetime of the plant would be counterbalanced by integrating the benefits over the lifetime of the plant.

Q.6. Can the Staff provide an upper bound estimate of the incremental impact on people who live near the plant for many years as a result of exposure to radioactive effluents from normal operations?

A.6. Yes. The Staff has estimated the incremental impact on people who live near the plant for many years (hereinafter referred to as the cumulative impact) in the following manner. First, the Staff conservatively estimated the dose to the total body that a member of the public might receive from exposure to radioactive effluents from one year of normal operations. Second, the Staff multiplied

the dose from one year of operations by 40 years of reactor operations to estimate the cumulative dose for 40 years. Finally, the Staff estimated the risk of potential fatal latent cancers to the exposed individual by multiplying the cumulative dose by health risk estimators.

Q.7. For the purpose of estimating cumulative risk, how did the Staff estimate the dose that a member of the public might receive from exposure to radioactive effluents from normal operations of Shearon Harris Unit 1?

A.7. In Appendix D of the FES, the Staff presented its analysis which showed that the Shearon Harris plant had sufficient waste treatment systems to meet the dose design objectives in Appendix I of 10 CFR Part 50.[2/] Operation of the Shearon Harris facility will be governed by operating license Technical Specifications that will be based on the dose-design objectives of Appendix I to 10 CFR 50. Because these design-objective values were chosen to permit flexibility of operation while still ensuring that doses from plant operations are "as low as reasonably achievable," the actual radiological impact of plant operation may result in doses close to the dose-design objectives. For the purpose of this testimony, the Staff based its dose estimate to a maximally exposed individual on the annual

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2/ Some of the estimates in the FES pertain to operation of a two-unit facility. Since Unit 2 has been cancelled, the Staff in this testimony has provided cumulative risk estimates for operation of one unit at the Harris site.

dose-design objectives in Appendix I of 10 CFR Part 50 for exposure to the various types of radioactive effluents.

Q.8. What are the dose design objectives in Appendix I?

A.8. Appendix I of 10 CFR Part 50 provides numerical guidance on dose-design objectives for lightwater reactors to assure that doses to the public are as low as reasonably achievable.

The annual dose-design objectives in Appendix I for all unrestricted areas are as follows: 3 mrem/yr per reactor to the total body or 10 mrem/yr per reactor to any organ from all pathways of exposure from liquid effluents; 10 mrads/yr per reactor gamma air dose, or 20 mrads/yr per reactor beta air dose from noble gaseous effluents or 5 mrems/yr per reactor to the total body or 15 mrems/yr per reactor to the skin from noble gaseous effluents whichever is more limiting; and 15 mrems/yr per reactor to any organ from all pathways of exposure from airborne effluents that include the radioiodines and particulates.

Q.9. What dose did the Staff use in estimating the possible risk to an individual in the public?

A.9. The Staff has assumed that a hypothetical individual will be exposed to 5 mrems/yr to the total body. For 40 years of plant operation, the cumulative dose would be 0.2 rems. This is a conservative estimate of the dose to an individual, because it is unlikely that an individual will be simultaneously exposed at the dose-design

objective levels from gaseous and liquid effluents to the same body organs for 40 years. Actual doses to real individuals in the near vicinity of the site are expected to be a fraction of the dose of 0.2 rems. In order to obtain a dose of 0.2 rems, an individual would have to spend almost all of his or her time at the site boundary, and obtain almost all of his or her food grown at an offsite location where the highest concentrations of radionuclides are expected. The average dose to an individual within 50 miles of the site is expected to be about 500 times less than the preceding value. (FES, Table D-7, p. D-10).

Q.10. How did the Staff calculate the risk to an individual from this dose (i.e., 0.2 rems)?

A.10. The Staff estimated the risk of fatal cancers to the individual by multiplying a conservative estimate of the dose to the total body of an individual exposed to radioactive effluents from 40 years of operations by somatic (i.e., cancer) risk estimators.

Q.11. What risk estimators were used by the Staff in estimating potential health effects?

A.11. The following risk estimators (see FES, Section 5.9.3.1.1) were used to estimate potential health effects: 135 potential deaths from cancer per million person-rems and 258 potential cases of all forms of genetic disorders per million person-rems. The cancer fatality risk estimators used in this testimony are based on the "absolute risk" model described in BEIR I. Higher estimates can be

developed by use of the "relative risk" model along with the assumption that risk prevails for the duration of life. This would produce risk estimates up to about four times greater than those used in this testimony. The Staff regards this as a reasonable upper limit to the range of uncertainty. The lower limit of the range would be zero because health effects have not been detected at doses in this dose-rate range. The number of potential cancers would be approximately 1.5 to 2 times the number of potential fatal cancers. (BEIR III, 1980).

Values for genetic risk estimators range from 60 to 1500 potential cases of all forms of genetic disorders per million person-rems (derived from BEIR I, page 57). The value of 258 potential cases of all forms of genetic disorders is equal to the sum of the geometric means of the risk of specific genetic defects and the risk of defects with complex etiology.

Q.12. What would be the cumulative risk of cancer fatalities to an individual due to 40 years of plant operation?

A.12. Multiplying the preceding somatic risk estimator (i.e., 135 potential fatal cancers per million person-rems) by a conservative dose estimate of 0.2 rems, the Staff estimates that the risk of potential premature death from cancer to an individual exposed to radioactive effluents from 40 years of reactor operation is about 3 chances in one hundred thousand. This risk is a small fraction of the current incidence of actual cancer fatalities (about 20%,

American Cancer Society, 1978). As indicated in response to question 9, an individual would have to spend almost all of his or her time at the site boundary, and obtain almost all of his or her food grown at an offsite location where the highest concentrations of radionuclides are expected in order to obtain a dose of 0.2 rems over the plants lifetime.

Q.13. How does the Staff's estimate of the cumulative dose to an individual exposed to radioactive effluents for the plants lifetime compare with the dose from exposure to natural background radiation?

A.13. Exposure to natural background radiation in the United States varies from about 0.07 rems/yr to about 0.3 rems/yr depending on geographical location (Oakley, 1972). Assuming an average annual exposure of about 0.1 rems to natural background radiation for the State of North Carolina (Oakley, 1972), the dose to an individual exposed to radioactive effluents for the plants lifetime (i.e., 0.2 rems) is conservatively estimated to be about 3 percent of the dose from exposure to natural background radiation (i.e., about 7 rems over a 70-year lifetime).

Q.14. Has the Staff estimated the number of potential genetic disorders that may occur as a result of exposure to radioactive effluents from normal operations?

A.14. Yes. The Staff estimated the number of potential genetic disorders associated with exposure of the general public to radioactive

effluents from normal operations in the following manner. First, the Staff estimated the collective dose-equivalent commitment (hereinafter referred to as the population dose) to the population within 50 miles of the plant from exposure to radioactive effluents from one reactor-year of normal operations to be about 15 person-rems to the total body (FES, Table D-7, p. D-10). The cumulative population dose would be about 620 person-rems for 40 years of operation. Second, the Staff multiplied the cumulative population dose by genetic risk estimators to obtain the number of potential genetic disorders.

Q.15. What are the Staff estimates of the number of potential genetic disorders due to exposure to radioactive effluents?

A.15. Multiplying the cumulative population dose from exposure to radioactivity attributable to the normal operations (that is, 620 person-rems) by the preceding genetic risk estimator, the Staff estimates that about 0.16 of a potential genetic disorder may occur. The value of 0.16 is the sum of the number of potential genetic disorders that may occur over all future generations of the exposed population (within 50 miles) due to exposure to radioactive effluents from 40 reactor-years of operation. This value is small compared with the current incidence of actual genetic ill health in each generation (about 11%, BEIR III (1980)) of the population of about 1,750,000 persons within 50 miles of the plant.

Q.16. What do you conclude with respect to the issue raised in the Board's modification of Joint Contention II(c)?

A.16. I conclude that potential "long term somatic and genetic effects of radiation releases from the facility during normal operation" were estimated over an appropriate period of time. The risk of long term somatic and genetic effects of radiation releases from the facility during normal operation are a small fraction of the current incidence of actual cancer fatalities and actual genetic ill health in each generation. Estimation of cumulative risk instead of annual risk would not change that conclusion.

References

Advisory Committee on the Biological Effects of Ionizing Radiation, BEIR I, "The Effects on Populations of Exposure to Low Levels of Ionizing Radiation," National Academy of Sciences/National Research Council, November 1972.

Advisory Committee on the Biological Effects of Ionizing Radiations, BEIR III, "The Effects on Populations of Exposure to Low Levels of Ionizing Radiation," National Academy of Sciences/National Research Council, July 1980.

American Cancer Society, "Cancer Facts and Figures - 1979," 1978.

Oakley, D. T., "Natural Radiation Exposure in the United States," EPA Report ORP/SID 72-1, U.S. Environmental Protection Agency, Washington, D.C., 1972.

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

PROFESSIONAL QUALIFICATIONS

From April 1979 to the 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, a 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.

BY MS. MOORE:

Q Dr. Branagan, would you please provide a brief summary of your analysis and conclusions contained in your testimony?

A Yes. My testimony addresses Joint Intervenor's Contention II(e) which is concerned with the attachment of radioactive effluents from the Harris plant to ambient levels of coal fly ash. In addressing this contention, I have reevaluated the annual dose to a maximally exposed individual.

Inhalation of radioactive iodines and particulates constitutes the most direct means by which an individual could be exposed to radionuclides attached to coal fly ash. The annual dose to any order of the maximally exposed individual for the inhalation pathway was estimated in Appendix D of the FES, to be less than 2 percent of the annual dose design objectives in 10 CFR Part 50 Appendix I for all pathways of exposure to radioiodines and particulates.

In reevaluating the annual dose to a maximally exposed individual, I have conservatively assumed that 100 percent of the radioiodines and particulates were deposited in the respiratory tract, rather than a value of 75 percent that was used in the FES. The annual dose to any organ of the maximally exposed individual for the inhalation pathway is still less than 2 percent of the dose

design objective.

The annual dose to the maximally exposed organ from all pathways of exposure to radioiodines and particulates is still less than a third of the applicable dose design objective.

My testimony contrasts with Dr. Mauro's and Dr. Schaffer's in that they estimated annual doses to the various organs of the maximally exposed individual, whereas, I reevaluated the annual dose to that body organ that was most limiting in the relation to the Appendix I dose design objectives.

JUDGE KELLEY: Is that the thyroid? Which organ is that?

THE WITNESS: I'm going to get to that. A large part of their testimony was concerned with the dose to the total body, whereas, I concentrated on the dose to the thyroid.

In contrast to Dr. Mauro and Dr. Schaffer's testimony, I have compared my estimated doses to the annual dose design objectives in 10 CFR 50, Appendix I.

MS. MOORE: Your Honor, the witness is now available for cross-examination.

JUDGE KELLEY: Thank you. Mr. Eddleman?

CROSS-EXAMINATION

BY MR. EDDLEMAN:

Q Mr. Runkle is also going to have some questions but I will start in.

Dr. Branagan, in your resume and statement of professsional qualifications attached to the back of your testimony -- do you have that before you?

A Yes, I do.

Q Okay. You received your Ph.D. in 1976, correct?

A That's correct.

Q And your doctoral research work was in the area of DNA-based damage by gamma radiation; is that correct?

A That's correct.

Q After that you went to work for the NRC, did you not?

A That's in my professional qualifications. That's correct.

Q And you have been continuously employed by the NRC in one position of another from that date?

A That's correct.

Q Doctor, on page of your testimony, you state in answer 3 that in your opinion the primary pathway of potential concern would be exposure via inhalation of radioactive iodines and particulates, do you not?

A That is what's in the testimony. That's correct.

Q I gather from your summary and from reading over your testimony that your analysis really doesn't take much account of tritium and noble gases, does it?

A The analysis I have here in this testimony is concentrated on the dose to the thyroid, rather than dose to the whole body from tritium and noble gases. And the reasons for that are stated in the testimony.

Q Okay. And do those reasons begin down in the middle of answer 3 with the sentence that says, "It is unlikely that radioactive noble gases would attach to coal fly ash to such an extent that they would present pathways of concern other than those already evaluated in the FES for several reasons."

A Yes. In regard to the doses from noble gases, that is where the reasons are.

Q And have you put all your reasons there, Doctor?

A Those are the principal reasons. There might be a few others, I guess.

Q All right, sir. Well, let's go over those reasons. You say first, "Noble gases are very stable chemically." Isn't it true that these noble gases decay radioactively into other chemical forms?

A That's correct.

Q Now what exactly do you mean by chemical stability there, Doctor?

A As I explain in the testimony, they exhibit very low reaction rates under ambient conditions.

Q So when you say they are very stable chemically, what you mean is, that they do exhibit very low reaction rates under ambient conditions; correct?

MS. MOORE: Objection, Your Honor. Asked and answered. He just answered that question.

JUDGE KELLEY: Well, I think there's an ambiguity in the sentence in the record. Could began be because in this sentence?

THE WITNESS: Yes, that would be a valid way to read the sentence.

JUDGE KELLEY: I think he was exploring what I thought was an ambiguity, but go ahead.

MR. EDDLEMAN: Well, the judge has taken care of it.

BY MR. EDDLEMAN:

Q The low reaction rates that you're talking about, are they rates of chemical reaction?

A That's correct.

Q All right. You're not talking about adsorption or ionization or absorption or anything like this in this reason, are you, Doctor?

A That particular sentence is concerned with chemical reaction.

Q Now, your second reason is that although activity concentrations of radionuclides in coal fly ash have been measured, noble gases from nuclear power plants have not been detected in coal fly ash. And you give a reference there to UNSCEAR 1982, Annex C, do you not, if you turn over to page 3?

A That's correct. That's what the testimony says.

JUDGE KELLEY: Let me just make a seemingly small point, but it might expedite things a bit. I think it's fair enough for you to quote a sentence and then ask a question. But you don't have to ask him whether he said it. If he said it, then we'll just go with that.

MR. EDDLEMAN: All right.

BY MR. EDDLEMAN:

Q Doctor, do you have a copy of that Annex C with you?

A Not on the witness stand, but I do have it in the courtroom.

Q All right, maybe we'd better come back to that after the break. But you say you do have a copy in the courtroom?

A That's correct.

Q Doctor, let me ask you if you know where was that fly ash measured that was dealt with in this U.N. report?

A Some of the locations within the United States.

Some of them were in Australia and Germany.

Q How many nuclear power plants are in Australia, Doctor?

A I couldn't answer that. I don't know.

Q Do you know how many there are in Germany?

A I know there's more than one. The exact number, I don't know.

Q And you are familiar with nuclear power plants in the United States.

A Yes, I am.

Q Do you know what relation the locations of measurement of coal fly ash bear in the United States to the locations of nuclear power plants in the United States as they are dealt with in this report.

ngc 2-1

A There are a number of locations in the United States. There are some in the Eastern United States and some in the Western United States.

Q Okay. Perhaps I had better wait and let you look at the report, but let me ask you one other question, if you know, now.

Do you know how much time may have passed between the collection of the fly ash that was referred to in this UN report and the analysis for chemical content, including radionuclides?

A No.

Q Okay. I think it would be best to come back to this after the break, if we can.

Doctor, may we turn to page 4 of your testimony? At the end of your Answer 5, which is up at the top of the page, you say, "The ICRP Committee II," -- Roman II -- "assumed that 75 percent of the particles that were inhaled would be deposited in the respiratory tract."

Isn't it true that that ICRP committee assumed that only 25 percent would be deposited into the deep lung?

A That's correct.

Q Okay. Isn't it likewise true that even of that 25 percent deposited in the deep lung, ICRP Committee II assumed that half would be cleared from the lung within 24 hours, while the other half would be cleared within

mgc 2-2

120 days?

(Pause.)

A The answer is yes and no, or maybe no and yes. You'd better wait a second.

The answer is no in regards to how it affects this testimony. The radionuclides that were the largest-dose contributors to the thyroid in my analysis were soluble radionuclides, and those were assumed to be taken up into the circulation system instantaneously.

In regards to insoluble radionuclides, what you did say would be correct. However, they are not important in my analysis.

Q I understand that you didn't treat the insoluble nuclides directly in your analysis, but, Doctor, do you have any knowledge as to the solubility of coal particulates?

A Very little knowledge in that regard.

Q Sir, would you please state what knowledge you do have?

A Well, I assume they are insoluble.

Q Okay. As far as you know, they are insoluble?

A That's correct.

Q In Answer 6 on the same page, you begin by saying, "The Staff has not determined the particle size distribution of fly ash from coal-fired power plants."

mgc 2-3

Doctor, did you try to make such a determination?

A No, I did not. I did not think it was necessary for the analysis.

Q Do you know, Doctor, whether the size of particulates has any impact on the percentage deposited in the deep lung for coal particulates?

A Would you repeat the question?

Q Do you know whether the size of coal fly ash particulates has any impact on the percentage of those particulates which are deposited in the deep lung?

A Yes, there would be a relationship between them?

Q What would that relationship be, Doctor?

A My understanding is, that as the particle size increases, the deposition in the deep lung would decrease.

Q Let me ask you if this is a fair restatement of that, that as the particle size decreases, the deposition in deep lung would tend to increase?

A Over a certain range, that would be true, a certain range of particle sizes.

Q Do you know what the bottom of that range where this phenomenon takes place would be?

A I do not know the exact value.

Q Do you know an approximate value?

A I would say approximately one tenth of a micron AMAD.

mgc 2-4

Q That is median aerodynamic diameter?

A Activity median aerodynamic diameter.

Q Thank you, Doctor. Now you then state, "Assuming that the fly ash and the iodines and particulates formed particles of an optimal size such that all of the inhaled particles were deposited in the respiratory tract, then the preceding dose estimates would increase by a factor of one-third."

Now I would like to ask you a few questions about those assumptions.

When you say "deposited in the respiratory tract," does that refer to anyplace in the respiratory tract, or does it refer to particular places in the respiratory tract?

A In regard to the analysis I have done for the thyroid, it doesn't make any difference which part of the respiratory tract they are deposited in.

Q Well, as to the impact of the dose on the lung, for example, or to other body organs or the whole body, couldn't it make a difference?

A Would you repeat the question.

Q As regards the impact of those radionuclides on the lung or other organs of the body besides the thyroid, couldn't it make a difference where they are deposited in the lung?

A Yes. But I did not specifically look at the doses

mgc 2-5

to the other body organs other than the thyroid. I chose the thyroid because that was the most limiting body organ to be exposed in relation to the annual dose design objectives in 10 CFR 50, Appendix I.

Q And your analysis of the thyroid was with respect to radioiodines and particulates, was it not?

A That's correct.

Q Isn't it true that in simply increasing the dose estimates by a factor of one-third, as you state in Answer 6, you have made no distinction between particulates deposited in the upper respiratory tract and particulates deposited in the deep lung?

MS. MOORE: Objection. Asked and answered. Dr. Branagan has already stated, Your Honor, that in his analysis, for the purposes of his analysis, it didn't matter in which portion of the respiratory tract the particles were deposited.

JUDGE KELLEY: Isn't that right?

MR. EDDLEMAN: Well, if she says so, I will accept it.

JUDGE KELLEY: Okay. Sustained.

BY MR. EDDLEMAN:

Q Doctor, in the calculating part of your answer where you talk about how the dose to the thyroid of the maximally exposed individual would be increased, is it fair

mgc 2-6

to say that you simply added a third to the value that you had already established for the FES to get your 0.3? Is that how you did it?

A That's correct.

Q Okay. Now, Doctor, in analyzing this maximally exposed individual, did you make any analysis of the concentrations of fly ash near the Harris plant or in the direction from the plant toward the maximally exposed individual?

A No. I did not think it was necessary to go into that detail.

Q What you, in effect, assumed, isn't it, was that if these particulates picked up all the iodines and radionuclide particulates that the ICRP model assumed were held in the lung, held them in the lung, then the dose would come out the way you calculated it? Isn't that your assumption, Doctor?

A Would you repeat that, please?

Q Sure. What you effectively assumed was that if the coal particulates moving past the Harris plant toward the maximally exposed individual picked up all of the radioiodines and particulates which the ICRP model assumes would be exhaled, rather than deposited in that individual, and deposited those in their lungs somewhere, then the dose would be as you calculated it?

mgc 2-7

A I think that's a fair characterization, yes.

Q On page 5, Doctor, in Answer 8, you state your conclusions. Did you make any conclusions about deposition of radionuclides attached to coal particles on crops?

A I considered that pathway; however, I did not think it was a very significant pathway.

Q Doctor, where in your contention is this consideration -- I mean in your testimony -- where is the consideration of that pathway made?

End 2

mgc 3-1

A It's not explicitly stated in the testimony. I didn't think it was necessary to state that.

Q Did you even state that you had determined that this pathway, in your opinion, was not significant?

A Yes. It's stated on page 2, Answer 3, the second line: "In my opinion, the primary pathway of potential concern would be exposure via inhalation of radioactive iodines and particulates, hereinafter referred to as iodines and particulates. This pathway constitutes the most direct means by which an individual could be exposed to radionuclides attached to coal fly ash."

Now in the pathways that I have analyzed, the dose from inhalation was less than two percent of the dose design objectives in 10 CFR 50, Appendix I, for radioiodines and particulates. And those are three orders of magnitude below the public health and safety limits in 10 CFR Part 50.

Q Doctor, if I understand you correctly, you are saying you identified the primary pathway of potential concern here, in your opinion, but you did not explicitly discuss other pathways; is that correct?

A My testimony speaks for itself. I do not explicitly discuss the other pathways.

Q Now, Doctor, I may have already asked you this, but did you make any study of the adsorption or absorption

Mgc 3-2

of noble gases or tritium on coal particulates in preparing this testimony?

A Adsorption of noble gases and tritium on coal particulates?

Q And/or tritium, let's say.

A Insofar as the second reason I have on the bottom of page 2, "Although the activity of concentrations of radionuclides in coal fly ash have been measured, noble gases from nuclear power plants have not been detected in coal fly ash." That was the study.

Q But you said that you didn't know how long it was between the collection of that fly ash and when it was analyzed.

A That's correct.

Q Doctor, did you make any study of the effect of ionization, either in tritiated water droplets or in noble gas atoms or in radionuclides which could decay from a noble gas state into a particulate state by changing into an atom -- in changing into an element, a chemical element -- it's not a noble gas -- did you make any analysis of these matters as regards the attraction of those radionuclides for fly ash?

A No, I have not, in relation to the attraction for coal fly ash.

Q All right. So basically, you are just relying on

this UN report and its statement that these noble gases have not been detected in coal fly ash?

A That is one of the reasons that I gave in my testimony.

Q Well, --

A That's not the only reason.

Q It's the main reason, isn't it, Doctor, for your conclusion that it is unlikely that radioactive noble gases would attach to coal fly ash to such an extent, as you state in the upper part of your Answer 3, isn't it?

A Well, I also give the reason that noble gases are very stable chemically and exhibit very low reaction rates under ambient conditions.

Q Well, that's talking about a chemical reaction with the coal particulate, isn't it?

A That's referring to a chemical reaction.

Q And we've established that in using the term "low reaction rates" there, you are not talking about adsorption or absorption or ionization, haven't we?

A Yes. It refers to chemical reactions.

Q Well, now, isn't true, Doctor, that for an inert gas, the main means of attachment would be these physical means -- that is, ionization, adsorption, absorption, rather than chemical reaction?

A I don't consider myself an expert in the area

mgc 3-4

of adsorption. I didn't think it was necessary for this, because as I stated earlier, the doses are very small compared to the Appendix I dose design objectives, which, in turn, are three orders of magnitude below the public health and safety limits.

Q Doctor, just for clarity, could you state what that public health and safety limit you're referring to is in millirems per year, or whatever units it's in?

A 10 CFR Part 50, the dose to the total body is 500 millirems per year.

Q Is there a limit in that Part for thyroid dose?

A It's not explicitly stated there; however, my understanding is, it's based on ICRP-2 which is based on a value of 30 rem to the thyroid for occupational exposure and would be one-tenth that for exposure to the general public.

Q So 3 rem per year?

A That's correct.

End 4

4-bl

JUDGE CARPENTER: Mr. Eddleman, since you interrupted, and I don't want to interrupt a lot, but it seems to me that the record would benefit at this point from the following question. It would sort of help me.

Dr. Branagan, you mentioned a series of questions about noble gases, and I'm not as familiar as you are with the details. I would like to ask the following question. Which noble gases may be emitted from a nuclear power plant that decay to ionized chemical forms that may become associated with particulates that may undergo further radioactive decay?

THE WITNESS: I'm sorry, Judge, I'm having difficulty following your question.

JUDGE CARPENTER: We're talking about noble gases, and I'm asking of the several -- I'm trying to get my thinking focused a little bit -- which of the noble gases that may be emitted from a plant would decay to form ionized chemical forms that might become associated with particles. And I am particularly interested in those which have decay chains so that subsequently they may undergo further radioactive decay.

THE WITNESS: I don't know that answer to the question.

JUDGE CARPENTER: Okay, thank you. Go ahead.

MR. EDDLEMAN: Judge, are you finished?

JUDGE CARPENTER: Yes, thank you.

BY MR. EDDLEMAN:

Q Let me try to follow up on that. Doctor, in your work do you deal with the decay chains of radionuclides?

A Occasionally I do, yes.

Q When you need to know the decay chain of a radionuclide, do you have that in your memory or do you look to references?

A I look to references.

Q What references would you look for decay chains of , say, noble gas radionuclides?

A The reference I usually refer to is the Radiological Health Handbook.

Q It's a standard reference work?

A Standard reference.

Q Who publishes that handbook?

A The Bureau of Radiological Health.

Q U.S. government?

A That's correct.

Q Is the Bureau of Radiological Health part of the Public Health Service, do you know?

MS. BAUSER: Could you speak up, Mr. Eddleman? I cannot hear you.

BY MR. EDDLEMAN:

Q Is the Bureau of Radiological Health part of the

Public Health Service?

A Part of the Food and Drug Administration which is part of the Public Health Service. That's my understanding.

Q Okay. So it is not an NRC publication?

A It's not an NRC publication.

Q Doctor, does this publication give the complete decay chain for various nuclides?

A Yes.

Q Okay. So you could look in that reference, say for krypton 85 or xenon 133 and find the decay chains that go from that particular noble gas nuclide, all the various modes of decay and what it decays into down to stable forms, could you not?

A That's correct.

Q Doctor, do you have any idea how many different forms are in a typical decay chain from a noble gas radionuclide I mean, does it go through, you know, one change and then become stable? Or does it particularly go through five or ten?

A It depends upon the radionuclide.

Q Okay. But again, you could find out how many forms it would decay into subsequently after decaying from a noble gas to its next form by consulting the standard reference work.

A That's correct.

Q And you would rely on the reference work statements is you had to use this information in your own work.

A That's correct.

Q Let me ask you this, do you have a copy of that handbook with you?

A No, I do not.

MR. EDDLEMAN: At this point, I am to the point where I can't ask any more of the questions I want to until Dr. Branagan has had a chance to look at his U.N. report. But I believe Mr. Runkle has a few questions that he can ask before we get to that point also.

JUDGE KELLEY: All right.

MS. MOORE: Your Honor, I would just like to ask a question. I thought it was supposed to be the rule that on Joint Contentions, one Joint Intervenor does the cross-examination. Is that a misunderstanding of the procedure?

JUDGE KELLEY: I think you're going to have to refresh my recollection. The only time we have talked about ground rules in this case that I know of, is that early May prehearing where various things were gone over. I think I have a copy of the transcript someplace. Did we establish that?

MS. MOORE: I thought we had.

JUDGE KELLEY: We may well have. I'm not sure.

Can you point me --

MS. MOORE: Unfortunately, I cannot. That's why I was asking the question. I thought when these contentions were originally consolidated that that was the purpose, to limit the amount of people who would be conducting cross-examination.

JUDGE KELLEY: So you are -- and again, I'm not disagreeing with you, I'm just trying to get it resolved. You are saying now that it wasn't something we talked about specifically last month, but rather something that is inherent in the notion of a consolidated contention?

MS. MOORE: That was my understanding.

MR. BARTH: Your Honor, Mr. Baxter and I are the only people here who were at the prehearing conference where this was discussed.

JUDGE KELLEY: Does anybody think we talked about it? I don't remember.

MR. BARTH: It's my recollection that the Board took the tact that we consolidated these for the purpose of simplifying the procedure, which would put on one person the burden of assuming responsibility for one of the Joint Intervenor contentions.

JUDGE KELLEY: Let me ask a narrower question. When we had a prehearing on the first of May in this case, did we talk about this point?

MR. BARTH: My recollection is yes, but I would have to check the transcript.

JUDGE KELLEY: Do you think we did?

MR. BAXTER: I don't recall that. I recall discussing consolidation in a general way back in July of '82 with the very first prehearing conference.

JUDGE KELLEY: There may be something there.

MR. BAXTER: We described how consolidation works, generally speaking. And I certainly thought, while we did not discuss it explicitly, the whole purpose was more that of -- of joint contentions was to have consolidated representation and an effort by the Intervenors for discovery, presentation of the evidence, cross-examination and proposed findings.

MR. BARTH: My recollection concurs with Mr. Baxter's, Your Honor.

JUDGE KELLEY: Fair enough, as far as it goes. It seems to me though, that that doesn't necessarily resolve the question that we are looking at right now. Namely, can you get questioning from different members of the Joint Intervenors during the course of the evidentiary hearing, provided of course that they don't go over the same grounds twice.

It's one thing to have four different Intervenors come up here and take different cracks at the witness and

keep going over the same ground. And certainly we're not going to do that. On the other hand, if Mr. Runkle's lines of questioning are distinct from those of Mr. Eddleman, is there a separate problem with that? Apart from the difficulty sometimes in distinguishing between lines of questions.

MR. BAXTER: I don't have one if both parties are here during the entire examination. I am concerned about really more down the road, for instance, on Joint Contention I, which will be very lengthy. We have different representative coming in and out and not hearing each other's examination even. And thereby, overlapping to a great extent.

JUDGE KELLEY: I'm not necessarily with the point that anybody is making. I mean, I have tried cases where counsel agreed that they wouldn't double-team. There would be one lawyer on one witness, and that is that.

And part of the reason was to avoid duplication. But if we've got, as we have this morning, two people in the same room and Mr. Runkle knows what Mr. Eddleman has been through, the hazard of somebody who just walked in out of the hall to go over the same ground is much, much lower, it seems to me.

MR. BARTH: Your Honor, with or without the jointness, the practice that I have incurred in the last 12 years has been the practice that you have in federal district court, one attorney per witness. Rather than

teams of attorneys on the same side working over one witness.

JUDGE KELLEY: Is there a federal rule of civil procedure to that effect?

MR. BARTH: No, there is not, Your Honor.

JUDGE KELLEY: But you said it's a practice in the federal courts. I thought it varied from court to court.

MR. BARTH: I've tried 172 cases in federal court and I've never run into a team of lawyers on one party working over one witness.

JUDGE KELLEY: Well, why don't we take a short break? I'd like to see what my colleagues think of this, and Mr. Branagan can look at his -- I forget what it was, but you were going to look at something, right?

MR. EDDLEMAN: Judge, if you will, I don't think we've ever responded.

JUDGE KELLEY: I'm sorry. I agree. Just a minute, I'm sorry.

Let's go to you then, Mr. Eddleman.

MR. EDDLEMAN: Well, this is not meant to nitpick, but I am not an attorney. So, you know, you're talking about one person cross-examining. The Joint Intervenors, my lack of memory is about equal to Mr. Baxter's about how these things were discussed in the past. But the Joint Intervenors have always thought it would be more efficient for us to

divide up cross-examination into different areas. And that's what we have done here. And we'd anticipate that we'd be doing the same thing on Joint I.

That rather than one person having to be there for say, seven days, cross-examining away, that one person could take one area and one person could take another. We don't know. For all we know, CP&L may put on a panel of 37 witnesses all at the same time. We don't know how they're testimony is going to be divided up.

JUDGE KELLEY: There won't be 37 witnesses on any panel.

MR. EDDLEMAN: Well, I'm being a little facetious. But very large panels have been seen in some cases, and to tell you the truth, Judge, I'm sort of amazed that I can keep on asking questions for as many hours as I've been doing it. And I think at some point there's a kind of exhaust of Intervenors that takes over.

And if we're not able to share these responsibilities then there is no meaning to the term Joint Intervenors at all. As long as we divide up the areas, even if counsel is not present, if we know that say, Mr. Runkle is going to cover some item and Mr. Payne is going to cover another, and I'm going to cover another; as long as we've got that pretty clearly divided up, I think if we make a mistake of a minor nature in getting over to something then counsel can object.

But it's much less efficient for us to try to get all this stuff into one person's head, than it is to use three of four people to cross-examine a complex situation. In this case, Mr. Runkle worked up with Dr. Johnson some questions. It turned out we had a couple of foul-ups with Dr. Johnson that made it very difficult if not impossible for me to talk with him about these things because I was already here asking questions of other witnesses.

So that's why we have this at this point. And I guess that's all the response I want to make right now.

JUDGE KELLEY: Mr. Runkle, any comment?

MR. RUNKLE: No.

JUDGE KELLEY: I think we should talk about this before making the ruling on the point for the morning. Let me just suggest to you that obviously we have a lot in front of us beyond just this morning in this case, but I don't see any reason why we can't adopt a somewhat flexible attitude, at least at this early stage. We may go one way today and find out it doesn't work very well. If not today, some other time, and then change it.

I don't think it's written in stone, in short. We're not going to decide some landmark procedural matter this morning. We're going to decide it for this morning's purposes, I would think and keep our eyes on the result and considering changing if it seems to be a wise thing to do.

11

Why don't we take ten minutes and then we'll tell you. We'll give you a ruling on this. And Dr. Branagan can look at the document.

end 4

(Recess.)

mgc 5-1

JUDGE KELLEY: We are back on the record.

Dr. Branagan has a correction.

WITNESS BRANAGAN: Your Honor, I would like to make a correction to the response to a question that I gave Mr. Eddleman. I told him that the dose design objectives in Appendix I were approximately three orders of magnitude below the public health and safety limits. I should have said two orders of magnitude below the public health and safety limits.

JUDGE KELLEY: Okay. Let's just get back to the procedural question that we were talking about at the break, and we will make a ruling for this morning, and then say a word or two about the future.

For this morning, we are going to allow Mr. Runkle to do some cross-examining of Dr. Branagan. We are concerned, as a general matter, about duplicated questioning, but we don't see that it's much of a problem here. Mr. Runkle has been here all along with Mr. Eddleman. He knows where the questioning has been.

We are also concerned about unduly burdening one member of a group. I don't think that would happen here. But if we don't have some understandings about having different people put questions on a contention, I think that could become burdensome.

So for this morning, Mr. Runkle can go ahead.

mgc 5-2

Let me just say a couple of words, though, about the future, and particularly the management contention coming up in the fall. We haven't talked about this.

I suppose we will probably have a prehearing conference on that. If we don't, we'll at least have to do some work on the phone about how that particular hearing is going to be structured and the applicable groundrules.

It seems to me, when we get around to doing that sometime in August, one of the things we should look at is this very point, and there ought to be a clear understanding of how cross-examining could be done.

Now this morning, we were talking about having two counsel or more, two people crossing one witness. That is the only context in which I have seen that question arise. I don't know if any -- I'd be happy to stand corrected, but I haven't seen this applied contention by contention.

You weren't suggesting that, were you, Mr. Baxter, or were you?

MR. BAXTER: I'm sorry, Judge Kelley. That is applies on a contention basis?

JUDGE KELLEY: No. I'm saying that I don't think it does. Do you?

Take Joint Contetion I, Management. Now you would be coming -- there might be a fairly long hearing on it; we don't know that, but there might be -- you would

mgc 5-3

envision in the course of that, that as to different witnesses, you might use two or three different lawyers to cross or question, correct?

MR. BAXTER: That's possible.

JUDGE KELLEY: Okay. So, too, would the Staff; so would the Intervenors. What we are talking about is doubling up on one witness; is that right?

MR. BAXTER: Or a panel.

JUDGE KELLEY: But then a panel is sort of a different case. They may be on longer. That's the kind of thing I think you ought to talk about and attempt to work out some understanding.

It might include, for example, if you intend to have -- if the Intervenors intend to have more than one person putting questions to a particular panel, for example and only as an example, you might want to say in advance, "I will deal with this; the other fellow will deal with that" and so on, so the other parties are at least on notice that they intend to do that. And the other parties may be opposed to that, and then we can argue about it. But that's the kind of thing that I'm suggesting ought to be discussed in advance of that hearing, so that we can at least have a clear ground when we go into it.

MR. BARTH: Your Honor, I would suggest that in my view, this would apply equally to a panel. We would

mgc 5-4

treat a panel as one witness. It's been my experience for twelve years of Federal experience that you have one lawyer, whoever is on the stand, whether it's one or more.

JUDGE KELLEY: We don't want to argue it this morning. That is a seprate issue, and there may be various issues bound up in this whole area. But that is the kind of thing I would like to see the parties work out, and to the extent they cannot work it out and disagree, bring it to the Board, and the Board will rule, and then we will know where we are.

For today, I think that's enough said on that subject.

You might think about, before we leave here, whether we should have a face-to-face prehearing in advance of the September 5 hearing, and if so, when. Maybe we should set at least a tentative date, or whether you think we don't need one. But before we break up, let us revisit that question.

So could we go now to Mr. Runkle? Do you want to go back to the question you had pending on the document that Dr. Branagan was going to look at?

MR. EDDLEMAN: I think it would be best to let Mr. Runkle go first, and then maybe I can come back to that.

mgc 5-5

CROSS-EXAMINATION (CONTINUED)

BY MR. RUNKLE:

Q Dr. Branagan, in your testimony, you state that the primary pathway of potential concern of exposure would be the inhalation of particulates that have radioactive iodine somehow connected with it; is that correct?

MS. MOORE: Objection, Your Honor. Mr. Eddleman has already asked questions on the primary pathway, as far as I understand what he asked.

JUDGE KELLEY: Well, are you saying that this is "the" same question or the same general area?

MS. MOORE: He seemed to ask questions on Question and Answer 3, which discusses the most likely pathway that Dr. Branagan addressed.

JUDGE KELLEY: Well, you know, if that's the approach, then there's not much left. I think Mr. Eddleman asked questions on just about every question and answer in there, didn't he?

MS. MOORE: I believe he may well have, and that's the problem with allowing two attorneys in the same party to cross-examine.

JUDGE KELLEY: Well, let's see how serious a problem it is by overruling the objection, and you can go ahead for now. We'll see where it takes us.

If it's obvious that the question you are asking

mgc 5-6

has been asked before, I will sustain the objection. But go ahead.

THE WITNESS: Would you repeat the question?

BY MR. RUNKLE:

Q In your testimony, you state that the primary pathway of concern was exposure via the inhalation of radioactive iodines on the particulates; is that correct?

A No, that is not correct. I said the primary pathway of potential concern would be exposure via inhalation of radioactive iodines and particulates.

Q Are there iodines on the particulates?

A The particulates I refer to there are radioactive particulates.

Q As opposed to fly ash?

A That's correct.

Q What are some of these radioactive particulates?

A They are listed in the Final Environmental Impact Statement, Table D-1 on page D-4. The particulates include manganese-54, iron-59, cobalt-58, cobalt-60, strontium-89, strontium-90, cesium-134 and cesium-137.

Q Are there any transuranic radionuclides in the Environmental Statement there?

MS. MOORE: Objection, Your Honor. Transuranics are a source term consideration which are not relevant to this contention, and the Environmental Statement speaks for

mgc 5-7

itself.

JUDGE KELLEY: Excuse me a moment.

(The Board confers.)

JUDGE KELLEY: Can you give me a link, Mr. Runkle, between your question about transuranics and the focus of the contention, which is about the mechanics of things going through the air and into the lungs?

MR. RUNKLE: I'm just trying to establish which radionuclides do attach themselves to fly ash.

JUDGE KELLEY: Which particular ones?

MR. RUNKLE: Yes, which particular ones. I would imagine there are some that would have other effects other than on the thyroid.

JUDGE KELLEY: Excuse me.

(The Board confers.)

JUDGE FOREMAN: I guess the situation comes down to trying to see where you are going. Could you tell us what you intend to find out in asking what other nuclides Dr. Branagan thinks might attach to fly ash, and then what will you do with that information?

MR. RUNKLE: Okay. We have fly ash, and there would be different radionuclides that would be attached to it, either in the Final Impact Statement or someplace else in this source, and some of those would have different effects on different bodily organs. His study is based on

mgc 5-8

the assumption that they thyroid is by far the most sensitive organ, and there are several other organs, and cobalt and strontium may have an effect on different organs besides the thyroid.

JUDGE FOREMAN: My thought is that if you are questioning, then you should have some idea of the isotopes in which you're interested, and you should ask him, then, "Does this particular isotope attach to fly ash? If it does, why haven't you considered it?", if that's what you are trying to find out.

MR. RUNKLE: Well, he states that the only one he considered was the iodines, and also the noble gases were not considered, but all the other ones he has not considered. I can go down the whole list of radionuclides.

JUDGE FOREMAN: Ask him why he didn't consider them.

MR. RUNKLE: I certainly can do that.

JUDGE KELLEY: Go ahead.

JUDGE FOREMAN: If you want to shortcut it, why didn't he consider other radionuclides other than iodine?

BY MR. RUNKLE:

Q Dr. Branagan, why did you not consider any other radionuclides that might attach themselves to fly ash?

A We did consider other radionuclides that might

mgc 5-9

attach themselves to fly ash; however, the dose to the thyroid was the most limiting dose, and the doses from the other radionuclides, the dose to the thyroid, was essentially zero or very close to zero.

Q Are there other radionuclides that would have --

A Excuse me. From the inhalation pathway, anyway.

Q Would there be other radionuclides that can come through the inhalation pathway which may affect different organs?

A Yes.

Q And what are some of those radionuclides?

A They are the nuclides that are listed in Table D-1 on page D-4.

Q And for some of those radionuclides, would there be other organs that are more sensitive to them?

A I have difficulty in answering your question "more sensitive."

Q Well, would there -- would, say, another organ, say a bone, be more sensitive to other radionuclides other than iodine which might attach themselves to fly ash -- or the brain or the lungs?

A I have difficulty in answering your question, because it seems to have some basic misunderstandings in the question itself about how to calculate doses and how to calculate health effects, things of that sort.

mgc 5-10

JUDGE KELLEY: Your picking up thyroid as sort of the worst case?

THE WITNESS: That's right.

JUDGE KELLEY: Could you sort of explain in general terms why that is so?

THE WITNESS: Yes. In the Final Environmental Impact Statement, we evaluated doses to the thyroid and to various body organs from all pathways of exposure to radioiodines and particulates, and the dose estimates are provided in Appendix D. However, the thyroid was the most limiting body organ in relation to the dose design objective for radioiodines and particulates from all pathways of exposure. It was the most limiting.

JUDGE KELLEY: Is that because -- I'm sure this is a very simple question, but I'll go ahead anyway -- is that because the thyroid or the nature of the organ is more vulnerable to radiation, or is that because radiation naturally gravitates to the thyroid in larger amounts, or both?

THE WITNESS: It is not because the thyroid is more vulnerable to radiation. I would say it is because of a combination of factors. It is because of the quantities of radioiodines that are released from the plant, as compared to the other radionuclides that are released from the plant.

mgc 5-11

JUDGE FOREMAN: Maybe I could help a little. I think what you have to say, you have said very clearly. The question that I think is arising or coming out is, aside from radioiodines, what other radioisotopes you might have considered that could have attached to fly ash, and why didn't you consider them, or why didn't you make a calculation for them?

If you did make a calculation for them, why aren't you presenting that information in the testimony?

THE WITNESS: I think I understand the question.

We calculated the dose to the thyroid from all radioiodines and particulates.

JUDGE FOREMAN: But why did you pick only on the thyroid? That's the question being asked, I believe. Why didn't you pick on any of the body tissues?

THE WITNESS: We did look at the dose to all body organs, and the dose to the thyroid was the highest dose from all pathways of exposure to radioiodines and particulates.

The dose to the other body organs was less.

JUDGE FOREMAN: You have said that quite clearly. But what I don't hear you saying is, what about the other radioisotopes, not just radioiodines, and the other radioisotopes in relationship to tissues and organs other than the thyroid?

mgc 5-12

THE WITNESS: Well, when we did the dose analysis for the FES, we included in our source term all radioactive iodines and particulates that were released from the plant.

JUDGE FOREMAN: We're not talking about iodines. We're saying other isotopes, not just iodines.

THE WITNESS: We included all other isotopes in particulate form that are released from the plant that are quantified in Table D-1, as well as the radioiodines.

JUDGE FOREMAN: Which include radionuclides that were not iodine, that were other elements?

THE WITNESS: That's correct.

End 5

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JUDGE FOREMAN: You included them and what did you find out?

THE WITNESS: Well, in our analysis, the dose to the thyroid from the inhalation of all radioiodines and particulates was dominated by the radioiodines in the tritium. The other radioactive particulates essentially contributed zero --

JUDGE FOREMAN: What about doses to other organs and tissues than the thyroid?

THE WITNESS: Doses to the other organs and the thyroid were less than the thyroid. And all radionuclides were included in the dose estimates to the other body organs.

JUDGE FOREMAN: Is it a fair conception of what you're saying that of all of the radionuclides that could be -- that can be taken in by inhalation, particularly particulates or radionuclides that could be attached to fly ash, the greatest dose to any of the tissues was to the thyroid? And that that comes about because the most abundant of the radioactive radioisotopes are the isotopes of iodine. Is that the concept you are trying to --

THE WITNESS: That's the concept. And I would also add that the dose conversion factors were the dose per unit of radioactive particulate inhaled. That's also an important factor that was included in the analysis.

JUDGE FOREMAN: Does that answer your question?

MR. RUNKLE: It does. It answers the question and it leaves some other questions open.

BY MR. RUNKLE:

Q Did you look at the effects of any of the radioactive iodines on any of the other organs besides the thyroid?

A If by effects, do you mean did I look at the doses, I would say yes we looked at the doses to the other body organs from radioiodines as well as all the particulates.

Q And what were some of the doses to the lung?

MS. MOORE: Objection. I don't understand the scope of the question. Doses to the lung and from what?

MR. RUNKLE: From inhalation of radioactive iodine.

JUDGE KELLEY: Just iodine?

MR. RUNKLE: Yes.

JUDGE KELLEY: All right.

THE WITNESS: You're asking what was the dose to the lung from the inhalation of only radioactive iodines.

BY MR. RUNKLE:

Q Yes.

A It would be less than .22 millirem.

Q What is the dose to the lung of the radioactive particulates?

A For the maximally exposed individual it would be less than .22 millirem.

Q Let's change the tack a little bit. Dr. Branagan, in 1981 you published along with W. Passiak and F.J. Congle and J.E. Farroban, a study in the Health Physics, April 1981, a study on doses to the population from xenon 133 from the Three Mile Island accident, did you not?

A Yes, I was, I think the secondary or third author on that publication.

Q What were some of the pathways for radioactive xenon, xenon 133 to -- what were some of the pathways to the population --

MS. MOORE: Objection, Your Honor. Perhaps it's not an objection, but I think the witness should be provided with a copy of the document which is the subject of cross-examination. It was written in 1981.

JUDGE KELLEY: That's reasonable. Do you have a copy?

MR. RUNKLE: I do not have a copy of it.

MS. MOORE: Then, Your Honor, I don't believe that he should be permitted to cross-examine on a document that the witness cannot review. He cannot establish the context or anything in which the question is addressed.

JUDGE KELLEY: What's the scope and extent of this, Mr. Runkle?

MR. RUNKLE: Well, xenon 133 is a noble gas, and I'm just trying to find out what percentage of exposure

to xenon 133 would come through inhalation of fly ash. There's probably a lot of pathways. What percentage of that is through inhalation.

JUDGE KELLEY: Let me ask Dr. Branagan, do you think that you could, with an acceptable level of confidence address questions about that article, not having looked at it again, or not?

THE WITNESS: It would depend upon what the particular question was. It has been three years since the article was published. And the article was written, at least the copies I saw were a few years before that.

JUDGE KELLEY: Well, let's try a question. You may have a point, Ms. Moore. Normally you should bring a copy, and we may sustain objections if the witness cannot respond. If you don't feel confident about a response, you should say so, and we will terminate the question.

BY MR. RUNKLE:

Q The question, Dr. Branagan, is what are the pathways of exposure for xenon 133?

A Direct radiation from the plume. The pathways that we looked at in the article you referenced.

Q Okay. What percentage of the exposure would come through inhalation of xenon 133? Either on fly ash or -- let me rephrase that question.

What percentage of exposure would come through

inhalation of xenon 133 in relat[illegible] fly ash?

A I would refer back to my testimony in answer 3. It is unlikely that radioactive noble gases would attach to coal fly ash to such an extent that they would present pathways of concern other than those already evaluated in the FES. And the reasons are given in the testimony.

MR. RUNKLE: I have no other questions, Your Honor.

JUDGE KELLEY: All right.

MR. EDDLEMAN: Judge, this brings us to the point --

BY MR. EDDLEMAN:

Q Dr. Branagan, did you get a chance over the break to get out your copy of the U.N. document that you referenced in that answer about noble gases?

A Yes, I have a copy of the report.

Q Have you had a chance to look at the Annex C that you referenced in your testimony?

A My understanding is there wasn't a specific question in relation to Annex C. The direction was to get a copy of it and I have it here.

Q All right. Well, the reference is in Annex C, is it not?

A That's correct.

Q Can you show me what page or pages of Annex C you reference?

A Annex C covers a number of topics. I've looked at a number of pages in Annex C. Page 108, 109 contains relevant information. Page 112 and page 125.

Q Those are the principal pages that appear to you to contain the information that you relied on?

A That's correct.

Q May I take a look over your shoulder at those pages?

JUDGE KELLEY: Can we have the source or can you say where that came from?

THE WITNESS: This is a report by the United Nations Scientific Committee on the Effects of Atomic Radiation 1982 report to the General Assembly with annexes. The title of the report is ionizing radiation sources and biological effects.

JUDGE KELLEY: Thank you.

BY MR. EDDLEMAN:

Q All right. If we may start, Annex C starts on page 107, doesn't it?

A That's correct.

Q On page 108 the title of the main section that begins on this page is radiation exposures due to coal-fired power plants, correct?

A That's correct.

Q Can you point out to me on this page where the

information that you're relying on mainly is?

A Section 2 of that particular page, 108, activity concentration in ash,and the following page, page 109.

Q All right. Now, the activity concentrations in ash -- it says here that, "The fly ash is carried through the boiler along with hot flue gases and any volatilized mineral compounds to the stack. We are depending on the efficiency of emission control devices. Some fraction is collected while the rest escaping fly ash is released to the atmosphere."

So far so good?

A I think you just read from page 108.

Q All right. Now, it then says that, "Table 2 presents a list of reported activity concentrations of natural radionuclides in bottom ash, collected fly ash, and escaping fly ash."

What do you understand the term natural radionuclides to mean there, Doctor?

A That would be radionuclides that are naturally occuring in fly ash.

Q That are naturally occurring in the coal?

A In fly ash.

Q Well, where do the natural radionuclides in fly ash come from, Doctor?

A They come from the coal.

Q The coal that's burned to make the fly ash?

A That's right.

Q Now, in this section, I still can't see a reference to noble gases from nuclear plants. Let me ask you this, is there anything in this section or anywhere else in this report that you know of that discusses the concentration, if any, of radioactive noble gases in coal?

A No. I didn't see noble gases activity for the coal or the fly ash in the UNSCEAR report.

Q And UNSCEAR is the short name of the United Nations Scientific Committee on the Effects of Atomic Radiation, the agency that put together this report, is it not, Doctor?

A That's correct.

Q Doctor, would you expect, based on your knowledge of the half-lives of noble gases, their decay products that there would be any measurable amount of radioactive noble gases in coal?

A No. As I indicated in my testimony, I did not think that it would be very likely that radioactive noble gases would attach to coal fly ash. And I guess you could also probably say for coal, although I haven't specifically evaluated that.

Q Let me ask you this, are you familiar with the origin of coal deposits, how many million years ago they may have been laid down.

A I'm not really familiar with that.

9

Q All right. So you couldn't say one way or another whether the age of the coal would, when compared to the half-lives of these noble gases indicate anything about how much noble gas may be in coal, even if there were some there when you started? Radioactive noble gases.

A I think you made a statement.

Q I said, you couldn't say anything about that one way or another, could you, based on your knowledge?

end 6

mgc 7-1

A Would you repeat the question?

Q All right. You could not, from your own knowledge, compare the geological age of the coal with the halflives of noble gas radionuclides and draw any conclusion from that as to the likely concentrations of radioactive noble gases that might remain in naturally-occurring coal, could you?

JUDGE FOREMAN: Mr. Eddleman or Dr. Branagan, if you will excuse me, I would like to interrupt, because I am concerned about what you are saying.

In the testimony, the statement that was of concern and that led to looking at the UNSCEAR report says, "Although radioactive concentrations of radionuclides in coal fly ash have been measured, noble gases from nuclear power plants have not been detected in fly ash."

He didn't say anything about noble gases that might be present in fly ash, quote, "naturally." That isn't at issue at all.

MR. EDDLEMAN: Judge, what I'm trying to do, I think if you measure your concentration of radioactive noble gas on the fly ash, okay, if it is possible that some of that radioactive noble gas was in the coal to start off with and stayed on the fly ash, then you would have a problem distinguishing, because a radionuclide itself doesn't come with a little tag that says, "I came from" --

ugc 7-2

JUDGE FOREMAN: Are you saying that there wasn't any detected at all?

BY MR. EDDLEMAN:

Q Is that what you said, Doctor?

A Yes.

Q Okay. Let's go to that point, then. Where in this document does it tell us about the checking for noble gases on -- for nuclear plants on coal fly ash particles? Where is that discussed, Doctor?

A There is a basic misunderstanding here. The document is not primarily concerned with the detecting of radionuclides from nuclear power plants on fly ash. But they have measured the activity of various radionuclides in fly ash and nuclides from power plants that have not been detected were not listed.

Q Well, then, let me ask you this. Do you know whether analysis was made of this coal fly ash to detect radioactive noble gases? Were those specifically examined for?

A I cannot say specifically. I would assume that if they had detected radioactive noble gases from nuclear power plants, that they would report these values.

Q Well, Doctor, where in this document does it describe the sort of analysis or examination of this fly ash for radioactive materials that was conducted? Can you

mgc 7-3

point that out to me?

A There is a range of values that is given in Table 2 of the document, and the reference for each of the values is included.

Q All right. Now this Table 2 appears on page 125 of this document, does it not?

A That's correct.

Q And the nuclides that are listed in this table are potassium-40 and the uranium-238 decay series and the thorium-232 decay series, are they not, Doctor?

A That's correct.

Q Okay. No values for noble gases appear in this table, do they?

A That's correct.

Q Okay. Just for clarity's sake, in Table 1 on page 124, this gives activity concentrations of radionuclides in coal samples for those same sets of nuclides that are listed in Table 2, with one possible exception. That is 228-thorium, is it not, Doctor?

A That's correct.

Q Okay. Now is there any note to Table 2 that discusses noble gases?

A No, I'm not aware of where they have detected any noble gases in the fly ash.

Q You are not even aware of whether this reference

mgc 7-4

in this table looked for noble gases in the fly ash, are you?

A I can't say that for a fact.

Q All right.

A However, I would not that there were many studies done, as they are listed on page 125. And it would seem likely, if they detected significant quantities of noble gases in fly ash, that these would be reported.

Q Well, but you don't even know if this -- wait a second -- the title of Table 2, if I read it correctly, says "Activitiy Concentrations of Natural Radionuclides in Ash Samples."

Are these radioactive nuclides released from nuclear power plants considered to be natural radionuclides?

A No, they would not be natural radionuclides.

Q So this table, then, would not report those, would it, by its title?

A I think the text would indicate that. If radioactive noble gases were detected in this, I think that would be mentioned in the text.

Q All right, but it's not in the table, is it?

A It's not in the table.

Q In fact, of these many studies, not any study reports on every radionuclide, does it, Doctor?

A Not every study reports on every radionuclide.

mgc 7-5

Q In other words, some of these studies report one or two radionuclides; some report four or five; some report three and so on, rather than all eight that are listed across the top; isn't that correct?

A That's correct.

Q And that is just as true of fly ash, as it is for bottom ash, isn't it?

A That's correct.

Q Isn't it also true that even as far as fly ash goes here, the sources listed for the United States are West Wyoming-1 and Wyoming-2?

A For the escaping fly ash, those are listed. There are other values listed for collective fly ash and bottom ash -- other locations in the United States.

Q Okay. This contention is concerned with the fly ash which has escaped, is it not?

A Yes, it is.

Q Ambient fly ash loose in the environment which would have escaped?

A That's correct.

Q Okay. Doctor, I'm going to go back to the text that you mentioned that might have some reference to noble gases in it in a moment.

But what I'm trying to do is see if in any of these other tables, of which there are quite a number here,

mgc 7-6
S2BU1

any noble gases, radioactive noble gases, are listed at the top of the tables. The only radioactive noble gas that I am finding in these tables is 222-radon.

Would you agree that appears in Tables 5 and 6?

A Radon-222 is included there, as well as radon-220.

Q All right. That is correct.

Radon-222 occurs both naturally and as an emission from nuclear power plants, doesn't it?

A It occurs naturally. I'm not aware that it's an emission from nuclear power plants.

Q The uranium in a nuclear power plant contains a good bit of uranium-238, does it not?

A Yes, it does.

Q And doesn't that eventually decay into radon-222?

A Yes, it does.

Q So are you saying that the amount of 222-radon that is produced by this decay in a nuclear plant is not significant, in your view? It is not measurable perhaps?

A I'm getting into an area where I am not the person directly responsible. In our analysis, we had a person who specializes in the source term of what comes out of the reactor and another person who specializes in meteorology and then myself. I specialize in the tail end of the dose calculations.

My understanding is that radon-222 does not come

mgc 7-7

out of the reactor.

Q So then this would all be natural radon that's referred to here, coming from sources in the coal?

JUDGE CARPENTER: Excuse me. I've lost track. Are you looking at a table that relates to nuclear power plants or the combustion of coal?

MR. EDDLEMAN: All of these tables, so far as I know, relate to coal. We are looking at Tables 5 and 6. The title of Table 5 is "Committed Doses Per Unit Activity Inhaled," and it gives units of the most important natural radionuclides released from coal-fired power plants. And Table 6 is "Estimates of Collective Dose Commitments Per Unit Energy Generated Resulting from Atomspheric Releases from Coal-fired Power Plants."

BY MR. EDDLEMAN:

Q Doctor, this Table 6 lists basically the same radionuclides as are listed in Table 5, does it not? I think possibly with the exception of the 222-radon and daughters.

A Mr. Eddleman, could you relate this to my testimony? I'm having difficulty. This Appendix C deals with a lot of material, not all of which is related to my testimony, in my opinion.

Q All right. Well, Doctor, you are saying that if they had found a concentration of noble gas, that it

mgc 7-8

would be reported. Are there any tables in this Annex C which show a concentration of noble gas that is a radionuclide that is emitted from a nuclear power plant?

A There are a lot of things in Appendix C.

Q Annex C, you mean, don't you?

A Annex C, that are not related to my testimony. Some of it is; some of it isn't. There's a table in here on the breakdown of adsorbed dose and dose --

JUDGE FOREMAN: Why don't you look only at those that are related to your testimony that you used for reference?

THE WITNESS: Okay. Mr. Eddleman has been asking me questions about some of the other tables.

JUDGE FOREMAN: I know. But I think he is really asking you with respect to your reference to that particular section. So why don't you concentrate on that?

THE WITNESS: Okay.

(The witness reviews the document.)

JUDGE KELLEY: Do you need a break to do that?

THE WITNESS: No.

JUDGE FOREMAN: You should have been able to go right to it. You make a reference in your testimony. Go to that place that you referenced.

THE WITNESS: Yes. The table that I referenced was Table 2, and there are no radioactive noble gases --

mgc 7-9

JUDGE FOREMAN: It doesn't even say they looked for it.

THE WITNESS: It doesn't specifically say they looked for it. That's correct.

JUDGE FOREMAN: So that reference doesn't have any meaning at all for what you are saying. You aren't sure that your statement has meaning, are you?

THE WITNESS: I would have to say, I would think if they had detected radioactive noble gases, they would have reported it in this appendix.

JUDGE FOREMAN: But, I mean that is sort of a negative approach. If they had detected anything that you want to name, you could make that statement. But is that really why you make a reference there?

THE WITNESS: It is indirect, in my opinion, a sort of conclusion to base my statement that it is unlikely that radioactive noble gases would attach to coal fly ash to such an extent that they would present pathways of concern, other than those already evaluated in the FES.

JUDGE FOREMAN: But they are only looking for the natural. That's what the table says. Is that true?

THE WITNESS: The table heading is for the natural radionuclides. That is correct.

JUDGE FOREMAN: I'm sorry to interrupt.

MR. EDDLEMAN: That's quite all right, Judge.

mgc 7-10

I thank you.

BY MR. EDDLEMAN:

Q Doctor, let me ask you this. As to the sources referenced in this Table 2 for the studies of escaping fly ash, have you personally examined any of these studies to see whether they report specifically on noble gas radionuclides from nuclear power plants?

A No, I have not.

Q I believe you also mentioned that perhaps the text could shed some light on this table. Can you point me to where in this Annex C the text discusses this table, Doctor?

(Pause.)

A Table 2 is specifically discussed in the first paragraph on page 109.

Q Okay. Do you find anything in that paragraph concerning examinatin of this coal fly ash for radionuclides released from nuclear power plants?

A No, I don't.

Q This paragraph is relatively short. I think I would like to read it. It says, if I can begin where the paragraph begins over on 108, "The radionuclides inc[illegible]ed in the noncombustible mineral matter are thus partitioned between the bottom ash and fly ash, except for the gases and volatalized minerals which will be incorporated directly into the flue gases."

"Table 2 presents a list of reported activity concentrations of natural radionuclides in bottom ash, collected fly ash and escaping fly ash. Owing mainly to the elimination of the organic component of the coal, there is very approximately an order of magnitude enhancement of the activity concentrations from coal to ash.

"Consequently, the natural radionuclide concentrations in ashes and slags from coal-fired power stations are significantly higher than the corresponding concentrations in the earth's crust, Reference L-4." And then it gives the arithmetic averages of the concentration in escaping fly ash from Table 2 in becquerels per kilogram." Is that right?

A That's correct.

Q And then it gives numbers --

THE REPORTER: Could you spell that, please?

BY MR. EDDLEMAN:

Q B E C Q U E R E L S. Is that correct?

A BQ is the abbreviation.

Q Okay. BQ per kilogram, and it gives them for potassium-40, uranium-238, radium-226, lead-210, polonium-210, thorium-232, throium-228 and radium-228; does it not, Doctor?

A That's correct. You read the paragraph.

Q And I read it correctly as far as you follow?

A Yes.

Q Okay. And that's the end of the paragraph there,

isn't it, Doctor?

A Yes.

Q Doctor, I believe you already testified that you didn't know how long it took between the collection of the

coal ash and the analysis that was made and reflected in this annex. Do you know anything about how the analysis was made of this coal fly ash?

A As I stated earlier, I haven't read the individual studies that are referenced in this report.

Q So you don't even know if these analyses looked for radionuclides from nuclear power plants in this coal fly ash, do you?

A I do not know that for a fact.

Q Do you know, Doctor, in any of these studies, whether the ash was trapped right as it came out of the stack, or whether it was trapped from the environment after it might have been exposed to a direction with radionuclides --

MS. MOORE: Objection, Your Honor. The witness has already testified that he has not read the individual studies which comprise the report.

MR. EDDLEMAN: Judge, may I comment?

JUDGE KELLEY: Yes, do.

MR. EDDLEMAN: Whether he has read these studies or not, he might know whether this fly ash that is analyzed in these studies has even been exposed to ambient air outside of the coal-fired power plant. And that's what I want to get at.

MS. MOORE: Your Honor, he is specifically referring to the studies. And the witness has testified to

his knowledge of those studies.

JUDGE KELLEY: I think the question is different. Overruled.

BY MR. EDDLEMAN:

Q Doctor?

A No, I don't know just where the fly ash was collected, other than it was escaping fly ash as reported in the table.

Q Right, okay. So wouldn't it be fair to summarize what we have gone through here to say that there is no definite information in this annex, or in what your personal knowledge is of the studies reported in this annex that tells whether or not these studies really looked for radionuclides from nuclear power plants on coal fly ash.

A Yes, I think I stated before that I do not definitely know that they did look for radionuclides on coal fly ash. However, it seems quite possible that they did.

And those values would be reported if significant concentrations were found on coal fly ash they would be reported here, either in the tables or the text.

Q Doctor, is there any other place in the text that we have not looked at already where you know that this Annex C discusses radionuclides of noble gases released from nuclear power plants? Can you find me any reference to it in this annex?

A No, I guess I couldn't.

Q Okay. So then your opinion in your second reason on pages 2 and 3 of your testimony is based on your opinion that if this report had found -- if the studies that are reflected in this Annex C of this U.N. report had found noble gases from nuclear plants on the coal fly ash that it would have reported it. That's the basis for your opinion there, isn't it?

A Yes. If the individual studies found radioactive noble gases from nuclear power plants, if they found those being concentrated in radioactive coal fly ash, I would think they would report it there.

Q All right. Doctor, is there anything in Annex C that even discusses any nuclides emitted from nuclear power plants, as far as you know?

JUDGE KELLEY: I think you have worked that one rather thoroughly, Mr. Eddleman.

MR. EDDLEMAN: Well, if you think the record is sufficient, Judge, I'm not going to pursue it.

JUDGE KELLEY: I think it's more than sufficient. Why don't you move on?

BY MR. EDDLEMAN:

bu 3 Q All right. Doctor, I believe you may have already said this, Doctor, but let me ask to be clear in my own mind. Is there any other information other than that Annex

5

C which rely on to support your second conclusion on pages 2 and 3 of your testimony regarding noble gas radionuclides attached to coal fly ash?

end 8

mgc 9-1

A The only other reference, I would say, is I have spoken with individuals from the Effluent Treatment Systems Branch that are concerned with the source term, what comes out of the plant, and they have also indicated that they did not think that, based upon their knowledge, radioactive noble gases would contribute significantly or would attach significantly to coal fly ash to such an

drop

extent that they would change the basic dose estimates that we provided.

Q Doctor, is the Effluent Treatment Systems Branch' part of the NRC?

A They are.

Q These are not people, then, who routinely analyze coal fly ash or deal with pollution control and coal fly ash, are they?

A No, they are not; however, they are familiar with filtration systems for nuclear power plants.

Q But that wouldn't have anything to do with coal fly ask itself, would it?

A I think there are some similarities between the two. That's my understanding.

Q Are electrostatic precipitators commonly used to control noble gases coming out of nuclear power plants?

A No.

Q Are cyclones commonly used to control either

mgc 9-2

radioactive noble gases or radioactive particulates coming out of nuclear power plants?

MS. MOORE: Objection, Your Honor. This is irrelevant to the subject of the witness' testimony.

MR. EDDLEMAN: He said he thought there were similarities between the pollution control methods between coal plants and nuclear plants.

MS. MOORE: I don't believe he stated pollution control methods. I think that is Mr. Eddleman's statement.

MR. EDDLEMAN: He said filtration systems, and he said he thought they were different.

JUDGE KELLEY: Would you restate your question, Mr. Eddleman?

MR. EDDLEMAN: Perhaps, Judge, I can save all of this by backing up to a more fundamental question.

BY MR. EDDLEMAN:

Q Doctor, when you say filtration systems for nuclear plants are similar to those dealing with coal fly ash, what does that statement mean as regards coal fly ash pollution control systems?

A In discussions with other people who are more knowledgeable in this area on the source term, what comes out of the reactor, than I am, they have indicated that you might be able to do an analysis by comparing the coal fly ash with the charcoal filters that are used in a nuclear

mgc 9-3

power plant. There would be some similarities, and you can make some approximations in the area.

Q All right. So what you are saying, then, was, there are similarities between the absorption characteristics of the activated charcoal used in nuclear plants and the likely absorption characteristics of coal particulates for the same radionuclides; is that correct?

A That is my understanding, but I would have to say that I am not an expert in the area of waste treatment systems for nuclear power plants.

Q I understand, Doctor. Have you looked at Attachment 2 of the testimony of the Applicants' witnesses on this contention?

A Yes, I have.

Q I believe in the footnotes to their table in that attachment, there is reference made -- and I think it is Footnote 3 -- to activated charcoal and a reduction factor accounting for differences in specific surface area of activated charcoal and coal fly ash particulates.

Can you locate that, Doctor?

A Yes, I can.

JUDGE KELLEY: Can you help the rest of us? Where is it? What page is it?

MS. BAUSER: It is page 2-3.

MR. EDDLEMAN: It's on page 2-3.

mgc 9-4

JUDGE KELLEY: Footnote 3?

BY MR. EDDLEMAN:

Q It is Footnote 3, isn't it, Doctor?

A Footnote 2.

Q Okay. That's my mistake.

Doctor, based on your knowledge and your discussions with these people in the Effluent Treatment Systems Branch at the NRC, is the kind of relationship that they are talking about here similar to the relationship that you discussed with your people at the NRC? That is, it's a comparison between the absorption of radionuclides on activate charcoal filters for nuclear plants and the absorption of those nuclides on coal fly ash?

A I am not familiar with the specific methods, how they, I guess, came to their conclusion. This is an area I do not have much expertise in, so that's all I can say.

Q Okay.

A In regard to the attachment of coal fly ash and radioactive particulates to coal fly ash, that absorption, because I don't claim expertise in that.

MR. EDDLEMAN: No more questions.

JUDGE KELLEY: Okay.

We might take a break pretty soon. Are the Applicants going to have questions?

MS. BAUSER: I think I have a few.

mgc 9-5

JUDGE KELLEY: Do you want to take a break now?

MS. BAUSER: I would like to take a break, because I'd like to take a look at that international study.

JUDGE KELLEY: Let's take a ten-minute coffee break.

(Brief recess.)

End 9

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JUDGE KELLEY: We are back on the record. Let's just take a minute to comment and maybe get comments from counsel on the question of exhibits in the case. Not exhibits, contrasted to exhibits.

What I'm thinking about now is that we are having some questioning on a document, or a book rather which I gather there is only one copy in the courtroom. And it is very hard for the Board and other counsel to follow where the discussion is going. We let it go this morning.

If you have a formal exhibit, the rule spells out how many copies you have to come up with. It is quite a few. You have to give the reporter three or four, and all parties and it's a lot of xeroxing. That is one thing.

It's another thing when you are using a monograph or a book or something as the basis for cross-examination. You're not necessarily going to put it in as an exhibit, but you're going to ask questions on the basis of it. The practice that I'm familiar with, and I suppose it can be varied, is that counsel who wants to cross-examine on a document like that brings in enough copies so they can distribute them informally among the Board and counsel, but not the total number that you need for formal exhibits. This holds down copying costs a bit. But at the same time, it allows participating to follow what is being done.

In this case, as I recall it, we had a document

that the witness referred to, and you then asked about that. And then that surfaced, and off we went. Maybe I could just get some reactions.

Mr. Baxter, how do you favor handling this kind of thing?

MR. BAXTER: Well, we have not objected but I share your concern, Mr. Chairman. It's typical in my experience that if someone is going to cross-examine from a large document, they will at least reproduce those sections or pages from which they are going to ask questions, provide copies, and sometimes have it marked for identification as an exhibit, even though it's not going to be offered as subsequent evidence, just so the record is clear as to what the questioning was.

And it has been very difficult for us to follow along, although we have many of the documents in anticipation. But I'm sure the Board doesn't. One of the problems is that Mr. Eddleman from my perception doesn't know in advance what pages he's going to ask about, because he is asking the witness where in the reference is the basis for his testimony, what he relied on. And then we go from there and sort of feel your way along approach.

But I think it's been time consuming to do it that way, and also unfair to the parties who don't have copies, as well as confusing for the record.

JUDGE KELLEY: Mr. Eddleman? Let's just get comments from all around and maybe we can get to a consensus, or at least adopt some kind of procedure.

MR. EDDLEMAN: All I wanted to point out here is that without a page reference in Dr. Branagan's testimony, I about had to ask him where it came from.

MR. BAXTER: I don't agree with that. These pieces of testimony all come with very complete references. Yesterday we had some confusion about an EPA document as to whether it was January or March. But if you look at the reference list in the back the title is clear, and there's no reason to be confused about what reference it was, that he was referring to.

And there's no reason why the interrogating party can't bring the document in.

MR. BARTH: For the Staff, I would stay that our views comport with those of Mr. Baxter. I'd like to also point out, this matter came up before the appeal board in Clinton in which the licensing board chairman was Dr. Lazo. And that came up in regard to underlying computer runs for the cost of nuclear fuel prepared by Stoler for the Applicant.

And Dr. Lazo took the point of view there that the references were in the prefiled testimony, which is the reason we have prefiled testimony, to prevent surprise. And this is adequate warning. And if a party wanted to

further they could do so.

This comports with Mr. Baxter's statement that there was ample notice in this case to obtain these documents or to write a letter to the Staff or to the Applicant saying bring these along, I intend to question from this document and I'd like to see this document. Rather than end up as we do here with surprise.

It is inconvenient. Ms. Moore does not have the articles in front of her to which Dr. Branagan is referring, nor does the power company. It creates a mess of the situation, which is preventable.

JUDGE KELLEY: Let me ask you, let's take this case and just look at the sheer mechanics of the thing. Mr. Eddleman gets the prefiled testimony and he reads it and he sees a citation to the U.N. publication. And he doesn't have the publication and doesn't find it in the Wake County Library. Now can he call you up and say he's interested in looking at this? Would you send him a copy or loan him a copy? Would you mail him one?

MR. BARTH: Yes, Your Honor. And this was the suggestion by Dr. Lazo before the licensing board in Clinton, and the suggestion was adopted by Chairman Rosenthal on the appeal board when it went up for appeal.

I don't like to drag in other cases, but in Zimmer we had a number of calculations by intervenors

regarding costs. And I simply called up the intervenor and said, I would like to see your calculations so I know how you came to it. There's no problem. They xeroxed them and sent them.

I think that any party who would refuse to is really being obdurate over nothing. We want to prevent surprise and make the thing move meaningfully and slowly.

JUDGE KELLEY: I think the more informally you can do it, so long as it gets done. You shouldn't have to write a letter and serve all the parties. A phone call ought to do. If you want a copy of some piece of paper, or if it's a book, you could loan the book maybe.

But the questioner, the cross-examiner either knows -- or at least he ought to know -- that he or she wants to ask questions based on some certain document. And then I believe we would expect them to come to the courtroom equipped with enough copies to serve around the circle here so that everybody can follow it.

I would suggest, just like the prior question about cross and lawyers and panels that we may finalize and refine this a little bit later. We don't want to take a lot more time this morning. But the concept of having copies, and their being provided by the cross-examiner, and the cross-examiner being responsible for getting ahold of the appropriate document if something's been cited in someone

else's testimony is one that we plan to adopt and to follow as the case progresses.

MR. BARTH: It sounds like a very acceptable solution, Your Honor.

MR. EDDLEMAN: I don't have any problem with that either, Judge. I just would point out that as big a thing as that document is it would be a great strain on my resources to make even half a dozen copies of the whole thing to hand out.

JUDGE KELLEY: No, no. Let me say again. Relevant portions, whatever is needed for context, that kind of thing. Not the whole book.

MR. EDDLEMAN: Yeah. But you see when he says he references Annex C, I don't know if Annex C then references Annexes D and F and so on without looking into the thing in some detail, because I don't know where in Annex C he's talking about. He didn't give a page.

JUDGE KELLEY: Well, I think in that case you have to get ahold of the U.N. publication, look it over, and make a judgment.

MR. EDDLEMAN: I can discuss this with his counsel is what you're saying.

JUDGE KELLEY: I think so, that part of it, yes.

MR. EDDLEMAN: I understand.

JUDGE KELLEY: And by the same token, those who

are preparing testimony and citing scholarly articles of one kind or another, I think generally you do, but don't you cite the article, give the page and table, or whatever that you are relying on, and the accompanying text.

So, it's a sign post for what you are really looking to to support your statement. Okay. Let's resume. We were over to the Applicant's questioning of Dr. Branagan.

MS. BAUSER: Chairman Kelley, we wanted to respond to the question posed by Judge Carpenter, and it would be our preference that we put Dr. Mauro back on the stand in order to do so. If that is not acceptable to the Board, I would go ahead and ask Dr. Branagan a few questions. But it would be our preference to ask Dr. Mauro directly the question posed by Judge Carpenter.

JUDGE KELLEY: Any objection from the parties?

MR. EDDLEMAN: I don't really understand what they're trying to do. They want to re-examine their witness on redirect about what he said?

JUDGE KELLEY: Let her clarify.

MS. BAUSER: As I understand it, Dr. Carpenter earlier this morning asked Dr. Branagan which noble gases emitted from the nuclear power plant would decay to form iodized chemical forms that might associate with particles, which might undergo further radioactive decay. That is paraphrasing of the question.

I don't believe Dr. Branagan answered the question at the time that it was asked. And we are in a position to answer the question. We didn't want there to be any confusion on the record about that point, which was not asked of the panel yesterday.

JUDGE KELLEY: Let me ask you this, too. If you were allowed to do that, do you also have questions for Dr. Branagan or not?

MS. BAUSER: No.

JUDGE KELLEY: So if you could do that, that's all you want to do right now?

MS. BAUSER: Right.

JUDGE KELLEY: Mr. Eddleman?

MR. EDDLEMAN: Judge, I think I asked their witness or their panel a number of questions along this line yesterday and they said they would refer to a certain standard reference book if they wanted to answer that question. So unless he has looked at the book and wants to tell us what it says, I don't see any reason to do this.

MS. MOORE: Your Honor, might I respond?

MR. EDDLEMAN: I'm not really objecting.

JUDGE KELLEY: Just a minute, I have a question of Mr. Eddleman. Apart from the point you just made, do you have an objection? Is this unfair to you? Is it going to disadvantage you in some way?

MR. EDDLEMAN: Not as far as I know. I'd rather have it on the record even if it did disadvantage me. I'd rather have the facts. But I don't see any point in it unless he really has analyzed the question or something.

JUDGE FOREMAN: The point is that Dr. Carpenter wants to know the answer.

MR. EDDLEMAN: Okay, well, I'm perfectly willing to give Dr. Carpenter all the answers he wants.

JUDGE KELLEY: Let me finish the procedural part of this. If you do that, put your witness on, then I assume, if Mr. Eddleman has recross he could put that, correct?

MS. BAUSER: Yes. It's our intention to limit Dr. Mauro's rebuttal or whatever you call it --

JUDGE KELLEY: He's coming on for a limited purpose, understand that. And the Staff also may have further questions of your witness on the same topic.

MS. BAUSER: Yes, of course.

JUDGE KELLEY: Ms. Moore?

MS. MOORE: I have no objection to that procedure. I just wanted to make a point. Mr. Eddleman referred to the fact that the witnesses relied on the standard reference. One of the problems with just focusing on that reliance is that that standard reference is not in evidence. But this testimony would in fact provide a record answer to Dr. Carpenter's question.

JUDGE KELLEY: Okay. The Board doesn't hear any objections to this. Subject to the ground rules we indicated -- hold on just a moment.

(Board conferring.)

JUDGE KELLEY: Should we finish with Dr. Branagan or insert Dr. Mauro?

MS. BAUSER: We would recommend finishing with Dr. Branagan.

JUDGE KELLEY: It seems a little neater. Let's do that, okay. You are waiving your rights on Dr. Branagan, but you instead will call your own witness when he is through, correct?

MS. BAUSER: Yes, sir.

JUDGE KELLEY: Okay.

BOARD EXAMINATION

BY JUDGE KELLEY:

Q I asked a question, Dr. Branagan, in layman's terms and I think you got off on something else. I think you answered it later, but just so I understand, my question was about the thyroid and why the thyroid was the limiting dose that you looked at. And if I understood you correctly, that is because, through the inhalation pathway, that is the organ to which the largest dose goes, as compared to other organs. And it is not because the thyroid is more sensitive to radiation or more vulnerable to radiation than

11

some other organ; is that right?

A Yes. The thyroid is not more vulnerable to radiation than some other organ. It is certainly not more vulnerable than whole body exposure.

Q So if you have so many rems to the thyroid, the same number of rems to a hand or a foot would be equally a matter of concern, or lack of concern depending on the size?

A The International Commission on Radiological Protection has published a report, ICRP-26, and they propose risk weighting factors for the various body organs. And the value that they use for the thyroid is .03, as compared with the whole body radiation which would be 1.0.

Q So the body as a whole, according to that is more vulnerable?

A Whole body radiation would present more potential fatal cancers than exposure of just the thyroid.

Q I see. One other question, I assume you are familiar with the testimony we heard yesterday from Dr. Mauro and Dr. Schaffer. I know you were here during the testimony. Do you have any significant disagreement with their analysis?

A No, the basic conclusions I agree with. I don't have any problem with them.

JUDGE KELLEY: Thank you.

JUDGE CARPENTER: I would just say for the record, I am more familiar with the term critical organ as sort of summarizing the results of all the analyses.

BY JUDGE CARPENTER:

Q So am I correct in believing, or having the impression that that's really what you meant to say about the thyroid is, as a result of analysis, it was a critical organ considering all the factors you're talking about?

A Considering all the factors, it was the organ with the highest dose.

Q Yes, so therefore, it becomes the critical organ. Not the most sensitive or what have you, but the organ to be considered. I think the common scientific jargon is that it is the critical organ; is that right?

A Yes, you could speak to it as the critical organ or the most limiting organ, in terms of the dose design objectives.

Q Thank you.

JUDGE KELLEY: Redirect?

MS. MOORE: Staff has no questions, Your Honor.

JUDGE KELLEY: Any recross, Mr. Eddleman, that we generated?

MR. EDDLEMAN: No, no questions.

JUDGE KELLEY: Okay. Mr. Branagan, thank you very much. You're going to rejoin us, are you not?

13

THE WITNESS: Yes, I will.

JUDGE KELLEY: All right. Thank you. You are excused for now.

(Witness Branagan excused.)

MS. BAUSER: Applicants recall Dr. Mauro. I believe he's already been sworn.

Whereupon,

JOHN J. MAURO

a witness, called for examination and, having been previously duly sworn, was examined and testified further as follows:

DIRECT EXAMINATION

BY MS. BAUSER:

Q Dr. Mauro --

WITNESS MAURO: Shall I proceed to answer the question?

JUDGE KELLEY: Yes, you are on for the limited purpose previously described and subject to possibility of further questions.

JUDGE CARPENTER: Please restate the question exactly as you expect to answer it.

WITNESS MAURO: As I understand the question, the concern is that noble gases which have been estimated to be released routinely from the Harris facility are presented in the FES. And dose calculations were performed related to that. Those calculations primarily address whole body and skin doses.

14

The concern is the possibility that some of these noble gases will decay, and their daughters will be of a particulate form, and thereby may be inhaled and behave as a particle and deliver a dose to the lung. Something that -- the concern is it was overlooked.

That is, when we do our dose calculations we may have overlooked this contribution. And I am going to address the degree to which this in fact was overlooked, and whether or not it was significant. That is my understanding of the question.

BOARD EXAMINATION

BY JUDGE CARPENTER:

Q I think the question was limited to noble gases, and whether or not they decayed into a form that had a charge on in that was ionized, that then might become associated with fly ash. And then subsequently undergo further radioactive decay.

A Your reiteration is a bit narrower.

Q That's what I intended it to be, that narrow.

A Okay. There are estimated to be 13 different types of noble gases released from the facility. Of those, by far the most important noble gases in terms of quantity is xenon 133 and krypton 85. They make up over 93 percent of the total quantity of noble gas released from the facility.

Upon decay, they decay into stable isotopes, not

15

radioactive isotopes. Krypton 85 decays to rubidium 85, which is stable. And the xenon 133 decays to cesium 133, which is also stable. So the first part of my answer is basically that over 93 of the noble gases that are estimated to be released decay to stable radionuclides and therefore, are not at issue.

JUDGE FOREMAN: 93 percent in terms of what? Weight, volume?

WITNESS MAURO: Curies. 93 percent of the curies. Now there remains in the remaining 13 radionuclides, four of them have daughters which are radioactive. Now as it turns out -- I would just like to preface this with in the development of all dose conversion factors, consideration is given to the daughters.

However, in cases where the daughters cannot contribute significantly, it is a miniscule contribution to the dose, they are just ignored. And I will give you an example.

One of the radionuclides of the 13 that has a daughter which is radioactive is krypton 87. It decays to rubidium 87. Now it turns out the source term for krypton 87 is six curies per year. Assuming that -- taking into consideration decay, the additional source term due to the rubidium 87 would be 18 picocuries per year.

That is, that would be, in effect, what is not

16

accounted for, that 18 picocuries. It is general practice to not even consider radionuclides as a source term if they are less than 10^{-4} curies. We are talking about 1.8 times 10^{-11} curies per year.

So it's just that totally miniscule, insignificant contribution to the source term, and it is typically not included because it is below any level that could possibly, by any pathway, contribute significantly to the dose to any organ.

end 10

mgc 11-1

BY JUDGE CARPENTER:

Q One last question. I did say, based on Mr. Eddleman's cross-examination, I did specify that some intermediate, either rubidium-87, for example -- would you expect it to be ionized, or would you expect it to be a neutral atom?

A Upon decay, you would expect the daughter for a short period of time to be carrying a charge. That is, you would expect it to be ionized because it is part of the decay process.

Q When you say "short," can you give me some order of magnitude -- minutes, seconds?

A I would say less than seconds.

Q Thank you.

JUDGE KELLEY: Does that complete your answer?

THE WITNESS: Yes, it does.

JUDGE KELLEY: Mr. Eddleman, any questions?

MR. EDDLEMAN: I have a few.

JUDGE KELLEY: Maybe I should have checked back here. Did you want to elicit anything further?

MS. BAUSER: Yes.

JUDGE KELLEY: Why don't you go ahead, and then we will go to Mr. Eddleman?

mgc 11-2

REDIRECT EXAMINATION

BY MS. BAUSER:

Q Dr. Mauro, you addressed one, I believe, of four noble gases that would decay into a radioactive -- did you want to address the other three?

A Yes, I can. But that was indicated as an example.

Q Are the other three comparable?

A That's a comparable situation except, I guess, one of them that may be in a little different context, xenon-138, which the source term contributes less -- well, it is one curie per year as compared to the total curies of all noble gases, which are on the order of thousands or perhaps 3000. So one curie per year of xenon-138 is released. It decays to cesium-138, which is radioactive.

Now if you were to calculate the additional dose due to the cesium-138, it is three percent of the dose from xenon-138. So in effect, when we calculate our dose from xenon-138, we are ignoring this additional three percent that comes from cesium-138. It's a very small fraction, and when you consider that in light of the fact that the xenon-138 itself is only one curie per year source term compared to 3000 curies total noble gases, you can see how not explicitly addressing this daughter of xenon-138 in the calculation does not change your results by any means which could be considered significant.

mgc 11-3

Q That three percent is three percent of the one curie?

A Three percent of the dose from xenon-138.

Q That's three percent of the one?

A Of the one. That is correct.

MS. BAUSER: Thank you. I have no further questions.

JUDGE KELLEY: Mr. Eddleman?

RECROSS EXAMINATION

BY MR. EDDLEMAN:

Q Doctor, is it your testimony that all atoms of xenon-133 decay into the stable isotope cesium-133?

A That's correct.

Q And likewise all atoms of krypton-85 decay into rubidium-85, which is stable?

A That's correct.

Q You have mentioned two of these four nuclides which have radioactive daughters. Among those 13 listed from the plants, you have listed krypton-87 and xenon-138.

What are the other two?

A Krypton-88 and xenon-135.

Q Can you tell me what the decay chain is from xenon-135?

A Xenon-135 goes to cesium-135, and this isotope is similar in situation to the krypton-87; namely, the

mgc 11-4

quantity -- that is, when it decays, the quantity of radionuclide that we are talking about would be equivalent to cesium-135 source term along the order of 452 picocuries per year, which is well below the 10^{-4} cutoff point that we typically use, because below that level, it's just so miniscule as to have very little meaning.

Q Doctor, cesium-135 is also radioactive.

A That's correct.

Q What does it decay into?

A I don't have that in front of me. I would have to go check back with my source, Lederer and Hollander. Hold on a minute.

The question was cesium-135?

Q Yes.

A I don't have it. It would take only a moment to check it.

Q Do you have a copy of the source here now?

A I could find it. It's probably here in the courtroom somewhere.

JUDGE CARPENTER: I think it would be useful. Otherwise, I will simply have to do it subsequently.

THE WITNESS: Would you mind if I walk over and get it?

JUDGE CARPENTER: No.

THE WITNESS: The particular source I am looking

mgc 11-5

at right now apparently does not address specifically that isotope, so I would have to check different sources.

BY MR. EDDLEMAN:

Q Can you check under xenon-135 in that source and see if there is a decay chain given?

A That's what I'm looking for, and I can't find it.

Q Okay.

MS. BAUSER: Could you give us one minute, please?

MR. EDDLEMAN: Sure.

(Pause.)

JUDGE KELLEY: Off the record a second.

(Discussion off the record.)

BY MR. EDDLEMAN:

Q Doctor, that book you have in your hand there is the reference we discussed yesterday, isn't it?

A No. It turns out to be a different one.

Q So you still don't have the one that you would rely on?

A Yes. This is also a well-used reference for decay chains, but the one I typically use is the Lederer and Holander table of the isotopes. This is called "The Radiological Health Handbook."

Q Now, Doctor, let me just ask you one thing about Lederer and Hollander. In Lederer and Hollander, each isotope is shown with the decay chains, isn't it?

mgc 11-6

A That's correct.

Q So if we wanted to know about these decay chains, either from these noble gas phases or passing through a noble gas phase as something else decays into a noble gas out of the environment and then decays further into other radioisotopes, we could find that in Lederer and Hollander, couldn't we?

A Yes, that's correct.

Q Let me also ask you, we discussed three of the four isotopes. Your counsel discussed two with you, and the other one is krypton-88.

What does krypton-88 decay into?

A Rubidium-88.

Q And rubidium-88 is radioactive?

A That's correct.

Q All right. And what does rubidium-88 decay into, if you know?

A I don't have that information. I could check that also.

Q And you would be able to find that kind of information in Lederer and Hollander?

A I presume so. I expect so.

Q Doctor, you mentioned that of the thirteen types of radioactive noble gases to be released fromthe Harris plant, we have now mentioned six isotopes explicitly,

mgc 11-7

the four which you say have radioactive daughters and two which you say do not. That leaves us with seven other isotopes, doesn't it?

A Yes. They are all stable, the others.

Q You mean their decay products are stable.

A Yes, that's correct.

Q Do you have a list of those, the isotope and its decay product?

A Yes. We can go down the list.

Q If you could just read it out.

A Okay. Argon-41 decays to potassium-41 stable. Krypton-83m decays to krypton-83 stable. Krypton-85 decays -- excuse me -- krypton-85m decays to krypton-85, a noble gas which is radioactive, which decays to rubidium-85 which is stable.

Q So what you are saying there is, for both krypton-83 metastable and krypton-85 metastable, both of those when they decay, decay into a krypton of the same mass, and then krypton-83 is stable, but krypton-85 is radioactive and decays into rubidium-85.

A That's correct.

Q Okay. Please go on.

A Then the next isotope in the list -- I'm basically going down the list of isotopes that are addressed in the FES.

mgc 11-8

Krypton-85 decays to rubidium-85 which is stable. Then we get to krypton-87, which is one of the isotopes that has a radioactive daughter. It decays to rubidium-87, and that daughter, as I pointed out before, that effectively means a source term for rubidium-87, which is on the order of 18 picocuries per year. That's what I testified to previously.

Q Excuse me, Doctor. I just want to tie this in here. I think this might be the most convenient place.

What does rubidium-87 decay into?

A I don't have that information here.

Q Okay.

A Do I understand your concern now is that you would like to look at the daughters of each of the radioactive isotopes that I am describing, the daughters and the daughters of the radioactive daughters that we are discussing right now?

Q That's right. I think that was explained on discovery. But what I am asking you is just to state the information you have. In other words, whenever you get one of these decays, if you can take it down to a stable isotope, please just give the chain to the stable isotope. And if you don't know, just state at what point you know and at what point you don't know the further decays.

A Fine. Yes, sir.

mgc 11-9

MS. BAUSER: Excuse me. I don't want to be unreasonable here, since we have all this testimony, but I'm not sure what relevance this further chain would have, since those we have already analyzed, the impact of the radioactive daughter, and you are only going to get a lesser version of the same thing. At best, I just don't see -- this just doesn't address the concern that was originally voiced.

We will be happy to get it, but --

MR. EDDLEMAN: It may not address Judge Carpenter's concern, but it does address what I was asking about yesterday, and I think if he has his table of isotopes in front of him, I'm at least entitled to ask how far he knows these decay chains.

MS. BAUSER: Could you identify, Mr. Eddleman, what it was yesterday that this relates to?

MR. EDDLEMAN: I asked him about decay yesterday, as to what these things decay into, and he said that he didn't have the information, but he would use this reference, Lederer and Hollander. And at some point I think I said, "Well, since you don't have the reference, I can't ask you anymore about that."

MS. BAUSER: But, Mr. Eddleman, assuming that he had had the reference, what relevance does his answer have to either the contention or the question posed by

mgc 11-10

Judge Carpenter?

MR. EDDLEMAN: If, as in Judge Carpenter's question, a noble gas atom, whether it's released from the plant as a noble gas or released as something else that decays into a noble gas, is near a coal particle and it decays, the noble gas atom decays and ionizes itself and may attach to that coal particle, okay?

Now if, in fact, that coal particle carries that daughter atom into someone's lung and it keeps on decaying through a change, then you get all those daughter atoms' activities in the lung, which is not a place where you generally assume in these analyses that it's going to be.

JUDGE KELLEY: I thought that the witness had already told us about the unstable, when they do decay, and the only ones left were the stable ones.

JUDGE CARPENTER: Mr. Eddleman, if I may interrupt, I would like to go back to the witness for a second.

JUDGE KELLEY: Could I get the answer to my question first? Is that right or not?

MR. EDDLEMAN: I think so, Judge. I'm just trying to get it all clearly laid out as to which ones he says are stable and which are not. I can't check his reference again, because he cannot find some of them. I just want to get it on the record which ones he says decay into stable ones and which ones don't.

mgc 11-11

JUDGE KELLEY: I couldn't repeat it, but I thought he said that clearly enough.

Did you state that?

THE WITNESS: Yes. I indicated that there were four that were radioactive, and I gave you those, and the remainder are all stable. So therefore, four of the thirteen have radioactive daughters, and the remainder are stable.

Now Mr. Eddleman wanted to go down each of the thirteen.

JUDGE KELLEY: That's what I thought. And what is the point, if they are stable?

MR. EDDLEMAN: Well, if he is correct in saying they are stable, there is no point.

If I may, I'll just back off from that.

BY MR. EDDLEMAN:

Q Cesium-138 is one of those daughter products of these noble gases. Do you know what that decays into?

A Cesium-138? No. I would have to check that. All of the daughters of the daughters, I don't have the information here.

Q Okay. Doctor, where are those thirteen types of radioactive gases released from Harris listed? What is your source on that?

A It's contained in -- I believe it is Appendix D

mgc 11-12

of the FES.

Q Did you note in preparing your notes at what table or page of Appendix D this information comes from?

A I don't recall the exact table number.

MS. BAUSER: Excuse me. I would like to give the witness a copy of the FES (handing document to witness).

THE WITNESS: Table D-1 on page D-4.

BY MR. EDDLEMAN:

Q And what is the title of that table, Doctor?

A "Calculated Release of Radioactive Materials From Gaseous Effluents from Harris (Curies per Year per Reactor)."

Q Do you use the number of curies per year from one reactor in your computation?

A That's correct.

S2BU

Q And you just took all of the noble gases that are listed in that table and analyzed whether they decayed into a stable or radioactive nuclide?

A That's correct.

Q Now these, Doctor, are the nuclides that when they come out of Harris are noble gases; is that correct?

A That's correct.

Q So your analysis would not address other nuclides which might be in particulate form or some atom or some chemical element which is not a gas when released

mgc 11-13

from Harris but which might or do decay into a noble gas outside the plant.

A Oh, I see. That's a different question. You are asking now, are there any particulate emissions from the plant which decay to noble gases, the converse.

Q Yes.

JUDGE KELLEY: Wasn't Judge Carpenter's question about noble gases that came out of Harris?

THE WITNESS: Yes, sir. That's how I understood it.

JUDGE KELLEY: I object to the question.

MR. EDDLEMAN: I'm sorry, Judge. I'm trying to follow what I was going after yesterday.

JUDGE KELLEY: You don't have permission to do that. We put this witness on to answer a specific question, and we opened up cross for the narrow purposes of that question and that question only, and that is it.

MR. EDDLEMAN: So even if he has the information that he didn't have yesterday, that I couldn't ask him about then, I can't ask him anymore; is that right?

JUDGE KELLEY: Right.

MR. EDDLEMAN: Well, your the Judge.

JUDGE KELLEY: That's right.

End

mgc 12-1

JUDGE CARPENTER: I would like to ask the witness to help me recall the testimony in response to my question, the initial response, and the question specifically focused on the formation of ionized particles, charged particles, and I believe you told me, as an example, for krypton-87, you might go to rubidium-87, which might exist as a charged particle for seconds. I'd like your opinion, if that charge led to its being able to compete or site on a particle such as a fly ash coal particle because of its charge, in your professional opinion, once that charge is dissipated, would it then have to compete with all the uncharged substances for that site?

THE WITNESS: In my opinion, yes.

JUDGE CARPENTER: So the fact that it went on because it was charged might lead to its coming off once it was uncharged. Have you ever looked at that sequence?

THE WITNESS: You are asking me a question that really relates to aerosol physics. In other words --

JUDGE CARPENTER: I am talking about the chemical affinity because of charge and disappearance of charge and then competing with many things. like oxygen and nitrogen, aromatic carbons, all manner of things.

THE WITNESS: No, I haven't specifically looked into that.

JUDGE CARPENTER: Thank you very much. That's

mgc 12-2

the limits of my question.

JUDGE KELLEY: I think that covers this point with this witness; is that correct, as far as you are concerned?

MS: BAUSER: Yes, sir.

JUDGE KELLEY: Does Staff have questions on this point, Ms. Moore?

MS. MOORE: May I have a moment?

(Pause.)

MS. MOORE: Staff has no questions, Your Honor.

JUDGE KELLEY: Okay. Thanks very much.

THE WITNESS: Excuse me.

JUDGE KELLEY: Yes.

THE WITNESS: Am I to be prepared to answer the daughters of the daughter question when I come back for II(c)?

JUDGE KELLEY: This was something that you indicated to Mr. Eddleman that you could look up but didn't have before you then?

THE WITNESS: That's right.

JUDGE KELLEY: Why don't you see if you can do that, and you can just recite them and move on when you get on this afternoon.

THE WITNESS: Yes, sir.

mgc 12-3

JUDGE KELLEY: Thank you.

Excuse me just a moment.

(The Board confers.)

JUDGE KELLEY: To beat the crowds to the lunch spots today, why don't we adjourn until quarter of one?

(Whereupon, at 11:35 a.m., the hearing was recessed to reconvene at 12:45 p.m. this same day.)

13pb1

AFTERNOON SESSION

(12:50 p.m.)

JUDGE KELLEY: We are back on the record, and we are moving now to Contention II(e), the Contention II(c). Anything before we launch into that?

MS. BAUSER: There was one brief remaining thing that Dr. Mauro had to respond to. He wasn't able to --

JUDGE KELLEY: He was going to look at that over lunch, was that the idea? Would you say to him just what that is?

MR. MAURO: The question was raised that certain radionuclides, noble gas radionuclides that had daughters which were themselves radioactive -- and I addressed which ones they were earlier.

The next question that was raised by Mr. Eddleman pertained to, well, what about those? The daughters of those radionuclides. Basically the daughters of the daughters.

JUDGE KELLEY: The granddaughters.

MR. MAURO: Yes. Were they also radioactive, and the answer is no, they are all stable.

MS. BAUSER: Your Honor, I'd like to call to the witness stand Dr. Mauro and Stephen Marschke. I believe Dr. Mauro has already been sworn, but Mr. Marschke has not.

Whereupon,

JOHN J. MAURO

a witness, called for examination and, having been previously duly sworn, was examined and testified further as follows:

Whereupon,

STEPHEN F. MARSCHKE

a witness, called for examination and, having been first duly sworn, was examined and testified as follows:

DIRECT EXAMINATION

BY MS. BAUSER:

Q Gentlemen, could you please state your names, position and places of employment?

A (Witness Mauro) My name is John Mauro. I am director of radiological assessment and health physics at Ebasco Services in New York City.

A (Witness Marschke) My name is Stephen Marschke. I'm a principal radiological assessment engineer at Ebasco Services, Incorporated, New York City.

Q I draw your attention to a document dated May 31, 1984 entitled Applicant's testimony of John J. Mauro and Stephen F. Marschke on Joint Contention II(c) (Radiological Dose Calculations). This document consists of 14 pages, eight attachments and a list of references.

Dr. Mauro, does this document represent testimony by you and Mr. Marschke, or under your direct supervision?

A (Witness Mauro) Yes, it does.

Q Dr. Mauro, do you have any changes or corrections to make to the testimony?

A Yes, there are a few. There are two. One on page 10, at the bottom of page 10, the footnote. Delete the following words. There is a typographical error in Table D-6. As noted, that should all be deleted.

The next word, in, should become the beginning of the sentence with a capital "i." Then, at the end of the footnote after the period, insert the sentence, "Table D-6, identifies this location as 2.3 kilometers north-northwest.

And there is one other correction. That is in my resume, in Attachment 1-A, very close to the top where it indicates my receiving a B.S. in 1963. That should be corrected to 1967.

Q With those changes, Dr. Mauro, is this testimony true and correct to the best of your knowledge?

A Yes, it is.

Q Mr. Marschke, with these changes is the testimony true and correct to the best of your knowledge?

A (Witness Marschke) Yes, it is.

MS. BAUSER: Mr. Chairman, I move that the testimony of Dr. Mauro and Mr. Marschke be admitted into evidence and physically incorporated into the record as if read.

MR. EDDLEMAN: With the attachments and everything, no objection.

JUDGE KELLEY: So ordered.

(The prepared testimony of John J. Mauro and Stephen F. Marschke follows:)

May 31, 1984

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
CAROLINA POWER & LIGHT COMPANY	)	Docket Nos. 50-400 OL
and NORTH CAROLINA EASTERN	)	50-401 OL
MUNICIPAL POWER AGENCY	)	
	)	
(Shearon Harris Nuclear Power	)	
Plant, Units 1 and 2)	)	

APPLICANTS' TESTIMONY OF JOHN J. MAURO AND STEPHEN F. MARSCHKE ON JOINT CONTENTION II(c) (RADIOLOGICAL DOSE CALCULATIONS)

TABLE OF CONTENTS

I. Introduction

My name is John J. Mauro. I am the Director of the Radiological Assessment and Health Physics Department of Envirosphere Company, a division of Ebasco Services, Inc. Ebasco is the architect-engineeer for the Shearon Harris Nuclear Power Plant. As indicated in Attachment 1A to this testimony, I have a doctorate in biology and radiological health and am a certified health physicist. I have worked for the last twelve years in the field of radiological assessment, and have written a number of publications in this field.

My name is Stephen F. Marschke. I am Principal Radiological Assessment Engineer at Envirosphere Company. As indicated in Attachment 1B, I have a bachelors degree in nuclear engineering. I have worked for ten years in the field of radiological assessment.

We have assisted Carolina Power & Light Company (CP&L) in the preparation of the radiological assessments contained in the Harris Plant Environmental Report (ER). We also have reviewed the Draft and Final Environmental Statements (DES and FES) prepared by the NRC Staff which assess the environmental impacts of operation of the Harris Plant. The radiological dose calculations that are included in the ER, the DES and the FES rely on the methodology specified in Reg. Guide 1.109.

The purpose of this testimony is to respond to the issues raised by the Joint Intervenors' Contention II(c) which remain in controversy.

Contention II(c) states:

> The long term somatic and genetic health effects of radiation releases from the facility during normal operations, even where such releases are within existing guidelines, have been seriously underestimated for the following reasons . . . c) the work of Gofman and Caldicott shows that the NRC has erroneously estimated the health effects of low-level radiation by examining effects over an arbitrarily short period of time compared to the length of time the radionuclides will be causing health and genetic damage.

In its Memorandum and Order dated January 27, 1984, as supplemented by its Memorandum and Order dated March 15, 1984, the Licensing Board partially denied Applicants' motion for summary disposition on Joint Contention II(c). In doing so, the Board limited the issues to be litigated to "whether the NRC staff should confine itself, as it has done in this case, to computations of annual doses and effects," and "whether it would be more appropriate to disclose the total risk represented by the life of the plant." The Board also ruled that the time period over which doses should be calculated should not include geologic time periods.

This testimony, prepared in response to the Board's January 27 and March 15 Orders, is designed to accomplish three objectives:

1) to briefly describe the method used in the FES and the ER for calculating radiological doses and risks, and to explain the reasons for characterizing the offsite impacts of these doses on an annual basis;

2) to quantify the impacts in terms of the life of the plant; and

3) to demonstrate that the impact of radiation released from the Harris Plant on the population and the maximally exposed individual over the life of the plant are vanishingly small relative to background radiation.

In evaluating doses from Harris Plant radiological releases, consideration must be given both to the population dose, i.e., the sum of the individual doses, and to the dose to the hypothetical maximally exposed individual. These two different ways of assessing dose are used in order to insure that (1) regulatory limits, which are designed to protect the individual, are met; and (2) the risk to the population as a whole is understood. In response to the Board's Order, this testimony is based on the calculation of doses to the population from 40 years of plant operation. The calculation includes consideration of any residual exposures from releases during the life of the plant (40 years) for a period of 100 years after plant operation ceases. The highly speculative doses accrued over geologic time periods are excluded. Doses to the maximally exposed individual are expressed in terms of lifetime dose from the 40-year operating life of the plant. As with population doses, the maximum individual doses are calculated on the basis of exposure to radionuclides released over a 40-year plant life, and the individual's exposure to residual radioactivity in the environment after the plant ceases operation.

This testimony is divided into two sections. The first section addresses the doses and risks to the 50-mile and U.S. populations; the second section addresses the doses and risks to the maximally exposed individual.

II. Population Doses and Risks

A. Current Values in the FES

Table D-7 of the FES, which is included as Attachment 2A to this testimony, presents the whole body and thyroid population doses within 50 miles (80 km) of the Harris Plant on an annualized basis. Separate values are provided for doses from liquid effluents, and from noble gases, radioiodines and particulates in the gaseous effluents. Table D-9 of the FES, which is included as Attachment 2B, summarizes annual U.S. population doses from the Harris Plant and from natural background radiation.

The doses from the liquid effluents are from the ingestion of sport and commercial fish harvested from the main reservoir and from the Cape Fear River. The values are calculated by assuming the annual source term, presented in Table D-4 of the FES, is diluted in the reservoir. The calculation also assumes that the reservoir water overflows to the Cape Fear River, where it is mixed in the river flow. Fish in the reservoir and the Cape Fear River are assumed to reconcentrate the radionuclides to varying degrees, depending on the element; the fish then are harvested and consumed.

The doses from the gaseous effluent include external exposure from air submersion and deposited radioactivity, and internal exposure from inhalation and the ingestion of contaminated vegetables, milk and beef. These exposures are presented in Table D-7 for an 80 km radius from the plant, and in Table D-9 for the U.S. population.

The annual population doses from operation of the Harris Plant are compared to the annual doses from background radiation in Tables D-7 and D-9. This comparison also could have been presented on the basis of plant life. Since the annual doses represent the average annual dose over the life of the plant, the annual dose may be multiplied by 40 to estimate the cumulative dose from the operating life of the plant. There are no regulatory or other limits established for population doses; consequently, in order to evaluate their significance, population doses from nuclear power plants are compared with annual natural background population doses. It is also convenient to annualize doses from the Harris Plant because, for the purpose of NEPA assessment, the impacts from the nuclear fuel cycle are generically expressed on an annual basis (see Tables S-3 and S-4 of 10 CFR 51), and are compared to the benefits of the facility, which also are annualized. In sum, annualizing doses from the Harris Plant facilitates the assessment of the significance of those doses and provides a reasonable representation of the radiological impacts of plant operation.

B. Population Doses and Risk for the Life of the Plant

Life-of-the-plant population doses can be obtained by multiplying the values in Tables D-7 and D-9 by the assumed 40-year plant life and adding in the residual dose to the population due to radionuclides which reside in the environment after plant operation terminates. The annual doses contained in the FES would change to reflect the population doses for the life of the plant as follows:

Table 1 */

Pathway	Annual Whole Body Person-rems 80 km	Annual Whole Body Person-rems U.S.	40-Year Whole Body Person-rems 80 km	40-Year Whole Body Person-rems U.S.
Liquid	1.7	1.7	68	68
Gaseous	13.7	24	556	1670
Total	15.4	25.7	624	1738
Natural Bkgd	180,000	26,000,000	7,200,000	1,040,000,000

*/ The number of significant digits is not intended to indicate the degree of calculational accuracy, but is provided to facilitate independent verification of the tabulated values.

Attachment 3 to this testimony demonstrates that the total additional dose to the population within 50 miles of the plant and to the U.S. population due to residual radioactivity in the environment is about 8 person-rems and 706 person-rems, respectively, over a 100-year period following plant shutdown. Considering that this residual dose is relatively small and in light of the numerous conservatisms inherent in the calculation

of annual dose during operation (see Attachment 4), the residual doses following plant operation are not significant. Accordingly, the 50-mile and U.S. population doses due to the operating life of the plant may be estimated by multiplying the annual doses presented in the FES by 40.

Similarly, the U.S. population health risk of 0.008 cancer deaths per year, referred to on page 5-35 of the FES, is multiplied by a factor of 40 to yield the risks due to the operating life of the facility. The result is 0.32 cancer deaths associated with the operating life of a two-unit plant, which means 0.16 cancer deaths for the single unit Harris Plant.

C. Comparison of Population Doses and Risks for the Operating Life of the Plant to Doses and Risks from Natural Background Radiation

As indicated in Table 2, the risk to the population as a whole due to the cumulative exposures associated with 40 years of operation is many thousands of times smaller than the risks due to natural background radiation over the same period of time.

Table 2 - Doses & Risks (Fatalities)

Source of Exposure	Population Dose (Person-Rems)	Population Risk	Average Individual Dose (Rems)	Average Individual Risk
40 yr operation				
50-mile*	624	0.10	3.5×10^{-4}	5.0×10^{-8}
U.S.**	1738	0.25	7.0×10^{-6}	1.0×10^{-9}
Natural Bkgd over 40 year				
50-mile	7,200,000	1,000	4	6.0×10^{-4}
U.S.	1,040,000,000	150,000	4	6.0×10^{-4}

* For 50-mile radius, the exposed population is assumed to be 1.8 million people.

** For U.S., the exposed population is assumed to be 260 million people.

Table 2 also reveals that the cumulative risk to the 50-mile population (0.10) and the U.S. population (0.25) due to 40-years of plant operation is less than one cancer fatality. In fact, the above results reveal that the best estimate of the number of cancer fatalities due to plant operation for 40 years is zero. This number can be compared to both the expected number of cancer fatalities over 40 years in the U.S., which is over 10 million,1/ and the expected number of cancer fatalities

1/ There are approximately 190 cancer fatalities per year per 100,000 people in the United States (Cancer Facts and Figures, 1984), and there are approximately 260 million people in the U.S.

within a 50-mile radius of the facility over 40 years, which is over 100,000.2/

III. Exposure of the Maximum Individual

A. Current Values in the FES

Table D-6 of the FES (provided in Attachment 5 of this testimony) presents the annual dose commitment to the hypothetical maximally exposed individual. Prior to the performance of the dose calculations, a land use survey was performed to identify the locations of residents and food ingestion pathways near the Harris Plant site. The result of this survey is the identification of the limiting exposure pathways and their locations, i.e., the locations with the potential for the highest exposure. As for most sites, the important radiation exposure pathways are inhalation, direct exposure, and the ingestion of vegetables, milk and beef. The limiting locations typically are farms or gardens closest to the plant. The limiting locations for each pathway are those presented in Table D-6.

Table D-6 presents doses for 4 locations.

(1) The first location is the nearest site boundary (2.1 km north of the plant). This is the offsite location with the greatest potential for exposure from routine gaseous effluent, and although no one resides there, doses are provided for two

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2/ There will be approximately 1.8 million people in the 50-mile plant vicinity at the year 2000.

reasons. First, Appendix I to 10 CFR Part 50 sets a limit on the annual air dose offsite. Second, should a person reside at that location some time in the future, it is desirable to determine annual exposures which may be expected. Thus, this location establishes the limiting benchmark for calculated annual offsite doses.

(2) The second location is the residence that is actually nearest to the plant site (2.7 km NNE).3/ At this location, individuals may be expected to receive exposure from inhalation and ground deposition. In addition, it is likely that the resident will have a backyard garden. Accordingly, the exposure from vegetable consumption is considered.

(3) The third location (2.9 km N) is the closest farm on which milk cows and beef cattle are exposed by consuming grass contaminated by deposited radionuclides.

(4) At the fourth location (7.4 km NNW), the closest milk goat pathway is considered.

At each location, and for each pathway at that location, doses are calculated for four age groups (adult, teen, child and infant) and for eight organs (bone, liver, total body, thyroid, kidney, lung, GI tract, and skin). The doses are presented in this way because the dose limits in Appendix I to 10 CFR 50 are expressed in terms of total body and organ doses.

3/ ~~There is a typograhical error in Table D-6. As noted~~ In Table D-2 of the FES and Table 5.2.2-1 of the ER, the nearest residence and garden is located 2.7 km NNE. Table D-6 identifies this location as 2.3 km NNW.

In Table D-6, the highest doses from these calculations are tabulated.

Table D-6 is useful in determining the maximum dose to the critical organs via each pathway for the critical age groups. In order to determine the maximum dose to an individual, the doses in Table D-6 must be summed. Thus, for example, the highest dose to any organ for any age group is to the infant thyroid gland due to the consumption of milk at the nearest cow milk location. In order to determine the infant's total thyroid dose, which is the maximum and, hence, limiting organ dose, the exposure to the thyroid from inhalation (0.22 mrem/yr), ground deposition (0.20 mrem/yr) and milk consumption (4.19 mrem/yr), must be combined, yielding 4.6 mrem/yr. This is the value reported in Table D-7 of the FES as the limiting "dose to any organ from all pathways." Table D-7 compares the calculated annual commitments for the maximally exposed individual to the Appendix I design objectives.

The doses from the liquid effluent pathways are determined in very much the same manner as those for the gaseous pathway. However, the analysis is simpler because all exposures, except for drinking water, are conservatively assumed to occur at the plant liquid effluent discharge area. This location is selected because it is possible that people will fish there. Since drinking water is not taken from the reservoir, the closest source of drinking water, which is at Lillington, is assumed in the dose calculations.

B. Maximum Individual Doses for the Life of the Plant

The previous discussion reveals that the annual doses in the FES are for selected organs and age groups at selected locations. Accordingly, the maximum dose to an individual over the operating life of the plant cannot be obtained by directly multiplying the values in Table D-6 by 40. Doing so would be unrealistically conservative because it would mean, for example, that an infant remains an infant for 40 years. Instead, a calculation was performed to determine the doses to an individual who receives the maximum lifetime exposure because he is initially exposed at birth and lives his entire life in the vicinity of the plant. The calculation takes into consideration changes in internal dosimetry and feeding habits as the individual grows to an adult. In order to simplify this calculation, it is conservatively assumed that a family resides at the nearest site boundary and obtains its beef, milk and vegetables at that location, drinks water from Lillington and fishes near the discharge area. It is also assumed that the individual remains at this location for a period of 70 years, which is taken as his life expectancy. The results of the analysis, presented in Attachment 6, are stated in terms of the annual dose to each organ and age group for each pathway.

As indicated in Attachment 6, the maximum lifetime whole body radiation dose to an individual from the 40-year operation of the Harris Plant is 130 mrem. This figure was obtained by

multiplying the annual doses for each age group by the number of years the individual is in that age group while the plant is operating,4/ and then summing these values. To this number is added the residual dose after plant shutdown (from 41 to 70 years). The calculated risk of cancer mortality from this exposure is estimated to be about 2×10^{-5} (0.00002). This risk was calculated using the age specific cancer risk coefficients and the methodology presented in BEIR I. Attachment 6 briefly describes this calculational method.

C. Comparison of Doses and Risks for the Operating Life of the Plant to the Maximally Exposed Individual Relative to Background Radiation

The above section indicates that the lifetime dose to the maximally exposed individual due to a 40-year operating life of the facility is 130 mrem. This dose appropriately is compared to that individual's 40-year and lifetime doses from natural background radiation, which is 4,000 and 7,000 mrem, respectively.

The maximum individual's calculated lifetime risk of dying of cancer from radiation released from the plant and from natural background radiation is about 2×10^{-5} (0.00002) and 1×10^{-3} (0.001), respectively. The risk posed by operation of the Harris Plant also can be compared to the average risk of dying of cancer from other causes of about 2×10^{-1} (0.2).

4/ Infant 0-1 year
Child 1-11 years
Teen 11-17 years
Adult 17-40 years

IV. Conclusions

The calculated cumulative radiation exposures to the 50-mile population and U.S. population due to operation of the Harris Plant is demonstrated to be less than one ten-thousandth of the doses to these populations due to background radiation over the plant lifetime. The calculated lifetime whole body dose to the individual maximally exposed to the Harris Plant's operation, assuming a 40-year plant operating life, is 130 mrem, which is about two one-hundredths of the lifetime dose from natural background radiation.

Based on these calculations, it is reasonable to conclude that even using extremely conservative calculation assumptions, the offsite radiation doses and associated health risks to individuals and the population from normal operation of Shearon Harris are vanishingly small and are, in our opinion, totally insignificant.

ATTACHMENT 1A

Resume

JOHN J MAURO

Education:

BS - Long Island University 1963
MS - New York University 1970
PhD - New York University Medical Center - Institute of Environmental Medicine 1973

Awards:

- Alvin Gruder Memorial Award for Excellence in Biological Sciences
- Member of the Optimates Society for Academic Achievement
- Founder's Day Award for Doctoral Dissertation

Societies:

- Health Physics Society
- American National Standards Committee on Emergency Planning

Certifications:

Certified by the American Board of Health Physics

Consultancies:

- Radiological Health Bureau of the California Office of Emergency Services
- Battelle Memorial Institute
- Louisiana Power and Light Company
- Shaw Pittman, Potts and Trowbridge
- EG&G Idaho
- Union Carbide Corporation - Nuclear Division

Current Position:

Director of the Radiological Assessment and Health Physics Department of Envirosphere Company in New York City.

Summary of Professional Experience:

While a graduate student at the Institute of Environmental Medicine of New York University, I was also a full-time Research Assistant from 1970 to 1973. In this position I assisted Principal Investigators on numerous research projects on the ecology and radioecology of the lower Hudson River Estuary. These activities included the collection of aquatic organisms from the estuary to determine species abundance and diversity, the life history of white perch and the concentration of radionuclides in aquatic organisms, water and sediment. These activities also included experimentation into the ability of microorganisms collected from the Hudson River sediment to organify inorganic mercury.

In addition to my responsibilities as Research Assistant, I was a full-time graduate student, studying environmental health, health physics and radioecology. My doctoral research was on the radioecological behavior of Cs-137 in the lower Hudson River Estuary. Research for my thesis covered a three-year period which included extensive field studies and laboratory experimentation to identify and mathematically model the uptake and elimination of Cs-137 by aquatic organisms.

After receiving my doctoral degree in 1973, I joined Ebasco Services as a Radiological Assessment Engineer. Ebasco Services is a major architect-engineer-constructor for power generating facilities. My initial responsibilities at Ebasco were to evaluate the radionuclide release rates from proposed and operating nuclear power facilities under normal plant operation and following postulated accidents, and to determine the radiation exposures and health risks to workers and members of the nearby general population. In this capacity I developed several models for performing radiological impact assessment, and have prepared the radiological impact assessment sections of license applications.

Since joining Ebasco I have held positions of increasing responsibility, and am currently Director of the Radiological Assessment and Health Pnysics Department in Envirosphere Company, the Nuclear Licensing and Environmental Health Division of Ebasco Services. In this position, I report directly to the Vice President of Nuclear Operations and, I am responsible for all radiological health and emergency planning services provided by Envirosphere Company. I manage a technical staff of 10 senior level consultants with advanced degrees in nuclear and biological sciences, with a combined 150 years of professional experience in technological risk management.

My responsibilities as Director of the department are divided into radiological health consulting (40%), project management (30%), marketing and business development (20%), and department administration (10%). A brief description of each of these areas of responsibilities follows.

Though my management responsibilities have increased considerably since joining Ebasco, I continue to personally provide consulting services to our clients. These services include the analysis of radiological source terms, environmental transport, radio-ecology, internal and external dosimetry, health risk assessment, radiological surveillance, emergency planning, regulatory analysis and the preparation and defense of expert testimony on these subjects. Recently I have also become involved in the evaluation of toxic chemical hazards at industrial sites and low-level radioactive waste management. These services have been provided for a large number of clients representing the nuclear power industry and federal and state agencies and their subcontractors.

I have also managed several consulting contracts in the areas of radiological and chemical toxicology, health physics, and emergency planning. A detailed description of these projects will be provided upon request. Most of these projects have been of a multidisciplined nature and included participation of specialists in the areas of toxicology, nuclear engineering, mathematical modelling, meteorology, hydrology and computer sciences. On these projects I had overall responsibility for budget, schedule and technical quality of deliverables.

As director of the Radiological Assessment and Health Physics Department, I am also responsible for developing and meeting an annual budget. The budget includes staff and non-staff salaries and out-of-pocket expenses for client billable work, department overhead and business development. My effectiveness as Director is judged by my ability to achieve or exceed the budget for billable work and to effectively control non-billable expenses. Non-billable expenses include business development, training and publications, presentations, participation on standards committees and other professional practices. I have responsibility for hiring new staff and for staff performance review, promotions and merit increases. In this capacity I am assisted by 2 department managers who report directly to me.

Publications and Presentations:

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Mauro, J J and W R Rish 1982. Dealing with Uncertainties in Examining Safety Goals for Nuclear Power Plants. In NUREG-CP-0027. Proceedings of the International Meeting on Thermal Reactor Safety.

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Mauro, J J, S Schaffer, W Rish and J Parry. Application of Probabilistic Techniques to Dose and Risk Assessment Performed by EPA in Support of 40 CFR 191. Submitted for Publication.

ATTACHMENT 1B

STEPHEN F. MARSCHKE
Principal Engineer

SUMMARY OF EXPERIENCE (Since 1973)

Total experience - Ten years in the area of radiological impact assessment and nuclear engineering.

Professional Affiliations - American Nuclear Society
Health Physics Society
Ecological Society of America

Education - B.S., State University of New York at Buffalo, 1973 - Nuclear Engineering
Harvard School of Public Health, 1980 - Planning for Nuclear Emergencies

REPRESENTATIVE ENVIROSPHERE PROJECT EXPERIENCE (1977-1978, Since 1979)

Radiological Assessment Engineer

Lead radiological assessment engineer on the development team for Envirosphere's real time dose assessment computer program, CEPADAS. As such, responsibilities include:

- development of specifications,
- review of input from other disciplines,
- performing quality assurance,
- writing user's manuals, and
- training utility operators.

One of the principal authors of the report "Decommissioning Requirements for Nuclear Waste Repository Licensing" for the Office of Nuclear Waste Isolation. Prepared the alternative waste disposal concepts, radiological impact sections of the Environmental Impact Statement - DOE/EIS-0046F.

Other responsibilities include performing the analyses and preparation of the radiological impact sections of Safety Analysis Report Chapters 11 and 15 and Environmental Impact Report Chapters 5 and 7. Performs cost-benefit analyses to determine the most advantageous mode of radwaste system design, calculating both the in-plant and offsite radiological impacts.

Responds to questions from the various regulatory agencies concerning the radiological safety of LWR's, both domestic and foreign. Performs studies to determine the environmental and radiological consequences of decommissioning nuclear facilities. Developed Emergency Plans and Implementing Procedures for nuclear plants. Determine the effect on reservoir radionuclide concentration of the transfer of radionuclides to sediment.

PRIOR EXPERIENCE

Ralph M. Parsons Company
Nuclear Engineer (1 year)

Assigned to the design of a nuclear fuels reprocessing facility. Duties included the determination of individual component and area gamma shielding requirements. Performed analyses to determine the proper design for shield wall piping, instrumentation and HVAC penetrations. Was responsible for developing acceptable designs for access labyrinths. Determined the dose rate above a spent fuel storage pool from the spent fuel, the contaminated water and "skyshine".

United Engineers and Constructors, Inc.
Nuclear Engineer (4 years)

Responsible for performing the radiological analyses of various postulated accidents in both PWR and HTGR systems. These analyses included the determination of the radiological impact at the site boundary and to control room personnel. Determined inplant shielding requirements. Performed site radiological evaluation studies to determine which of a number of alternative sites was the preferred site and for a given site which of the NSSS would be the preferred system. Performed studies for the HTGR to determine the offsite effects of various modes of operation of the containment ventilation system and the waste gas management system. Responsible for the determination of fuel cycle costs for a number of nuclear fuel bid evaluations. From June 1975 to the termination of the project, was the Coordinating Engineer between the Nuclear Staff and HTGR project. As such, directed the flow of all work between the project and the staff.

Publications

Kang, C.S., R.L. Simard, S.F. Marschke and J.W. Trost 1976. Fuel bid evaluation, UEC-NSR-003-0, Proprietary report, August.

Marschke, S.F., J.J. Mauro 1980. Radiocesium transport into reservoir bottom sediments - a licensing approach. Presented at the 1980 Annual Meeting of the American Nuclear Society, June.

Table D-7 Calculated Appendix I dose commitments to a maximally exposed individual and to the population from operation of the Harris nuclear plant

	Annual Dose per Reactor Unit	
	Individual	
	Appendix I Design Objectives*	Calculated Doses**
Liquid effluents		
Dose to total body from all pathways	3 mrems	1.6 mrems
Dose to any organ from all pathways	10 mrems	2.1 mrems (liver)
Noble gas effluents (at site boundary)		
Gamma dose in air	10 mrads	0.3 mrads
Beta dose in air	20 mrads	0.8 mrads
Dose to total body of an individual	5 mrems	0.2 mrems
Dose to skin of an individual	15 mrems	0.6 mrems
Radioiodines and particulates***		
Dose to any organ from all pathways	15 mrems	4.6 mrems (thyroid)

	Population Within 80 km	
	Total Body (person-rems)	Thyroid (person-rems)
Natural background radiation†	180,000	
Liquid effluents	1.7	0.04
Noble gas effluents	1.7	1.7
Radioiodine and particulates	12	22

*Design Objectives from Sections II.A, II.B, II.C, and II.D of Appendix I, 10 CFR 50 consider doses to maximally exposed individual and to population per reactor unit.

**Numerical values in this column were obtained by summing appropriate values in Table D-6. Locations resulting in maximum doses are represented here.

***Carbon-14 and tritium have been added to this category.

†"Natural Radiation Exposure in the United States," U.S. Environmental Protection Agency, ORP-SID-72-1, June 1972; using the average background dose for North Carolina of 100 mrems/yr, and year 2000 projected population of 1,750,000.

Table D-9 Annual total-body population dose commitments, year 2000 (both units)

Category	U.S. population dose commitment, person-rems/yr
Natural background radiation*	26,000,000*
Radiation from Harris Units 1 and 2 (combined) operation	
Plant workers	1000
General public:	
Liquid effluents**	3.5***
Gaseous effluents	48
Transportation of fuel and waste	6

*Using the average U.S. background dose (100 mrem/yr) and year 2000 projected U.S. population from "Population Estimates and Projections," Series II, U.S. Department of Commerce, Bureau of the Census, Series P-25, No. 704, July 1977.

**80-km (50-mile) population dose

***See Errata to FES dated January 12, 1984

Attachment 3

Exposures from Residual Radioactivity Following Plant Shutdown

In the main text of this testimony, the population dose from 40 years of plant operation is presented. The dose was obtained by multiplying the annual dose in the FES by 40 and adding in the residual dose due to radionuclides which remain in the environment after the plant terminates operation. In this attachment, an estimate is made of the integrated population dose due to these radionuclides over a 100-year period following plant shutdown (after 40 years of operation).

Liquid Effluents

The population doses in the FES for the liquid pathway are presented in Appendix D and discussed in Appendix B of the FES. The methods and assumptions used by the NRC Staff to calculate population doses are as follows. The annual radionuclide releases in the liquid effluent listed in Table D-4 of the FES are assumed to be mixed in the circulating water discharge. The discharge water is assumed to mix in the reservoir and flow into the Cape Fear River where it mixes and is transported downstream. Commercial fishing, as estimated in Appendix I of the FES, is assumed to be taking place. The total commercial and sports fishing harvest in the reservoir and Cape Fear River

is conservatively estimated by the NRC Staff to be about 46,000 kg/yr.

The harvested fish are assumed to reconcentrate the radionuclides in the water in accordance with the reconcentration factors listed in Table A-1 of Regulatory Guide 1.109, and are assumed to be ingested and the population doses calculated using the dose conversion factors listed in Tables E-11 to E-14 of Regulatory Guide 1.109. As indicated in Table D-7 of the FES, the results of this calculation yields a 50-mile population dose of 1.7 person-rems/year to the whole body and 0.04 person-rems/year to the thyroid gland.

Assuming a 40-year plant operating life, the population dose integrated over the life of the plant may be simply estimated by multiplying the annual dose by 40. This approach, however, neglects the population dose which may be delivered by radionuclides which remain in the environment after the plant terminates operation. The radionuclides which could contribute to this residual dose are those with a half life that is relatively long, i.e., comparable to the operating life of the plant. There are several radionuclides that fall into this category, including Cs-137 (T1/2 = 30 yr), Cs-134 (T1/2 = 3.4 yrs), Co-60 (T1/2 = 5 yrs); H-3 (T1/2 = 12.6 yrs), and Sr-90 (T1/2 = 27.7 yrs). However, except for tritium (H-3), these radionuclides will be bound to the sediments in the reservoir and Cape Fear River, after termination of operation, where they will decay away. Thus, it is only tritium that remains in

solution and delivers a dose to the population. This tritium will mix uniformly in the world oceans and become part of the water cycle. The global dose commitment from tritium is 10^{-3} person-rems/Ci released (Benison; NUREG-0597). The dose to the population in the 50-mile vicinity of the plant is obtained by calculating the individual dose and then multiplying that figure by the 50-mile population size. Assuming a 40-year operating life and 370 Ci/yr released (see Table D-4 of the FES), the additional dose is less than 0.01 person-rems to the population within 50 miles of the plant. Similarly, the residual dose is less than 1 person-rems to the U.S. population.

Gaseous Effluents

The 50-mile population doses from the gaseous effluents are estimated in Table D-7 of the FES to be 13.7 person-rems/year. In these calculations, the gaseous effluents in Table D-1 of the FES are assumed to disperse in the atmosphere. As the radionuclides are transported they decay, deposit onto the ground and are further diluted in the atmosphere. Individuals located in the vicinity of the plant can receive external exposure from the passing airborne activity or from deposited activity on the ground. The population also can receive internal exposure from inhalation and the ingestion of foods contaminated from deposited radionuclides.

Assuming a 40-year plant operating life, the population dose integrated over the life of the plant may be estimated by multiplying the annual dose by 40. This approach, however, neglects the population dose which may be delivered by long-lived radionuclides which will remain in the environment after plant operation ceases, which includes Kr-85 (10 yr T1/2), H-3 (12.6 yr T1/2), C-14 (T1/2 = 5730 yrs) and several particulate radionuclides.

Krypton 85 is a noble gas which may be assumed to mix uniformly in the global atmosphere and deliver an external dose until it decays away within about 100 years. The 50-mile and U.S. population doses due to this residual activity are about $2x10^{-4}$ (0.0002) person-rems and $3x10^{-2}$ (0.03) person-rems, respectively (Benison, NUREG-0597).

The residual population dose from tritium in the gaseous effluent may be calculated in the same manner as that in the liquid effluent since it will also become part of the global water cycle. The 50-mile and U.S. population doses from this source of tritium are about 0.01 and 1 person-rems, respectively.

Particulate radionuclides include Cesium-137, Cesium-134 Strontium-90 and Cobalt-60. Within 50 miles of the plant, these radionuclides will all deposit onto the land and decay away within 100 years following plant shutdown. During this time, these radionuclides will reside in the soil and contribute to external exposure from direct radiation, and internal

exposure due to ingestion of foods contaminated via root uptake. Table A presents the residual population doses for these radionuclides via these pathways. In summary, from plant shutdown to 100 years after plant shutdown, there is a residual particulate dose of 4.2 person-rems.

TABLE A

Population Dose (person-rems)

	External Exposure	Internal Exposure			
		Vegetables	Milk	Beef	Total
Cs-137	3	1.5×10^{-2}	3.3×10^{-2}	7.0×10^{-3}	3.1
Cs-134	1.0×10^{-1}	2.9×10^{-4}	6.5×10^{-4}	1.3×10^{-4}	1.0×10^{-1}
Co-60	1	1.2×10^{-4}	2.6×10^{-5}	1.5×10^{-4}	1.0
Sr-90	-	6.2×10^{-3}	1.0×10^{-3}	3.7×10^{-4}	7.6×10^{-3}
Total	4.1	2.2×10^{-2}	3.5×10^{-2}	7.7×10^{-3}	4.2

Carbon 14 has a 5,820 year half life and, thus, will reside in the environment for a long period of time after plant operation ceases. In order to calculate the residual dose from Carbon-14, it may be assumed that the Carbon-14 uniformly mixes in the troposphere and slightly changes the specific activity of the carbon cycle. The 100-year dose to the population within 50 miles of the plant and to the U.S. population from Carbon-14 is estimated to be about 4 person-rems and 700 person-rems, respectively. (Killough, NUREG-0597).

Summary

As indicated in Table B, the total residual radiation doses accumulated for 100 years after the Harris Plant has ceased operating both by the populace living within 50 miles of the plant and by the entire U.S. population are 8 person-rems and 706 person-rems, respectively.

Table B

Residual (100 year post-operation) dose
(person-rems)

Isotope	50 Mile	U.S. Population
H-3	0.2	2
Kr-85	0.0002	0.03
Particulates	4.2	4.2
C-14	4	700
Total	8	706

Attachment 4

Conservatism in the Dose Calculations

In the main text of this testimony, it is stated that the population dose due to residual radioactivity in the environment following plant shutdown is relatively small compared to the dose during operation, and that this residual dose may be ignored because it is more than accounted for by the conservatism in the calculation of dose during operation. This attachment describes some of the more important conservatisms.

The calculation of the doses in the FES and the ER consist of a three-step process, each with varying degrees of inherent conservatism. The following presents a brief description of some of the more important conservative assumptions in each step.

Source Terms

The first step in the calculation of individual and population doses is to estimate the liquid and gaseous radionuclide release rate (i.e., source term). The source term, as estimated using the standard methods described in Regulatory Guide 1.112, is based on 0.12% failed fuel. However, operating experience over the four-year period 1978-1981 reveals a percentage of failed fuel of about 0.01% (NUREG-0633, NUREG/CR-1818, NUREG/CR-2410, NUREG/CR-3001). As a result, the radionuclide

concentrations in primary coolant are much lower than assumed, resulting in much lower radionuclide release rates. Tables 4-1 and 4-2 compare the measured radioiodine release rates in gaseous and liquid effluents at operating PWRs with the estimated values. Actual measured releases are many times smaller than those predicted using standard methods.

Dispersion

The second step in the calculation of individual and population doses is to determine the concentration of the released radionuclides in the environment. For gaseous releases, dispersion is calculated using the methods described in Regulatory Guide 1.111 which have been demonstrated to be conservative (Gogolak, et al; Miller and Hoffman). For aquatic releases, dispersion is calculated using the methods described in Regulatory Guide 1.113. Those methods take no credit for removal of radionuclides by sedimentation, resulting in an overestimate of the concentration of many radionuclides in water (Marschke and Mauro).

Dose Calculation

In calculating the dose to the individual and population, numerous assumptions are made which tend to overestimate the dose. Some of these assumptions are: (1) no reduction in dose is taken for removal of radionuclides from foods during preparation; (2) no reduction of dose is taken for removal of

radionuclides from drinking water due to treatment; and (3) no reduction of dose is taken for the weathering of radionuclides from the soil.

Table 4-1

AIRBORNE RADIOIODINE SOURCE TERMS

UNIT	PREDICTED[1,3] (Ci/Yr - unit)	MEASURED (Ci/Yr)[2] Average	Range
Arkansas 1	.048	.14	.003-.74
Arkansas 2	.17	.0047	.0047
Beaver Valley	.014	.021	.0001-.072
Calvert Cliffs (2 units)	.25	.27	.035-1.0
Crystal River	.12	.0071	.0025-.019
Davis-Besse	.12	.0021	.00026-.0057
D.C. Cook (2 units)	.10	.028	.005-.055
Ft. Calhoun	.065	.011	.0016-.02
Haddam Neck	.04	.019	.0017-.05
H.B. Robinson	-	.063	.0004-.3
Indian Point 1 & 2	.36	.22	.005-.81
Indian Point 3	-	.0084	.0039-.013
J.M. Farley	.049	.032	.022-.041
Kewaunee	.081	.12	.00062-.66
Maine Yankee	-	.14	.0021-.94
Millstone 2	.105	.0059	.0-.013
North Anna 1	.095	.045	.032-.057
Oconee (3 units)	.10	.062	.0033-.18
Palisades	.79	.1	.01-.38
Point Beach (2 units)	-	.049	.0025-.28
Prairie Island	.137	.0093	.0009-.021
Rancho Seco	-	.013	.005-.032
R.F. Ginna	.11	.039	.01-.17
Salem	.21	.016	.0-.04
San Onofre	-	.17	.00014-1.6
St. Lucie 1	1.0	.22	.01-.52
Surry	2.1	.097	.0076-.35
TMI 1	-	.035	.01-.14
Trojan	.24	.028	.01-.051
Turkey Point (2 units)	.80	.44	.03-1.8
Yankee Rowe	-	.077	.0-.53
Zion (2 units)	.20	.033	.005-.07
Average (Ci/Yr-unit)	.34 ci/yr-unit	.065 ci/yr-unit	

FOOTNOTES

(1) The predicted values were obtained from the FES for each plant and are based on calculations performed by the NRC using industry wide standard methods. The values are for I-131 except where indicated.

(2) The average and range are inclusive over the years of operation from 1970 to 1979. The values are a slight overestimate because they include I-131 and particulates with half lives greater than 8 days.

(3) Value not available is denoted by "-".

Table 4-2

I-131 RELEASES IN LIQUID EFFLUENTS IN 1979

PLANT	PREDICTED(1,3) (Ci/Yr-Unit)	MEASURED(2) (Ci/Yr)
Arkansas 1	9.2	.28
Arkansas 2	.26	.24
Beaver Valley 1	.34	.0008
Calvert Cliffs 1 & 2 (2 units)	.27	.65
D.C. Cook 1 & 2 (2 units)	.47	.012
Crystal River 3	2.0	.06
Davis-Besse 1	2.37	.0035
J.M. Farley 1	.48	.0013
Ft. Calhoun 1	1.8	.019
R.E. Ginna 1	.27	.0093
Haddam Neck 1	.36	.067
Indian Point 1 & 2 (2 units)	2.06	.079
Indian Point 3	-	.059
Kewaunee	.51	.00059
Maine Yankee 1	-	.41
Millstone 2	.9	.12
North Anna 1	1.2	.16
Oconee 1, 2 & 3 (2 units)(?)	.2	.14
Palisades 1	-	.00038
Point Beach 1 & 2 (2 units)	-	.088
Prarie Is. 1 & 2 (2 units)	3.8	.00076
Rancho Seco 1	0	.0
H.B. Robinson 2	-	.0037
Salem 1	1.43	.019
San Onofre 1	-	.025
St. Lucie 1	.17	.048
Surry 1 & 2 (2 units)	12.15	.064
TMI 1	-	.14
Trojan 1	.21	.012
Turkey Pt. 3 & 4 (2 units)	10.2	.020
Yankee Rowe 1	-	.0041
Zion 1 & 2 (2 units)	.81	.011
Average (Ci/Yr-unit)	2.1	.065

(1) From the Final Environmental Statement

(2) From NUREG/CR-2227

(3) Value not available is denoted by "-".

Table D-6 Annual dose commitments to a maximally exposed individual near the Harris plant

Location	Pathway	Doses (mrems/yr per unit, except as noted)			
		Noble Gases in Gaseous Effluents			
		Total Body	Skin	Gamma Air Dose (mrads/yr/unit)	Beta Air Dose (mrads/yr/unit)
Nearest site boundary* (2.1 km, N)	Direct radiation from plume	0.20	0.57	0.33	0.81
		Iodine and Particulates in Gaseous Effluents**			
		Total Body		Organ	
Nearest*** site boundary (2.1 km, N)	Ground deposition	0.44 (T)		0.44 (C) (thyroid)	
	Inhalation	0.24 (T)		0.56 (C) (thyroid)	
Nearest residence and garden (2.3 km, NMW)	Ground deposition	0.26 (C)		0.26 (C) (bone)	
	Inhalation	0.13 (C)		0.003 (C) (bone)	
	Vegetable consumption	0.49 (C)		1.13 (C) (bone)	
Nearest milk cow and meat animal (2.9 km, N)	Ground deposition	0.20 (C)		0.20 (I) (thyroid)	
	Inhalation	0.11 (C)		0.22 (I) (thyroid)	
	Vegetable consumption	0.41 (C)		N/A	
	Cow milk consumption	0.18 (C)		4.19 (I) (thyroid)	
	Meat consumption	0.04 (C)		N/A	
Nearest milk goat (7.4 km, NMW)	Ground deposition	0.016 (C)		0.016 (I) (thyroid)	
	Inhalation	0.014 (C)		0.027 (I) (thyroid)	
	Vegetable consumption	0.052 (C)		- (I) (thyroid)	
	Goat milk consumption	0.035 (C)		0.43 (I) (thyroid)	
		Liquid Effluents**			
		Total Body		Organ	
Nearest drinking water at Lillington	Water ingestion	0.007 (A)		0.01 (C) (liver)	
Nearest fish at plant discharge area	Fish consumption	1.7 (A)		2.3 (A) (liver)	
Nearest shore access near plant discharge area	Shoreline recreation	0.002 (A)		0.002 (A) (liver)	

*"Nearest" refers to that site boundary location where the highest radiation doses as a result of gaseous effluents have been estimated to occur.

**Doses are for age group and organ that result in the highest cumulative dose for the location: A=adult, T=teen, C=child, I=infant. Calculations were made for these age groups and for the following organs: gastrointestinal tract, bone, liver, kidney, thyroid, lung, and skin.

***"Nearest" refers to the location where the highest radiation dose to an individual from all applicable pathways has been estimated.

Attachment 6

Estimate of Individual Doses and Risks

In the main text of this testimony, the lifetime doses and risks to the maximally exposed individual are presented. The values include doses due to the releases from the plant during the 40-year life of the plant and doses due to residual radioactivity in the environment following plant shutdown. This Attachment presents the bases for these values.

In order to derive the maximum lifetime doses to an individual, it is assumed that at the time of plant start-up, a family with a newborne infant resides at the site boundary at the location of the highest average annual atmospheric dispersion factor. It is also assumed that the family has a backyard garden and milk and beef cows grazing on their property.

Table 6-1 presents the annual doses during plant operation for the maximum individual during infancy, childhood, teens and adulthood. The doses are presented for each organ. The lifetime dose due to annual plant operation is obtained by multiplying the dose by the number of years the individual is in each age category and then summing the doses. This covers the 40-year period of plant operations. To this is added the additional dose from residual radioactivity in the environment following shutdown. This residual exposure is assumed to continue until the individual is 70 years old. Using this calculation method, the maximum lifetime whole body dose is estimated to be

about 130 mrem. The lifetime risk of death to the individual due to this lifetime exposure is calculated to be about $2x10^{-5}$ (0.00002). This value is obtained by summing the lifetime risk associated with each year of exposure. These, in turn, were obtained by multiplying the age specific annual dose (described above) by the age specific risk coefficients. The age specific risk coefficients, presented in Table 6-2, were derived using the methods described in BEIR I for a linear dose response model.

Table 6-1

ANNUAL ADULT DOSES (MREM/YEAR)

GASEOUS PATHWAY	T.BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
PLUME	2.58E-01	2.58E-01	2.58E-01	2.58E-01	2.58E-01	2.58E-01	2.66E-01	6.64E-01
GROUND	7.07E-02	7.07E-02	7.07E-02	7.07E-02	7.07E-02	7.07E-02	7.07E-02	8.28E-02
VEGET	7.40E-01	7.23E-01	1.63E+00	7.46E-01	7.25E-01	9.13E-01	7.17E-01	7.13E-01
MEAT	1.89E-01	1.89E-01	6.33E-01	1.89E-01	1.87E-01	2.14E-01	1.86E-01	1.86E-01
MILK	2.99E-01	2.80E-01	7.05E-01	3.07E-01	2.91E-01	1.11E+00	2.81E-01	2.79E-01
INHAL	2.34E-01	2.33E-01	3.76E-03	2.35E-01	2.34E-01	4.94E-01	2.48E-01	2.31E-01
TOTAL	1.79E+00	1.75E+00	3.30E+00	1.81E+00	1.77E+00	3.06E+00	1.77E+00	2.16E+00

LIQUID PATHWAY	T.BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
DRINK	6.48E-03	6.21E-03	2.23E-04	6.59E-03	6.33E-03	6.87E-03	6.24E-03	0.
FISH	1.61E+00	5.74E-02	1.22E+00	2.17E+00	7.28E-01	4.45E-02	2.52E-01	0.
SHORE	1.16E-03	1.16E-03	1.16E-03	1.16E-03	1.16E-03	1.16E-03	1.16E-03	1.35E-03
TOTAL	1.62E+00	6.48E-02	1.22E+00	2.18E+00	7.35E-01	5.25E-02	2.59E-01	1.35E-03

TOTAL PATHWAY	T.BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
TOTAL	3.41E+00	1.82E+00	4.52E+00	3.98E+00	2.50E+00	3.11E+00	2.03E+00	2.16E+00

ANNUAL TEENAGER DOSES (MREM/YEAR)

GASEOUS PATHWAY	T.BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
PLUME	2.58E-01	2.58E-01	2.58E-01	2.58E-01	2.58E-01	2.58E-01	2.66E-01	6.64E-01
GROUND	7.07E-02	7.07E-02	7.07E-02	7.07E-02	7.07E-02	7.07E-02	7.07E-02	8.28E-02
VEGET	1.02E+00	1.00E+00	2.71E+00	1.05E+00	1.01E+00	1.16E+00	1.00E+00	9.94E-01
MEAT	1.44E-01	1.44E-01	5.34E-01	1.45E-01	1.43E-01	1.64E-01	1.43E-01	1.42E-01
MILK	4.58E-01	4.40E-01	1.30E+00	4.86E-01	4.60E-01	1.76E+00	4.43E-01	4.37E-01
INHAL	2.35E-01	2.34E-01	4.77E-03	2.38E-01	2.36E-01	5.61E-01	2.57E-01	2.33E-01
TOTAL	2.19E+00	2.15E+00	4.08E+00	2.25E+00	2.18E+00	3.97E+00	2.18E+00	2.55E+00

LIQUID PATHWAY	T.BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
DRINK	4.52E-03	4.38E-03	2.15E-04	4.74E-03	4.49E-03	4.95E-03	4.42E-03	0.
FISH	9.14E-01	4.29E-02	1.29E+00	2.22E+00	7.30E-01	3.90E-02	2.91E-01	0.
SHORE	6.47E-03	6.47E-03	6.47E-03	6.47E-03	6.47E-03	6.47E-03	6.47E-03	7.55E-03
TOTAL	9.25E-01	5.38E-02	1.30E+00	2.23E+00	7.42E-01	5.04E-02	3.02E-01	7.55E-03

TOTAL PATHWAY	T.BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
TOTAL	9.25E-01	2.20E+00	6.17E+00	4.48E+00	2.93E+00	4.02E+00	2.48E+00	2.56E+00

ANNUAL CHILD DOSES (MREM/YEAR)

GASEOUS PATHWAY	T.BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
PLUME	2.58E-01	2.58E-01	2.58E-01	2.58E-01	2.58E-01	2.58E-01	2.66E-01	6.64E-01
GROUND	7.07E-02	7.07E-02	7.07E-02	7.07E-02	7.07E-02	7.07E-02	7.07E-02	8.28E-02
VEGET	2.04E+00	2.02E+00	6.56E+00	2.10E+00	2.04E+00	2.27E+00	2.02E+00	2.01E+00
MEAT	2.45E-01	2.44E-01	1.00E+00	2.47E-01	2.45E-01	2.76E-01	2.44E-01	2.44E-01
MILK	9.32E-01	9.16E-01	3.19E+00	9.96E-01	9.51E-01	3.53E+00	9.23E-01	9.14E-01
INHAL	2.07E-01	2.06E-01	5.73E-03	2.10E-01	2.09E-01	5.83E-01	2.26E-01	2.06E-01
TOTAL	3.75E+00	3.71E+00	1.11E+01	3.88E+00	3.77E+00	6.99E+00	3.75E+00	4.12E+00

LIQUID PATHWAY	T.BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
DRINK	8.50E-03	8.38E-03	6.18E-04	9.11E-03	8.61E-03	9.75E-03	8.45E-03	0.
FISH	3.55E-01	2.16E-02	1.59E+00	1.93E+00	6.22E-01	3.7 E-02	2.30E-01	0.
SHORE	1.35E-03	1.35E-03	1.35E-03	1.35E-03	1.35E-03	1.35E-03	1.35E-03	1.58E-03
TOTAL	3.65E-01	3.13E-02	1.59E+00	1.94E+00	6.32E-01	4.90E-02	2.40E-01	1.58E-03

TOTAL PATHWAY	T.BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
TOTAL	4.12E+00	3.75E+00	1.27E+01	5.83E+00	4.41E+00	7.04E+00	3.99E+00	4.12E+00

ANNUAL INFANT DOSES (MREM/YEAR)

GASEOUS PATHWAY	T.BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
PLUME	2.58E-01	2.58E-01	2.58E-01	2.58E-01	2.58E-01	2.58E-01	2.66E-01	6.64E-01
GROUND	7.07E-02	7.07E-02	7.07E-02	7.07E-02	7.07E-02	7.07E-02	7.07E-02	8.28E-02
MILK	1.77E+00	1.75E+00	6.23E+00	1.91E+00	1.80E+00	8.09E+00	1.76E+00	1.74E+00
INHAL	1.19E-01	1.19E-01	3.40E-03	1.22E-01	1.20E-01	4.64E-01	1.31E-01	1.18E-01
TOTAL	2.22E+00	2.20E+00	6.56E+00	2.36E+00	2.25E+00	8.88E+00	2.23E+00	2.60E+00

LIQUID PATHWAY	T.BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
DRINK	1.28E-02	1.27E-02	9.92E-04	1.42E-02	1.31E-02	1.60E-02	1.28E-02	0.
TOTAL	1.28E-02	1.27E-02	9.92E-04	1.42E-02	1.31E-02	1.60E-02	1.28E-02	0.

TOTAL PATHWAY	T.BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
TOTAL	2.23E+00	2.21E+00	6.56E+00	2.37E+00	2.26E+00	8.90E+00	2.24E+00	2.60E+00

Table 6-2

Age Specific Fatal Cancer Risk Coefficients

Age	Risk of Fatal Cancer/Person-Rem*
0	0.5 x 10-3
0-4	1.0 x 10-4
5-9	1.0 x 10-4
10-14	2.4 x 10-4
15-19	2.4 x 10-4
20-24	1.9 x 10-4
25-29	1.6 x 10-4
30-34	1.4 x 10-4
35-39	1.1 x 10-4
40-44	0.9 x 10-4
45-49	0.6 x 10-4
50-54	2.8 x 10-5
55-59	1.0 x 10-5
60	0.5 x 10-5

* Values derived from Table 3-2 of the BEIR I Report. The time of risk, or plateau, was assumed to last the duration of life following the specified latent period which was assumed to begin at the midpoint of each age interval. Lifetime was assumed to be 70 years. For those age groups in Table 3-2 which were given a specific plateau duration, the specified value was used or that portion of it which did not exceed the 70 year age cutoff point.

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BY MS. BAUSER:

Q Dr. Mauro, could you please explain which part of the testimony on Contention II(c) is yours and which is the work product of Mr. Marschke?

A (Witness Mauro) Well, this was very much a collaborative effort where we both worked on the drafts together, edited together, checked each other's numbers, and performed calculations. So it is very difficult to make a clear distinction between the different sections which I prepared and those which Mr. Marschke prepared.

Q Mr. Marschke, could you summarize the testimony please?

A (Witness Marschke) Yes. What we did is we looked at the doses that are presented in the FES on an annual basis and we tried to calculate what the doses from operation of the Harris plant would be in total, over the total operating lifetime of the plant. And we started with the annual doses, and we multiplied those by 40 to account for the 40-year operating license of the plant and came up with a dose at that point in time.

To that dose we added what activity would be remaining in the environment when the plant ceases operation, to come up with a total dose to the population. Then we looked at that dose to determine what the risk would be and compared these doses and risks to the background doses

and risks which would be received by the population in the area.

And we found them to be negligible or very small compared to the background doses.

MS. BAUSER: I have no further questions.

JUDGE KELLEY: Are you ready for cross, Mr. Eddleman?

CROSS-EXAMINATION

BY MR. EDDLEMAN:

Q Dr. Mauro, I believe I asked you some questions about your resume under Contention II(e). If I ask you the same questions now, would your answer be any different?

A (Witness Mauro) No, they wouldn't, I assume.

Q Mr. Marschke, you are an employee of Envirosphere, are you not?

A (Witness Marschke) That is correct.

Q And Envirosphere is a wholly-owned subsidiary of Ebasco.

A That's correct.

Q It says in the middle of the first page of your resume, which is Attachment 1-B that you were the lead radiological assessment engineer on the development team for Envirosphere's real-time dose assessment computer program. And it gives a seven-letter acronym, C-E-P-A-D-A-S. How do you pronounce that acronym, Doctor?

A You pronounce it CEPADAS.

Q Doctor, did you use that program in any of the calculations prepared for this testimony?

A We did not. I'm not a doctor.

Q I'm sorry. I'm used to calling everybody doctor. Forgive me, it's my mistake. If I make the mistake again, you could just let it pass, if you will.

Gentlemen, however I may address you, let's turn to page 3 of your jointly prepared testimony. Before I start in here, let me ask you something about your statement that this was prepared by you and under your direct supervision.

Did other people assist you in preparing this testimony?

A No.

A (Witness Mauro) All of the work, all of the writing was prepared by us. It was, of course, reviewed by our legal counsel, but the technical content of it, the analyses presented in it were prepared by myself and Mr. Marschke.

Q Okay. And by your legal counsel, do you mean the counsel for the power company over here?

A That's correct.

Q Not Ebasco's counsel.

A No, sir.

Q Down toward the bottom on page 3 you have a sentence that reads, "The highly speculative doses accrued over geologic time periods are excluded." Now, how long -- I take it back, scratch the how long.

Above that you say that your calculation includes consideration of residual exposures for a period of 100 years after plant operation ceases. Taken together with this other sentence about doses over geologic time periods being excluded, does that mean, if I had a nuclide, say, with a half-life of 24,000 years, that you would look at the effects from that nuclide over 100 years after the plant operation ceased, and then exclude its further effects from your calculations here?

A That's correct.

Q Then you say the maximum individual doses are calculated on the basis of exposure to radionuclides released over a 40-year plant life. Now those radionuclides released, is that the source term for Harris?

A That's correct.

Q So you take the source term and you just multiply those dose numbers by 40. Now do I take it correctly that you drew your dose numbers from the FES for annual exposures?

A (Witness Marschke) No.

Q You calculated them yourselves?

A That's correct. Because calculating the dose

to an individual over a 40-year life of the plant, what we did was we assumed that the individual was born when the plant first started up. And he was an infant and then a child, and then a teenager, and then an adult for the remaining period of the plant operation.

So the doses, depending on the age group, or what age the individual was, the annual doses would be different. And we took that into account.

Q All right. Dr. Mauro, if you have something to add, please add it at any point. But Mr. Marschke, are you saying that you effectively assumed that this maximally exposed individual was born on or about the date that the plant starts operation?

A That's correct. And he lived his entire life at the nearest site location, site boundary.

Q You say, he. What if the maximally exposed individual were a woman? Would that make any difference to your calculations?

A (Witness Mauro) No.

Q Do you concur?

A (Witness Marschke) I concur.

Q Are either of you gentlemen aware of any different risk estimators for cancer induction for women and for men in the BEIR reports?

A (Witness Mauro) Yes, I'm aware that there are

10

some differences for certain types of health effects.

Q Do you know if the effects of a given amount of radiation on a woman are greater or less than those on a man from the same radiation?

A I believe it depends on the exposure. For example, I believe that the risk per rem of exposure for cancer induction in breasts is greater for a woman. However, the exposure of the ovary compared to testicles, the risk for adverse effect is lower in a woman. So there are these types of differences, and they are described, as you indicated in the BEIR reports.

Q Now we have been discussing some differences in risk per rad or rem delivered to various organs. Are you aware of any information in these reports as to the overall risk per rem to a man or a woman of the same exposure?

A I believe the differences are not great, and the risk co-efficients that we used are reasonably applied to either sex.

Q Are the risk co-efficients that you used derived from a weighted average of the risk co-efficients for each sex, by their percentage or proportion of the population?

A That's correct. It represents the average -- the risk co-efficients that we used represents the data -- a calculation of risk co-efficients based on data from exposure of large populations to radiation which includes both men and women.

end 13

mgc 14-1

Q Suppose a maximally exposed individual were, in fact, conceived shortly after the Harris plant began operation and was born within the first year of operation and then lived around the plant for the rest of their natural life; would that have any effect on your estimates here?

A The values that we have calculated include the risk from birth through life. If you were to add in the incremental increase in risk to -- due to exposure from conception to birth, it would have very little effect on our results. But the numbers that we provide here in terms of dose and risk start from birth, and I have considered your question subsequent to the preparation of this, and it would not have a signifcant effect on the results.

Q You say that after you prepared this testimony, you then considered this question?

A That's correct.

Q Do you have any quantitative information as to what the risk to the fetus is from the emission at the Harris plant?

A I wouldn't want to indicate what the risk to the fetus is from the exposures from the Harris plant, but I would say that risk coefficients have been developed per unit exposure to the fetus. These are estimates based on very high exposures, primarily from the Hiroshima and

mgc 14-2

Nagasaki data, and based on that data, the BEIR Committee has estimated that the risk per rad to the developing fetus -- and that data plus other data from other studies independent of the Hiroshima and Nagasaki data, that the best estimate is that the risk per rad to the developing fetus is somewhat higher than it is to the child or adult.

Q I believe, if we look back to your attachments, there is a risk per rad by age shown in Table 6-2 on page 6-3, which is the second from the back in this testimony packet; is that correct, gentlemen?

A That's correct.

Q Would you please turn to that table? At the top of this table is a listing -- well, this is a table of age-specific fatal cancer risk coefficients, right?

A That's correct.

Q And it gives for various ages and age ranges a risk of fatal cancer per person-rem as explained in the footnote, correct?

A That's correct.

Q Okay. Now for Age 0, that is at birth, you have a 0.5×10^{-3} risk, correct?

A That's correct.

Q So what you are saying is, that the risk to the fetus would be something higher than this.

A No, sir. That is the risk to the fetus.

mgc 14-3

Q That is the risk to the fetus? That is approximately twice the Birth-to-Age-4 risk, is it not -- pardon me -- about five times?

A Five times.

Q Okay. Now further, at the bottom of this listing, at Age 60, there is a number of 0.5×10^{-5} for risk of fatal cancer per person-rem, correct?

A That's correct.

Q And you assume, as you explain in the footnote, do you not, that that risk is the same throughout the rest of the person's life?

A Except for leukemia. We treated all cancers as having a lifetime, a plateau, except for leukemia which we treated with having a plateau of a limited duration.

Q It doesn't mention leukemia in this footnote, does it, Doctor?

A No. But it does indicate that distinction has been made between types of cancers, and if you refer back to the original table from which this calculation was prepared -- namely, Table 3-2 of the BEIR-I report, you will see that the table indicates that the recommended approach for calculating these risk coefficients for leukemia is to use a limited-duration plateau for the risk period, based on their epidemiological data.

Q What is the duration of that plateau?

mgc 14-4

A I don't recall.

Q But you could find it in the BEIR report?

A That's correct.

Q Let me ask you this. Suppose for nine months of our maximally-exposed individual's lifetime, we substitute that fetus risk for Age 0 that's in the top of this for nine months from Age 70 back to Age 69¼. Would we not, in fact, by making that substitution be increasing the overall risk of fatal cancer to which that individual was exposed?

A I'm not following you. Could you ask the question again, please?

Q Well, let me try to ask it in two parts.

The risk to the fetus of 0.5×10^{-3} is approximately 100 times the risk given for Age 60, of 0.5×10^{-5} fatal cancers per person-rem, is it not, Doctor?

A That's correct.

Q Okay. So if I were to substitute nine months of fetal life in the 70-year lifetime, for nine months of life after age 60, so that I am starting their lifetime with the conception, after the plant starts operating, soon after the plant starts operating, then wouldn't I, by making that exchange of nine months of fetal life at fetal risk for nine months of later life at this much lower risk after Age 60, wouldn't I be increasing the

mgc 14-5

total risk to that maximally-exposed individual of getting cancer?

A I guess I'm just not quite sure of what you are asking. Are you asking if we included the fetal risk, how would our risk change?

Q Basically, yes.

A And the answer is, it would have a very small effect, simply because we looked into this matter, and the dose to the fetus is comparable to the dose to an adult that you would calculate. There is very little difference. So therefore, the dose is about the same on annual basis, and the risk coefficient is about five times higher. However, it is only delivered for a nine-month period.

As a consequence, if you add in that increment, you really don't change very much, because we are talking about a 70-year period here. So what happens is, though you do have a five-times-higher risk coefficient, it does not have a significant effect on the total sum of risk over all age groups. And we went through that.

So I am trying to answer your question and show you what significance it has in our results, and it is very small.

Q Let me ask you this. Did you explicitly calculate an overall lifetime risk of fatal cancer per person-rem?

mgc 14-6

A Yes, sir.

Q And that appears back in your testimony, doesn't it?

A Yes, sir.

Q I'm having a little difficulty. Perhaps you could assist me. Could you point out where that jumps from? I can refer forward from the testimony to the tables. I have a little trouble referring backwards.

A Okay. It's on page 13. It's on the sixth line down, 2×10^{-5} probability of cancer due to the lifetime dose of 130 millirems.

Q Now is that 2×10^{-5} derived by basically summing the products of the numbered years in each age range times the risk for that age range over the persons lifetime out of Table 6?

A That's correct.

Q Isn't it so, then, if I want to quantify this, that if I subtract from that overall risk three-quarters of a year times the 0.5×10^{-5} risk for after Age 60, that is the equivalent of moving the person's lifetime forward nine months, moving their date of birth forward nine months. So now in your 70-year period, you start with conception, and your age is at Age 69¼?

A I much prefer starting -- assuming the person is exposed for 70 years and 9 months as opposed to the approach

mgc 14-7

you just used. I would just add in.

Q Okay. Suppose we do that, and we add in, do we not, three-quarters of the year times this .5 x 10^{-3} cancers per person-rem?

A Times the dose per year.

Q Right. But I thought your number on page 13 was the risk number.

A That's correct.

Q Okay. 2 x 10^{-5}. And in fact, the actual risk, if we look in Table 6-2, it doesn't drop below 2 x 10^{-5} until the person is about 55 years old, does it?

A No, I think you misunderstand Table 6-2. Table 6-2 gives the risk per person-rem or per rem exposure. No individual receives a rem. The individuals we looked at receive on the order of millirems. For example, over the entire life of the person, he receives a small fraction of one rem.

Of course, in any one age grouping -- for example, the infant, the 9-month period, it will be a much smaller fraction of that, so you have to bear that in mind.

Q Well, then, Doctor, it appears you may have misunderstood one of my earlier questions. Let me try to ask it again.

Did you calculate an overall risk per rem of -- for a person's lifetime, based on Table 6-2?

End 14

mgc 15-1

drop

A We tried to do a more refined estimate here by doing it age-specific. The overall risk per rem for an average individual is on the order of 1-to-2 x 10^{-4} fatalities per person-rem. That's an overall number. And you can see that sort of like lies in the middle of this distribution. But I did it age-specific to try to be a little bit more rigorous in my treatment of the problem. You can note that for the earlier age groups, the risks are a little higher than that number, and for the older age groups, they are a little bit lower.

The overall effect is for population in general, which reflects all of these ages. The risk coefficient is between 1-to-2 x 10^{-4} fatal cancers per person-rem based on the epidemiological data from Hiroshima, Nagasaki and other locations.

Q That's the absolute risk from the BEIR report, is it not?

A That's correct.

Q The relative risk is higher, as you state in your testimony, isn't it?

A I don't believe I mentioned relative risk coefficient here, do I?

Q Not in that table, but I think you mentioned in your testimony that there are other measures of risk that give numbers about four times higher.

mgc 15-2

MS. BAUSER: Objection. I would like him to point that out, because I am not familiar with that in his testimony.

JUDGE KELLEY: Could we find the reference?

WITNESS MAURO: I don't believe you will find it in my testimony.

JUDGE KELLEY: I thought somewhere there was a reference to 4 times something.

WITNESS MAURO: Perhaps it might be Staff testimony.

MR. EDDLEMAN: He is right. It's not in his testimony.

BY MR. EDDLEMAN:

Q Let me ask you this. You say that absolute risk is 1-to-2 x 10^{-4}. Now the risk to the fetus, then, is 25 to 50 times higher, isn't it, .5 x 10^{-3}.

A (Witness Mauro) 5 x 10^{-4}, about five times higher.

Q So if you took a five times higher risk for 1/70th of the time -- well, I could be a little more precise. I could say that nine months is about a 1/100th of a 70-year lifetime. If you took a five times higher risk times a 1/100th of the 70 years, that is the 9-month gestation period at that fetal risk, then you add about five percent to the overall number, wouldn't you?

mgc 15-3

A That's correct.

Q Okay. That's the quantitative thing I was trying to get.

Now let me step back here, Doctor and Mr. Marschke, on page 5 of your joint testimony in the middle -- well, it's kind of in the middle of that long paragraph -- there is a statement that there are no regulatory or other limits established for population doses. This is based, I take it, on your review of the applicable NRC and other regulations; is that right?

A That's correct.

Q So the only limitations are on doses to particular individuals.

A Yes.

Q Does the NRC or anybody else, to your knowledge, measure the doses to particular individuals?

A During plant operation?

Q Do they measure the dose to the individuals?

A They measure the radiation doses in the environment and the radioactivity content of food, and they perform calculations to determine what the dose is to individuals who are exposed to that. If that's your question, the answer is yes.

Q Well, the answer is that they measure the content of this radioactive material in the environment. They

mgc 15-4

measure the radioactive content of various foods, and from that, they calculate an exposure to the individual.

A That's correct.

Q They don't actually survey the individual and see how much radioactive material is in them, do they?

A No, sir.

Q Let's turn to page 6. You have Table 1 here with the little starred note that says, "The number of significant digits is not intended to indicate the degree of calculational accuracy, but is provided to facilitate independent verification of the tabulated values."

Now that means, does it not, that you really worked these things out to the number of digits that came out of the numbers that you put into them, regardless of whether those last few digits are significant?

A Including round-off. So that is correct.

Q Okay. The 40-year doses are computed by multiplying the annual doses by 40, are they not?

A No, sir. Multiplying the annual doses by 40, and then adding in any residual dose from 40 years on to 100 years, the termination of plant operation.

Q Well, from the liquid pathway, 40 times the annual dose would be 68 person-rems, wouldn't it?

A That's correct.

Q So you are saying there is no residual dose

mgc 15-5

from the liquid pathway?

A That's correct.

Q I am trying to locate the point where you are talking about the radionuclides that have gotten out through the liquid pathway being bound in sediment.

A You want to look at page 3-1.

Q That's in one of your attachments, isn't it, Doctor?

A Yes, sir.

Q And that is kind of in the middle of the attachments. The first page of Attachment 3, correct?

A That's correct.

Q All right. Now --

MS. BAUSER: Mr. Eddleman, it's the bottom of page 3-2, are the phrases that you just referred to about sediment.

MR. EDDLEMAN: Right, okay.

BY MR. EDDLEMAN:

Q You list some nuclides, including cesium-137 with a halflife of 30 years, and strontium-90 with a halflife of 27.7 years and cobalt-60 with a halflife of 5 years and some others. And then you say, "Except for tritium, these radionuclides will be bound to the sediments in the reservoir and Cape Fear River after termination of operation, where they will decay away."

mgc 15-6

Are there any organisms which live in lakes or rivers which might have occasion to swallow some of these sediments and remove the radionuclides from them?

A (Witness Mauro) There is an extensive body of literature on the mobility or lack of mobility of these radionuclides, once bound to sediment, and for all intents and purposes, they are gone from the biosphere.

Now there are organisms that possibly could acquire some of this activity, but it's extremely small amounts. And based on our review of this material, we decided the treatment of the problem the way we've done it here was a fair characterization of the environmental behavior of these radionuclides. So we ignored this very small portion that possibly may be accessible through bottom organisms. But in general, even those organisms are not able to strip the cesium and other radionuclides from the sediment because of the tenacious binding of the radionuclides to the sediment.

Q Are there any organisms that might stir up sediment on the bottom and therefore spread it around in the water?

A But it will remain bound. Certainly there is turbulence, and some sediment could resuspent and then deposit again, but during the process, the radionuclides remain bound to the sediment.

mgc 15-7

Q And there are no organisms which might swallow them or filter them out, say, like clams or oysters or something like that, shrimp?

A They would be swallowed and passed through and excreted in the fecal plug for organisms which were ingested in general. That's what has been found. They just are not efficiently stripped.

Q And all these things are your judgment, but are not explicitly set forth on this page of Attachment 3?

A That's correct.

Q Okay. Let me turn back here, then, to the gaseous pathway on page 6 and Table 1 of your testimony.

(Pause.)

If we took the United States annual whole-body dose of 24 person-rems from the gaseous pathway and multiplied by 40, we get about 960 person-rems, wouldn't we, Doctor?

A That's correct.

Q Okay. So you are adding approximately 710 person-rems by computing the residual dose to people throughout the country.

A Precisely.

Q And that would be approximately, in very rough terms, a 70 percent increase in the U.S. person-rems to whole body from gaseous emissions from the Harris plant,

mgc 15-8

wouldn't it?

A That's correct.

Q And likewise, that same increase from the gaseous pathway is the major component of the increase in the total dose, since there is no residual component of dose in the 40-year doses for the liquid pathway that you calculated; isn't that correct?

A That's correct.

Q Now I believe the Staff says in their testimony that they calculated for one unit. Are these calculations made for one unit or two units, Doctor?

A Per unit.

Q Okay. So this is on a comparable basis, a one-unit basis?

A That's correct.

Q Why did you use 100 years following plant shutdown as the outer limit of your analysis?

A For all radionuclides, just about all the radionuclides, their halflife is such that within 100 years, they would decay away to very small fractions of their original quantity. In addition, to go beyond 100 years, you would start to speculate on land use and behavior of radionuclides, which would be speculative. In addition, it would presume no advances in treatment for the cure of cancer to go ahead and calculate the

mgc 15-9

risks beyond that time, and there is some precedent for it also, that others have looked at this question in the past, such as the NRC and EPA, and for similar reasons have made the cutoff at 100 years.

In addition, it turns out that the dose delivered from -- over that first 100-year period is much, much higher than the dose delivered over any subsequent 100-year period. As a result, no individual would receive a dose -- the highest dose that would be delivered to any individual will occur over that first 100-year period, and after that, the individual doses drop off to essentially zero.

So based on our judgment, we thought that 100 years was an appropriate cutoff point to limit the extent of our analysis.

Q Well, for population doses, -- that is, the U.S. population as a whole or the population around the Harris plant within 50 miles -- isn't it true that certain nuclides like cesium-137 and strontium-90 have halflives such that -- oh, in rough terms, about 1/10th or an eight of the original amount would still be around 100 years following plant shutdown?

A That's correct. Approximately 90 percent would have decayed away, leaving a residual of about 10 percent, and that is not accounted for in our calculation.

S2BU4

Q You have said that the residual dose is relatively

mgc 15-10

small, here at the bottom of page 6, and that the residual doses are not signficant. And accordingly, you can take the dose to the U.S. population due to the operating life of a plant by multiplying the annual doses presented in the FES by 40. That's how it continues on to page 7.

Now what I want to ask you is, in the actual dose that you calculated for the U.S. population, isn't it more like multiplying the annual dose by about 70, if you look at Table 1?

A I'm sorry. I lost your train. Could you repeat it?

Q Let me just ask a question about the numbers first. If we look at Table 1, it is total dose to the whole body for the United States population. That's 25.7 person-rems, and the whole-body dose to the U.S. population is 1738 person-rems.

Isn't the latter number approximately 68 or 70 times the former number?

A (Witness Marschke) We calculate 67.

Q Okay. Whatever you get by dividing 1738 by 25.7. That is the number I'm talking about, right?

A Right.

Q Okay, so let's say 67. Then you go on to say on page 7, "Because of all these conservatisms, you may estimate by multiplying the annual doses presented in the FES

mgc 15-12

by 40."

Wouldn't it be just as possible, by your own calculation on the previous page, to take the U.S. population dose by multiplying the annual dose by 67?

A That would also give you an approximation.

Q Now if you -- let me ask you this. The U.S. population health risk from the FES that you reference in your second paragraph on page 7, do you know if that number is calculated with the absolute risk model from BEIR?

A (Witness Mauro) Yes.

Q It is. Then if we wanted to apply a relative risk model to this, we could just take the ratio of relative risk to absolute risk and multiply this population health rsk by that ratio to get the number that would result from using relative risk, could we not?

MS. BAUSER: Objection. We are starting to get into a challenge to the BEIR report, which I think has been ruled in summary disposition to be outside the scope of this contention.

MR. EDDLEMAN: I'm not challenging the BEIR report, Judges. I am using the BEIR report.

JUDGE KELLEY: Let's take it slow. Give me the question again.

MR. EDDLEMAN: Okay. The question is, if we wanted to use the relative risk numbers from the BEIR

mgc 15-13

report instead of absolute numbers and see what effect that would have on this U.S. population health risk from the FES, could we not simply take the ratio of the relative risk in the BEIR report to the absolute risk in the BEIR report and multiply this population health risk by that ratio to get a number that would be the cancer risk calculated with BEIR's relative risk model?

JUDGE KELLEY: Let me get the objection here.

MS. BAUSER: I may be wrong, I may need some clarification from the witness, but it is my understanding that the model adopted by the BEIR report and the one, for example, referred to by Dr. Fabergant in his original affidavit was the absolute one and not the relative one. So while the relative one may be referred to, it is my understanding that that is not the position of the BEIR report. So by raising this issue, Mr. Eddleman is, in fact, challenging the model that the BEIR report, that the BEIR committee has endorsed.

MR. EDDLEMAN: There are two models in the BEIR report, the absolute and relative risk, and I am not aware of the BEIR report specifically endorsing one or the other.

JUDGE KELLEY: Does the absolute and relative risk -- which produce the higher risk?

MR. EDDLEMAN: Relative risk.

mgc 15-14

JUDGE KELLEY: Relative risk produces the higher risk.

Where does this take you in terms of what we are looking at, name the time periods that ought to be looked at in the FES?

MR. EDDLEMAN: Well, if you use the relative risk model, you come out with a higher risk. And if you look at the Staff testimony, they actually discuss these higher risk estimators, what you could get with them.

What I want to know is, if you ask them about these higher risk estimators, did you use them on the same number, because as I understand the Board's question, it says, shouldn't the total risk over the plant's life be disclosed? And that total risk is higher or lower, depening on which risk estimator you use.

JUDGE KELLEY: So that using one risk estimator, at least hypothetically, you might decide that even over 40 years, it doesn't really matter. It is still pretty small.

But you want to say, let's use the other risk estimator, or another one, get a higher risk, and therefore require its disclosure, if you will, in the FES, right?

MR. EDDLEMAN: That's right.

JUDGE FOREMAN: Before you go on, would it be

mgc 15-15

too difficult for you to repeat your reasoning as to why you thought --

MS. BAUSER: I'm just trying to check. Perhaps we could ask Dr. Mauro if I am technically correct. It was my understanding that the BEIR committee endorsed the absolute risk model, and that is what they recommend, and not the relative risk model.

JUDGE FOREMAN: It may not be pertinent to the callenge to his question, but I am just curious about that concept.

JUDGE KELLEY: Well, let's get an answer to the argument question.

Do you know?

WITNESS MAURO: Yes. The BEIR committee recommends the absolute as opposed to the relative risk approach. However, they do present risk coefficients using the relative risk approach also, in the BEIR report.

MR. EDDLEMAN: Was your answer with respect to BEIR-1 or BEIR-3 or both?

WITNESS MAURO: Both.

JUDGE KELLEY: Why don't you let us huddle on this.

(The Board confers.)

End 15

16pbl

JUDGE KELLEY: Now having heard the comment on the -- having heard the objection and some comment on it, our feeling is that it's one of those things where you can go a little way down the road and perhaps should, and we intend to, but not as far as it might potentially -- we are here to litigate the comparative merits of absolute versus relative risk. That's not in the contention.

On the other hand, if you want to get some perspective on where these numbers go, if you use the other risk formulation, since we are looking at what ought to be in an FES, if an FES is a disclosure document, then within reason we think it is a fair question. It's a fair line of questions, within reason.

The particular question will --

MR. EDDLEMAN: Okay.

BY MR. EDDLEMAN:

Q Do you recall the question?

A (Witness Mauro) I do the recall the question. As I recall reading the BEIR reports, the risk co-efficient was obtained using the relative risk approach is about four times higher than the risk co-efficient obtained using the absolute risk approach.

Q So you could just multiply these numbers by four if you wanted to use the relative risk approach?

A That's correct.

Q And all your numbers in your testimony are calculated by absolute risk, are they not?

A That's correct.

Q So again, if we wanted to look at relative risk for any of those numbers we could just multiply by four.

A That would probably be a reasonable first cut at it. However, there may be some fine structure in that that I'd have to look more closely at. But as far as a first cut, I think four-fold is reasonable.

Q All right. I may ask you specifically about certain other numbers then since you mentioned this fine structure. But that's all I wanted to go into on this right now.

Let me ask you this, if you took your 1738 person rem, whole body dose to the U.S. population that's given in Table 1, page 6 of your testimony and multiplied it by the BEIR absolute risk estimator, which I think is something like 1.6 times 10^{-4}, is that close to the estimator?

A Closer to 1.4, if I recall. You are in the right area.

Q All right, let's say 1.4. If you multiply that 1738 person rem times 1.4 times 10^{-4}, wouldn't you come out with about, roughly speaking .25?

A Yes, sir. That's on page 8 in Table 2. .25 is the value presented there.

Q Now that .25 number is for one unit of the Harris plant, isn't it?

A That's correct.

Q And if we look back at your calculation on page 7, the first full paragraph on that page, the number derived from the FES is .16 for a single unit at Harris plant, isn't it?

A That's correct.

Q That number is -- the number in Table 2 is higher, isn't it?

A That is correct.

Q All right. Now in a number of these tables, you've got a natural background population dose. Is either of you gentlemen aware of any measurements of natural background dose in the area the Shearon Harris plant, within 50 miles of it?

A Yes, sir.

Q What estimates?

A There was a one-year study of the background radiation performed recently. And there are numbers in there for air doses in the vicinity of the plant. And if I recall, the doses are what would be expected to be observed in the area.

A (Witness Marschke) Also, in the FES on Table 9.1, there is a table which presents background doses, and they

have Durham and Raleigh, North Carolina. And they present the background doses for those two cities.

Q What are the background doses given in that table for Durham?

A For Durham, it's 87.8 millirems per year.

Q And what is it for Raleigh?

A For Raleigh, it's 87.6 millirems per year.

Q Okay. Less than 100 in both cases.

A Slightly.

A (Witness Mauro) Would you hold on for a second, please? Let me just take a look at this also.

Q Yes.

(Pause.)

A These doses would be external doses and would not include, I believe, from looking at this table, would not include the internal dose due to naturally occurring potassium 40, which would add another, about 20 millirems, bringing your dose to approximately 100 millirem per year.

Q Could you read the title of that table?

A Calculated average background doses.

Q Does it say anything about excluding internal dose?

A Yes, I'm looking at the table and I see where they addressed external terrestrial, and I believe cosmic ray, but I don't see anyplace where they have accounted for

internal dose from potassium 40. This table, I believe, came from a study by Oakley performed for the EPA. I think if you look at the reference, and if I recall correctly, the potassium 40 is not included in these numbers.

This is just external.

(Pause.)

MS. BAUSER: Could you identify the document?

WITNESS MAURO: We're looking at 9 -- page 9-12 in the FES.

BY MR. EDDLEMAN:

Q And are you looking over page 9-13 for the reference?

A (Witness Mauro) Yes, I'm looking. 9-14, I guess. This report is the one I recall. This report is the one I recall, the EPA report. And the author is Oakley.

Q Does it say the identity of the report in that note?

A Yes. Right in the title of the table. This is 9.1, and in a footnote it says, or right below the title, U.S. EPA ORP/SID 72-1. That again, that reference is repeated in the reference list on page 9-14, the fourth reference up from the bottom.

And just from looking at the table and the structure, I recall reading this report. And I believe it's the report performed by Oakley, and it does not include

potassium 40.

Q Does the note on page 9-14 mention the name of Oakley?

A No, it does not.

MS. BAUSER: Objection. The FES is in the record. It speaks for itself. Dr. Mauro stated his recollection several times now.

MR. EDDLEMAN: He said he recalled the name was Oakley, and I wanted to know if it's in the reference or just his recollection.

MS. BAUSER: The reference is in the record.

JUDGE KELLEY: Do you have an FES? You must have.

MR. EDDLEMAN: I don't have one in front of me.

JUDGE KELLEY: Well, then you're going to have to get one if you're going to ask questions about the FES.

MR. EDDLEMAN: Well, they, I think, brought the FES into this themselves.

MS. BAUSER: This is the subject of the contention, the FES -- the contention has challenged the FES. Mr. Eddleman has a copy

BY MR. EDDLEMAN:

Q Dr. Mauro, you mentioned another study that was a one-year survey of background around the Harris plant. Is that a different study from the ones you were just recalling, that you referenced in the FES?

A (Witness Mauro) Yes, that's correct.

Q When was that study completed, Doctor?

A Very recently. I don't have the exact date.

Q Have you seen the results of that study?

A Yes, I have.

Q What does it say for the background around the Harris plant?

A I recall when I read through the report, it was quite large, maybe on the order of 50 pages, they had information on sampling of food items, airborne sampling, and they also had some TLD readings, thermal luminescent dosimeter readings which give the external dose. And I recall in looking at it, nothing unusual.

That is, the dose rates and doses that they have measured are very consistent with what would be expected, and the type of information that's in this report also.

Q Do you recall what the total background dose around the Harris plant was as given in that report, Doctor?

A Well, it was given -- you see, as it turns out, there were many, many locations where they took these, let's say external TLD readings. And I found there was some variability. That is, natural background varied considerably depending on where your reading was taken, as would be expected. So there's not really one number. There's a lot of numbers characterizing dose rate in the vicinity of the site.

Q Well, do the airborne sampling locations and the sampling of food items correspond to the locations of those TLDs, Doctor?

A I recall in some cases they did, but in some they did not.

JUDGE KELLEY: Excuse me, are we clear in this context exactly which report you're referring to?

WITNESS MAURO: Yes, I am. I'm referring to a very specific report.

JUDGE KELLEY: Tell me, will you?

WITNESS MAURO: Yes, there's a report -- over the past year, CP&L has had an ongoing environmental radiological surveillance program around the plant site in order to characterize and get baseline information prior to plant operation. I believe the first of those reports summarizing the results has just been completed.

And I received a copy approximately two weeks ago of this --

JUDGE KELLEY: Done by CP&L?

WITNESS MAURO: From CP&L directly.

JUDGE KELLEY: Not done by Ebasco?

WITNESS MAURO: Not done by Ebasco. And I read through it. In fact, we have some of the numbers here if you're interested, some of the results. The range of the dose rates that were observed using thermal luminescent

dosimetry was ranged from .6 millirem per week to 2.2 millirem per week as being the range of doses, dose rates that were observed in the vicinity of the site.

BY MR. EDDLEMAN:

Q Do you know what the possible range of error on those TLDs is, Doctor?

A (Witness Mauro) I don't have that number offhand, no.

Q Do you have some comparable numbers about the airborne sampling dose ranges and the food item dose ranges?

A Not at my fingertips.

MS. BAUSER: Objection. He has answered the question. I don't see where we're going here at all. Dr. Mauro has testified that that data is consistent with the data in the FES, and I don't know where Mr. Eddleman is going.

MR. EDDLEMAN: Well, I'm trying to get some numbers. If he has numbers, that will tell me whether it's consistent. He says it's consistent and that's his opinion. I can't enter into the nerve cells of his brain to figure out if it's really consistent or not. But if he gives me a number, I can see if it's consistent.

JUDGE KELLEY: One at a time, please. These are all natural background numbers that we're talking about?

WITNESS MAURO: That's correct.

JUDGE KELLEY: Is this report going to end up in the record, or are we going to content ourselves with references?

MR. EDDLEMAN: I don't have a copy of the report. I presume if they completed it, they're probably going to serve it on me at some point, but I can't try to put it in the record until I get it.

JUDGE KELLEY: They will only serve you if they have served the NRC, right?

MR. EDDLEMAN: I think that's correct.

JUDGE KELLEY: That's how you get papers like that. It just seems to me we're having another extended discussion of some recent report, and it might be nice to have the report.

MS. BAUSER: It would not be our intent to put this into the record. We don't think that it's particularly enlightening with respect to the contention. I think the extent to which it is useful, Dr. Mauro has already stated.

Mr. Eddleman asked Dr. Mauro whether he knew of anything else and he told him that he did. But that doesn't mean that we think it has any particular value or additional value beyond the information that we already have here.

I think it's just really a complete sidetrack. It is not useful.

JUDGE KELLEY: So you don't intend to offer it in your case anyway.

MS. BAUSER: No, sir.

JUDGE KELLEY: And you don't have it, right?

MR. EDDLEMAN: That's right.

JUDGE KELLEY: So we have all these numbers in the record and we don't know -- well, we know where they came from.

MR. EDDLEMAN: And if your previous statement is correct, then CP&L is probably going to serve it on the NRC at some point. I don't know what the record can do with something that's in the files of the NRC. I don't know what your powers are to look at those things.

JUDGE KELLEY: I guess the only thing that comes to mind, as far as I'm concerned, so far I believe these numbers are consistent with all the other numbers you say?

WITNESS MAURO: Yes, they're consistent with what I would have expected to see at the site.

JUDGE KELLEY: All right. They're consistent with the numbers we've already got in the FES?

WITNESS MAURO: That's correct.

JUDGE FOREMAN: Could you repeat those numbers? After all that, I'd like to have them.

WITNESS MAURO: The range was .6 to 2.2 millirem per week.

12

JUDGE KELLEY: Where else do you want to go with this, Mr. Eddleman?

MR. EDDLEMAN: Well, all I want to do is see if he's got some numbers for airborne sampling and food items, and that will be the end of it because that will be the ranges of those numbers, and I can look at them and see if they're comparable.

If it looks ridiculously off, that would be different. But I'm already multiplying these ranges by 52 weeks and trying to figure out how much that is per year and so on. So I can add it up pretty fast and tell you if I'm going to go anywhere else at all.

JUDGE KELLEY: I'll allow you a couple more questions along that line. Go ahead.

BY MR. EDDLEMAN:

Q Doctor, do you have any information from this report concerning the range of doses from airborne sampling or food items that are based thereone?

A (Witness Mauro) I don't remember them. I know that analyses of that type are done. I recall that from reading the report. But I do not recall any of the values presented.

Q Does the report give at all, any range of total background doses for locations around the Harris site?

A As I indicated before, the report presents the

results for individual sampling locations, but does not, as I recall, does not make an effort to try to come up with some average overall value of the external dose around the site.

Q Well, I understand that, but I asked you a very slightly different question, which I'll ask again. For any particular location or locations within 50 miles of Harris, does this report give an estimate or number for overall background radiation dose, to your knowledge?

MS. BAUSER: I don't understand the question.

WITNESS MAURO: The values we just gave on a per week basis.

BY MR. EDDLEMAN:

Q But that's just from the external dose measured by TLDs. It's not --

JUDGE KELLEY: Excuse me, I have an objection here.

MS. BAUSER: Oh, I'll withdraw it.

JUDGE KELLEY: Go ahead.

BY MR. EDDLEMAN:

Q That's just in the TLDs, it's not from food, airborne radioactivity and so on?

A (Witness Mauro) No, sir, it is not.

Q So to make sure I'm not confused, you're saying that to your knowledge there are no total background radiation doses taking into account food, airborne radioactivity,

14

external dose, ground dose I guess is part of external dose, all those sources of natural background and adding them up for any site or sites within the 50-mile radius of Harris. That information, as far as you know, is not in this report?

A That's correct.

MR. EDDLEMAN: That's all I have along that line.

JUDGE KELLEY: Let's take 10 minutes.

end 16

(Recess.)

mgc 17-1

JUDGE KELLEY: We are back on the record.

MS. BAUSER: Judge Kelley, we have one further correction to make to this testimony that we missed the first time around.

Mr. Marschke, would you identify the correction, please?

WITNESS MARSCHKE: Yes. On page 4, the bottom paragraph, second sentence makes reference to Table D-1 of the FES. That should be changed to Table D-4 of the FES.

JUDGE KELLEY: All right.

MS. BAUSER: That's all. Thank you.

JUDGE KELLEY: Sure.

Okay, Mr. Eddleman, shall we resume?

BY MR. EDDLEMAN:

Q You actually use the values from D-4, the source term, in your calculations?

A (Witness Marschke) Yes. D-4 is the liquid releases; D-1 is the gaseous releases.

Q Okay. So when you were looking at gaseous releases, you did use D-1.

A That is correct.

Q Okay. Your population dose estimates in Table 2 on page 8 of your testimony, gentlemen, the 50-mile person-rem is just 100 millirems for 40 years times the number of people within 50 miles of the plant; is that

mgc 17-2

correct?

A (Witness Mauro) That's correct.

Q And you calculate the dose similarly at 100 millirems per person times 40 years times the 260 million people?

A That's correct.

Q And there is actually less than about 240 million people in the United States now, aren't there?

A (Witness Marschke) That's correct.

Q So your using 260 is sort of an implied average over 40 years or something like that?

A Yes.

JUDGE KELLEY: Did we look at Canadians and Mexicans, too?

WITNESS MARSCHKE: We did not. We assumed the 260 was the population in the United States.

JUDGE KELLEY: But radionuclides don't stop at the border, do they?

WITNESS MARSCHKE: No, they do not.

JUDGE KELLEY: Go ahead.

JUDGE FOREMAN: They probably go around the world.

JUDGE KELLEY: But just in terms of if you had a reactor in New England, you really could get more things into Montreal than in California.

mgc 17-3

Oh, go ahead.

MR. EDDLEMAN: Judge, do you want to ask something?

JUDGE KELLEY: No. Go ahead.

BY MR. EDDLEMAN:

Q The paragraph numbered 2 on page 10, in its first sentence, has a number of residence that is actually nearest to the plant site, 2.7 kilometers north-northeast. Then it goes down in Footnote 3 and says that that number comes from Table D-2 of the FES and a table of the ER, but then Table D-6 identifies this location as 2.3 kilometers north-northwest.

drop

Do you gentlemen know which of those two directions and distances is correct?

A (Witness Marschke) I believe the 2.3 kilometers is closer than the 2.7 kilometers, but the term "nearest residence" is actually not quite the way we should use it. It should be the critical residence, which is a combination of closeness and the frequency at which the wind blows in that particular direction. When we did our analysis in the ER, we came up with the nearest critical. The critical residence was the same as that given in Table D-2 of the FES.

Q That's the one at 2.7 kilometers to the north-northeast?

A Yes, even though the 2.3 kilometers is closer

mgc 17-4

in, in our calculation the people at 2.7 kilometers would receive a higher exposure because the wind was more frequent in that direction.

Q Okay. So that's why you used the one, that 2.7 kilometers, because of that higher exposure to them?

A That's correct.

Q Okay. It then says, "At each location and for each pathway at that location," -- I'm reading below paragraph numbered 4, the next paragraph after that -- "doses are calculated for for age groups: adult, teen, child, and infant."

Were doses calculated for the fetus at any of those locations, gentlemen?

MS. BAUSER: Objection. Asked and answered.

JUDGE KELLEY: Sustained. I thought he pretty clearly said at the outset that he didn't count fetal dose.

MR. EDDLEMAN: He's talking about what is in the FES here. I am asking him, is that stuff available in the FES.

JUDGE KELLEY: All right.

WITNESS MAURO: No.

MR. EDDLEMAN: Okay.

BY MR. EDDLEMAN:

Q On page 13 in the last paragraph on that page, you give a number of 1×10^{-3} lifetime risk from natural

mgc 17-5

background radiation for cancer death to a maximally-exposed individual.

Do you obtain that by taking 100 millirems a year background radiation times 70 years times an estimator of about 1.4×10^{-4} deaths per person-rem?

A (Witness Mauro) Yes.

Q And that is still an absolute risk estimate?

A Yes.

Q Okay. If you were to apply a relative risk model to that number, would you have any qualms about increasing it by a factor of four?

A I guess at this time I would say, if I was to do it right now, that is what I would do?

Q You would increase it by a factor of four to get relative risk?

A Four, yes.

Q Four, okay. So the 2×10^{-5} lifetime risk for cancer from the plant that's referred to in that last paragraph, that number actually comes from a paragraph up above at the top of this page, does it not?

A That's correct.

Q And in this one, you have taken a maximum lifetime wole-body dose to an individual of 100 millirems over 40 years plant operation, and then you added the residual dose. That is where you used -- wait a sec -- I take that

mgc 17-6

back.

In obtaining this number of 130 millirems, you used doses from your Attachment 6, did you not?

A (Witness Marschke) Yes, that is correct.

Q That is stated on page 12, isn't it?

A Yes.

Q And as shown in your Footnote 4 on page 13, you started with an infant. You didn't start with the fetus, correct.

A (Witness Mauro) That's correct.

Q Okay. The number 2×10^{-5} is obtained by absolute risk calculation, is it not?

A That's correct.

Q Now if you wanted to use a relative risk model on that number, would you need to go back into the relative risk per rem numbers in your Attachment 6, or could you just multiply by 4 to get the relative risk?

A At this time, I would say that just multiplying by 4 would be a reasonable approximation.

JUDGE FOREMAN: I think he is saying at this time.

WITNESS MAURO: Well, relative risk is a completely different method of assessing dose, especially if you start to look at any age-specific risk coefficients.

Overall, based on my recollection of the BEIR reports, that is overall for general population exposed,

mgc 17-7

the risk coefficient is about a factor of four higher. But that is just based on my recollection.

If I was asked now and I was given the time to go back and say, "Okay, go back and redo your whole analysis using the relative risk approach," I would go back and redo it from scratch. But right now at this time, just based on my recollection, I believe the results of that detailed would show about a fourfold difference.

JUDGE FOREMAN: I thought maybe you were thinking that that number might change with time. But this is with respect to your thinking.

WITNESS MAURO: With respect to my knowledge, that's correct.

JUDGE KELLEY: And if we were to take out the BEIR report, we could find out exactly what relative risk means in terms of that report.

WITNESS MAURO: That's correct.

BY MR. EDDLEMAN:

Q May I refer you to your Attachment 2-A, which is back about a third of the way in to your attachments, which is Table D-7 of the FES?

JUDGE CARPENTER: Do you have the page?

MR. EDDLEMAN: The page number at the bottom is D-10. It actually follows page -- it follows Attachments 1-A and 1-B, which follow the testimony. You go through

mgc 17-8

the two resumes, it's the next item. There is Attachment 2-A at the top and page D-10 at the bottom.

BY MR. EDDLEMAN:

Q Do you have that before you?

A (Witness Mauro) Yes, I do.

Q Okay. The total body doses given in this attachment to the population within 80 kilometers of the plant shows a dose of 12 person-rems from radioiodines and particulates, doesn't it?

A That is correct.

Q And for the thyroid, from radioiodines and particulates, it shows 22 person-rems, does it not?

A That's correct.

Q And in both cases, that is for the total body and the thyroid, the radioiodines and particulates form the majority of the person-rem, do they not?

A That's correct.

Q In Attachment 2-B, which follows that by a couple of pages, on page D-12, you again take from the FES Table D-9, some estimates of person-rems.

The natural background radiation of 26 million person-rems corresponds to 260 million persons, does it not?

A That's correct.

Q And the starred footnote shows that that 260

mgc 17-9

million persons therefore comes from a reference of the Bureau of the Census, correct?

A Yes.

Q That is where you got your 260 million number that you used elsewhere in this testimony, isn't it?

A That's correct.

Q And it shows a dose commitment to plant workers of 1000 person rems per year, doesn't it?

A Yes, sir.

Q That exposure would cease when the plant shuts down, except for decomissioning, would it not?

A That's correct.

Q And the triple-starred number, that 3.5 under "Liquid Effluents," is the correction of the number given in the FES, according to the errata dated January 12th, is it not?

A That's correct.

Q On page 3-4 of your Attachment 3, gentlemen, the second paragraph begins with the statement, "Krypton-85 is a noble gas which may be assumed to mix uniformally in the global atmosphere and deliver an external dose until it decays away within about 100 years."

That 100 years is roughly eight or ten halflives of that isotope, is it not?

A Yes.

mgc 17-10

Q So you've only got about a few thousandths to one-thousandth of it left after 100 years, correct?

A Yes.

Q Now when you assume that it is mixed uniformly in a global atmosphere -- well, let me ask you first, why do you assume that?

A As a noble gas, it would not be expected to attach to anything, and it would deposit, and you expect it to disperse and stay airborne and uniformly mix in the atmosphere.

Q Do you know if krypton is lighter or heavier than air?

A I don't know offhand.

Q Well, assuming that you are correct about it being uniformly dispersed, that would be the minimum concentration of tritium (sic) released in the atmosphere you could get, if you uniformly dispersed it through the whole atmosphere, then you minimize the concentration around the plant, don't you?

JUDGE KELLEY: I have an objection here.

MS. BAUSER: I think he said tritium.

MR. EDDLEMAN: Krypton, I meant to say.

BY MR. EDDLEMAN:

Q If the krypton is uniformly dispersed throughout the atmosphere of the whole earth, that would be the

mgc 17-11

greatest reduction of the amount of krypton-85 in the atmosphere to the plant that you could get, since you are mixing it with the whole atmosphere, isn't that correct?

A (Witness Mauro) I believe you misunderstand the way we did our calculations. We looked at both. That is, we looked at local concentrations within 50 miles and what the doses would be. And we also, then, after it passed 50 miles, we assumed that it is diluted in the atmosphere. So it is after -- we already looked at the more localized higher concentrations in order to give a complete assessment. Then we assumed dilution in the atmosphere.

So the answer to your question is yes. For the second half of the calculation, we did make that assumption.

Q All right. Now when you disperse it uniformly throughout the atmosphere of the whole world, wouldn't it be correct to use the population of the whole world to assess the dose that results from that?

A If I was interested in calculating the global dose, that's correct.

Q Well, that is the dose that does result from mixing the stuff uniformly throughout the whole world's atmosphere, isn't it?

A That's correct.

Q And you said it's reasonable to assume that that's what's actually going to happen to this krypton-85 once

mgc 17-12

it's released from the Harris plant?

A That's correct.

End 17

18pb1

Q Do you know what the population of the world is?

A Not exactly. About two billion.

Q You think it's about two billion?

A I don't know.

JUDGE FOREMAN: I don't see what that has to do with the contention.

MR. EDDLEMAN: Well, let me see if I can read this contention.

(Pause.)

MR. EDDLEMAN: It says, "Long term somatic and genetic health effects of radiation releases from the facility during normal operation, even where such releases are within existing guidelines, but seriously underestimated for the following reasons." And it talks about arbitrarily short lengths of time and so one.

But if we're talking about disclosure of the effects, you would have to include the effect of spreading the stuff out over the globe on everybody in the world. I would think that's the overall effect.

It doesn't directly relate to time if that's your question.

JUDGE FOREMAN: It is four billion approximately. I happen to know that number; four billion people.

MR. EDDLEMAN: I don't know if there's an objection pending or not.

JUDGE KELLEY: Not yet.

(Laughter.)

JUDGE KELLEY: I think you have a leading question, I suppose under NEPA you'd have to do global analyses. Do you know?

MR. EDDLEMAN: No, I don't, Judge. I think I already said in one of my pleadings that I didn't know the answer, but let me ask and see if I get an objection.

BY MR. EDDLEMAN:

Q To be consistent with your calculations for other aspects of the Harris plant where you used about a year 2000 U.S. population, and a median of plant life population around here, you would have to apply that global dose or global -- pardon me, dose resulting from the global average concentration of krypton 85, as you've assumed it here on this page of your Attachment 3 to the population of the globe as it is estimated for the year 2000, wouldn't you?

A (Witness Mauro) We did not calculate a global dose. We limited our calculation to a 50-mile and U.S. population dose commitments from these effluents.

Q But if you were to calculate a global dose for this globally dispersed krypton 85 consistent with your methodology for these other calculations, you would in fact use the world population in the year 2000.

A Depending on which isotope we were looking at.

Q For krypton 85, as you assumed here.

A I didn't do the calculation, but yes, I probably would do it that way.

Q May we turn to your Table 4-1 on page 4-5 of Attachment 4. Excuse me, page 4-4 of Attachment 4.

This is a table, in footnote 1 is says, "The predicted values of airborne radioiodine releases for the predicted phase were obtained from the FES for each plant." And then the measured numbers of the average range for 1970 to '79 for these various nuclear plants.

Let me ask you first, gentlemen, did all of these plants operate in every year from 1970 through 1979?

A Every plant had an emission. What power level it was operating at and the extent to which the time it was down, I don't know. But these are the releases for that year for those plants.

Q It doesn't actually give year by year releases, it just gives a range in the right-hand column, does it not?

A That's correct.

Q Okay. So you don't know whether each of these plants was always operating in each of these 10 years or not, do you?

A I don't know if each of the plants were operating the entire year during each of those years.

Q Do you know, for example, whether Oconee, any unit of Oconee was operating in the years 1970 or '71?

MS. BAUSER: Objection. He has already answered the question about what he knew with respect to all the plants --

MR. EDDLEMAN: He said for any part of each of those years. And now I'm asking about whole years. It's a very fine distinction but --

JUDGE KELLEY: Where are we going?

MR. EDDLEMAN: Well, first the table says that the average range is inclusive over the years of operation from 1970 to '79. Let me ask you this, this might be easier.

BY MR. EDDLEMAN:

Q Footnote 2 on the same page, it says, "The average in range are inclusive over the years of operation for 1970 to 1979." Do you gentlemen interpret that to mean those years between 1970 and 1979 when each of these plants was operating?

A (Witness Mauro) It's not only interpreted, that's what it is.

Q Okay. Now if we can look at the first line of that table for the unit Arkansas 1, you have a predicted curies per year of .048 and a measured average of .14, do you not?

A That's correct.

Q And in the range, the upper end of the range for

that is for that same plant is .74, is it not?

A That's correct.

Q If we look down to the fourth line of Calvert Cliffs, it has two units, we have a predicted value of .25 curies per year and a measured average of .27, do we not?

MS. BAUSER: Your Honor, I don't understand the relevance. The table is attached to the testimony of these witnesses. Mr. Eddleman can use this table in his findings as much as he sees fit. There's no need to have the witnesses repeat every number that is included. If he has questions about something, that's fine. But I think we're wasting time.

MR. EDDLEMAN: I certainly don't intend to repeat every number. In fact, I have about four more.

MS. BAUSER: There's no need to repeat any number.

JUDGE KELLEY: I think it's the same ballpark with the testimony. If they're looking at all of it, just ask the question about the numbers. He's a smart man, he can see the numbers, and he'll answer the question.

MR. EDDLEMAN: All right.

BY MR. EDDLEMAN:

Q Let me refer you then to a couple of other numbers besides the ones we've covered. If you look at the upper end of the range for Calvert Cliffs, do you see that?

A (Witness Mauro) Yes.

Q The upper end of the range for Indian Point. I mean, pardon me. Oh, it is Indian Point 1 and 2. The upper end of the range for that.

A Yes.

Q And for Turkey Point, the two units, if you look at the upper end of the range for that. Each of those upper ends of ranges considerably exceeds the predicted number, does it not?

A Turkey Point, yes, by a factor of two or three. A factor of two for Indian Point. A factor of four for Calvert Cliffs, that's correct

Q And for Arkansas 1, what would you say the factor is there, 15? A factor of 15 or 20, gentlemen?

A Yes.

Q Okay. And in fact, for Arkansas 1 and Calvert Cliffs and Kewaunee, if you could look at that one, too, the measured average exceeds in each of those cases the predicted curies per year per unit of radioiodine released.

MS. BAUSER: Could you repeat that?

MR. EDDLEMAN: Arkansas 1, Calvert Cliffs (two units), and Kewaunee, K-e-w-a-u-n-e-e.

WITNESS MAURO: Yes.

WITNESS MARSCHKE: Yes.

BY MR. EDDLEMAN:

Q So that even though these averages are what you used in your testimony, there is no guarantee that a particular plant is going to, either in any particular year or as measured on average, stay within the predicted limits for release of radioiodine, is there?

A (Witness Mauro) On the average you would expect it would be below. However, at any point in time for any particular plant, the release could be somewhat above or below the average.

Q Okay. And this table demonstrates that in some cases the release is substantially above the average, doesn't it?

A I think the intent of the table is to show that the average, which is what is being attempted to be predicted in the FES is typically -- the predicted value is typically considerably higher than the actual average for or observed. So comparing averages is really appropriate.

Each of these predicted values, you could probably go back and say, well, that's what you predicted to be the average release. You could ask the question, what would you predict to be the top end of the release, making other assumptions for any particular year. And that could have been done, too.

And perhaps under those circumstances it would be

8

side 2 bu 5

appropriate to compare it to the top end of the range. My intent here was to compare the predicted average versus the measured average, and to demonstrate that in general we tend to overestimate what we release when we try to predict.

Q Okay. But in fact, for at least the four units, Arkansas 1, two at Calvert Cliffs, and one at Kewaunee the measured average was higher than that predicted, was it not?

A That's correct.

Q Okay, let me ask you this. In averaging the curies per year per unit, how were these plants like H.B. Robinson, Indian Point 3, Maine Yankee and so on, which have a blank for the prediction column, how were they entered into that average, do you gentlemen know?

A Where there is no value presented?

Q Yes.

A That means there's no value presented in the reports that we looked at.

Q Okay. But did you make an average of all the ones for which values were presented?

A For the values presented, certainly.

Q All right. For the actual release values for those plants where no prediction was made, did you average the actual values into your actual release average?

A Say that again please.

Q All right, let me try to rephrase it.

Where there was no prediction made for radioiodine airborne release from a plant, did you use the measured release of radioiodine from that plant in computing your average measured release?

A No. What column are you looking at right now?

Q The second column where you have an average of .065. Does that average exclude the measured releases from plants for which there is no predicted release?

A No, that average -- you see those numbers, that long list, the second column. The .065 is the average of those numbers.

Q All right. So in fact, the predicted average excludes eight units as I count them. There are eight for which no predicted number is given; is that correct?

A That's correct.

Q So from the predicted column, when you take that average it excludes those eight plants. But in the measured average column you include those eight plants in the measured average.

A That's correct.

Q Okay. Even though there's no way to make a comparison between the predicted and measured performance of a plant for which there was no prediction.

A That's correct.

Q Okay. Why did you choose to include the measured

10

performance for plants for which no predicted performance was given?

JUDGE KELLEY: Mr. Eddleman, is this going to get tied in with appropriate durations at some point? I think you're going at this in very detailed. And frankly, it seems to me to be marginal from the standpoint of this contention.

MR. EDDLEMAN: What he's saying is, when he talks about conservative and he says, look there's a conservatism here and we can show this by comparing the predicted to the measured averages. I contend that in this respect of including numbers for which there was no prediction in this measured average, he's comparing apples and oranges. Or at least he's comparing one box of apples to that box and another box. And that may introduce some error in these numbers, which affects his degree of conservatism.

JUDGE KELLEY: Do you really think it would turn the numbers around? I mean, looking at these two columns.

MR. EDDLEMAN: It's not going to turn them upside down, Judge, but it is, I think, going to change them --

JUDGE KELLEY: It might even make his case stronger. We don't know what those numbers are, right?

MR. EDDLEMAN: I haven't calculated it out, you're right. Okay. I think that's a good invitation to drop it, so I'll just withdraw further questions.

(Laughter.)

end 18

JUDGE KELLEY: All right.

mgc 19-1

drop

MR. EDDLEMAN: I just have one other matter.

BY MR. EDDLEMAN:

Q On page 2 of Attachment 1-B of Mr. Marschke's resume under "Prior Experience," you list the Ralph M. Parsons Company. Is that Ralph M. Parsons any relation to the R.M. Parsons who is Project Manager at Shearon Harris?

A (Witness Marschke) No, not that I know of.

MR. BAXTER: That is Roland.

MR. EDDLEMAN: Well, I was allowing two possibilities, relative and same.

I have no further questions of these witnesses.

JUDGE KELLEY: Okay.

MR. RUNKLE: Your Honor, I do have a couple of question, just to clean up some matters.

JUDGE KELLEY: Go ahead.

MR. RUNKLE: They are fairly layman's questions. I would just like to pull some of the specific figures out of here.

FURTHER CROSS-EXAMINATION

BY MR. RUNKLE:

Q Based on your study, your knowledge, your opinion, everything, how many people will receive fatal cancers from the operation of Shearon Harris?

A (Witness Mauro) Are you asking my best estimate?

mgc 19-2

Q Yes.

A None.

Q In the results of your study, what percentage do you come up with? What is the possibility of fatal cancers?

A Take a look at page 8. Read the full paragraph that begins at the bottom of the page or the middle of the page. That basically answers your question.

Q Okay. The same question relating to genetic defects. Based on your study, your opinion, and your knowledge, how many genetic defects will crop up over the life of Shearon Harris?

A We did not address genetic effects in this testimony.

Q Did you study any of the effects of radiation released on miscarriages, spontaneous abortions?

MS. BAUSER: Objection. I believe we have already had a ruling from the Board that other diseases besides cancer and genetics are not within the scope of this contention. That is the Board's January 27th order, and I think it is at 41 to 43.

JUDGE KELLEY: Let me look at that.

(Pause.)

JUDGE KELLEY: There was a portion of the -- well, it wasn't a portion -- of Eddleman 37(b), which

mgc 19-3

referenced the works of Grauss and Bertell and referred to a host of other diseases, allergies, causes of death, et cetera, et cetera.

Excuse me a moment while I look at this.

(Pause.)

BU6

JUDGE KELLEY: I think Ms. Bauser is essentially correct, citing page 43 of our ruling of last January. We had a contention that referenced other diseases, and we said there that there was a lack of specificity in those references, and therefore we were going to restrict this to cancer and genetic defects.

MR. EDDLEMAN: Is that for Contention II(c) or 37(b)?

JUDGE KELLEY: It came in the context of 37(b). It's a fair enough point. Would you like to comment?

MS. BAUSER: I think it's even more remote with respect to the contention that is now pending before the Board. I mean, this was never the subject of Contention II(c). It is certainly not the subject of the Board's -- of the issues identified by the Board after the rulings on summary disposition.

MR. EDDLEMAN: Counselor, do you mean Joint II(c). I think you said Eddleman II(c).

MS. BAUSER: Yes, Joint II(c).

JUDGE KELLEY: Well, excuse me a moment.

mgc 19-4

(Pause.)

JUDGE KELLEY: All of II(c) is preceded by the following words: "The long-term somatic and genetic health effects of radiation releases from the facility," et cetera. I don't think that has anything to do with miscarriages. It seems to me that means cancer and genetic defects.

MR. RUNKLE: Okay. There are -- we use miscarriages as a more common word. There are miscarriages that are caused by genetic defects, and if you look at only from birth on, rather than fetal development, you would have miscarriages and spontaneous abortions directly caused by birth defects.

I don't have the --

JUDGE KELLEY: Are you now talking -- maybe I'm not with you. What is your scenario?

MR. RUNKLE: If the fetus would have genetic defects, it wouldn't become a death like you would have a death from a cancer or some other things. It would show up as a miscarriage or a spontaneous abortion.

JUDGE KELLEY: Sure. But I just want to get real clear now what we're talking about. This is a fetus that receives a radiation dose from the plant; is that right?

MR. RUNKLE: Yes.

mgc 19-4

JUDGE KELLEY: And you are suggesting what's going to happen? The defect will cause the miscarriage?

MR. RUNKLE: Yes, or a spontaneous abortion or whatever.

JUDGE FOREMAN: This is a scenario in which I have special interest, and indeed, a large number of individuals believe that spontaneous fetal losses are related to genetic effects. But this is due to the dose to the parents, and not necessarily a dose to the embryo.

So to my mind, your question is proper and fits within the contention.

JUDGE KELLEY: Go ahead, then.

BY MR. RUNKLE:

Q My question was just whether in studying the effects of radiation releases from Shearon Harris, you studied miscarriages or spontaneous abortions?

A (Witness Mauro) No, sir. Not in the piece of testimony, we did not.

Q Did you look at any other cancers that were not fatal?

A Yes, sir. We have addressed fatal cancers. But it is generally held that if you wanted to express all these numbers in terms of total cancers, it is reasonable to multiply all of our risks by a factor of two. That is a generally approved approach.

mgc 19-5

Q Is that also in your testimony?

A No, sir. We just address fatal cancers in our testimony.

Q Do you address not-fatal genetic defects?

A No, sir, we do not address genetic effects in this testimony.

Q Would any of your figures change, of fatal cancers in the 50-mile radius around Shearon Harris, if the population of that area increased or doubled perhaps?

A If you double the population -- difficult to answer. It probably would not double. It would increase but not double.

Q Can you explain that a little more? What would be the effects if the population doubled? Can you just run those figures through just briefly.

A Okay. The dose to the population within 50 miles can be looked at as due to two methods of exposure, external exposure from the airborne activity and deposited activity, and that would be directly proportional to the population, more people, because the dose rate would be the same. You put more people there. The person-rems would increase.

So from that regard, there would be proportionality. However, from the food pathway point of view, there's only a certain amount of food grown there and consumed. So you

mgc 19-6

could increase the population, but that doesn't matter, because we assume all the food that is grown there is consumed, so it would not increase with population.

Q But concomitantly with that, if there is more food grown in that area, you would have an increase in the amount of -- in that one pathway through food. Then you might expect that fatal cancers also do grow somehow in relation to that.

A If you increase the food production within 50 miles, you correspondingly increase the calculated person-rems from that pathway in direct proportion to the food production.

MR. RUNKLE: No other questions.

JUDGE KELLEY: Staff?

MS. MOORE: Staff has no questions.

BOARD EXAMINATION

BY JUDGE FOREMAN:

Q I am looking at page 3-4, and I think the answer is in the text here, but at the moment it's not clear to me, if you'll bear with me, and I am looking at the second paragraph beginning, "Krypton-85."

And what is puzzling me is the sentence that says, "The 50-mile and the U.S. population doses due to this residual activity are about 2×10^{-4} person-rems and 3×10^{-2} person-rems respectively.

mgc 19-7

I am a little confused as to why the number of person-rems for the U.S. population is lower than the number of person-rems to the 50-mile population?

A (Witness Mauro) No, sir. Just the reverse.

Q Well, somehow I am reading it wrong. I will have to read it through. Thank you.

A The 50-mile goes with the 2×10^{-4}, and the U.S. population goes with the 3×10^{-2}.

Q All right.

JUDGE FOREMAN: I guess that's all I have.

JUDGE CARPENTER: No questions.

JUDGE KELLEY: I have a couple of questions.

BY JUDGE KELLEY:

Q Mr. Runkle awhile ago, I think, put a question something like this: How many people would get cancer, how many people would die because of the operation of the Shearon Harris plant. And I tend to think of it that way, too, when I look at a risk. I am a layman; I am not a risk analyst, and I tend to translate risks, whether it's from a jet flight or whatever , into so many people will die.

I understand, though, that from the Staff point of your analysis, that is not really an accurate way to express it. It is rather in terms of the risk and what the risk will be to the whole population.

I'm not asking this very well. But would you

19-8

put the risk in terms of 2.3 people will die because of doing such-and-such a thing, or would you put it in a different context?

A (Witness Mauro) Well, the number that we estimated was .25, which means our best estimate of the number of fatal cancers that will be produced over the life of the operating plant in the United States is .25.

Now to put that into a common sense sort of approach, it means that less than one is your best estimate, which is your best estimate really becomes zero.

If you look at it from a probablistic point of view, that would be like a more discrete approach. It's less than one, so therefore really your best estimate is not. However, if you look at it from a probabiistic point of view, it means that there is a small probability that there may be one or greater cancers. There may be, but it's a very small probability. Your best estimate is less than one.

So that's the way you would look at it from a probablistic point of view.

Q And your probability that there would be 50 would be pretty small?

A Yes, it would approach infinitessimally small numbers.

Q Judge Carpenter has tried to explain this to me in the past, and I don't know if I quite grasp it, b ut

mgc 19-9

thank you.

Q On page 5, the second paragraph where you talk about annual dose, and you say that the comparison could have been presented on the basis of plant life -- okay -- no regulatory or other limits established for population dose; that is true.

But then you go on to say, "Consequently in order to evaluate the significance, population doses from nuclear power plants are compared with annual natural background populaton doses."

Well, why? Why not 40 years' worth? It just seems to me from a common sense standpoint, if what I'm doing is licensing a plant for 40 years, that's what I'm interested in, and I would like to know what the downside of doing that is in terms of the life of a plant.

A (Witness Mauro) I guess I don't see any difference. You could present it on a per-year basis -- that is, compare the dose per year of operation with the dose per year from background. Or I could see someone's preference being, "Well, let's present it, present the dose for the life of the plant which, let's say, is 40 years, and compare that to background for 40 years." The proportion will be comparable. That is, you haven't really changed your comparison any. They will both go up or down by the number of years that you are assuming.

mgc 19-10

Q Well, but an FES is supposed to lay things on the table, right, and if you work with the section of an FES that is addressed to this particular point and you fully understand everything that's going on in the calculation, I suppose it wouldn't matter to you. You know it's a 40-year plant and you do that almost automatically.

But it seems to me to be a little more revealing to put it in terms of plant lifetime risk. I just frankly don't see why not. I read over the reasons for not doing it and I don't find them very persuasive.

You say Table S-3 is in annual increments by 40, too, I suppose. Is there any good reason why you cannot?

A Not that I know of, no.

Q A question about the natural background concept in this context. I know it is used all the time, but is it possible, is it any source of concern that human beings over the millenia some how have acclimated themselves to a certain natural background dose, so that they do just fine at that level, but if you raise it one degree, who knows what would happen? Is that a concern at all?

A I would like to respond to that. Natural background, when we use it, when we talk about 100 millirems a year, it is really not an approriate, complete characterization. In fact, natural background in the

mgc 19-11

United States varies considerably from location to location, and that is the background in which our species has evolved and the background that has been changing and varying from anywhere perhaps 67, 60 , to perhaps over 200 millirems per year, depending upon your location.

So when you are saying, "Let's compare it to background," that is the background we are talking about. And I think it's revealing to point out that the incremental radiation doses to the maximally-exposed individual that we calculated here are small within that variation, not only small within the absolute value of 100 or 60, but small within the variation between living in one location, even in the vicinity of the Harris plant, and another location.

Q It can vary a lot in that close a difference?

A Yes. In fact, that is one -- you would expect that and you see it. That is, depending on whether you are over sandy soil or clay soil or a granite outcropping, it will have several millirems a year effect. If you live in a brick house versus a wooden house, it will have several millirem effect, much more than our calculated dose to the maximally exposed individual.

Q What about just atmospheric? Is not your background higher in the Rocky Mountains as opposed to the seashore?

mgc 19-12

A Yes, for two reasons. You are higher up, and therefore you get more cosmic rays, and also being the mountains, it is of a granitic nature, and it has higher levels of natural occurring radionuclides. So both the terrestrial component and the cosmic component is higher in the Rocky Mountains than it is at the shoreline.

Q What about people who live in an environment with a very high natural background, whatever that may be? Can you give an answer?

If you put nuclear power plants in an area which has a very high natural background level, would there be any concern about people around there? What is the incremental increase in relation to that?

A Any additions would still be small, compared to the variability of that location, the natural variability, so it still would be inside that. So if you had a location near Colorado, where you are talking about background radiation that may be twice as high as here, still the variability of that site will also be on the order of many millirems per year, which is greater than the increment due to the plant. So you cannot lose sight of that.

Q This may be self-evident from your numbers, too, but I just want to confirm it in my own mind.

When you do this arithmetic computation and multiply all the risks by 40, one of your points, I take it,

mgc 19-13

would be that even when you do that, the resulting number is not significant?

A That's correct. We came up with a value of less than one for the U.S. and well below one for the 50-mile radius.

Q And the only thing we talked about here that might significantly raise that would be this other risk approach in the BEIR report, right?

A Yes. We're talking about the possibility of using relative risk coefficients which would have perhaps a factor of four effect on this number.

Q What would a factor of four do to your high-side numbers?

A It would bring the .25 up to 1.

Q What's that again?

A In the testimony, if we go to Table -- the best way to do it is to go to Table 2 on page 8.

Q Right.

A The numbers that would be affected, the .1 and the .25, that would go up by about a factor of four.

Q And could you put that risk number, then, in sort of simple English? What does that mean?

A Well, as we are looking at it right here, the best estimate of the number of cancer fatalities within 50 miles is .1. It would then become .4, and the other

mgc 19-14

value would go from .25 to 1.

Q So it is still inconsequential.

End 19

20pbl

A That's correct.

Q When you compare it to background and these thousand of cancers you get otherwise.

A If you increase the risk from background accordingly, you would -- you see, when we developed the risks here for background, the 1,000 and 150,000, that was also based on the absolute. So to be consistent you would have to multiply those by four --multiply them by four, also

JUDGE KELLEY: Do the Applicants have redirect?

MS. BAUSER: Yes.

REDIRECT EXAMINATION

BY MS. BAUSER:

Q Dr. Mauro, do you know why the BEIR committee chose to recommend the use of the absolute rather than the relative risk co-efficient?

A (Witness Mauro) Yes. From reading it, they point out that the data on incidence of cancer is more consistent with an absolute risk co-efficient than a relative risk co-efficient.

Q On page 6 of your testimony, you say at the bottom of the page that you consider the residual dose that you calculated to be relatively small. And I believe Mr. Eddleman asked you a number of questions about that. Could you explain why it is that you reach that conclusion?

A I think the most compelling argument, if you look

down at the natural background radiation dose, we are talking about a billion person rems. That 700 person rems when looked relative to that number is of very little significance to me.

In addition, bear in mind that that 700 person rems is delivered over a 100-year period, over 260 million people. So the individual dose becomes miniscule. So in my judgment, it's insignificant.

MS. BAUSER: I have no more questions.

RECROSS EXAMINATION

BY MR. EDDLEMAN:

Q Let me also follow on that something Judge Kelley asked about. The environment in which human beings evolved didn't contain significant amounts of fission products until humans developed nuclear fission, did it?

A (Witness Mauro) That's correct. I would add to that that our environment still doesn't contain sufficient amounts of fission products.

Q Well, it contained virtually none, even compared to the levels today, during the period before human beings developed nuclear fission, did it not?

A That's correct.

MR. EDDLEMAN: May I have a moment?

(Pause.)

BY MR. EDDLEMAN:

Q Is the reason that you say that additional 700 person rem that was added in in your Table 1 on page 6 is insignificant, is that basically the same reason why you would also say that the effects of the 1,000 or so person rem that are obtained by just multiplying the FES dose levels by 40 are insignificant?

A (Witness Mauro) Well, I would say they are both insignificant. That is, the 50-mile number, whether we're talking 1,000 or 1700 are insignificant. Bear in mind though, that the 1,000 that's delivered to the U.S. over a 40-year period while the 1738, of the additional 700 is over a 140-year period.

Q Does the BEIR report make any distinction in the health effect of a dose of radiation regardless of how it's delivered?

MS. BAUSER: Excuse me, I couldn't hear the question.

BY MR. EDDLEMAN:

Q Does the BEIR report make any distinction in the health effects of a dose of radiation regardless of how it's delivered? Those risk per rem estimates.

MS. BAUSER: Could you clarify what you mean?

MR. EDDLEMAN: Well, the period of time over which it's delivered and the number of people to which it's

delivered. Does it make any distinction in the risk per rem absolute estimates that you used?

WITNESS MAURO: Yes, it most definitely does. It indicates that this approach, namely using a risk co-efficien which is unrelated to dose rate is extremely conservative approach. In fact, BEIR-III recommends against it and uses what is called the quadratic linear model, whereby the risks drop per unit exposure as the dose rate goes down.

So I would say that the approach that we used here is a conservative representative. The risk co-efficients we're using is quite conservative, especially when you are applying it to dose rates, which are miniscule.

BEIR-III in fact went as far as to say when they come up with their risk co-efficients they do it a t one rem per year and ten rem. Now what we've done here is assume that risk co-efficient holds all the way down. In some of these cases we're talking about very small fractions of one millirem per year. I would say by far, we are pushing this concept of risk co-efficient to the point where -- I don't think -- I think these numbers are more than just an upper estimate of risk. They are pushing the boundary of conservatism.

BY MR. EDDLEMAN:

Q That assumption that those risk estimators hold as you go down ten or one rem a year on down in dose, that's

known as the linear hypothesis, isn't it?

A (Witness Mauro) That's correct.

Q And don't the ICRP and BEIR recommend that for conservative purposes you should use the linear hypothesis?

A No, sir. They feel that the linear quadratic is the best way to model the effects of low doses of radiation.

Q BEIR does. What about the ICRP?

A The ICRP I believe recommends that for the purposes of placing an upper bound on risk the linear model will do that for you.

Q That's the International Commission on Radiation Protection?

A That's correct.

Q As to the quadratic linear model in BEIR-III, does it give higher risks per rem than just a straight linear model would at any points?

A I didn't use the BEIR. I used BEIR-I, which is --

Q I understand that. But when you were saying that this wasn't conservative, I thought you said one of the reasons for that was that BEIR-III recommended this quadratic linear model instead of the linear model.

MS. BAUSER: Objection. The witness did not say this was not conservative. He said it was extremely conservative, I think.

JUDGE KELLEY: I'm having a little trouble in

hearing, which is unfortunate. But I guess we have to live with it.

MR. EDDLEMAN: I will withdraw the question and end here. I don't want to keep us going in this environment.

JUDGE KELLEY: Okay. They are doing some renovating and I frankly don't think there's anything we can do about it except raise our voices a bit when we get back. Let's take ten minutes.

Is there something left here? Let's finish this if we're not finished.

MS. BAUSER: I just wanted to see if these witnesses were through.

JUDGE KELLEY: I guess we have made the rounds; isn't that right? Okay. Gentlemen, thank you very much, we appreciate your attention. You are excused.

(Witnesses Mauro and Marschke excused.)

JUDGE KELLEY: We will take a 10-minute break.

(Recess.)

21pbl

JUDGE KELLEY: We are back on the record now. That brings us to Ms. Moore and Dr. Branagan, correct?

MS. MOORE: Yes, sir. Your Honor, the Staff calls Dr. Edward F. Branagan, Jr. to the stand. Dr. Branagan has previously been sworn.

Whereupon,

EDWARD F. BRANAGAN, JR.

a witness called for examination and, having been previously duly sworn, was examined and testified further as follows:

DIRECT EXAMINATION

BY MS. MOORE:

Q Dr. Branagan, would you please state your name and business address for the record?

A My name is Edward F. Branagan, Jr. and I am with the U.S. Nuclear Regulatory Commission in Washington, D.C.

Q Would you please state your position with the Commission?

A I am a senior radiobiologist, radiology assessment branch.

Q Do you have before you a document entitled NRC Staff testimony of Edward F. Branagan, Jr. on Joint Contention II(c)?

A Yes, I do.

Q Did you prepare this testimony?

A Yes, I did.

Q Do you adopt this as your testimony in this proceeding?

A Yes, I do.

Q Is it true and correct to the best of your knowledge, information and belief?

A Yes, it is.

MS. MOORE: Your Honor, copies of the testimony have been delivered to the Board, the parties and the court reporter. I ask that the testimony and the attached professional qualifications be bound into the record as if read.

MR. EDDLEMAN: No objection.

JUDGE KELLEY: The testimony is admitted and will be bound into the record.

(The prepared testimony of Edward F. Branagan, Jr. follows:)

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
CAROLINA POWER AND LIGHT COMPANY AND	)	Docket Nos. 50-400-OL
NORTH CAROLINA EASTERN MUNICIPAL	)	50-401-OL
POWER AGENCY	)	
	)	
(Shearon Harris Nuclear Power Station,	)	
Units 1 and 2)	)	

NRC STAFF TESTIMONY OF
EDWARD F. BRANAGAN, JR. ON JOINT CONTENTION II (e)

Q.1. Dr. Branagan, please state your name and affiliation.

A.1. My name is Edward F. Branagan, Jr. I am a Senior Radiobiologist in the Radiological Assessment Branch, Division of Systems Integration within the Office of Nuclear Reactor Regulation. A copy of my professional qualifications is attached.

Q.2. Dr. Branagan, what is the purpose of this testimony?

A.2. The purpose of this testimony is to address the remaining portion of Joint Contention II (e) which states:

Joint Contention II

The long term somatic and genetic health effects of radiation releases from the facility during normal operations, even where such releases are within existing guidelines, have been seriously underestimated for the following reasons:

o

o

o

(e) The radionuclide concentration models used by Applicants and the NRC are inadequate because they underestimate or exclude the following means of concentrating radionuclides in the environment. . . radionuclides absorbed in or attached to fly ash from coal plants which are in the air around the SHNPP site. . .

Q.3. In regard to the remaining portion of Joint Contention II(e), what pathways are most likely to be of concern if radioactive particulates combined with coal fly ash to increase the size of the radioactive particulates?

A.3. The intervenor does not specify the particular pathways or body organs of concern. In my opinion, the primary pathway of potential concern would be exposure via inhalation of radioactive iodines and particulates (hereinafter referred to as iodines and particulates). This pathway constitutes the most direct means by which an individual could be exposed to radionuclides attached to coal fly ash. It is unlikely that radioactive noble gases would attach to coal fly ash to such an extent that they would present pathways of concern other than those already evaluated in the FES for several reasons. First, noble gases are very stable chemically and exhibit very low reaction rates under ambient conditions. Second, although the activity concentrations of radionuclides in coal fly ash have been measured, noble gases from nuclear power plants have not been detected in the coal fly ash (UNSCEAR, 1982,

Annex C). In the FES (pp. D-9 and 10), the dose to the critical organ (i.e., the thyroid) of the maximally exposed individual was estimated to be about 0.2 mrems/year from inhalation of iodines and particulates in gaseous effluents. Doses to all other organs of the maximally exposed individual were estimated to be less than 0.2 mrems/year from inhalation of iodines and particulates.

Q.4. Briefly describe the models used to estimate doses for the FES.

A.4. In licensing commercial nuclear power reactors, the NRC Staff uses mathematical models that characterize radionuclide movement in the environment to determine the radiological impact from nuclear power plant operations. These models are described in several NRC Regulatory Guides. Regulatory Guide 1.109 (USNRC 1977), entitled "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I," provides models for calculating doses to the maximum hypothetical individual from exposure to radioactive airborne releases.

Q.5. Briefly describe the dose conversion factors that were used to estimate doses in the FES.

A.5. The dose conversion factors used to estimate doses in the FES from inhalation of iodines and particulates were taken from Appendix E of Regulatory Guide 1.109. The bases for the dose conversion factors in Regulatory Guide 1.109 are described in a document entitled "Age-Specific Radiation Dose Commitment Factors For a

One-Year Chronic Intake," NUREG-0172. (Hoenes, 1977). The equations for calculating internal dose conversion factors in NUREG-0172 were derived from those given in ICRP Publication 2, "Report of ICRP Committee II on Permissible Dose for Internal Radiation." (ICRP, 1959). The ICRP Committee II assumed that 75% of the particles that were inhaled would be deposited in the respiratory tract. (ICRP, 1959).

Q.6. How would dose estimates change if radionuclides became associated with fly ash?

A.6. The Staff has not determined the particle size distribution of fly ash from coal fired power plants. However, assuming that the fly ash and the iodines and particulates formed particles of an optimal size such that all of the inhaled particles were deposited in the respiratory tract (rather than the value of 75% assumed in ICRP, 1959), then the preceding dose estimates would increase by a factor of one-third. That is, the dose to the thyroid of the maximally exposed individual from inhalation of iodines and particulates would be increased from 0.2 mrems/year to about 0.3 mrems/year. These dose estimates are based on inhalation of iodines and particulates from the reactor and do not include exposure to naturally occurring radionuclides in coal fly ash.

Q.7. How would the revised dose estimates for the maximally exposed individual compare with the applicable dose design objectives in 10 CFR 50, Appendix I?

A.7. Assuming that the fly ash and the radioactive particles formed particles of an optimal size and increased the dose from the inhalation pathway, the dose to the maximally exposed organ from all pathways of exposure to radioiodines and particulates would increase from 4.6 mrems/year (FES, Table D-7 on p. D-10) to 4.7 mrems/year. The revised dose estimate would be less than one-third of the applicable dose design objective of 15 mrems/year per reactor to any organ from all pathways of exposure to radioiodines and particulates.

Q.8. What do you conclude with respect to the issue raised in the remaining part of Joint Contention II(e)?

A.8. I conclude that it is unlikely that the attachment of radioactive iodines and particulates to coal fly ash would increase the dose to the thyroid or any other organ to such an extent that the estimated doses would exceed the applicable dose design objectives in Appendix I of 10 CFR Part 50. Therefore, I conclude the risks of "long term somatic and genetic health effects of radiation releases from the facility during normal operations" have not been "seriously underestimated" by the Staff.

References

Hoenes, G. R., and J. K. Soldat, "Age-Specific Radiation Dose Commitment Factors for a One-Year Chronic Intake," Prepared by Battelle Pacific Northwest Laboratories for the U.S. NRC, NUREG-0172, November 1977.

International Commission on Radiological Protection, "Report of ICRP Committee II on Permissible Dose for Internal Radiation," ICRP Publication 2, Pergamon Press, New York, 1959.

United Nations Scientific Committee on the Effects of Atomic Radiation, UNSCEAR, "Sources and Effects of Ionizing Radiation," 1982.

USNRC, Regulatory Guide 1.109, "Calculation of Annual Doses to Man From Routine Releases of Reactor Effluents for the purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I," Revision 1, October 1977.

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

PROFESSIONAL QUALIFICATIONS

From April 1979 to the 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, a 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.

MS. MOORE: Your Honor, at this time, in preparing his testimony, Dr. Branagan came across some typographical errors in the Staff Exhibit 1, which is the Final Environmental Statement, and he would like to present those corrections. Read them into the record as this point.

JUDGE KELLEY: Fine.

THE WITNESS: In Table D-2 on page D-5, that is Table D-2, page D-5, under the location column nearest residents and garden change 2.7 kilometers to 2.3 kilometers. Change north-northeast to north-northwest. So that should read 2.3 kilometers north-northwest.

Under the corresponding Chi over Q column, change 4.0 times 10^{-6} to 4.5 times 10^{-6}.

JUDGE KELLEY: This just raises a question. Maybe there's a short simple answer. The references to Units 1 and 2, Unit 2 has been canceled. Are your numbers keyed to two units, or to one?

THE WITNESS: The numbers in my testimony are based on one unit. The numbers in Appendix D are primarily concerned with one unit, although there is at least one table that's concerned with two units.

JUDGE KELLEY: Is that flagged when that is true?

THE WITNESS: Yes.

JUDGE KELLEY: Thank you.

THE WITNESS: Under the Chi over Q column in

Table D-2 change 1.9 times 10^{-5} to 3.4 times 10^{-5}. And under the relative deposition column, change 4.8 times 10^{-9} to 4.1 times 10^{-9}. And change 2.3 times 10^{-8} to 3.1 times 10^{-8}. And there's an additional correction on Table D-3, page D-6.

For the entry, residence and garden change north-northeast to north-northwest. And 2.7 to 2.3.

JUDGE KELLEY: Why do you have separate entries for goat's milk?

THE WITNESS: Well, the transfer of radionuclides from goat's milk or -- the transfer to goat milk is higher than for cow milk, so we do identify goal milk locations.

JUDGE KELLEY: And there are goats 50 miles from the Shearon Harris?

THE WITNESS: That's my understanding, yes.

JUDGE KELLEY: Mr. Eddleman lives there.

MR. EDDLEMAN: I have a friend who is a professional goat watcher at Duke University.

JUDGE KELLEY: Goat watcher?

MR. EDDLEMAN: Yes, he's a behaviorist and he studies the behavior of these goats, and he has a flock of goats that they maintain for lodging. The do milk them and they drink the milk.

JUDGE KELLEY: Okay, thank you.

BY MS. MOORE:

Q Dr. Branagan, does that complete your corrections?

A Yes, it does.

MS. MOORE: Your Honor, the witness is now available for cross-examination.

JUDGE KELLEY: Mr. Eddleman?

CROSS-EXAMINATION

BY MR. EDDLEMAN:

Q Dr. Branagan, if we turn first to your professional qualifications. It is true, that if I asked you -- these are the same professional qualifications that are attached to your testimony for Contention II(e), aren't they?

A Yes, they are.

Q And if I asked you the same questions about your employment history that I asked in connection with that contention, your answers would be the same, would they not?

A That's correct.

Q All right. In your answer 3 on page 2 of your testimony you have a fairly long quote from the FES. It is stated that your calculation is made for the 20th year, or midpoint of station operation. That implies a 40-year operating life, does it not?

A Yes, it does.

Q Did you hear the Staff's witness Ballard concerning

Contention 8(f)(1) state an operating life of 30 years?

A I wasn't here in the room when he made that statement. I have heard people say that he made that statement.

Q All right. In your answer to question 5 on page 3 of your testimony, you give two reasons, do you not, for presenting radiological impacts on health and genetic diseases on an annual basis, rather than summing them over the life of the plant.

The first of these is that applicable regulations contain annual limits. It is true, isn't it, that there are no plant life release limits in the NRC's regulations? No limits on releases over the life of the plant, rather than per year.

A For radiological effluents, that is correct.

Q Okay. And your second reason is that since the benefits were expressed on an annual basis in the FES the cause for adverse effects would be shown on the same basis.

Now, wouldn't it be just as easy to show the overall benefits over the operating life of a plant, and the overall costs?

A You could make that approach. That is a reasonable approach.

Q Okay. In choosing this annual approach, you are not saying then that you should not use an overall cost

7 side 2 bu 6

and benefit analysis for the plant, are you?

A No, I'm saying I don't think it makes much difference to your basic conclusions whether you look at it on an annual basis or on a cumulative basis. We have expressed it on an annual basis.

Q Well, have you read the testimony of the Applicants' witnesses on this contention?

A Yes, I did.

Q They identify some effects of radionuclides remaining after the plant shuts down, do they not?

A Yes, they do.

Q Do you have any basic disagreement with the way they calculate those radionuclides present and dose therefrom?

A It's seems like an appropriate method.

Q Would you say it is reasonable to include those impacts in the final environmental statement for the Harris plant?

A That would be a reasonable approach. It wouldn't be the only approach, but it would be a reasonable approach.

Q So then one reasonable approach would be to include the costs, or add costs, or adverse impacts of all 40 years of operation plus any residual adverse impacts that stay around after the plant shuts down as the cost side of the cost/benefit balance. And on the benefit side to enter

all the benefits that could be expected during or after operation of the plant.

A I think you made a statement. Is there a question?

Q I said, so that would be a reasonable approach. The approach that I just --

A That would be an alternative approach to what we did in the FES.

Q You say in your answer 7 on page 4 about midway down answer 7 toward the bottom of the page -- well, let me first refer you to your footnote on that page. You say that since Unit 2 has been canceled, the Staff in this testimony has provided cumulative risk estimates for operation of one unit at the Harris site.

Are all of your estimates in this testimony regarding one unit?

A Yes.

Q Okay. Now a little further down in that answer, you say that because the design objective values which are in Appendix I of 10 CFR 50 of the Nuclear Regulatory Commission regulations were chosen to permit flexibility of operation while still ensuring that doses for plant operation are as low as reasonably achievable, the actual radiological impact of plant operation may result in doses close to the dose design objectives.

Now you're saying there that -- well, let me ask

you this. If the Harris plant were to actually exceed one of those dose design objectives, the Staff would have to take some action to bring it back within those objectives, would it not?

A Yes. However, the radiological effluent technical specifications contain administrative limits for identifying doses that might exceed the dose design objectives prior to actually exceeding them.

Q Do you know if the actual limits on plant operation really restrain the plant to the dose design objectives?

MS. MOORE: Your Honor, I would ask for a clarification of the question. The actual limits on plant operation as expressed where?

MR. EDDLEMAN: In the technical specifications for the plant.

JUDGE KELLEY: Okay?

MS. MOORE: Okay.

THE WITNESS: We have not written, to the best of my knowledge, actual radiological effluent technical specifications for this particular plant.

BY MR. EDDLEMAN:

Q Does that complete your answer?

A Would you repeat the question again?

Q Okay. I think you did answer it. You just looked like you were going to say something else.

A I was trying to recall just specifically what the question was and make sure.

Q Well, let me ask the question again. You say you haven't written technical specifications for radiological effluents from the Harris plant yet. Does the Staff plan to write such specifications for Harris?

A Yes.

Q The specifications that you write for the Harris plant, those technical specifications, do you anticipate that they will actually restrain the radiation dose delivered by the Harris plant to these dose design objectives?

A That is the expectation. Yes, that's correct, to lessen the dose design objectives.

Q And you state at the bottom on page 4, "For the purpose of this testimony, the Staff based its dose estimate to a maximally exposed individual on the annual dose design objectives for exposure to various types of effluents."

That is because actual doses could come quite close to that, as you say on page 4, is it not?

22pbl

A It is possible, depending on how the plant is actually operated that it could come to the dose design objectives. However, the values that we estimated in Appendix D of the FES were less than the dose design objectives.

Q The Appendix D values are the ones that you project the plant would actually release in normal operation, correct?

A This would -- I have to pause for a second. It depends on the quantities that are released from the plant. Myself, I am not an expert in the area of what quantities are actually released from the plant, so I hesitate to respond to your question.

Q Well, let me ask another question which may be a little bit different. You say on page 4, "The design objective values were chosen to permit flexibility of operation, while still assuring that doses are as low as reasonably achievable.

"So the actual radiological impact of plant operation may result in doses close to those dose design objectives." Now doesn't that mean that realistically the dose might actually come up close to those dose design objectives at the Harris plant?

A It is possible that an annual dose would come close to that dose design objective.

22pb2

Q And are you aware of any limitation which would hold the Harris plant's radiological releases to those on which the dose estimates in the FES are based?

A The radiological effluent technical specifications are based upon the Appendix I, dose design objectives, not upon the dose estimates in the FES.

Q Do you happen to have a copy of the testimony of Applicant's witnesses Mauro and Marschke in this contention with you?

A Yes, I do.

Q Could you please turn in Attachment 4 to Table 4-1. Let me ask you first, on page 4-1 at the very front of that I believe it identifies the sources of these tables. Would you turn back to page 4-1, or do you already have it?

A I have that page in front of me.

Q Okay. Are you yourself familiar with Table 4-1 that is reproduced here in the Applicant's testimony?

A No, I am not.

Q Then let's turn back to page 4-1. The last sentence beginning on that page says, "As a result the radionuclide concentrations in primary coolant are much lower than assumed, resulting in much lower nuclide release rates."

And then it goes on to say Tables 4-1 and 4-2 compared the measured radioiodine release rates and gaseous

22pb3

and liquid effluents at operating PWRs, which I take it means pressurized water reactors, with the estimated values, okay?

Those tables then are taken from some NRC documentation. Isn't that what that says?

MS. MOORE: Objection, Your Honor. This is irrelevant to the analysis that Dr. Branagan performed.

MR. EDDLEMAN: It is relevant in this sense. He says they can come right up to the dose design objectives. Here in this table we have some measured versus predicted numbers.

If these predicted values were anywhere close to the dose design objectives, than these measured numbers in some cases are a great deal higher, could be outside that range. And I want to ask him about these things.

MS. MOORE: Your Honor, I object until Mr. Eddleman lays the foundation that the numbers contained in portions of Table 4-1 are the dose design objectives in Appendix I.

MR. EDDLEMAN: I didn't say they were. Let me ask you this, Dr. Branagan --

BY MR. EDDLEMAN:

Q Dr. Branagan, did you have anything to do with the FES's for any of the plants listed in this Table 4-1?

(Pause.)

22pb4

A Excuse me, it is taking me a second to scan the table.

Q Certainly. Take all the time you need.

A The only plant that I was involved with the FES according to my memory would be the FES for Turkey Point steam generator repair. Not for the Turkey Point FES for the operating license.

Q Okay. Doctor, footnote 1 of this table says that these predicted values were obtained from the FES based on calculations performed by the NRC and the industrywide standard methods. The values in the Harris FES for radioiodine source term were prepared in the same way, were they not?

MS. MOORE: Objection, Your Honor. Mr. Eddleman has yet to establish the relevance of this to Dr. Branagan's analysis.

JUDGE KELLEY: Can you tie it in with the analysis?

MR. EDDLEMAN: Well, he said that the FES numbers for Harris are lower than the design objectives.

JUDGE KELLEY: Is that in the testimony or in response to questions?

MR. EDDLEMAN: In response to questions. But he said they could come quite close to. Now these numbers are the FES predictions for other units.

JUDGE KELLEY: Right.

MR. EDDLEMAN: It doesn't give in this table what

22pb5

numbers you have to have to meet the design objectives. In fact, I don't know if that's in the FES at all for Harris.

But what I am trying to do is connect the numbers here and the much larger measured numbers back to --

JUDGE KELLEY: Some larger measured numbers? Larger than what?

MR. EDDLEMAN: Larger than the predicted in some cases in this table. The stuff I went over with Applicant's witnesses.

JUDGE KELLEY: The overall average is very much the other way, right?

MR. EDDLEMAN: That's right. But he testified that it would be the Appendix I guideline numbers that would be written into the technical specifications.

I don't know, maybe I should come at it directly. Let me try this. I will withdraw that question.

BY MR. EDDLEMAN:

Q Doctor, for these higher range numbers, if you just want to take a moment to scan down the right-hand column here, I believe the higher numbers include .94 for Maine Yankee, one unit, and 1.8 for Turkey Point, two units, curies per year of radioiodine is a measure of release. .74 for Arkansas 1.

Doctor, are you familiar in any way with whether those higher measured releases would or would not exceed

22pb6

the Appendix I guidelines for any of these plants?

MS. MOORE: Objection. My objection still stands, Your Honor. What is the relevance of this question to Dr. Branagan's analysis as set forth in his testimony?

MR. EDDLEMAN: If in fact you have got measured releases exceeding the guideline then his statement here is not conservative.

MS. MOORE: Objection again. Mr. Eddleman characterizes a word that Dr. Branagan did not say; it's not conservative. And I believe Dr. Branagan's statement was that the estimates in the Harris FES are lower than the design objectives.

JUDGE KELLEY: The estimates in the Harris FES are lower than the design objectives.

MS. MOORE: I believe that was Dr. Branagan's statement. If that was incorrect --

JUDGE KELLEY: Why isn't it then fair to ask about FES's generally for other plants, and whether what they in fact produced are within the Appendix I numbers? Are you implying that staying within Appendix I is customary for NRC plants? I would assume that you would. I would assume he would say that. I'd be surprised if he didn't.

MS. MOORE: But there has been no foundation laid by Mr. Eddleman that even these measures exceed the design objectives or the doses from these would exceed it.

22pb7

MR. EDDLEMAN: How can I lay the foundation when you objected to me asking that question?

MS. MOORE: It's irrelevant really to Dr. Branagan's analysis in his testimony.

MR. EDDLEMAN: I'm willing to back up and ask him about whether he considers this method of estimating that he's used here a conservatism or not, and go from there.

JUDGE KELLEY: Well, I don't think -- true enough it says analysis, it's his analysis that's being put forward subject to cross. But I think it is fair enough and within reason to ask about other approaches.

If your question is whether these higher range numbers are within Appendix I values I guess that's one of the questions that you asked; is that right?

MR EDDLEMAN: That's the one that was objected to.

JUDGE KELLEY: Okay, I will overrule the objection to that.

THE WITNESS: By the higher range numbers, I take it you are referring to the right-hand column in Table 4-1 of the Applicant's testimony, and those are in units of curies per year. The dose-design objectives are expressed in terms of millirems per year, and you need to run a computer program to calculate what the doses would be from those.

22pb8

BY MR. EDDLEMAN:

Q Okay. So what you're saying then is that you don't directly know whether these higher numbers, for example, the .94 curies that is the high end of the range for the Maine Yankee plant, do or do not exceed Appendix I guidelines.

A Based upon this table I don't know that.

Q All right. Let me ask you this.

JUDGE KELLEY: Is it a complicated matter to translate from curies to millirems and back and forth?

THE WITNESS: Yes. You run a computer program to do that. And that's what we did for the final environmental impact statement.

JUDGE KELLEY: I guess I don't understand. You mean there is really no relationship between curies and rems?

THE WITNESS: There is a relationship. It depends upon many factors. It depends upon the specific radionuclides that are released. It depends upon the pathways of exposure, where your nearest goat is.

JUDGE KELLEY: You can't just multiply by three is what you're telling me?

THE WITNESS: That's correct.

bu 7

JUDGE KELLEY: All right. Thank you.

BY MR. EDDLEMAN:

Q Do you know if there's any limit in the Commission's regulations as to the total curies of radio iodines released by nuclear reactor for any year?

22pb9

MS. MOORE: Objection, Your Honor. Relevance once more to Dr. Branagan's analysis. The analysis concerned in his testimony is whether risk ought to be accumulated, and Dr. Branagan has set forth how he did that.

MR. EDDLEMAN: I am exploring how consistent his assumptions are. Again, I am willing to back up and ask him about whether he considered these assumptions conservative.

JUDGE KELLEY: Well, maybe you could just spell it out for us, Mr. Eddleman. What is the relationship between your pending question and annualizing versus life of the plant? I'm not implying I don't think there is one, I would just like to hear it from you.

MR. EDDLEMAN: If the actual releases from a plant exceeded -- if the actual measured release from any plant had exceeded an applicable NRC guideline then one could not say it's conservative to use the NRC guideline here as the maximum dose that an individual might receive.

JUDGE KELLEY: Does your analysis, Doctor, depend upon the Appendix I guidelines directly?

THE WITNESS: Yes, my analysis depends upon the Appendix I --

JUDGE KELLEY: And you're assuming -- I take it your position is that Appendix I will be complied with I assume.

THE WITNESS: That's correct.

22pb10

JUDGE KELLEY: And hereafter, whether in some cases it might not be, correct?

MR. EDDLEMAN: Correct.

JUDGE KELLEY: You can pursue it within reason, Mr. Eddleman. Go ahead.

MR. EDDLEMAN: May I have a moment to confer?

(Pause.)

BY MR. EDDLEMAN:

Q Doctor, I believe the last question I asked you was whether you knew if there were any limits in the NRC regulations as to the number of curies of radioiodines which could be released from an operating nuclear power plant in a year.

A There is one such value in the rulemaking 50-2. It has a curie limit of one curie per year per reactor of iodine 131. The utility -- my understanding is if the plant is built in certain years the utility has the option of deciding whether they want to do a cost/benefit balance, which is $1,000 per man rem or come in under the RM-50-2 where it does have a curie limit.

Q That curie limit was one per reactor per year. Some of the values in Table 4-1, for example the .94 upper value for Maine Yankee is pretty close to one, the 1.0, are they not, Doctor?

A There is a value for Maine Yankee of .94 in Table

22pbll

4-1, the uppermost value.

Q Okay. And there's also a value, is there not, of two units at Turkey Point, an uppermost value of 1.8?

A Yes.

Q Now if we assume that that value were equally distributed between those two units, each would be 0.9, would they not?

A If you made that assumption, yes.

Q And if in fact the distribution was not 50/50, but say 60/40, one of those might have exceeded 1.0; one unit might have.

A Yes, but there is a fundamental misconception I think that you have here. The iodine limits are applied prior to licensing the plant. And this is an alternative to the cost/benefit analysis of $1,000 per person rem.

My understanding is that there are no iodine limits actually in the technical specifications after the plant is licensed, such as this.

Q None?

A There is no value. The 1.0 would not apply to an operating plant. Instead, they would have to be below the dose design objectives, not below a curie limit.

Q Do you know how that one curie per year in RM-52 of the regulation relates, if it does, to the dose design objective for radioiodine in Part 50 of the Commission's

23pbl

regulation?

A There is a relation between the two, however, it depends upon a number of site-specific parameters for the particular reactor being licensed. So it is not a straightforward relationship.

Q Okay. Is it a relationship that you could explain, say, for Shearon Harris?

MS. MOORE: Your Honor, I believe that question has been asked and answered. I believe Dr. Branagan has previously stated that to convert curies to dose he has to run a computer program.

BY MR. EDDLEMAN:

Q Would you use the same computer program -- I guess what I was trying to ask. I asked him this time about the rules and how that number in the rules of 1.0 curies per reactor per year related to the dose design objectives. And as I recall the answer was, well, it's a fairly complicated thing. It depends on a number of factors. And I then asked him, could you explain how those factors are done for Harris.

If it's done by the same computer program, then I think he can tell me that.

JUDGE KELLEY: I think the question is a little different. Is it the same computer program?

THE WITNESS: Well, we used the GASPAR computer

23pb2

program for evaluating the doses for Shearon Harris.

BY MR. EDDLEMAN:

Q Doctor, is that the same computer program you would use to convert the measured radioiodine releases from these reactors listed in Table 4-1 into population doses around those plants?

A You could run the GASPAR program with the site-specific information for those particular plants and you could estimate the dose.

Q All right. So what you would do for any plant, including Harris is if you knew the radioiodine curies released, that would be one of the inputs into this GASPAR program. Another input would be site-specific data. That's kind of the characteristics of the land and buildings and population around the site.

Are those the two major inputs or are they the only two inputs?

A The purpose of your estimating these doses, in my understanding. I mean, I'm not real clear on this. Is it, you are estimating the doses just from radioiodines, the ones that are listed in this table? You aren't interested in the noble gases or the particulates or anything else?

Q Not in this line of questioning, that is right.

A You would need the GASPAR computer program, you would need the site-specific information which would include

23pb3

the nearest locations, the nearest residence, garden, milk, cow, goats if there are any. You would need the meteorological dispersion factors for those locations. And you would need the source term for those.

Q And the source term would be the curies of radioiodine released from the plant?

A That's correct.

JUDGE KELLEY: Is GASPAR a person or acronym?

THE WITNESS: It's an acronym. It's the GASPAR computer code.

BY MR. EDDLEMAN:

Q Is that code one of the NRC standard codes?

A Yes, it is.

Q Is there a NUREG that describes it?

A Yes, there is.

Q Do you happen to know what the number of that NUREG is?

A NUREG-0597.

Q On pages 4 and 5 in your testimony, you say that for the purposes of this testimony the Staff based its dose estimate to the maximally exposed individual in the annual dose design objectives in Appendix I. Do you consider that that is a conservative assumption?

A I'm not sure I follow just what the assumption is. What is the assumption?

23pb4

Q Oh --

A I based my dose estimate on the Appendix I dose design objectives and I quantify in response to question 9 what that dose is. And I say the Staff has assumed that a hypothetical individual who would be exposed to five millirems per year to their total body --

Q Okay.

A And in the next line, this is a conservative estimate of the dose to an individual because it is unlikely that an individual would be simultaneously exposed at the dose design objective levels from gaseous and liquid effluents to the same body organs for 40 years.

Q So the use of the dose design limits is in your view a conservative assumption?

A The dose estimate of five millirem per year is a conservative assumption and that is based upon the dose design objective levels.

Q All right. In your answer 9 on page 5 you say your estimated dose is five millirems per year to the total body. Now, if I tried to compare that to the statement of the annual dose design objectives in Appendix I that's in your answer 8 immediately above that, that answer 8 says that you have these various limits to the total body or to any organ.

Is there a dose design objective in Appendix I

23pb5

for radioiodine exposure?

A There is a dose design objective for exposure to radioiodines and particulates of 15 millirems per year per reactor from all pathways of exposure.

Q Now that one is not included in the group for which you say, and summarize in Appendix I, whichever is more limiting, in the third from the bottom line of answer 8, is it?

A No, the previous passage, whichever is more limiting, refers to doses from noble gases.

Q All right. Why do you say that five millirems per year total body is more limiting for the Harris plant than any of these other objectives?

A Well, as I explained in response to answer 9, and I can read that passage to you. My response is really in answer 9.

Q Could you show me where it is? It's not quite obvious to me.

A The Staff has assumed that a hypothetical individual would be exposed to five millirems per year to the total body. For 40 years of plant operation, the cumulative dose would be 0.2 rems.

This is a conservative estimate of the dose to an individual because it is unlikely that an individual will be simultaneously exposed at the dose design objective levels

23pb6

from gaseous and liquid effluents to the same body organs for 40 years. Actual doses to real individuals in the near vicinity of the site are expected to be a fraction of those -- excuse me -- of the dose of 0.2 rems.

In order to obtain a dose of 0.2 rems, an individual would have to spend almost all of his or her time at the site boundary, and obtain almost all of his or her food grown at an off-site location where the highest concentrations of radionuclides are expected.

Q I still don't understand why that total body number is the most limiting number that you could use, rather than say, the 20 millirads, or 10 millirads per year gamma air dose, for example.

More limiting in what respect, Doctor, did you mean in answer 8?

A You said more limiting in respect -- I didn't use -- would you repeat the question?

Q All right. Let me re-ask, and perhaps change the question a little bit. Answer 8 of -- lists four annual dose design -- pardon me -- six annual dose design limits as I read it ending with the words on the third to the last line of that answer, whichever is more limiting.

Now do I correctly understand that to mean that whichever of these objectives is more limiting on the reactor is the one that should be selected?

23pb7

A I don't think you understand the passage.

Q Do you want to --

A Yes, the three millirem per year per reactor to the total body or 10 millirem per year per reactor to any organ from all pathways of exposure from liquid effluents. The first passage is concerned with liquid effluents. The second passage is concerned with noble gases, and the third passage is concerned with radioiodines and particulates. I am referring to answer 8 on page 5 of my testimony.

Q So the second passage is the one to which the words, whichever is more limiting applies.

A That's correct.

Q And you would have five millirems per year per reactor to the total body from that source, from airborne effluents of noble gases. And three millirems per year per reactor to the total body from liquid effluents to have the case that you are describing.

That is, an individual staying close to the site boundary and obtaining almost all of his or her food at the site boundary. I mean at the site where the highest concentration of radionuclides is expected, that you give in answer 9, would you not?

Wouldn't you have to add the three and the five?

A Not necessarily. There might be different persons exposed to the radioactive effluents. There are different

23pb8

pathways of exposure.

Q But don't you say in answer 9, that in order to obtain a dose of 0.2 rems -- well, the dose of 0.2 rems in answer 9 as you stated a couple times on page 6, is the same number that comes from the third line of answer 9 on page 5, is it not?

You calculate that number on page 5 and then you use it some more on page 6.

A That's correct, yes.

Q And that number is calculated by taking five millirems a year and multiplying it by 40, isn't it?

A That's correct.

Q All right. So that hypothetical individual is exposed to five millirems per year to get that 0.2 rem dose, correct?

A That is correct.

Q Now over on page 6 you say in the second complete sentence beginning on that page, "In order to obtain a dose of 0.2 rems," which I may remark we have already established is based on five millirems a year, "an individual would have to spend almost all of his or her time at the site boundary. And obtain almost all of his or her food grown at an off-site location where the highest concentrations of radionuclides are expected."

Now if you do both of those things, don't you

23pb9

get the five millirem per year dose from gaseous by being near the site boundary. And also the three millirem dose to the total body from all pathways of exposure to liquid effluents from the food?

A I guess the point I'm trying to make, and I want to make sure I answer your question, is that I think this is a hypothetical dose. I think real individuals would receive a dose less than this.

Q I understand that, Doctor. But isn't it so that the way you describe this dose on page 6, which results from five millirems per year actually describes, if you go back to answer 8 a dose that would be obtained of eight millirems or even more per year? Because you have not only got the three millirem component for liquid effluents to total body, and the five millirems per year per total body from noble gases at the location next to the site boundary, but you've also got some component from airborne effluents that include radioiodines and particulates.

So wouldn't you have eight or more millirems a year instead of five, to have a degree of conservatism that you describe there on page 6, when you say, in order to obtain a dose of 0.2 rems an individual would have to spend and on from there?

A No, I don't think you would have to. If you look in Appendix D of the FES, the doses that we estimated were

23pbl0

less than the Appendix I dose design objectives. As I stated in my testimony, it is possible that the utility may operate the plant close to the dose design objectives. However, they may operate it at much lower.

I don't think it's fair to assume that for 40 years of operation they would operate the plant close to the dose design objectives of all those radioactive effluents.

Q But Doctor, doesn't that contradict your statement on pages 4 and 5 in the last sentence beginning on page 4, "For the purpose of this testimony the Staff based its dose estimate to a maximally exposed individual on the annual dose design objectives in Appendix I."

A Yes, that's what they are based upon.

Q But aren't these two statements contradictory, Doctor?

A I don't see where they are.

Q Well, let me ask you this. You say on page 4 that the actual radiological impact of plant operation may result in doses close to the dose design objectives.

A Yes, it may result in that and it may result in much less than the numbers we estimated in the FES.

Q Okay. So then, as I understood you, you said okay, since it might get close to those dose design objectives, I'm going to base my analysis here on the dose estimate to a maximally exposed individual per those dose design objectives

23pbll

of Appendix I.

Am I misreading you so far?

A No, I don't think so.

Q Well, then what I would do if I said that is I would go down to Appendix I and I would assume that the maximally exposed individual gets the maximum dose under these guidelines.

A I wouldn't do that.

Q And you're not only saying you wouldn't do it. you're saying you have not done it. Is that correct?

end 23.

A That's correct. I have not done it.

24pbl

Q So in fact the assumption in answer 9 that a hypothetical individual would be exposed to five millirems per year to the total body is the same as the assumption in the dose design objectives just for noble gas effluents; isn't that true? Five millirems per year total body.

JUDGE FOREMAN: Excuse me a minute. Why did you assume that the hypothetical individual would be exposed to five millirem per year? What is the basis for that?

THE WITNESS: The basis -- it's based upon my judgment of looking at the dose design objectives and looking at the dose estimates in the FES. I feel that five millirem per year to the total body would yield a conservative risk estimate of the risk to the maximally exposed individual.

JUDGE FOREMAN: Based on the numbers in the FES.

BY MR. EDDLEMAN:

Q Dr. Branagan, do you believe that your judgment in answer 9 is based on the FES in setting that five millirems per year dose?

A It is based upon the Appendix I dose design objectives and the analysis that we did in the FES.

Q All right. So it is not just based on the dose design objectives in Appendix I as you state in your answer 7. It is also based on the FES, which is lower dose; isn't that correct?

A Yes, it includes the analysis in the FES.

24pb2

Q All right. And if you really wanted to base on the dose design objectives in Appendix I as you state in your answer 7, wouldn't you have to include dose from liquid effluents and noble gases and radioiodines and particulates?

A Only if the maximally exposed individual were being exposed to all those at the same location. It's not necessarily that the same person would be exposed to all those pathways.

Q I understand that too, Doctor. But don't you actually say on page 6 in answer 9 that in order to obtain this dose of 0.2 rems an individual would have to spend almost of his or her time at the site boundary, and obtain almost all of his or her food grown at an off-site location where the highest concentrations of radionuclides are expected? That's what you say, isn't it?

A I think in order for a person to receive that dose they would have to spend a substantial part of their time at the site boundary and obtain their food from the concentrations -- from the off-site locations where the highest concentrations of radionuclides are expected.

Q But that statement there, that must be based on the FES, is it not?

A It takes into account the analysis that we did for the FES.

24pb3

Q All right. Doctor, in your FES analysis, what is the maximum dose that you calculate that an individual -- if an individual did spend all of his or her time at the site boundary would receive from noble gases? What total body dose would they receive?

A If you refer to Table D-7, page D-10 of the FES, dose to the total body of an individual from noble gas effluents is listed as 0.2 millirems, which is less than 10 percent of the Appendix I dose design objectives. Which is also listed in that table.

Q Okay. Now if a person were in the same spot, what sort of dose would they receive from radioiodines and other particulates in airborne effluents?

A If you refer to Table D-6, the dose at the nearest site boundary from ground deposition and inhalation of radioiodines and particulates adds up to 0. -- approximately 0.7 millirem to the total body.

Q Okay. So we've got 0.2 and 0.7 so far, correct?

A That's assuming that somebody is at the site boundary.

Q Which is the assumption that you make in your answer 9, isn't it? It's correct that you state that assumption in your answer 9 on page 6 where you say an individual would have to spend almost all of his or her time at the site boundard, isn't it?

24pb4

A And obtain almost all of his or food grown at an off-site location where the highest concentration of radionuclides are expected.

Q Which is what I want to ask you next. I take it the answer to my previous question could be stated yes. Is that correct?

A I'm having difficulty, I guess, understanding your question and understanding your difficulty with the statement.

Q I'm trying to figure out what the millirems are at that point, because at first I thought you were saying this stuff was all based on Appendix I. But you tell me I misread you on that. I think it's a fair reading of what is said. But if you say it's different, then that's what you say.

But now, over here you're talking about the five millirems and its conservatism and you talk about what you would have to actually do to obtain this dose. Now I'm trying to go through the things that you said here because you say it's based on both Appendix I and the FES. I'm trying to figure out what dose it comes out to if you base it on the FES, okay?

We have covered the noble gas dose and the particulate radioiodine dose from being at the site boundary virtually all of the time. Now are there any other doses

24pb5

besides those two that would be incurred by an individual just spending all of his or her time at the site boundary, if they obtained their food from other source that had nothing to do with the plant?

A If they obtained their food --

Q From some other outside source that has nothing to do with the plant. It's not contaminated at all with Harris radionuclides or any other radionuclides. Just hypothetically.

You see what I'm saying? I just want you to isolate whether there is any other source of radiation dose to the person spending their time at the site boundary that has nothing to do with the food that they eat, besides the ones we already identified. Namely, noble gases and iodines and particulates, airborne.

A No. The direct radiation from the plume, ground deposition and inhalation. There wouldn't be any other really important pathways other than food, and you have excluded that.

Q All right. Now by direct radiation from a plume, do you include the shine dose and the breathing dose?

A Direct radiation from the plume is essentially direct radiation from the noble gases in the plume. As far as inhalation, that would be from the iodines and particulates. We are speaking of dose to the total body.

24pb6

Q All right. So now, noble gases aren't radioiodines, are they?

A No.

Q So in effect, in the language here you are classing them as particulates, aren't you?

A In the language where?

Q You say that the noble gas inhalation dose is included in radioiodines and particulates, right?

A The noble gas inhalation dose is included in radioiodines and particulates. That's what you said.

Q I thought that's what you said.

A I don't think I said that.

Q Well, the record will speak for itself, Doctor, but let me ask you. I thought you said that the shine dose, the direct radiation from the plume that comes from noble gases was what is in that noble gas dose, and the inhalation dose was included somewhere else. Is that wrong, Doctor?

A You referred to Table D-6, page D-9. There are several categories for effluent releases. From noble gases there is a value of 0.2 millirem per year from direct radiation exposure from the plume. This is for noble gases.

For the same location that also happens to be listed in the next part of the table for iodines and particulates, there is a value. If you add the values from ground deposition and inhalation you get an estimate of

24pb7

0.7 millirem.

Q Now inhalation includes inhalation of noble gases as well as radioiodines and particulates. Is that what you're saying?

A No, it includes inhalation of radioiodines and particulates.

Q Okay. So what is the dose to a person at that point of inhalation of noble gases, due to inhalation of the noble gases?

A I think it would be minor compared with the direct radiation from the plume.

Q Have you calculated it? Does it appear in the FES at all?

A I have not specifically calculated that, but my understanding is it would be quite minor compared with the direct radiation from the plume.

JUDGE FOREMAN: My impression is that Dr. Branagan did answer your question. And he said that the total exposure, other than exposure from the plume would be .2 plus .7 millirems; is that right?

THE WITNESS: That's correct.

JUDGE FOREMAN: And then the rest of the dose attributable to that individual would come from the food.

THE WITNESS: There would be a subsequent dose from the food.

24pb8

BY MR. EDDLEMAN:

Q The doses that we've already described, would they include the dose from tritium, Doctor? I just want to make sure I got it covered.

A Yes, tritium would be included in the category of iodines and particulates.

Q Now tritium is not a radioiodine, is it?

A No, it is not.

Q So it's effectively classified as a particulate here.

A Well, we include that in the category of an -- in that category. They are more similar to tritium. It's more similar to iodines and particulates than it is to noble gases.

Q All right, sir. Now we then come to the question of the dose from food. If an individual obtains almost all of his or her food grown at the off-site location where the highest concentration of radionuclides are expected, as you state on page 6, what sort of millirem per year dose do they get from that?

A Now, they're out a different location.

Q Well, the food comes from that different location, but that's what you said on page 6. I'm just asking you what dose do you get from what you said?

end 24.

25pbl

A I would have to add the values up in the table. And once again, it is from a different location. In other words, someone would have to be shuffling the food over from one location to another.

JUDGE KELLEY: Mr. Eddleman, we are approaching break time I think.

MR. EDDLEMAN: I think we are approaching a break point in the questions, too.

JUDCE KELLEY: Good.

THE WITNESS: Still focusing on the dose to the total body, the dose from -- excuse me --

(Pause.)

THE WITNESS: -- from ingestion of food would be about .6 millirem.

BY MR. EDDLEMAN:

Q 0.6 millirems?

A To the total body. This is for the maximally exposed individual that we evaluated in the FES.

Q All right, so if I add .6, .7 and .2 without allowance for these minor effects of noble gases and so on that you mentioned, I would come up with what the FES says that that individual you described on page 6 would get. And the FES says one and half millirems a year to that individual; is that correct? One and a half being .2, plus .7, plus .6.

A It would be about one and a half. But it is

25pb2

important to note that at least according to the analysis here in Appendix D of the FES that there is no actua' house located at the site boundary.

Q Doctor, I didn't ask you what the FES said. I was asking you all this time about what you said yourself on page 6 of your testimony in answer 9.

So in assuming five millirems per year to the total body, you have assumed a dose of about three and a third times higher than what the FES says. That's quantification of the conservatism in your answer 9; is it not?

A I have difficulties when you start adding these things up like this myself. I have some difficulties with that. If I could explain.

The dose from inhalation at the nearest site boundary, that is to a teenaged person. The dose from food ingestion to a child -- well, from food ingestion, that's to a child. So we're beginning to add up a number of things --

JUDGE FOREMAN: How did you arrive at that number of five millirems then if you didn't add these things up?

THE WITNESS: It is based upon my judgment of looking at the Appendix I dose design objectives as well as the analysis that we have done in the FES. It's a judgmental value.

JUDGE FOREMAN: It sounds like you picked it out

25pb3

of the air.

THE WITNESS: It's a judgmental value. I think that would be a conservative estimate of what the dose would be.

JUDGE FOREMAN: So it's an arbitrary number you got from somewhere, but it doesn't come from the addition of those doses.

THE WITNESS: No, I did not specifically add those doses, but I have noted that the doses in Appendix D are less than the Appendix I dose design objectives.

JUDGE FOREMAN: So you could have picked six, you could have picked four, but you just chose to pick five.

THE WITNESS: That's correct.

JUDGE FOREMAN: And you're calling that conservative.

THE WITNESS: I think that's a conservative estimate.

JUDGE FOREMAN: Does that answer your question?

MR. EDDLEMAN: Yes, Judge. My analysis indicates this is a good time to break.

JUDGE KELLEY: Let's do that. Ten minutes.

end 25

(Recess.)

mgc 26-1

JUDGE KELLEY: We are back on the record.

Mr. Eddleman can resume his cross-examination.

BY MR. EDDLEMAN:

Q Doctor, where in your testimony does it say that your five millirems per year number is, in fact, based both on Appendix I and your analysis for the FES? Does it say that anywhere in this testimony?

A I don't believe it explicitly says that, no.

Q Does it implicitly say it someplace?

A Well, I refere to Appendix D of the FES in response to Answer 7. I think the knowledge of the dose estimates goes to that. I don't explicitly say that, to answer your direct question.

Q And in fact at the end of Answer 7, you say, "For the purpose of this testimony, the Staff based its dose estimate on" and then you go over their dose design objectives in Appendix I, do you not?

A I do state that in my testimony.

Q So the statement there is not, in fact, what you have done in adopting this five millirems per year assumption in Answer 9, is it?

JUDGE FOREMAN: I think you have an answer to that already.

MR. EDDLEMAN: I will withdraw the question. Thank you.

mgc 26-2

BY MR. EDDLEMAN:

Q I believe you've already stated this, Doctor, but let me make sure I heard you right.

The technical specifications for the plant will, in fact, limit the plant's output or are intended to limit the Harris plant's output to the design objectives, the dose design objectives that are listed in your Answer 8; is that correct?

A Yes, that's correct.

Q All right. So consistent with the plant's license, it could actually deliver three millirems a year to the total body and -- I mean from liquid effluents -- five millirems per year to the total body from noble gases and fifteen millirems per year to any organ from radioiodines and particulates, could it not?

A It is possible.

Q Okay. And would it be possible for that dose delivered to exceed five millirems a year to an individual?

A It is possible, but unlikely, in my opinion.

Q All right, sir. You cite at the end of your Answer 9 the FES Table D-7 on page D-10. This gives down at the bottom or down toward the bottom of the table some population doses, specifically about 15.4 person-rems from the Harris plant to the population within 80 kilometers, doesn't it?

mqc 26-3

A That's the value in the table.

Q Okay. Did you participate in preparing this table?

A Yes, I did.

Q Okay. Do you agree with that value of 15.4 basically?

A Yes, I do.

Q Would you refer to your copy of the Applicants' testimony at page 3. There is a statement here in the first unnumbered paragraph, and I want to ask you if you agree or disagree with it.

It says, "In evaluating dose" --

A Excuse me. Where are you?

Q Page 3 of the Applicants' testimony on this contention. There is a -- there are a couple of numbered paragraphs at the top of that page, and the next paragraph is unnumbered. What I want to ask you is if you agree or disagree with the statement in that sentence, "In evaluating the dose from the Harris plant radiological releases, consideration must be given both to the population dose and to the dose to the hypothetical maximally-exposed individual."

A Yes?

Q Do you agree?

A Yes.

mgc 26-4

Q Okay.

A Let me back up just a second. The "must," I find that a rather strong term. I am not sure I would use the same word as "must," but in general, I think it's reasonable.

Q You wouldn't find it unreasonable to do such an analysis, taking both of those types of doses into account, would you, Doctor?

A No, I wouldn't find it unreasonable.

Q In your Answer 11, you describe the risk estimators that you use in making your calculations in your testimony, do you not?

A Yes, I do.

Q Now these are stated as absolute risk models in BIER-1, and if we go over to page 7, you say that by the relative risk model, you could produce risk estimates up to about four times greater than those used in this testimony, and you then say that you regard this as a reasonable limit, upper limit, to the range of uncertainty. The uncertainty there refers to the uncertainty of the amount of risk per person-rem, does it not?

A That's correct.

Q Have you ever examined the risk estimates by Dr. John Goffman for risk per person rem?

MS. MOORE: Objection, Your Honor. That is beyond

mgc 26-5

the scope of this contention.

JUDGE KELLEY: Why?

MS. MOORE: The Staff has used a certain risk estimator, and they have set forth the bounds of uncertainty, what they consider to be a bound of uncertainty, and Dr. Goffman's risk estimates are not at issue here. We are not to challenge the estimates in BIER-1, as I understand it.

JUDGE KELLEY: Excuse me?

MS. MOORE: As I understand it, there are not to be challenges to risk estimators extracted from BIER-1, which is where Dr. Branagan chose his riks estimators.

JUDGE KELLEY: Where is it written that we cannot do that?

MS. MOORE: It is my understanding of this contention, as the Board limited it in its January 27th order and its later order in which it stated that Dr. Goffman would not appear, that BIER-1 is to be taken, since the Intervenors could not meet their burden Black Fox, that BIER-1 is an adequate model to be used to estimate risk.

JUDGE KELLEY: Well, I just want to ask you a question or two, and I think we ought to confer on your objection.

But just to put it in front of us, I think I would suggest to you that we are not here to litigate

mgc 26-6

the merits of different risk estimators in the sense of Goffman versus -- I'm reaching for the word; we have already had two today -- BIER-1 and the one that is four times as big.

JUDGE FOREMAN: Relative versus absolute.

JUDGE KELLEY: Right. We cannot litigate the merits of those. But on the other hand, we are looking at what difference does it make whether you talk annual risk or plant life risk, and conceivably it might be different, depending on what you thought the right risk estimator ought to be, don't you think?

Suppose you had a risk estimator that multiplied the impacts by ten?

MS. MOORE: It's my understanding -- I understand your point, Judge Kelley, the Staff's understanding, that the risk estimators to be used here were the BIER risk estimators, and you just used the word "the right risk estimator," and that would get into the merits of risk estimation, it seems to me.

JUDGE KELLEY: Well, let me put it to you a little bit differently. I haven't read this case in years, but there is a case called the Sippy Case in the D.C. Circuit, right, and it involved the obligation of an agency to set forth differing opposing views, just like we do in the NRC, you know, different opposing scientific

mgc 26-7

views, if you will.

Now you may take one risk estimator because you think it's the best one. Might it not be argued that somebody else's risk estimator which had at least some aura of responsibility ought not to be included, too, at least in the footnote?

MS. MOORE: I would agree with you, except in this particular case, I think that the question of the reasonableness of a given risk estimator was argued on summary disposition, and the Intervenors were asked to put forth their reasons why Dr. Goffman's risk estimator was better than BIER-1, and they were unable to do that, and the Board ruled out the consideration of, as I understood it, the consideration of the appropriateness of the risk estimators contained in the BIER report.

JUDGE KELLEY: Any comment?

MS. BAUSER: Yes. I would concur with the Staff. I think there was some question about whether this issue was still at issue right after, you know, when there were several orders issued in a row by the Board, and the last order issued in response to summary disposition, the March 15 order, clarified it.

Since Dr. Goffman was not going to testify, the issues raised by Mr. Eddleman in connection with Dr. Goffman were no longer in this proceeding. And as I

mgc 26-8

understood and as our testimonies are written, the Staff's and Applicants', the address the issues raised by the Board in response to motions for summary deposition which do not include the Goffman, in fact, to the BIER reports.

So while in theory I would agree with the principle that you are talking about, I think in the context of this particular contention, it is outside the scope.

JUDGE KELLEY: But even in the case of your witnesses, they took certain variables, and they applied them in various ways and came down to the bottomline, right?

MS. BAUSER: Right.

JUDGE KELLEY: WAsn't one of them risk estimator?

MS. BAUSER. Yes, but I don't think that was an issue with respect to this contention. It was necessary that they do that, just like they accept the source term, in order to do some of the calculations, but the source term wasn't at issue either.

JUDGE KELLEY: Mr. Eddleman, am I even raising a question that you are interested in?

MR. EDDLEMAN: Judge, you certainly are. I think Mr. Runkle wants to argue this one, though.

JUDGE KELLEY: Okay.

MR. RUNKLE: I didn't think that the question was going to go to say that Goffman's risk estimators should be the only ones used. It's just an alternative. We have

mgc 26-9

absolute, we have relative, and now we have another one.

In the Board's order on this contention, I think the ruling that this was an issue in dispute, and it was unfortunate that Dr. Goffman refused to appear today. I think there's a whole raft of risk estimators, and we are not saying that one is better and one should replace the other one; it's just that Goffman is one more that should be considered.

MR. EDDLEMAN: In fact, if I may just add a little to that, Judge, where I came from in asking this is from his statement, the witness' statement, that this is the relative risk number, which is four times higher than the absolute risk, is a reasonable upper limit to the range of uncertainty. He said it's an upper limit. I think I ought to be able to challenge that.

JUDGE KELLEY: If that's the direction you're going, you would then say well, you know about Goffman; he would say yes, and then you would want to know, what is his risk estimator, and we would get some number for that, and then you would ask what he thought of that.

Is that where you're going roughly?

MR. EDDLEMAN: Well, more or less, yes.

MS. BAUSER: One of the troubles with this is, our testimony could have, but does not, address this kind of train of thought -- namely, the validity of the

mgc 26-10

risk estimator in question. It assumes that the risk estimator in the BIER report, as the Staff said, is a reasonable risk estimator to use for purposes of going ahead and doing the time analysis that is called for in the Board's questions.

I think for Mr. Eddleman to create a record on this at this point poses a problem for us, because it's not something that we addressed in responding to the statement of the issues.

MR. EDDLEMAN: Judge, may I comment? I would never disclaim responsibility for creating some problems for the Applicants, but I think that their witnesses very clearly defended their use of the absolute risk estimator on cross-examination, and I just can't imagine anything they need to add to that, because they describe exactly why they used it and why they wouldn't use any other.

MS. MOORE: Your Honor, I would also bring up another procedural point, in that it was my understanding that if there were going to be documents and things used in cross-examination, that they were to be provided or at least pointed out to us, and there was no indication that we were going to involve cross-examination on Dr. Goffman and his risk estimators.

JUDGE KELLEY: I do not recall, but I would be happy to be corrected, that we had an outstanding order --

mgc 26-11

maybe we should have, but I don't recall if we did -- have an order to the effect that all cross-examination papers had to be produced and exchanged.

MS. MOORE: I don't believe it was an order. I understood it as --

JUDGE KELLEY: Let me take it one at a time.

Ms. Moore?

MS. MOORE: I understood it as an agreement. The Board has not, to my knowledge, issued an order on that subject.

JUDGE KELLEY: Nor was I even aware of any discussion on it. Maybe we should have. I will say it again, but I don't know that we did.

MR. BARTH: Your Honor, I specifically raised this question at the prehearing conference in order to avoid surprise, and Dr. Carpenter, at the conclusion of my remarks, said, "Yes, I do not think that surprise should come about. We want to avoid it and have a more meaningful conference."

I raised the point intentionally that documents which were going to be either introduced or used fundamentally for cross-examination should be brought to the attention of all parties to avoid surprise. And certainly Dr. Goffman's book and the introduction of his risk estimators comes as a surprise to us. We had no

mgc 26-12

knowledge or forewarning that this would be part of the discussion, either in our affirmative case or on cross-examination, sir. It was not in the written order by you. There is no question of that.

JUDGE KELLEY: It was raised in the prehearing? Can you give me a citation?

MR. BARTH: I do not have the transcript with me, Your Honor.

(Pause.)

MR. EDDLEMAN: Judge, may I elaborate on that a little bit?

JUDGE KELLEY: Yes.

MR. EDDLEMAN: I think the Staff is correct. They have us under an interrogatory to identify documents. But I thought it was fairly clear that anything that had been mentioned in discovery was included, and heaven knows, we've mentioned Dr. Goffman's book a whole lot in discovery.

And also I would like to point out that I haven't used the document at all. It is sitting here, but I haven't touched it, and I'm not going to. I'm not going to ask him anything in it.

JUDGE KELLEY: Where were you headed, then, on the Goffman question?

MR. EDDLEMAN: I wanted to ask him if he is

mgc 26-13

familiar with those risk estimators, and if he is, are they higher than the relative risk estimators. That's about as far. There might be a little bit more in that line. But he says it's an upper limit, and I want to challenge that.

JUDGE KELLEY: All right. I think the Board should discuss this briefly, give a ruling.

(The Board confers.)

End 26

mgc 27-1

JUDGE KELLEY: Back on the record.

It seems to us that there is some competing considerations and something to be said for both the objection and the response.

We do feel that in granting summary disposition on the part of the contention that went to the merits of the Goffman estimates, we did exclude getting into the merits in this case.

On the other hand, a risk estimate is one part of one's calculations when you decide what you're looking at in this particular contention here. And you have talked about a couple of risk estimates.

If the question merely is something like, "Did you consider Goffman? If not, why not?", okay. We are not going to go much beyond that, though, into the merits.

MR. EDDLEMAN: That's all I want to do, Judge.

JUDGE KELLEY: Okay, go ahead.

BY MR. EDDLEMAN:

Q Doctor Branagan, are you aware of any cancer risk models or estimates which give a higher risk per person-rem than the relative risk model of BEIR.

A I am aware of estimates by some individuals that give higher risk estimates than the relative risk model in BIER.

Q Could you name some of those individuals?

mgc 27-2

A Dr. Goffman, Dr. Carl Morgan. Those are the two individuals that come to mind right now.

Q Do you know what Dr. Morgan's estimator is?

A I've read some papers of his and have seen different values that he has used.

Q Do you recall any of those values?

A One value I recall would be approximately risk of radiation of 10^{-3} potential fatal cancers per person-rem. However, the paper that I read -- the paper was unclear really. It wasn't real clear whether he was talking about potential fatal cancers or cancer incidence, from my recollection.

Q All right. But that would be 1000 fatal cancers per million person-rem in the terms you are using in your Answer 11, would it not, Doctor?

A That's correct.

Q What about Dr. Goffman's estimators? Do you know what those are in numbers?

A I know they are higher than that value. I forget exactly how much higher.

Q Dr. Morgan is a rather famous healthy physicist, isn't he?

A He is.

Q Okay. And you have stated that his estimators, at least in some cases, are higher than the relative risk

mgc 27-3

of BEIR.

Now given that, do you think it is really true to say the BEIR relative risk model is, in fact, an upper limit to the range of uncertainty of these estimators?

MS. MOORE: Objection, Your Honor. That is a challenge to BEIR.

MR. EDDLEMAN: It's a challenge to his statement.

JUDGE KELLEY: Give it once more, Mr. Eddleman.

BY MR. EDDLEMAN:

Q In light of the fact that at least some of Dr. Morgan's estimators of this cancer risk per million person-rem are higher than those of the BEIR relative risk model, is it correct to say that the relative risk model is a reasonable upper limit to the range of uncertainty of these estimators?

JUDGE KELLEY: I will allow it. It's moving up to the edge, but I will allow the question.

THE WITNESS: I believe, as I stated in my testimony, that the Staff regards this as a reasonable upper limit to the range of uncertainty.

BY MR. EDDLEMAN:

Q Are you saying that you are personally sure that the range of uncertainty doesn't extend beyond that?

A I think, as I stated in my testimony, I feel that is a reasonable upper limit to the range of uncertainty.

mgc 27-4

Q I'm not sure you quite answered my question.

MS. MOORE: Your Honor, I believe he did answer the question.

JUDGE KELLEY: I think he did, too.

MR. EDDLEMAN: Well, all right.

BY MR. EDDLEMAN:

Q In stating that that is -- that the BEIR relative risk model is a reasonable upper limit, as you have, you are not meaning to imply that there could not be a higher upper limit, are you?

MS. MOORE: Objection, Your Honor. Asked and answered. The witness' testimony speaks for itself.

JUDGE KELLEY: Aren't you saying, in effect, that the estimator you used is the one you think is the best estimator on the whole, right?

THE WITNESS: I think that's correct.

JUDGE KELLEY: All right. You are at least generally familiar with Dr. Morgan's work?

THE WITNESS: Yes, I am.

JUDGE KELLEY: I gather you don't agree with it.

THE WITNESS: No. Generally. I prefer to use risk estimators from the range of the radiation protection organizations which include scientists from many disciplines rather than--

JUDGE KELLEY: Do you think it is sounder?

THE WITNESS: Yes. I think it's a sounder basis.

mgc 27-5

BY MR. EDDLEMAN:

Q Well, accepting that answer, Doctor, for the purposes of argument here, still the reasonable upper limit, in your view, would be to multiply the absolute risk numbers that you get for numbers of fatal cancers by four, wouldn't it?

A That's correct.

Q Okay. Now in the next paragraph down on page 7 of your testimony, you start talking about values for genetic risk estimators, do you not?

A That's correct.

Q And you use a value of 258 cases of all forms of genetic disorders per million person-rems. And that is about four times the lowest risk estimator that you cite in that paragraph, isn't it?

A It is lower than the value of 1500; that's correct.

Q No, no. I may have misled you here. The 258 is approximately four times higher than the lowest risk estimator cited in the first line of that paragraph, isn't it, Doctor?

A That's correct.

Q All right. And it is likewise approximately one-sixth as much as the highest number, the 1500, in the first line of that paragraph, which is also dervied from BEIR-1; isn't that correct?

mgc 27-6

A That's correct.

Q Would you then say that a reasonable upper limit to the range of uncertainty for genetic defects would be to take your estimates using the 258 number and multiply them by six?

A I would regard that as an upper limit value, yes.

Q All right, sir. Now in Answer 12 --

A However, I would not just a point. In the BEIR-3 report, they didn't have a lower/upper limit value in the BEIR-1 report, but in this testimony, we included an upper limit value of 1500.

Q Okay. In your Answer 13, Doctor, on page 8, you used that 100 millirem value for natural background radiation from Oakley, do you not?

A That's correct.

Q Do you know if that is the same Oakley report that the Applicants' witnesses were talking about?

A Yes. It's my understanding it is the same report.

Q And you say that this 0.2 rem addition to an individual's exposure due to the Harris plant's radiological effluents, radioactive waste released into the air and water, would by conservative estimate raise the dose for an individual about three percent above background?

A That's correct. Over the lifetime of the individual.

mgc 27-7

Q Okay. Did you, in fact, Doctor, estimate the increased risk for operating the Harris plant over its operating life and then through residual radiation left over from that operation for the population around the Harris plant in your testimony?

A For the estimated dose to a maximally-exposed individual. And I also estimated the dose and provided a rough range on the average dose to an individual within 50 miles of the site.

Q Now that is back on page 6 in your Answer 9, is it not?

A That's correct.

Q And that number is drawn from the FES Table D-7 on page D-10, is it not?

A Yes. That is stated in my testimony.

Q Okay. Now let me ask you first, you take a dose of 0.2 rems, you divide it by 500, and you've got .4 millirems, do you not, Doctor? Did I do that division correctly?

A 0.2 divided by 500 -- 0.4 millirem.

Q All right. So if you take the 0.2 figure in that answer and divide it by the 500, you state that would be reduced for the average individual around the site, you get 0.4 millirems, correct?

A Yes.

mgc 27-8

Q Where does the number, 0.4 millirems, appear in the FES table that you cite at the end of that answer, Doctor?

A That number is not in the FES table, but it is derived -- the number I derived from the table.

Q All right. How do you derive that number from the table, Doctor.

A Okay, Table D-7, the dose to the total body of population within 80 kilometers --

Q Yes?

A -- consists of three entries: 1.7 and 1.7 and 12 for the various types of effluents. That gives you a value of 15.4 person-rems.

You divide that by the population, the projected population for the year 2000 within 50 miles of the plant. That's the population of 1.75 million persons. And that gives you a dose estimate of approximately 0.009 millirems per year.

Q And then you multiply that by 40, and you come out around .4, is that right?

A If you want to make that comparison, you can do it that way. Or the way I did it is, you compare that .009 millirems with the 5 millirems that I used as the dose to the maximally-exposed individual. And when you divide the numbers, you get a value of 568 as the exact

mgc 27-9

value, and I said about 500 just to show that it's much less than the dose to the maximally-exposed individual.

Q Now if we were to adopt the Applicants' witnesses' calculation of the residual radiation doses around the plant, that would increase the .009 by about 70 percent, would it not?

End 27

mgc 28-1

A I don't think so.

Q Let me refer you to their person-rem estimates. I believe it is their Table 1 on page 6 of their testimony.

(Pause.)

A Is there a question?

Q Let me ask a question based on this table. My premise is, you guess that it is not applied to the 50-mile dose, okay.

Doctor, did you make any calculation of the risk to the total U.S. population from the operation of the Harris plant and residual radioactive material released therefrom in preparing your testimony?

A No, I did not. I indicated the risk to the average individual within 50 miles of the site would be much less than the risk to the maximally-exposed individual. In turn, the risk to the average or the average dose to an individual within the whole United States would be much less than that.

Q All right. But in terms of the total effect, if the radiation reaches a certain number of individuals within 50 miles of Harris, once it goes beyond 50 miles from Harris, if it interacts with people, it still has an effect on them, doesn't it?

A Yes, there would be some very, very small effect.

Q But over a large number of people, that could

mgc 8-2

be significant compared to the effects within 50 miles of Harris, could it not?

MS. MOORE: Objection, Your Honor. That is not relevant to this contention. Dr. Branagan stated the assumptions he used in his analysis to state why -- what the effect of 40 years of operation is on the maximally-exposed individual within 50 miles of the plant. He stated that he did not estimate the dose to the U.S. population.

MR. EDDLEMAN: But, Judge, he also agreed with me that it would be reasonable to do it.

MS. MOORE: However, he did not do it, Your Honor, and the fact that he agreed or disagreed is not relevant.

JUDGE KELLEY: We had a population dose, did we not, from the Applicants' witnesses, but your calculation was only to the maximally-exposed?

THE WITNESS: My calculation was to the maximally-exposed individual, and indirectly I have also done the dose estimate to the population within 50 miles of the plant. I have not estimated the dose to the population -- to the whole U.S. population for this analysis.

JUDGE KELLEY: Would you repeat your question?

BY MR. EDDLEMAN:

Q Doctor, radioactive materials released by the Harris plant and passing beyond the 50-mile radius around

mgc 28-3

that plant, when their effects on people in the United States who live more than 50 miles from the Harris plant are summed over all those people, that could add up to a significant effect of damage to their lives or health, compared to the damage which is resulting from the nuclides released from the Harris plant to people within 50 miles of the Harris plant, couldn't it?

JUDGE KELLEY: Is the thrust -- did I misunderstand? Are you suggesting that the hazard is greater, more than 50 miles away than inside the 50-mile circle?

MR. EDDLEMAN: No, Judge. What I am asking him is the sum of the damage done to the individuals outside the 50 miles, notwithstanding the fact that it is less to each individual out there on the average.

Is that sum of damage significant compared to the sum of damage done by those same radionuclides within 50 miles of Harris? Does it make a significant difference?

JUDGE KELLEY: I'm going to sustain the objection on the ground that the thrust of this is towards the real hazards associated with this plant. And if you can focus on the maximally-exposed as well as the 50-mile sector, I think that is plenty to get the answer to this question.

BY MR. EDDLEMAN:

Q Let me turn, then, to your genetic defect

mgc 28-4

estimates, Doctor.

Now what you did in your Answer 15, you took the 620 person-rems from your Answer 14 on page 9 of your testimony, and you applied this BEIR-1 risk estimator to that to get the genetic risk from that radiation dose, did you not?

A You are referring to Answer 15?

Q Yes.

A Yes, that's correct. That is based upon the BEIR-1 risk estimator.

Q And if we wanted to get an upper limit, we would take that value that you give there and multiply it by six, would we not?

A You could do that.

Q Did you estimate genetic risk beyond 50 miles of the plant?

A No, I did not do that in my testimony.

Q Does the FES calculate exposure to radiation for people beyond 50 miles of the plant?

A Yes, the FES does have some estimates of exposure beyond 50 miles from the plant.

Q Where are those located, Doctor?

A Table D-9, page D-12.

Q Now if we wanted to apply risk estimators to those, we could just take the FES and apply the risk estimators to

mgc 28-5

them, couldn't we?

A Yes, you could.

Q Okay. Doctor, concerning the conclusion in your Answer 16, you state, "Estimation of cumulative risk instead of annual risk would not change your conclusion that the risk of long-term somatic and genetic effects of radiation releases from the facility during normal operation are a small fraction of the current incidence of actual cancer fatalities and actual genetic ill health for each generation."

I want to ask you a couple of things about that.

First, any effect that the Harris plant has is added to the actual incidences that are already there, is it not?

A We have conservatively assumed that these effects would be added to the natural incidences that are already there.

Q If the Harris plant doesn't exist, then there is no effect from it. If it doesn't exist or doesn't operate, there is no effect from it that would add to the existing levels of somatic and genetic -- or somatic cancers and genetic defects and other measures of ill health, would there?

MS. MOORE: Objection, Your Honor. That's not relevant to the subject of the contention.

mgc 28-6

JUDGE KELLEY: Repeat it, please. The hour is late.

MR. EDDLEMAN: I'm sorry.

BY MR. EDDLEMAN:

Q If the Harris plant didn't operate, then it would not add any risk of cancers or genetic defects from radiation releases from it to the population, would it?

MS. MOORE: Objection. There is an objection pending, Your Honor.

JUDGE KELLEY: There is an objection to that question?

MS. MOORE: Yes. He repeated the question that he asked, which I objected to as being not relevant to the question of whether you use annual risk of 40-year plant life risk.

JUDGE KELLEY: Your question is, if they never turn the plant on, it won't add to the risk?

MR. EDDLEMAN: That's right.

JUDGE KELLEY: Isn't that innocuous? What argue about that?

JUDGE FOREMAN: Are you leading to something else from that?

MR. EDDLEMAN: Yes, I am.

JUDGE KELLEY: Okay. We will allow that, and the answer is, it would not affect anything, right?

mgc 28-7

THE WITNESS: If they don't turn the plant on, there wouldn't be any change.

BY MR. EDDLEMAN:

Q Right. And to the extent that the plant's released radiation has an effect, then, it would be added to that preexisting background of deaths and genetic defects, wouldn't it?

A If there is an effect, it would be added to that.

Q Now you conclude that estimates of cumulative risk instead of annual risk would not change your conclusion on that. But wouldn't it be okay to state the cumulative risk in the final environmental statement for the Harris plant, Doctor?

A I wouldn't have a problem with that, to state that in the FES.

MR. EDDLEMAN: I have no further questions.

S2BU

JUDGE KELLEY: Mr. Runkle has a few questions.

FURTHER CROSS-EXAMINATION

BY MR. RUNKLE:

Q Dr. Branagan, in your look at the effects of radiation released from Harris, did you look at any not-fatal cancers?

A Yes. At page 7 of my testimony, the first paragraph, last sentence, I say, "The number of potential cancers would be approximately 1.5 to 2 times the number

mgc 28-8

of potential fatal cancers.

Q And where did you come up with that figure?

A That figure is from the BEIR-3 report, as it is stated in the testimony. It is referenced in the testimony.

Q And do you feel that is a reasonable estimate of non-fatal cancers to cancers, relative to fatal cancers?

A Yes. Potential cancers to potential fatal cancers.

Q Okay. Did you in your study look at fetal losses?

MS. BAUSER: Could you repeat it? I didn't hear you.

BY MR. RUNKLE:

Q In your study, did you look at fetal losses, including miscarriages, spontaneous abortions and the like?

A No, I did not.

Q Did you look at any effects of radiation on the fetus, maybe including birth defects, learning disabilities, cognitive damage?

MS. MOORE: Objection.

MS. BAUSER: Objection.

I have no objection to the genetic effect element in that question, but I think he has also gone into a number of other -- it sounded like somatic effects.

JUDGE KELLEY: What is in the question other than genetics? It seems to me we went around on this before

mgc 28-9

with the last two witnesses, and the upshot, I believe, was that we considered questions about cancer and genetics legitimate, but they were sort of bounding tests of damage, and that we didn't see the relevance of heart attacks or whatever all else one wanted to postulate.

If you have a question about genetics, go ahead.

BY MR. RUNKLE:

Q To the extent that birth defects, learning disabilities and cognitive damage are caused by genetic defects caused by radiation, did you make any study of that?

MS. MOORE: Your Honor, I would like to interpose an objection concerning the cognitive disabilities and the -- the learning disabilities and cognitive damage. He has not indicated -- Mr. Runkle has not indicated or laid a foundation that these are, in fact, genetic defects as encompassed in the term as defined in the BEIR report.

JUDGE KELLEY: I may have missed it. I thought the question was phrased that those items were caused by genetic defects. I thought you were saying somebody had a learning disability and the reason was genetic in nature.

MR. RUNKLE: Yes. I'm just trying to find the extent of the study, whether they studied this area of genetic defects.

mgc 28-10

JUDGE KELLEY: I think it is sufficiently tied to the genetic aspect. We will allow it.

Did you make such a study, Doctor?

THE WITNESS: I'm not sure exactly what you are referring to -- cognitive disabilities. We have included in our genetic effects the effects of Mongolism. That would be one of the diseases in there.

Now whether you would classify that as a cognitive disability , I don't know.

MR. RUNKLE: I think that adequately answers it.

JUDGE FOREMAN: The answer to the question is, you don't know, then?

THE WITNESS: Well, Mongolism was included as one of the genetic defects. Cognitive disabilities, I don't know whether that includes Mongolism or not. If it does, to the extent it does, we did consider it.

JUDGE FOREMAN: Do you have --

MR. RUNKLE: That adequately answers my question. If they considered Mongolism, if that's the only one they looked at, that answers the question.

JUDGE KELLEY: Okay.

MR. RUNKLE: I have one other question. It is more, you know -- I would just like to know this. I don't know --

JUDGE KELLEY: Uh-oh. Questions that begin with

mgc 28-11

"I was just curious whether" -- well, go ahead. Take a shot.

BY MR. RUNKLE:

Q In your experience and knowledge, is 100 millirems per year reasonable for background level around the plant? Does that seem to be a reasonable estimate?

A That would be a reasonable estimate for this area. That includes internal exposure as well as external exposure.

Q And so the maximally-exposed person hypothetically at the fence line for the 40 years of life is getting 5 millirems per year.

A That's what I have assumed in my testimony as a conservative estimate.

Q All other things being equal, is that person five percent more susceptible to cancer? Is he five percent more likely to get cancer than the normal person?

A No.

Q Because he's getting five percent more radiation?

A No.

Q Can you explain that? Do we have time?

A The cancer is not necessarily due to radiation. It can be caused by many things. When you estimate what the risk from that 5 millirems per year is, it is very small compared with the natural incidence of cancer. And

mgc 28-12

I did provide an estimate in my testimony.

MR. RUNKLE: I can look it up.

JUDGE KELLEY: Anything else?

MR. RUNKLE: No, no other questions.

JUDGE KELLEY: Okay.

Ms. Bauser, do you have questions?

MS. BAUSER: Would you give me one minute, please?

(Pause.)

End 28

mgc 29-1

CROSS-EXAMINATION (CONTINUED)

BY MS. BAUSER:

Q Dr. Branagan, in response to the question just posed by Mr. Runkle, I believe the impression may have been left that Mongolism was the only genetic effect encompassed by your genetic risk estimator. Is that true?

A No. Other genetic effects were included in the genetic risk estimator.

Q Could you give me some feel for how many?

A The genetic risk estimators are based upon, according to the BEIR-3 report, all genetic defects that would cause some serious handicap during an individual's lifetime.

MS. BAUSER: Thank you. That is all.

JUDGE KELLEY: I have one question.

BOARD EXAMINATION

BY JUDGE KELLEY:

Q The proposition about whether the effects of radiation should be stated in annual terms, per-reactor-year terms or life-of-the-plant terms, who would you say you write for when writing an FES? And by that I mean, are you aiming at exclusively or primarily a pretty sophisticated audience, your counterpart at the EPA?

I assume that whether you put it in annual terms or life-of-the-plant terms, the fellow over at EPA

mgc 29-2

knows what that means and doesn't need to be told.

Or are you also speaking to an audience for whom it would be helpful to put it in simpler English and perhaps both life of the plant and annual terms?

A I think ideally you want to express it in a way that more people can understand the impacts from the Environmental Impact Statement.

Q Yes. But what kind of people? I guess that's my question.

A The larger spectrum of the population that you could write it for. Ideally, you would like to have it so everyone could understand it, if they read it.

Unfortunately, many of the previous regulations that we have and various pathway analyses make things fairly complicated.

Q What if you gave an FES to a junior high school civics class interested in nuclear power? Wouldn't it help them, wouldn't you think, to have this written in life-of-the-plant terms as well as annual?

A That would probably be a parameter that someone could zero in on as a few numbers rather than a lot of numbers. It might be more helpful.

Q I think it is a serious question, because it may be all very well to say we should write these documents so everybody could read them. But if in the real world

mgc 29-3

nobody reads it anyway, then why take the time to try to put it into elementary terms when the specialists who actually do read these things don't need it?

And I'm not saying that I know the answer, either, but it does seem to me that if you think a lot of people sould be able not just to read it, but to comprehend it, the more you put in in the way of translating things, perhaps as alternative measurements, then the better off you are, whereas if you are really just writing for the guy over at EPA, it doesn't really matter, I don't suppose, and I am just proposing -- if you want to comment, go ahead.

A It strikes me that there is a balance between the two. You like to write it in simple language, and if you do write it in simple language, then the technical experts tend to pick away at some of the points, some of the simplifications. And there is a balance.

Q So you could get in trouble, so to speak, if you try to simplify it.

A Yes.

Q That was really more a comment than a question, I guess. I appreciate your comments.

JUDGE KELLEY: Am I correct that we don't have further questions? Does the Staff have any redirect?

MS. MOORE: Yes, I do.

mgc 29-4

REDIRECT EXAMINATION

BY MS. MOORE:

Q Dr. Branagan, under questioning by the Board, Dr. Foreman referred to your number of five millirem as arbitrary.

Why is your selection -- was it arbitrary?

A No.

Q Why did you not select the dose design objective in Appendix I instead of your five millirem figure?

A I think it is unlikely that the plant would be operated at the dose design objective levels for 40 years. So I thought that would be too high a value.

Q Is it reasonable to assume that the plant would operate at the levels set forth in Table D-6 and D-9 of the FES without variation over the life of the plant?

A I think it is somewhat unreasonable to assume that for the 40 years operation of the plant. There are many things that could change. The dose estimates are based upon the locations of the nearest residence, a cow, and things of this sort, and those could change over the operating life of the plant.

Q Is it correct that you chose the figure of five millirems which is between these two estimates, between the dose design objectives and the estimate in the FES; is that correct?

mgc 29-5

A Yes, that's correct. I thought it was more appropriate professionally to select what I consider a conservative estimate of the dose.

Q Could you explain why you believe it was professionally more correct to do that, based on your professional experience and background?

A Well, I evaluated the impacts for a number of reactors, and I am aware that the actual dose estimates will, from plants really operating, may be different from the values we estimate in the FES.

However, I think that the values will not be at the dose design objective levels for many years of operation. So I think it is more appropriate to choose a value -- what I believe to be a conservative value for the analysis.

Q Dr. Branagan, could you have selected, say, four, as Dr. Foreman suggested?

A Yes. I don't think there's a great deal of difference between four millirem versus five or six millirem, but I chose to pick what I considered a rounded-off number of five milli-rem.

mgc 29-6

(6:00 p.m.)

BY MS. MOORE:

Q You believe, then, don't you, that the number you chose encompasses your view of the 40-year operation of a nuclear power plant?

A Yes.

MS. MOORE: Staff has no further questions, Your Honor.

JUDGE KELLEY: Okay.

Mr. Eddleman?

RECROSS EXAMINATION

BY MR. EDDLEMAN:

Q Dr. Branagan, the rather extensive explanation that you have just give for how you chose the five millirem value, does any of that appear in your testimony as prefiled?

A Not in the exact words that I said that. However, I thought that was in the testimony in my reading of it, but the exact words that I just stated are not in there.

Q Well, Judge Kelley raised the question about writing for an ordinary person or something like that. Let me ask you this.

On pages 4 and 5 where you say, "For purposes of this testimony, the Staff based its dose estimate to a maximally-exposed individual on annual dose design

mgc 29-7

objectives in Appendix I," do you think that an average person would understand that that means you based it on that and a lot of other considerations like you just explained to your counsel?

MS. MOORE: Objection, Your Honor. That's beyond the scope of the redirect. And also, another ground for this objection is that Mr. Eddleman has raised that same point numerous times on cross-examination, and Dr. Branagan answered that question.

JUDGE KELLEY: I think it has been plowed pretty thoroughly. I will sustain the objection.

BY MR. EDDLEMAN:

Q Dr. Branagan, is Down's Syndrome the only genetic defect impacting mental function that's included in the BEIR --

MS. MOORE: Objection. That's beyond the scope of my redirect.

MR. EDDLEMAN: I'm not going on just theirs. I'm going on everybody's.

JUDGE KELLEY: It was opened up by Ms. Bauser. Go ahead.

MR. EDDLEMAN: This is the only one I have.

BY MR. EDDLEMAN:

Q Doctor, is Down's Syndrome the only genetic defect impacting mental function that's included in that

mgc 29-8

BEIR analysis?

A I don't know.

Q One more question. How do you think an ordinary member of the public would learn your judgment of the overall cost and benefits of licensing for the Shearon Harris plant from the FES, given the way that the benefits and also the costs, like the deaths resulting from radiation and genetic effects and so on, are stated in it?

MS. MOORE: Objection, Your Honor. Beyond the scope of redirect and any cross that I'm aware of that was asked.

MR. EDDLEMAN: Judge Kelley asked him about this very point.

MS. MOORE: I believe that was a comment, as the Judge phrased it, rather than a question.

JUDGE KELLEY: You said this was your last question, right?

MR. EDDLEMAN: Yes, Judge.

JUDGE KELLEY: I will allow it. Go ahead.

BY MR. EDDLEMAN:

Q Dr. Branagan, how would an ordinary member of the public learn your judgment of the overall costs and benefits of licensing the Shearon Harris plant from the FES, given the way that not only the benefits but also such costs as total deaths from cancer caused by radiation and

mgc 29-9

genetic defects caused by radiation are stated in the FES?

A I think they would have to read the FES, and once again, I think the FES takes a fairly sophisticated reader to understand this complex subject. It is a complex subject.

MR. EDDLEMAN: I think that probably answers the question. At any rate, I said it was my last question, so I won't ask any more.

JUDGE KELLEY: Okay. I believe that brings us to the point where we can let Dr. Branagan step down.

Dr. Branagan, you have had a rather long collective stint yesterday and today. We appreciate your coming and your responses to the questions.

Thank you very much.

(Witness Branagan excused.)

JUDGE KELLEY: There are two or things to take up with Intervenors and other counsel.

Do we have anything else on this particular contention that could be said, that needs to be said? Nothing that I can think of.

We will be through here shortly. Let me just tick off a couple of things.

Mr. Barth indicated that there was some discussion about findings and filing dates and related matters, the general subject of findings.

mgc 29-10

I asked earlier whether we should plan on a prehearing before the next hearing. If you have thought about that, maybe you could say what you think, and whether we ought to set a tentative date, at least, if we decide that we ought to do it.

Do you want to take a five-minute stretch break, and then we can sit down and address that and anything else you want to rais, and then we'll quite?

MR. BARTH: We're ready now, Your Honor.

MR. EDDLEMAN: We're ready right now.

JUDGE KELLEY: You are ready right now? All right. I guess that's okay.

Mr. Barth, where did you come out on findings?

MR. BARTH: Your Honor, Mr. Eddleman, Mr. Runkle, Mr. Baxter, Mrs. Moore and I had a discussion regarding the proposed findings. 10 CFR Section 2.754 is the agency's regulations regarding proposed findings.

Mr. Eddleman, Mr. Runkle, Mr. Baxter, Mrs. Moore and I have agreed simultaneously for all parties to submit findings to the Board on July 20th, Wednesday, on the contentions which have been heard here in Raleigh during this hearing session -- that is, July 20th, Wednesday.

JUDGE KELLEY: Simultaneously?

MR. BARTH: Yes, sir. This has been done in Zimmer and most of the other cases I've been in.

mgc 29-11

In so doing, we are well aware that Mr. Eddleman, by the scheme and the regulations, has a right to comment upon the Applicants' findings, and we have a right to comment upon his. Working an arrangement between all of us, we have agreed to simultaneously file replies to any and all other parties' findings on August 1, which is a Monday.

Then the regulations, if you recall, Your Honor, give an absolute right to the Applicant whose license is at stake and who has a burden of proof under 5 USC 566(d), has an absolute right to reply and have the last word.

Mr. Eddleman and myself and Mr. Runkle and Mr. Baxter and Mrs. Moore have agreed that the Applicants may make a final further reply to all proposed findings that have been filed on Saturday, August 6th, as a final last word for anybody to say anything about these contentions at all.

JUDGE KELLEY: Can I have your assurance?

MR. BAXTER: Except the Board.

(Laughter.)

End 29

JUDGE KELLEY: Does everyone all concur on these proposed dates and filings? Let me just ask you a couple things in that regard. That would mean that the bulk of the work gets done in the next month or so, and that applies to in early August, and that gets this material before the Board prior to your testimony writing, or most of it, for the fall. I suppose that makes some kind of sense.

I think we had assumed earlier -- let me just raise this with you. I think we even said it in the first prehearing or post-prehearing conference order that this case would be split up in environmental, safety and emergency planning, and that we would have hearings and findings and opinions based on those three segments.

And my question to you is this: We have had, as it turns out, a fairly small, if you will, environmental hearing. We didn't have a lot of issues; it took just four days to try it. Do you think it important that this Board write a separate partial initial decision on these contentions as opposed to putting that out along with the safety materials, say?

MR. BARTH: Your Honor, from the Staff's point of view, we don't think it's of critical importance. We think what is more important is that the parties submit their proposed findings so the Board may consider them.

But the bottom line is nothing can operate until

you issue a final, final decision on everything. So from our point of view, we don't care that youwrite these in dribbles or parts, if I may say so.

JUDGE KELLEY: One of the reasons I ask, I think there was an appeal board decision last year --

MR. BARTH: In Point Beach, Your Honor.

JUDGE KELLEY: Some case where the Board kept dribbling out decisions and the appeal board said cut it out. They kept cutting it up into little pieces.

MR. BARTH: They were smaller dribbles than we contemplate here.

JUDGE KELLEY: That could be, okay.

Mr. Baxter, what's your view?

MR. BAXTER: Certainly, the cases I've been involved in recently we have had partial initial decisions on major sections. And here we're talking about one of the two statutes under which the NRC governs and regulates, which is NEPA. And I think there are very separate kinds of considerations that go into the Board's decision.

And while we have ended up with only three contentions that are actually being tried in an evidentiary basis, there are potentially appeals that go to many other decisions that have led up to this point; whether it be summary disposition or --

JUDGE KELLEY: Let me get that. Yes. If we

issued a partial initial on this hearing of the last few days, that would take up all the summary disposition stuff, too, wouldn't it?

MR. BAXTER: On environmental issues. As far as I'm concerned, a partial initial decision on NEPA, that means everything in the case under NEPA is ripe at that point for appeal. And I would rather find out this fall than next summer if the appeal board is unhappy with something.

JUDGE KELLEY: Mr. Eddleman, any thoughts?

MR. EDDLEMAN: It would be a little easier, I think, on the Intervenors to have it as a separate document, the partial initial decision on environmental matters. But we'll do whatever the Board wants. You are the ones who have to write the decision; you can write it whenever you want to in our opinion.

JUDGE KELLEY: And I'm not suggesting that we wouldn't; I'm just asking a question.

MR. EDDLEMAN: What I'm saying is we will accomodate you in any way you want. It would help us a little bit to have it earlier, and you know, if it will help Mr. Baxter more, we'll go along with that and try to get all our exceptions and appeals filed whenever you come out with it.

But it doesn't make a very large difference to us at this point.

Let me ask one other question, though. I don't

know if the Board has come to a ruling on the 2.758 petition.

JUDGE KELLEY: It will be sometime this summer, but we haven't. yet.

MR. EDDLEMAN: Technically, I believe that that might be considered an environmental issue. I don't know this relates to all this, but I just wanted to mention that as kind of a wild card sitting here. We haven't had a decision --

JUDGE KELLEY: We need to act on that and we intend to. I would say we will do that in any event. Okay.

Well, there are some reasons at least for our going ahead and doing it, and I just wanted to sound you out on it.

MR. BAXTER: We only contemplate that there will be two more partial initial decisions.

JUDGE KELLEY: Yes. If we did this one separately, it would be this one plus the safety, and that would merge management and the others, I assume. And then the emergency planning down the road.

Well, we hear you, and we will take it under consideration.

On the findings, let me just for the record say one thing. 2.754 has some permissive language in it. Yes. 2.754(a), any parties to a proceeding may -- or if directed by the presiding officer shall -- file proposed findings of

fact, so the Board is directing all parties to file. It's not optional; it's required. And I think that's pretty customary, too. But there is that other language in here that could cause problems if we don't make such a directive. So we have done that.

Do those dates sound okay?

(Board conferring.)

JUDGE KELLEY: Normally, it's the parties that are more interested in that. As long as it gets in reasonably soon. If you all agree on it.

The Board will hereby adopt the dates and filings as described by Mr. Barth, and that are concurred in by the other parties.

The other thing I mentioned was whether we should have a prehearing conference prior to -- and an actual coming together prior to the now-scheduled for September 5 hearing on the management capability question.

MR. BARTH: Your Honor, on behalf of the Staff, we really feel that no useful purpose would be served by a prehearing conference prior, with the small caveat that should the Board decide otherwise, we would suggest that such prehearing be held after August 9 when the testimony has been filed, and that the Board at that time hold a prehearing conference for the purpose of setting the course of the hearing on management.

And that is, what will cross consist of. I think it's proper to ask for a profer of what is intended to be proved by a lot of cross examinations, what documents will be crossed from so we avoid surprise.

But I think prior to the filing of testimony on August 9, no useful purpose will be served. Afterwards, as is often done in the federal district courts, and I think it's proper for the judge in this case, or the bench, to ask what do you intend to prove and how are you going to go about proving it.

In these NRC hearings, credibility, insofar as talking about a criminal, is not at stake. We're talking about scientific facts, scientific calculations.

JUDGE KELLEY: In the management part? You think that's true in the management part?

MR. BARTH: Well, I think that that is judgment. I think the credibility goes to, are you telling the truth. And I think there's no question that people tell the truth and they may see it differently, and you may perceive different judgments from certain series of facts, and people may perceive things differently, but I don't think the credibility of the witnesses is involved.

And therefore,I think it's perfectly legitimate for the Board, after the filing of testimony, to inquire as to what lines of cross examination will be followed, and to

ask for a profer of proof as to where they will lead, so we will have a moremeaningful and better constructed hearing, rather than just loosely asking questions page by page as we go along.

A purpose should be served by cross examination, is our view. When Intervenors have witnesses, I think you should inquire of us, what do you intend to prove by your cross examination, rather than just let us wander, too, Your Honor.

JUDGE KELLEY: It does kind of concern me about management. The contention itself is kind of amorphous; what are we going to talk about, where is it all going to go. But maybe you're right about having the testimony filed before we try to talk about that.

Do you still think -- I don't remember when we set that date of August 9. If we have a hearing that starts on the 5th, do you have enough time? I would just as soon not have to get on the phone on August 8th and move it to the 16th. Is the 9th all right?

MR. BARTH: The 9th is the date you set, and that's the date I'm sweating under, Your Honor.

MR. BAXTER: Yes, we set that date in March of 1983. It was a long time ago. And I think the reason we set it so far in advance of the hearing was because we were going to be filing testimony for both of those phases, and

the parties need, I think, some period of time after August 9 to review and start to make plans. Not just for the first phase, but for the second phase as well.

JUDGE KELLEY: Oh, the 9th is not just management, but the whole thing.

MR. BAXTER: That's right.

On the prehearing conference question, I would agree with Mr. Barth that I don't think there's a need for it. And any consideration should await filing of the testimony.

I think we have identified today the most significant question as to how many people can cross examine on what issues. And I think we should at least take a stab at the parties talking about it and perhaps have a telephone conference at some point in August.

But otherwise, I think -- you know, it's one contention. The basic order of the hearing is obviously going to be Applicants putting on their case, followed by Intervenors, followed by the Staff, and we understand that.

JUDGE KELLEY: Well, you've got the advantage of having been through discovery. We've been served with copies, and I'll be honest with you, I haven't read it. But you've been working on it, so you know more about this contention than we do.

What about the proposition of at least waiting

until the testimony is filed before we decide for sure whether to have a prehearing or not?

MR. EDDLEMAN: Well, I think that would probably be very proper, Judge. We, at least as far as I know, Joint Intervenors, would do it any way you want. If you want to do some talking by phone, we'll do that. If you want to come down here and bring us all together, we'll do that. It's up to you-all.

We would say that knowing our resources and coordination, it's going to be very difficult for us to get together sort of a unified and clarified plan within even about two weeks of receiving the testimony, so we don't want that date moved forward from August 9 if it can at all be avoided.

Because I just had a horrible time with all the other stuff I was having to do, trying to get this testimony read and cross examination prepare . And the management issue, if I may say, is much more complicated than these issues. I mean, if you've seen the record from 1979 on that remand, it's a pretty thick record.

Here, I think we're going to be dealing with more stuff than was dealt with there. And based on discovery, a lot of different areas were gone into. I think it would be very difficult for us to focus it down without having had at least a week or two to study the testimony and try to

divide up responsibilities among us.

I think in principle what you're talking about is saying well, where are you going, is a reasonable idea. Now I have to say I don't think Mr. Barth can get out of us every question that we're going to ask and so on. I think he's asking for too much detail, and I think I'm entitled to surprise his witnesses at least with something. If not a document, at least with a question.

But I would just point out to you respectfully that we are here, you know, not full time on this issue, having to deal with other things. My school meetings start on August 20, so I would urge you to please try to get your conferencing done before that time, because I'm going to be tied up more in the period after August 20th than I am before that.

MR. BAXTER: Well, that's less than two weeks after the 9th.

MR. EDDLEMAN: All right, so I'm stuck. So as usual, I will sacrifice school for this hearing. School is remarkably tolerant of that stuff.

But anyway, I do have a difficulty, and the difficulty grows much greater, Judge, after the 30th of August when school actually starts. And that, I think, is what I have to say about it.

JUDGE KELLEY: Once school starts, are you going

to be participating in the hearing? Will you be here for the hearing?

MR. EDDLEMAN: Yes, I will, but that is leave time, Judge. I am there when school starts, and then when the hearing come up I take off on leave to do the hearing, and then I come back to school. And that's the way I'm going to do the whole year.

JUDGE KELLEY: Okay. Mr. Runkle?

MR. RUNKLE: In my opinion, the phone conferences are not working. I have been involved in maybe less than half of them, and I am available during the day. I'm just not getting called. I will find out at 11:30 that one was held at 11:00. Or given 10 minutes' notice that somebody is calling.

JUDGE KELLEY: I think what has happened -- and we will take responsibility for this, it's my secretary who usually sets these up, and I think what I'm accustomed to, there are X number of people and then there seem to be more active players than the numbers, depending on the issue. And you have been the security person, for example.

I know you are one of the Joint Intervenors, but I tended to look to Mr. Eddleman on the joint intervention questions. Maybe I made a mistake, but that's the fact.

I think that henceforth, if you want us to be sure to make an effort --

MR. RUNKLE: We would urge that you get all the Joint Intervenors, especially on the management capability. We're going to have to split that up. It's a very long, involved issue. I think we should all be involved in any discussion on that.

JUDGE KELLEY: I do have an electronic limitation on our calls. I forget whether it's 9 or 11 people, but sometimes we have problems there in just sheer capacity.

MR. EDDLEMAN: Do you mean 9 or 11 lines, or 9 or 11 people?

JUDGE KELLEY: Numbers of separate people on the phone. That's probably not clear, but that's my guess at this point.

In any event, I understand what you're saying and we will try to improve our record in that regard.

MR. EDDLEMAN: One of the things we could do if we had sufficient notice is all perhaps get together at Mr. Payne's office or Mr. Runkle's office and get all of us on one number.

JUDGE KELLEY: That sounds good. I think we have a consensus that we may not need a prehearing conference face to face at all, that we certainly ought not to schedule one until after the testimony is in, so why don't we leave it that way. So things like cross examination rules and how many people get to cross examine I would hope you could

stipulate to those, as you speak to each other in the course of the summer. And I don't think we have to convene just to talk about that.

Is there anything else that ought to be brought up?

MR. BAXTER: I would just make a request that obviously, the Board has quite a few summary disposition motions before it that are important to our filing testimony on August 9. If it works out for you that you are able to decide some of the motions before you actually have time to write the memorandum and order, we, for the Applicants at least, would still appreciate oral notification of the bottom line, if that is acceptable for you to do, before you've had a chance to write the memorandum and order, just to get it sooner.

JUDGE KELLEY: If that's satisfactory to all parties, I think what we ought to do -- if we go over the papers and decide on a result, and if it would help you, we can make a phone conference and give you the bottom line.

MR. BARTH: That's agreeable to us, Your Honor.

JUDGE KELLEY: Is that okay with you, gentlemen?

MR. EDDLEMAN: It's fine with me. In fact, I don't think you'd have to get on the phone in a conference. You could just, if you will, issue something like a notice of decision saying you lose, or something like that.

(Laughter.)

JUDGE KELLEY: With your permission -- well, okay. I understand.

MR. EDDLEMAN: I have no objection to an informal procedure like that. Anything you want to do. If you want to have someone call us up individually -- I think I actually got notice from your law clerk at one point in that way, that the thing was going to be filed, you know. So it doesn't matter to me. You can do it any way you want.

JUDGE KELLEY: Generally, we're kind of uncomfortable calling people one at a time on something like that. I think it's better to do it in a conference call. But okay. The idea is to put the word out earlier, just so you know what you have to do. And the rationale may come later.

MR. BARTH: We'd like to bring up one other matter, Your Honor.

MR. EDDLEMAN: Just to be real clear about this, I'm saying I have no objection to your separately notifying any other parties besides me, as long as I get notified at some point. If you want to do a conference call or whatever, you can. But I have no objection to your issuing separate notifications as long as I get one in the same timeframe.

JUDGE KELLEY: That may be helpful.

MR. BARTH: The Staff would appreciate that if

the Board has any particular format in which it wishes the proposed findings to be filed or written, that you advise us. In the absence of any such recommendation or request by the Board, we will file these as we have in the past 12 years, starting out and recapitulating history, and then a summary of what has happened and what the contention is and evaluating the evidence and conclusions.

JUDGE KELLEY: I'm glad you mentioned that. Let me just confirm my own impression.

(Board conferring.)

JUDGE KELLEY: Let us underline that on your proposed findings, cite to the record, exhibits, transcript. Get it tied in with the record. That's stated in the rule itself, but I would just restate it for the Board.

What your question reminded me of, though, is one of these rules speaks of filing proposed findings in the form of initial decisions, and this is taken very literally in the NRC. It comes in and says "Opinion" at the top, and then it starts, "We, the Board, met such and such a place..." and on it goes. And it's all written in "Our" voice, which I find kind of artificial, and I would prefer not to have it.

Just file findings on the issues that are in the case, and it doesn't have to be "We" doing this, that and the other thing; it's just whatever your position is on the merits. I find I have never used those "We" paragraphs

anyway, and I'd rather not have them.

MR. BARTH: Your Honor, I'm advised by my co-counsel that not only is it good, but it's marvelous that the agency is finally waking up to this. We appreciate it, Your Honor.

MS. MOORE: Your Honor, might I interpose something? Do you mean you would want just numbered findings of fact?

JUDGE KELLEY: Yes, it would just be Contention 8(f)(1), the contention is as follows, -- the Staff's position was, bump, bump, bump, and on down the line. The conclusion ought to be such and such.

Contention II(c), II(e), just a straight layout as opposed to attempting to put words in the Board's mouth; what we very often see.

There's a reason for that, because that's what the rule talks about. But I don't think it's required.

MR. BAXTER: Are we required to follow the format that somebody in the licensing board panel once raised -- opinions and findings of fact separate from each other?

JUDGE KELLEY: No. Findings of fact, period.

I don't think we need the history of the case, but if you want to put in a couple of paragraphs -- everybody knows that. We get a lot of that, anyway. I would just go

right to the findings.

MR. BARTH: I join my co-counsel in saying this is marvelous.

MR. EDDLEMAN: May I make an inquiry of a non-lawyerly type? When you say you propose findings and conclusions, as I understand it, --

JUDGE KELLEY: Yes?

MR. EDDLEMAN: So instead of saying, you know, "We, the Board, don't find this credible," you just say, "This should or should not be found credible because..." -- and make that a finding. And at the last say, "From the above the conclusions should be so-and-so," and state whatever conclusion we want?

JUDGE KELLEY: You can say that it is. It's a proposed finding. But you're writing it and saying, "I, the Joint Intervenor, think... and you ought to find this way." So that we ought to conclude that there's no reasonable assurance or whatever.

MR. EDDLEMAN: Right. So in other words, I will save a lot of words by never saying "We" or "The Board findgs" or anything like that.

JUDGE KELLEY: You can skip all that. Just say what it is that you want found and concluded or that Joint Intervenors want, and list it off in numbered findings and conclusions. And it will say right on the package that

it's coming from you.

I don't mean to be too flip or quick on this. I know what we want, and I don't know if it's clear or not.

MR. EDDLEMAN: It's just my lack of legal background. I want to be clear on what you're asking me for and in what form it's supposed to be in. I think I understand it.

I think I will certainly have an opportunity to look at the transcript and figure it out a little more.

JUDGE KELLEY: Anything else?

Just one thing. Can we make an effort -- it will only take a few minutes to pick up and clean up this place, move the tables back where they were and whatnot, and put it more or less in the status quo ante.

Thank you very much, we are adjourned.

(Whereupon, at 6:30 p.m., the hearing in the above-entitled matter was adjourned.)

CERTIFICATE OF PROCEEDINGS

This is to certify that the attached proceedings before the NRC COMMISSION

In the matter of: DP&L & No. Carolina Eastern Municipal Power Agency (Shearon Harris 1 & 2)

Date of Proceeding: Tuesday, June 19, 1984

Place of Proceeding: Raleigh, North Carolina

were held as herein appears, and that this is the original transcript for the file of the Commission.

Suzanne Young
Official Reporter - Typed

Suzanne Young
Official Reporter - Signature