# ORIGINAL

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

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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)

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

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| In the Matter of: | : | |
| 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 | : | |

Federal Building
Courtroom 225
310 New Bern Avenue
Raleigh, North Carolina

Thursday, June 14, 1984.

The hearing in the above-entitled matter convened at 9:00 a.m.

BEFORE:

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

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

DR. HARRY FOREMAN, Member
Acomic Safety and Licensing Board
Nuclear Regulatory Commission
Washington, D.C. 20555

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Raleigh, North Carolina 27602

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# I N D E X



# E X H I B I T S



# LAY-INS

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P R O C E E D I N G S

JUDGE KELLEY: On the record.

Good morning, my name is James Kelley. I am Chairman of this Atomic and Safety and Licensing Board.

To my left is Judge Glen Bright. Judge Bright is a physicist with a background in reactor safety. He and I are both full-time members of the Atomic Safety and Licensing Board Panel.

On my right is Dr. Harry Foreman. Dr. Foreman is a part-time member of the panel, and he is also the Director of the Center for Population Studies, University of Minnesota.

I know you are an MD doctor -- oh, a Ph.D. too -- and he does have a considerable background in the health effects area, so we are fortunate to have him with us for the contentions we are going to be reviewing these next few days.

I think I would like to go around the room now and have counsel and intervenors and others with them, as appropriate, to introduce themselves for the record, and we will start with Mr. Read.

MR. READ: My name is Daniel Read from Raleigh, North Carolina, on behalf of CHANGE.

MR. PAYNE: I am Travis Payne with the law firm of Edelstein, Payne and Jordan, and I represent the intervenor, Kudzu Alliance.

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MR. EDDLEMAN: I am Wells Eddleman, representing myself.

MS. MOORE: My name is Janice Moore. I am counsel for NRC Staff. With me today is Charles A. Barth, also representing the Staff. Also present is Bradley W. Jones, Regional Counsel, NRC Region 2.

MR. CARROW: I'm Hill Carrow, counsel for Applicants.

MS. BOUSER: Deborah Bouser, counsel for Applicants.

MR. BAXTER: Thomas A. Baxter, also for the Applicants.

MS. FLYNN: Samantha Flynn, also for the Applicants.

JUDGE KELLEY: Thank you.

The word on logistics is, as I think all counsel know from the notice that's been sent, we have this room here today in the Federal Courthouse. For tomorrow and Monday and Tuesday, we have arranged to have the Bankruptcy Courtroom at -- I don't have the exact address -- it's 300 Fayettville Mall, I believe, and that should have a witness box and other things that one finds in courtrooms, and it will be a little bit easier to work in. If necessary and if the hearings run into next Wednesday, we will then come back here. We have not made any arrangements beyond

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that, based on the pleadings and what we know about the contentions. We don't see that there is any reason why we can't finish in that timeframe. So that is where we will be for the hearings.

We thought it was worthwhile to get a courtroom if we could, even if it involved some moving. We did consider awhile back whether we would have limited appearance sessions in connection with this particular hearing phase, and we decided at that time, since it was a relatively short hearing with the expectation of longer hearings in the fall and later on in emergency planning, this was not particularly appropriate, so we had planned not to arrange special sessions for interested members of the public to come and make statements about the facility.

I mentioned, partly for the record and partly also because of the fact that there was a brief story in this morning's paper, The News and Observer, about this hearing, and there was a sentence in there which seems to imply that we would be taking limited appearance statements at this hearing, and that is not correct. That is not our intention. But we do intend to have such sessions later, and we will be issuing a press release in that connection, and we will see to it that the local papers and radio and TV stations get it, so that people in the area who are interested should have adequate advanced notice.

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We run these hearings on a relatively informal basis, and if you want to take your coat off, feel free to do so, as I guess I've already indicated myself. If you want to bring in a cup of coffee, you can do that. We do not allow smoking. But apart from the No Smoking Rule, it is a relatively informal atmosphere.

In prior discussions, either down here or on the telephone, we have worked out certain groundrules for the hearing, as far as the way in which we will proceed.

We have before us three separate contentions. Mr. Eddleman's contention -- it is No. 8.F.1, and it has to do with the health effects of coal emissions associated with the fuel cycle -- and then there are two other joint intervenor contentions, and by "joint", I mean sponsored by Mr. Eddleman and Kudzu Alliance, CHANGE, and I believe CCNC also, and both of those contentions have to do with health effects.

One has to do with the airborne transmission of radionuclides and fly ash, and the other has to do with the appropriate time periods that the NRC Staff should be looking at in assessing health effects in their Environmental Impact Statement.

Now the procedure with respect to the three is as follows: We are going to address first Contention 8.F.1, the fuel cycle contention, followed by, as I understand it --

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and correct me if I'm wrong -- 2.E, which is the radionuclides attached to coal particulates. And then the last of the three would be 2.C, which is the time period contention.

We had a difference in preference between -- well, it was expressed between Mr. Eddleman Mr. Baxter on the phone awhile back -- about how far we ought to try to go these first couple of days and the first part of next week, and the Applicants wanted to simply go ahead and cover as much ground as we could. And Mr. Eddleman, at least then, had an arrangement with the witness, Dr. Johnson, who is not expected, as I understand, Mr. Eddleman, he wasn't expected until Monday, correct?

MR. EDDLEMAN: That's correct.

JUDGE KELLEY: So your preference would have been to not start on 2.E and 2.C until Monday, and the Board heard those contending points of view, and we ended up with a compromise. What we said essentially was this.

We will do the first contention, 8.F.1, and if that takes us most of the way through these first two days -- for example, it took us into sometime Friday afternoon, even though other being equal, we might keep going longer, we would stop at that point and not start 2.E until Monday.

On the other hand, if 8.F.1 is pretty well done today or early tomorrow morning, we would move ahead and we would put on the affirmative case as much as we could,

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do some cross-examination, but we reserve to Mr. Eddleman, if we go that way, we reserve to him the right to have the first couple of hours on Monday for cross, assisted by Dr. Johnson, the assumption being that he could have access to a transcript and get some focused questioning in on Monday morning, if that was necessary. And that is the way we will proceed in that regard.

End 1

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JUDGE KELLEY: Gentlemen, let me ask you -- Mr. Barth, we have a new --

MR. RUNKLE: I'm sorry. I guess you all started without me.

JUDGE KELLEY: Why don't you introduce yourself for the record?

MR. RUNKLE: My name is John Runkle. I am general counsel for Conservation Council of North Carolina.

JUDGE KELLEY: And that is CCNC for short in our pleadings anyway. And the Conservation Council is also one of the four Joint Intervenors I believe.

Gentlemen, do you have references about -- we sometimes take opening statements in hearings of this sort. It is not required, but if counsel want to make a brief opening statement they can do so.

Mr. Baxter, do you want to make a statement?

MR. BAXTER: Yes, I would, Mr. Chairman. Since this is the first day of the evidentiary hearings, we appreciate just a few minutes.

JUDGE KELLEY: Mr. Barth? I'm sorry, Ms. Moore.

MS. MOORE: The Staff does not want to make an opening statement.

JUDGE KELLEY: Okay. And Mr. Eddleman -- let me be clear, Mr. Eddleman. You are representing yourself, I understand that. We do have as -- as Joint Intervenors

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we have four different groups here. And yet we have four in one, so to speak. I don't think we need four opening statements. Do any of the lawyers or Mr. Eddleman wish to make an opening statement?

MR. EDDLEMAN: I would like to make one please, Judge.

JUDGE KELLEY: Okay. Why don't you, if that is agreeable then? I don't know that we would impose a strict time limit, but the idea is just a few minutes rather than a lot of minutes.

Do you want to start, Mr. Baxter?

MR. BAXTER: Thank you, Mr. Chairman. On behalf on Carolina Power & Light Company, I would like to express our welcome to the Board, the parties and the public to the first of several sets of evidentiary hearings on the application for a license to operate the Shearon Harris nuclear power plant.

As the Board has indicated, this hearing addresses environmental concerns raised by the Intervenors under the National Environmental Policy Act. In September and October of this year, hearings will be held on health and safety issues under the Atomic Energy Act, followed by hearings in February '85 on the state of emergency response preparedness; both on-site and off-site.

The timely completion of these hearings is

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critical if the Board is to render its decision on all contested issues before the plant is completed and ready to load fuel in early June 1985; less than one year from now.

For those in the room who have not participated directly in this proceeding, I would like to take just a moment to explain what has taken place prior to today, and what the issues are in this hearing. Before the NRC granted permits authorizing construction of the Shearon Harris facility, its Staff conducted a detailed review of CP&L's application. This included a safety evaluation of the site and proposed design of the facility, as well as a complete environmental review with draft and final environmental impact statements, which compared the projected benefits and impacts of the plant against available alternatives.

CP&L's application and the NRC Staff reviews were then subjected to the review of the independent and Congressionally chartered Advisory Committee on Reactor Safeguards in public hearings before an Atomic Safety and Licensing Board, and as subsequent reviews on appeal.

This complicated and detailed review process is being repeated at the operating license stage, with updated and more complete information on the facility design and CP&L's plans for operating the Harris plant. The NRC Staff's draft environmental impact statement on operation was issued for comment in May 1983, and the final statement was published

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in October.

One difference in the hearing process however, goes to the jurisdiction of this licensing board. At the construction permit stage, the Atomic Energy Act requires a hearing and the board must review all of the NRC Staff's findings, whether or not it is requested to do so by public intervenors. And the board must decide all issues associated with the permit applications.

Congress has provided at the operating licensing stage, however, that a hearing may be held only if requested by one or more interested members of the public. The board's job then, is to decide the issues in contest among the parties. We call them contentions. The board's decisions on those issues are binding unless modified on appeal. But the NRC Staff makes all the other findings relevant to the operating license application.

In short, we are all here, and this proceeding only exists to resolve the issues that have been raised by the Intervenors. Since the notice of opportunity for hearing on the operating license application was issued on January 15, 1982, the Intervenors have proposed over 500 contentions for hearing and decision by the board. That is an unprecedented number in my experience with these proceedings. Over 300 of these have been proposed by one individual who represents himself in the case.

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Since January 1982, the board has been required to rule on which of these multitude of issues meet the standards to be admitted as contentions that the board will then decide on the merits. Somewhere over 40 of them have been admitted, three of which remain in the environmental sphere to be heard at this hearing this week and next.

Once a contention is admitted, we, the Applicants, have the burden of proving that the Intervenor's concern is unfounded or resolved. First, the parties exchange information on the admitted contentions through the discovery process, to sharpen the focus of the matters really in dispute, and to make the hearing more efficient by getting the facts on the table early in advance.

With respect to the environmental issues, over one and a half years was devoted to this discovery process. Where there were no material issues of fact between the parties on some contentions, the board has decided then, in advance of this hearing, on the basis of expert affidavits filed by the parties.

Even though the first piece of evidence is yet to be received in a hearing on the operation of the plant, the parties have submitted, and the board has issued roughly 750 filings in this proceeding. Thousands of pages of documents not filed in the case have been produced for inspection and copying by the parties.

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We believe this history illustrates the proceeding has been comprehensive, as well as both an open and a fair one. As a result of this sifting process, we are down to three environmental contentions, which will be the subject of evidence presented at this set of hearings. To deal with the impacts of the very low levels of radiation released during normal operation of the Harris plant.

While the board has already determined that the composition and level of radiation to be released has been accurately identified, one of the remaining contentions questions whether the dose calculation methodology is sufficiently conservative in its treatment of radiation absorbed onto coal fly ash particles already in the atmosphere.

Applicant's testimony will show, on the basis of empirical studies, that the models used adequately account for the radionuclides attached to coal fly ash particles.

The second contention questions whether the estimates of doses received by the surrounding population which are expressed in the NRC Staff's environmental impact statement on an annual basis, as are other impacts and benefits, should instead be presented in terms of doses received for the 40-year life of anticipated commercial plant operation. And whether the dose estimates aptly account for those who live near the plant for extended periods of time.

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Applicant's testimony will show that these annual estimates may simply be multiplied by 40, if that is desirable. For completeness, the testimony examines the amount of residual radioactivity out to 100 years after plant operation, and shows that it is not significant in comparison to the natural occurring level of background radiation. The testimony also demonstrates that the maximum hypothetical individual exposure has been identified and properly considered.

The third contention essentially has nothing to do with the Harris plant specifically or its impact on its surrounding environment. The NRC has decided to reflect in its environmental impact statements on individual power plants, the consequences of the uranium fuel cycle which supports Harris and all other plants. The NRC adopted a regulation which sets the amount of effluents released during that fuel cycle and attributable to support a nuclear power plant.

For one significant portion of that cycle, the uranium enrichment process, electricity generated by coal fired power plants is needed to run the enrichment facility. Consequently, the NRC rule includes the releases of particulates from the coal-fired plants which support enrichment facilities, which facilities in turn are located in Ohio, Tennessee and Kentucky.

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The Intervenor alleges that the health effects of those coal particulate emissions in this states have not been adequately considered in the environmental impact statement on operation of the Shearon Harris plant. Our testimony will demonstrate that these impacts are not significant.

end 2.

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JUDGE KELLEY: Thank you.

Mr. Eddleman?

MR. EDDLEMAN: I am speaking for myself and not for anyone else here. This is going to be a rather different sort of opening statement.

Since I found the notice of this proceeding hidden deeply under a shoe ad far away from the legal ads in the News and Observer, we have, indeed, gone through a great deal of paper in this proceeding. I hope the trees will forgive us.

Applicants' counsel have said that the effects of this plant are insignificant when compared to background levels of radiation. In my view, that is like a person saying, after they have killed somebody, "Well, there are 20,000 murders by handgunds in this country each year, and one more doesn't make a lot of difference." And I differ with that sort of analysis.

And it came home to me very much last Friday when I attended a memorial service for one of our former students at Friends School. She had been missing for over a year, and what they found of her was mostly bones. Nobody knows what caused her death. So I think that in a way, she is a stand-in for these people whose deaths are caused by these statistical forces that don't identify who is going to be killed or when.

I would like to read you the statement about her that was put into the graduation record of Friends School.

"It would be easy to write several pages about Jenny, but this is to be short. 'Intense' is probably the best single word to describe her -- intensely creative, caring, a listener, someone to cry or laugh with, a laughing poet, Jenny Hall."

And I think when you consider a real-life person and what it means for them to be dead, then these statistics take on a very different kind of meaning, and I think it should be taken very seriously.

JUDGE KELLEY: Thank you.

Ladies and gentlemen, we had submitted, as you all know, those of you participating, a motion from the Applicants last week on the proposed testimony of Dr. Johnson, and we had pleadings in response from the Applicants and Intervenors. We had a discussion of that the other day on the phone. The Board had not decided it at that point.

I think we would like to go to that next. Now I think there are probably some other procedural things to talk about, but we indicated the other day that we would turn to this early on, and we would like to do so.

As a matter of more background, one of the reasons for our reluctance to decide the motion the other day was that Dr. Foreman has just been added to the panel, and he

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didn't have the motion papers before him. And of the three of us, as you doubtless inferred, he is our lead expert on this particular subject matter. So we were quite loathe to address that motion on the merits until we had a chance to talk among the three of us and until we he'd had a chance to read the motion papers.

So we had some preliminary discussion on the phone and decided to put it over until today. We did suggest that the Intervenors indicated on the phone that there were some portions that they likely would agree among themselves might be dropped. So we suggested that that would be a step in the right direction, if that proved to be the case, and that they should put their heads together and see if they couldn't come up with an, in effect, stipulation.

I did get a phone message from Mr. Payne the following morning, which transmitted a message to the following effect:

Maybe I should read it into the record. It's very short, and that will put into the record what we are now taking out of the proposed testimony. What I did was just mark up my copy in accordance with these instructions. But I will read this message.

"The Intervenors will agree to strike the following portions of Dr. Johnson's testimony" -- if I make any mistakes please call my attention to it -- "all of Paragraph 1 on

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the first page, all of Paragraph 2 on the first page except the last two sentences" --

MR. PAYNE: That's the sentence that begins, "An article in Health Physics Journal," and from then on, we want to keep in.

JUDGE KELLEY: Right, and that stays in under the stipulation.

"On the second page, in the third paragraph," -- does that mean in the paragraph beginning, "The relative toxicity"?

MR. PAYNE: Yes.

JUDGE KELLEY: Okay.

Strike the sentence which begins, "The fallout from all nuclear weapons testing." That is the next to the last sentence in the paragraph, as I read it, okay, and they do not agree to strike anything on page --

MR. BARTH: Your Honor, is the last sentence, "Commences in Table 5," is that also stricken?

JUDGE KELLEY: No. Just the single sentence.

Intervenors did not agree to strike anything on Pages 3 or 4.

On the fifth page, they agreed to strike all of the first and third paragraphs, which means, I take it, the paragraph beginning at the top, "Projected releases of radioactive gases" -- that paragraph is out.

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And the third paragraph begins on Page D-7. "I note that the total releases," -- is out. Okay.

Now the paragraph that begins on 5, continues onto Page 6, strike all but the first two sentences. So that means at the bottom of Page 5, strike out, "Further, if a war should break out, indeed" -- and then all of the top paragraph on Page 6. "And that is the message, as it came to me..."

MR. PAYNE: That is correct, Judge. You have a good secretary.

JUDGE KELLEY: Thank you.

Now I gather the motion from the Applicants, supported by the Staff, was to strike the entire testimony. So I gather we still have a contest between the parties as to the remainder; is that correct, Mr. Baxter?

MR. BAXTER: Yes, sir.

JUDGE KELLEY: Do I understand correctly, Ms. Moore?

MS. MOORE: Yes, sir.

JUDGE KELLEY: All right.

We are open to suggestions as to how to proceed. What occurred to us, we have read the pleadings, as I said. We are familiar with them in general, with the positions. But when it comes to striking material, individual paragraphs and sentences, it seemed to us, although it might take a little time, perhaps the best approach would be to go through the letter as it is now proposed, paragraph by paragraph,

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and what we would like to hear from the Intervenors is -- we can do it either way -- it is Mr. Baxter's motion. I'm not sure about the sequence, but we would like to hear from Mr. Baxter why he thinks the paragraphs are out, and we would like to hear from the Intervenors why they think the paragraphs are in, and the Staff, insofar as they want to add anything to what Mr. Baxter's position is, their posture is one of supporting the Applicants, as I understand it.

Is that right, Ms. Moore?

MS. MOORE: That's correct.

MR. BAXTER: I don't have a preference on the order, Mr. Chairman. I would say that I think the burden is on the joint Intervenors to show that the testimony is admissible. We have been the moving party because we wanted a decision in advance of the hearing, but essentially we are objecting to what we anticipated was going to be a motion to offer this testimony.

MR. READ: It seems to me that just as a matter of general practice, I have read their paper, and their objection is fairly general, at least, and we think the burden should be on them initially to show why it isn't relevant to the proceeding, particularly in view, as I stated in my motion paper, that the definition of "relevance," as I understand how the practice is, is rather broad.

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JUDGE KELLEY: Well, I would just make an observation in that regard.

One, there can't be any doubt about our authority to strike irrelevent testimony. That is clear.

As far as definitions go, I really don't think we have to go to the dictionary on that. I'm not sure about federal practice, but I can tell you what our practice is, this Board's anyway.

If something has a logical relationship or there is something in human experience that suggests that it makes a proposition more likely than that, then it may be relevant. What you and I had for breakfast this morning has nothing to do with whether it's hot outside, and that's just a common sense sort of thing.

I think -- we don't want to get hung up on semantic definitions of "relevance." I think we will trust our judgment on that.

One reason for asking for a paragraph-by-paragraph approach is because Mr. Baxter's motion, although it urges various points -- it isn't a paragraph-by-paragraph approach -- and since that's what we have to do operationally, that is what we would like to do this morning. And I think, Mr. Baxter, we would like to hear from you first. And if the Staff wants to add, fine, they can add, and then we will hear from the Intervenors, and that is the format we are going to take.

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Would you like to take a short break, since we are asking you take a somewhat different tack on this piece of paper?

MR. BAXTER: I don't need one.

JUDGE KELLEY: Okay, then let's go ahead.

MR. BAXTER: It's going to be difficult for me not to make some general observations, even though I am addressing the first sentence that is in -- it is our motion, which is twice as long as the testimony that it is addressing --

(Laughter.)

MR. BAXTER: In any case, we do say that we think the essential thrust of Dr. Johnson's proposed testimony -- and I think what is left, now that these parts have been voluntarily withdrawn -- is clearly a challenge to the source term, the estimates of what is going to be released from the Shearon Harris Nuclear Power Plant during normal operation.

Do we have discussions of plutonium and other transuranic isotopes? These things were addressed already in Subparts B and F of Joint Contention 2. We have very, very clear Board rulings that the Staff's estimates of the source terms are adequate, and that in particular, the amounts of plutonium expected to be released by the facility during normal operation contribute insignificantly to the dose estimate and need not be considered. And I have quoted all of these in our motion to the Board.

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So our basic position is that the testimony is clearly irrelevant, and I will talk about it paragraph by paragraph. But I think that was is left comes back all the time to the source term, with the exception of the filter system. That is the other side issue, and that also goes to what comes out of the plant.

And the Board told the Intervenors on January 27, 1984, when Dr. Johnson tried to address the filter system, that that was, in your view, irrelevant, and I think it remains so today. Either the time period over which these doses should be estimated and to whether or not the radionuclides are going to attach to coal fly ash.

JUDGE KELLEY: Would you cite us to the statement about the filter system?

MR. BAXTER: Yes. Do you have my motion, or do you have the order of January 27?

JUDGE KELLEY: I have both.

MR. BAXTER: It's quoted on Page 11 in my motion, and it is taken from Pages 9 and 10 of the January 27, 1984 memorandum and order.

End 3

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MR. BAXTER: The quote on page 11, it is on pages -- I have the citation -- pages 9 and 10 of your January 27 memorandum and order.

JUDGE KELLEY: Okay. We said they appeared to be irrelevant. Are you saying, in effect, that the effluents from the plant in normal operation, for purposes of this case at least, are as stated in the FSAR and the FES?

MR. BAXTER: In the environmental report and FES, yes. In fact, we addressed what assumptions were made about filter efficiency in the motions for summary disposition on the source term. And I know it must be difficult for Dr. Foreman at this stage to step in, but we have been through very lengthy and careful process. The board has labored with lengthy orders, and has reviewed expert affidavits to try and get a good definition of what the issues are going to be. And I think they are very clear here.

JUDGE KELLEY: Your general point, I think, is made. Can you give us some specific help on the letter itself?

MR. BAXTER: Well, the first two sentences that are left, and beginning at the bottom of paragraph 2, they refer to health physics journal article listing 240 radionuclides of potential importance in routine releases in a fuel cycle. In fact, these are a listing of all potential

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radionuclides that are in fuel at various portions.

The article says nothing about what is coming out of a nuclear power plant during normal operation. It goes on to say that what these isotopes include. Gee, there's no effort there to relate it to anything. I assume he's trying to build on the idea that we ought to consider the releases of some of these isotopes. That is the source term.

I can envision no other reason for those two sentences. The next paragraph is really the same thing, except it's a different article, and it has 500 instead of 240. And it explains what the half-life of plutonium is, and its potential impact on populations, longer than man may exist, which also challenges the board's ruling that geologic time periods would not be considered.

And as I have read, plutonium was specifically addressed in deciding on the source term issue.

JUDGE KELLEY: Okay.

MR. BAXTER: Did you want me to keep going through the testimony or have them respond as we go?

JUDGE KELLEY: References? It might be better to respond as you go. Well, maybe not. If it's terribly long you will get lost otherwise. But if it's short enough, your points are pretty much to the same effect.

MS. MOORE: Your Honor, the Staff would prefer to go paragraph by paragraph individually.

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JUDGE KELLEY: All right.

MR. EDDLEMAN: Do I understand that that means Mr. Baxter makes his statement about a paragraph, you make your comments and we make a response?

MS. MOORE: Yes.

MR. EDDLEMAN: Okay. That's what I'd like to do too, Judge. And if we're going to do that, then I need to back up and start with my generalities.

JUDGE KELLEY: Okay. We have gone over, or we have Mr. Baxter's comments, let me put it that way, on the first page, and on the first paragraph on page 2. Why don't we stop at that point and see if Ms. Moore wants to expand on that and make a point?

MS. MOORE: I would like to add just one thing briefly on both of those paragraphs, and Mr. Baxter touched on it. The contention before this Board today, deals with the normal operation of Shearon Harris, releases from normal operation.

The first two sentences clearly refer to the fuel cycle. That is a totally different issue. And it is not an issue that's before the Board at this point.

My second point is just -- well, a little bit of a reiteration of Mr. Baxter's generalization. And that is, that the issues before the Board are very narrow. Whether we should look at plant lifetime risk, and whether we should

4pb4

look at the attachment of coal fly ash or radionuclides to coal fly ash. Neither one of these issues is specifically addressed in this testimory, nor or they even implicitly addressed, especially by these first two paragraphs. Cumulative risk is not discussed.

And the time periods mentioned in the paragraph on page 2 are far longer than the 40-year license life of the Shearon Harris plant. Therefore, these two paragraphs are irrelevant to the narrow issues before the Board in Joint Contentions 2.C and E.

JUDGE KELLEY: Okay. Mr. Eddleman?

MR. EDDLEMAN: Judge, at the outset I would like to say that we certainly could have done a better job on this. This testimony came into my hands four hours late, and on the day that it had to be filed.

I would like to go into the history a little bit, because I think it is relevant. We did not have Dr. Johnson available to us as an expert when we went through most of the pleadings on summary disposition. As you know, the board ordered us to come up with experts, and due to a quirk in the mail, that order actually got to me within two or three days before the deadline for answering came up. And I made a bunch of desperate phone calls, and Dr. Johnson agreed to help us out and send some information.

So the information which Dr. Johnson had produced

4pb5

was not really before the board in large respect, almost totally as I recall, when the summary disposition rulings were made.

Now you have pointed out that the board's order of January 27, '84 says that these issues appear to be relevant. Joint Intervenors take the position that because of the explanation of this alpha recall phenomenon, and its effect on moving radionuclides through filters, that all these alpha-emitting things can get through filters. And also escape detection at the levels they are present in a lot of systems which employ filters to track alpha-emitters. That it's extremely relevant to the question of the health effects of these nuclides loose in the environment.

Now, as to the attachment on coal fly ash, I think again, Dr. Johnson certainly made a more direct reference, but he does mention attachment to particles. And he also mentions the lifetimes of these things. Now, as to these particular paragraphs, one difficulty we as Joint Intervenors had in deciding how to slice this thing up is, the references to these tables are important for the information they give which supports the presence in the Harris source, that is the fuel in the reactor of all these different alpha emitters.

The only one that is being really considered in the Applicants and Staff analysis, as I recall, is Neptunium 239, which of course decays into plutonium 239.

'pb6

If Dr. Johnson is correct that these other alpha emitters can get through the filters much more readily, and he gives the source and supplies the documentation for it being able to penetrate five or six HEPA filters. And I think the maximum they have in the train is two in a row. They would show that these alpha emitters coming out as particulates loose in the environment, and they are going to be having health effects which occur over the life of the plant, and after the lifetime of the plant, the long half-lives of these emitters is certainly relevant to the issue of how long you should consider the effect of the plant's emissions on it.

Now we don't maintain that every nuclide from the uranium fuel cycle is going to be emitted by this plant in quantities given in a certain table. Not at all. But it's almost impossible for us to cut this up without rewriting it and have the references to the tables, which we believe are necessary, in order to document the concern that Dr. Johnson is talking about.

So that is my general comment.

JUDGE KELLEY: Let me ask you just a general question. If I follow you here, Dr. Johnson is saying that if these alpha-emitting particles would get through the filters, that therefore, what gets out into the atmosphere is something other than, and something more dangerous than

4pb7

what was thought, if one read the environmental report of the impact statement.

MR. EDDLEMAN: That's correct.

JUDGE KELLEY: Now, isn't that fairly characterized as a source term problem?

MR. EDDLEMAN: It is an emissions problem, and the source term attempts to calculate those emissions. I'm not trying to be nit-picky but the source term has a technical meaning, and I'm not sure I understand it for that matter, because it is seen in different ways.

Sometimes you talk about a source term that is actually in the fuel. And sometimes you talk about a source term that's expected to be emitted from the plant. I think that's true. He is contrasting what you would actually expect, or what is going to be expected to be emitted from the plant.

JUDGE KELLEY: Okay. What I'm getting at, and I think I understand source term in the same sort of fuzzy way -- maybe we are right, who knows -- but what is procedurally, if we ruled out source term last January as seem to have done, are you now saying to us, in effect, gee, you ought to reverse that and reopen the question? Or are you saying that the contention as now before us somehow encompasses this, even though we seem to have ruled out source term?

4pb8

MR. EDDLEMAN: I think mostly the former, Judge. I sort of suggested that this go intc the pleading that we filed in response, and I don't know if we did or not. But basically it was evidence that we did not have available when we went through summary disposition. In fact, I didn't see it, as I say, until a matter of hours before we had to put it in the mail.

I think however, that there is relevance of these emissions to the questions of the nuclides attaching to the fly ash and to the lifetime over which the health effects have to be considered. And that relevance to the Neptunium 239 becoming plutonium is there, even if you accept the Applicant's view. Because they concede in their source term, that if Neptunium gets out, any business can tell you that it's going to go into plutonium. And there it is.

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MR. BAXTER: That is considered. And it's discussed by the Board on page 9 of my motion. The fact that Neptunium-239 decays into plutonium-239.

But the Board found that with result of the formation of pie times $10^{-12}$ curies per year pluntoium-239 --

JUDGE KELLEY: I thought we made a finding that that was insignificant.

MR. EDDLEMAN: Well, Dr. Johnson does discuss the health effects of that amount. I have not got the stuff all together that much, Judge. I'll be honest about it. But

4pb9

I think that what we are really getting at here, I think is the source term. And that's where we are coming down to.

And my opinion would be that we didn't have it when we went through summary disposition. We are working with a volunteer witness who has been very kind to us to try to help us out. He is under a lot of time pressure, and so are we. And we readily concede that we could have done a much better job if we had even had a couple of days for me to talk and revise this thing. We would have done a much better job.

But we have to go with what we filed on the deadline. We agreed to do that. And we're trying to do the best we can with it. But I think it's a serious issue.

And to that extent, I think we would ask the Board to reconsider that January 27th order that says that some of these things appear to be irrelevant. That doesn't rule out quite as strongly as Mr. Baxter seems to apply.

JUDGE KELLEY: It says appear on page 9 or 10. But in some pages further on, it just flat throws out the source term contention I thought.

end 4.

mgc 5-1

MS. MOORE: Your Honor, I believe the pages are 21 and 23.

JUDGE KELLEY: Yes, 21 et seq.

MR. BAXTER: If I could, Mr. Chairman, I appreciate Mr. Eddleman's candor in recognizing this for what it is, but -- and efforts have been made, I think, to accomodate their lack of resources -- but after all, this contention was admitted in September '82. Dr. Johnson was identified as a potential witness in December of last year, and what the issue is was specified in January. The date for filing the testimony was known way in advance, and, in fact, extended one week. And while they didn't discover the evidence until now, I don't think there is a good reason for not having diligently pursued it earlier. And ultimately, since we have the burden of proof and the moving forward of these proceedings is desirable, and you certainly can't say it's been railroaded in any way up to this point, I think we cannot have summary disposition reconsidered on the day that testimony is filed by everybody. It's like ships passing in the night.

JUDGE KELLEY: I understand your point. I'm more concerned with where we are in the format.

MR. EDDLEMAN: Judge, may I respond to that, because there is a reason --

JUDGE KELLEY: Why don't you respond to that, and then we will get back to your particular comments, and we

mgc 5-2

will go back to the format?

MR. EDDLEMAN: All right.

Well, last December, I prepared, at Dr. Johnson's request, a stack of documents to send to you, and I had to leave town, and I left them for somebody else to mail, and I found out from you, Judge, on December 22nd, that the hearing had been postponed. So I left them instructions that it was not critical to get it out immediately.

It turned out that these documents didn't actually get mailed to Dr. Johnson until some time in May, and not only that, but the Board's January 27th order, I made a copy of, and I put it in the mail to Dr. Johnson at his address in Colorado, first class mail, like they say to do. I found out from him -- I think it was Monday night -- that he had never received that order, and I assumed he had it.

I don't know whose fault it is. I should have followed up on it better, but he had never seen that order when he wrote this testimony. And I had sent it to him, and I assumed that he had it.

I think it's an excellent illustration of Murphy's Law. You know, honestly, we're not going to complain when the Board rules, but that is the reason.

JUDGE KELLEY: Well, a general observation, and we will get back to the particulars of the testimony.

Insofar as you do view this as a request to reopen

mgc 5-3

the summary disposition point and get back to the source term, it is almost like a latent contention based on new information, and we are not or we haven't been until this morning anything resembling a procedural format for that sort of thing.

Well, why don't you go on with your particular points about the first, what is on Page 1 in the top paragraph there?

MR. EDDLEMAN: All right.

I think the importance of that is basically that those radionuclides and the food chain -- the importance of this, we think, is to connect these nuclides to the food chaing. But as I said, we do recognize that only the nuclides to be omitted from the Harris plant are relevant. We think it makes it almost impossible to read and understand this testimony if you don't have the references to the tables, so that's why we want to leave it in.

We don't claim that there is great relevance residing in this particular paragraph. In fact, that's a problem I have in general. In other words, when I say that this particular paragraph is directly on the point of the contention, not necessarily so, but if taken together, they establish information that you need to underly, to explain, to give scientific references for the point that we think Dr. Johnson is making about the alpha recoil, which is

mgc 5-4

crucial, in our view, to both these issues of the coal particulates and the lifetime over which you consider these health effects. That, I think, is relevant.

And really the same argument applies to the second paragraph. This is an assessment of contamination around nuclear facilities, and that means all kinds. And again, we would restrict it to those that are to be emitted from the Harris plant.

But you will notice, there are quite a few isotopes in there of these long-lived radionuclides -- plutonium and elements beyond plutonium. There are some elements lower down. But all our alpha emitters, I think.

Let me just take a look at it and make sure. I think they are all alpha emitters.

Oh, no, they are not all, but the alpha emitters start in -- well, some of the others are alpha emitters, radium and thorium, and some of these other isotopes are alpha emitters, but the ones of concern would be uranium, neptunium, plutonium, americium and curium, and conceivably some of the higher ones, although you expect lesser amounts of those.

But again, here we are beginning already to get a tie-in. We are talking about half-lives of some of these things and the lifetime that we are dealing with, and I think that given that the source term issue could be resolved

mgc 5-5

somewhat in our favor, then that is obviously relevant, and that is all I have on that.

Now I think we are up to the same place.

JUDGE KELLEY: Okay.

Well, let's go back to Mr. Baxter. If you think you can combine a couple of paragraphs, that is all right, too.

MR. BAXTER: The next paragraph is sort of different from the ones before it and after it, I'm afraid. But two points.

First of all, it doesn't say anything. It says there are a range of health effects listed in the BEIR report. That is true. It says, "As time goes by, we may add more to the growing list." I may say, we may lose some, too. It doesn't really make any point health effects.

Secondly, the health effects of radiation and challenges to the BEIR report were first ruled by the Board only to be worth hearing if Dr. Goffman could come, and secondly, on March 15, it was ruled by the Board in our favor because of Dr. Goffman's unavailability. So I think health effects are out here, and the paragraph makes no point one way or the other.

JUDGE KELLEY: What about the next one?

MR. EDDLEMAN: Well, do you want to go paragraph by paragraph?

JUDGE KELLEY: Well, I'm beginning to wonder how

mgc 5-6

long it will take.

(Laughter.)

JUDGE KELLEY: There's only one more on Page 2. Let's take two at a time.

MR. BAXTER: The second paragraph on Page 2 is really just a different way of discussing their challenge to the source term, which is to talk about amounts of plutonium, americium, and curium. And the reference a table, Table 4, on radionuclides that are involved in reprocessing spent fuel from a nuclear power plant.

That should be obviously irrelevant to discussing releases from normal operation of the Shearon Harris plant, and again, to be discussing what the maximum body burden is of plutonium is only relevant if one is assuming that there is plutonium that is coming out of this power plant in any kind of significant way. And that is again, with what the Board has already found is not the case, but it is insignificant, and it need not be considered in the source term.

JUDGE KELLEY: Ms. Moore?

MS. MOORE: I have nothing to add to Mr. Baxter's statement.

MR. EDDLEMAN: Judge, in our view, the third paragraph is simply Dr. Johnson's statement as a scientist -- he is an epidemiologist -- that these things do have health

mgc 5-7

effects. We readily concede that he made a stronger statement, but we think that it is relevant, because he is saying this is why these contentions are -- that these things have health effects.

Now the fourth paragraph, we think -- excuse me -- this is the third paragraph on Page 2. The third paragraph on Page 2 describes the relative toxicity per cubic centimeter and also per curie, and it refers to the isotopes listed in Table 4. That certainly is true, that Table 4 is reprocessed nuclides, but where are they reprocessed from? They are reprocessed from the core of this power plant. And it lists in the first column, uranium fuel water reactors. That's what the Harris plant is.

And as Dr. Johnson says, since it's a 900 megawatt plant, and this table is for 1000 megawatts, he would find .9 times these number of curies, these various isotopes, in the core.

Now he explains later on, I think, that these things can get out. So we think again that it is very relevant to that alpha recoil issue.

And then he discusses Table 5, which points out that among plutonium workers inhaled plutonium lodges in every organ and tissue in the body.

Now certainly that is relevant to health effects from plutonium. In other words, that they find it throughout

mqc 5-8

the body of people who are exposed to it as an aerosol.

Now what that means is, if it is in the air, it's going to get everywhere in your body, and that is experienced with people who are exposed to it.

Now again, we think that, you know, it's hard to get more relevant to the health effects of plutonium that is inhaled than to say it gets to every part of your body, and then also to say that it has this large range of health effects. And again, we absolutely agree that it could have been better written and better connected, but we think it is relevant.

JUDGE KELLEY: But if we were to consider that paragraph as to what plutonium -- the effects of plutonium, would we not have to disregard or set aside the finding we made in our order in January on Page 22?

MR. EDDLEMAN: I think so, Judge.

JUDGE KELLEY: We would have to say, "Well, we were wrong about that, and there is more that's going to get out."

MR. EDDLEMAN: You wouldn't have to say you're wrong. You'd have to say that you might be wrong.

JUDGE KELLEY: All right. But it is inconsistent.

MR. EDDLEMAN: That's correct.

JUDGE KELLEY: All right. Page 3.

Do you want to comment on Page 3, Mr. Baxter?

MR. BAXTER: Well, together they once more are

mgc 5-9

assuming that we have alpha emitting isotopes like plutonium, americium and curium being released by a power plant. And the source term in our arguments shows that there are no detectable alpha emitters released during normal operation of the plant. So again, it's a challenge to the source term.

This theory about the filters, we could argue the merits of that, but I don't think that's what we're supposed to be doing. I think we're supposed to be trying to argue whether or not it's related to any of the contentions that we have here, and I don't believe it is. I don't believe they have s'own that it is.

JUDGE KELLEY: So you're saying that we have already determined what gets out of the filters, and it is that which we should be litigating?

MR. BAXTER: Yes, and transuranics around the Rocky Flats weapons production facility, I think, is on its face not relevant to normal operation of the Shearon Harris power plant.

JUDGE KELLEY: Ms. Moore?

MS. MOORE: I would only add that the testimony, this portion of the testimony, does not contain any specific analysis of the normal operation of Harris. It doesn't talk about the filters at Harris, and it doesn't talk about their efficiency. As a matter of fact, it just asks a question about it which adds nothing to the testimony, because the

mgc 5-10

question remains unanswered. That would be assuming that the issue were relevant in the first place, and the Staff submits that the issue of efficiency of filters is not relevant to the two particular contentions before this Board.

JUDGE KELLEY: Thank you.

Mr. Eddleman?

MR. EDDLEMAN: Judge, there are several things here. First, to go back to Murphy's Law, I did get a good bit of material on the filters at Harris out of the Applicants, and that was in the same package that I sent Johnson that had that other order in it which he never got. That is my fault, and I will take the blame for it. I will absolve the U.S. Postal Service.

But I think that this shows precisely how these nuclides do get through the filters. Mr. Baxter says they are not detectable, but as we have already pointed out, the alpha recoil phenomenon also makes them less likely to be trapped in the thing that detects them, which lowers the amounts detected, and that certainly has to be taken in conjunction with the article that is referenced, which is attached, and I think we even messed that up in a prehearing, and we served you with new copies of the entire article. We are sorry about that.

But I think it explains exactly how this phenomenon happens. If you want to take it up as a new

mgc 5-11

contention with all the things that that entails, we are certainly prepared to do so.

Also, I think Mr. Baxter mischaracterizes the sentence about Rocky Flats. What he says is, the result is that these transuranics around such plants as the Rocky Flats plant or nuclear power plants are mostly in the form of single atoms or particles too small to measure. And I think it is very logical, if you look at the MEVs of those alphas, you are talking five or six MEV when the alpha is kicked out, and every action has an equal and opposite reaction. Six MEV is not a lot of power at the level at which we live, but if the level of being, say a nucleus of Plutonium 240, six MEV is a lot of power behind you. It is a tremendous kick, and it can probably break loose from any sort of surface adhesion force that exists.

So I think it is very clear that this phenomenon is being explained here.

Now he also points out that microcurie amounts of plutonium and americium result in pretty high doses to these dogs. I believe these are the vehicles, and he gives a reference.

MR. BAXTER: The dogs are -- these are experiments in which the dogs are exposed.

MR. EDDLEMAN: That's correct. And my point is that it would be totally unethical to expose humans on purpose

mgc 5-12

to these levels and see what doses they got. So you can't do that.

I'm not implying, Mr. Baxter, that you would think it is right, ethical or whatever. Not at all. But what it does show, then, if you want to talk about nanocuries, a thousandth of that, then you change these things to millirems, okay?

If you talk about picocurie doses, you are changing these to microrems. But 3250 microrem is three and a quarter millirem. It is a dose that can have an effect.

I think these body burdens that are referenced in one of these other exhibits show that, and again, we readily concede that it could have been much more tightly written and so on, much better connected.

Now I think the reason Dr. Johnson asked the question about the filters is obviously because he didn't have the filter information, and I didn't understand it when I got it, but I knew I had to file the thing. But he does again supply a reference, just as he did for the experiment with the dogs, and he says that the usual method of measuring efficiency of such industrial filters does not yield a meaningful efficiency value, since it is purely an empirical leak test. And then he points out that the ionized air stream -- of course, the ionization comes in part from the decay of nuclides, and there are nuclides in the air stream,

mgc 5-13[1] of course, other than the alpha emitters, which are decaying much faster. Their stream is ionized. He is pointing out a problem with it.

Again, we are prepared to argue this as a new evidence kind of thing, if necessary, but I think it is certainly relevant to how much gets out of a plant and how it gets out. And this section in here, and going over to the next page, is basically, in our view, the core of this testimony, which the rest of the information supports.

End 5

6pb1

JUDGE KELLEY: Would you characterize the alpha recoil aerosol phenomenon then as the main point that you want to emphasize?

MR. EDDLEMAN: I think so. There is a little bit besides that, Judge, but I think we have to say that it is a little. The biggest thing is the alpha recoil.

JUDGE KELLEY: Okay. Page 5, Mr. Baxter.

MR. BAXTER: I would only add that that alpha recoil phenomenon is clearly aimed at challenging the source term. It doesn't go to length of time or the particles.

MR. EDDLEMAN: Well, to the extent that it gets alpha emitters with normal half-lives out, it does. But I think you have to challenge the source term first.

MR. BAXTER: If the source term were wrong, lots of other things would flow from that. The thing is, this source term has been decided.

Page 4 is arguing that the plutonium again, which it's assumed is released in some insignificant amount americium and curium, which again is a challenge to the source term, then becomes attached to dust. You know, other fine particles, whatever that is.

It points out that plutonium is measured in Antartica and it discusses plutonium levels resulting from nuclear testing. Well, you know, what the level of plutonium in that article or nuclear testing has to do with normal

6pb2

operation releases from the Shearon Harris is not explained. And I imagine, it doesn't serve me to speculate on what it does mean.

The second paragraph simply goes back again to the list of 500 radionuclides, except this time it complains that our monitoring system at the Shearon Harris plant doesn't adequately consider all 500 radionuclides that Dr. Johnson says are somewhere in the core. He doesn't explain how they're going to get out.

In passing reference to the recoil phenomenon, and as we pointed out in our motion, the monitoring system was the subject of Joint Contention 6 on which we moved for summary disposition. The Intervenors defaulted on discovery as well as the response to that motion, and the Board dismissed it on May 10.

And the rest of the paragraph is simply an elaboration on what some of the characteristics are of these radionuclides that are listed on the table that we discussed previously.

MS. MOORE: Staff has nothing to add to Mr. Baxter's statement.

MR. EDDLEMAN: Judge, I regret to add yet another thing to our list of slip-ups. On page 1, the sentence right before you take up the article in the health physics journal, the second paragraph on page 1 says, in fact,

6pb3

reactors such as this one develop pinhole openings and cracks in the fuel rods during operation which permit radionuclides to be released through the period of operation.

JUDGE KELLEY: I lost you. Where are you reading?

MR. EDDLEMAN: This is the middle of the second paragraph on page 1. And we apparently struck that, and we should not have because it is what explains how these things get out, which Mr. Baxter referred to in not explaining. It is there, but we, in error, had struck it. And I think we should have to put that in to flesh out this matter on page 4.

Now, I think the first paragraph on page 4, again could have been better written, but is clearly relevant to this particular issue. It says, attached to other fine particulates. Now, I don't think that either the Applicants or the Staff would disagree that many of these coal particulates are fine particulates.

That phrase, "fine particulates" occurs time and time again in their testimony. And these are certainly things to which these nuclides can attach.

Now as to the monitoring in Antartica and the levels in the stratosphere, I think what is being said is that plutonium can be dispersed on these particles to very great distances throughout the world, in fact. We don't think that that particular point is as strongly relevant as

6pb4

most of the rest of this is. You can take it or leave it. We are not going to make a big argument about that.

The second paragraph on page 4 does directly lead to source term. It does explain the half-lives of some of these nuclides which are of importance. And again, if you accept the alpha recoil phenomenon, then I think it's very clearly relevant to the times over which the health effects of these things would have to be considered.

That's all I have on that.

JUDGE KELLEY: Can you speak to the remainder, Mr. Baxter?

MR. BAXTER: The second paragraph on page 5 is making the point about the fetus being most susceptible to radiation. There is no attempt to link this either to -- I assume it doesn't relate to the fly ash, but to the time which the dose estimates are expressed in the environmental impact statement. And instead returns, I assume, as a challenge to the BEIR report and the health effects which were decided on by the Board in its March 15 order.

At the bottom of the page, we're talking about what the population is, and about, depending upon whether there will be some radiation in the air which people will inhale. There is no particular point made that I think is relevant to the contention.

And the last paragraph talks about, on page 6,

6pb5

monitoring the food chain within 50 miles of the plant for the 500 radionuclides, again, that he claims are in the core somewhere. And I think this monitoring program was not even covered by Joint Contention 6, let alone any contention we previously had. It's essentially the background monitoring program that is done in the vicinity of the power plant.

JUDGE KELLEY: Ms. Moore?

MS. MOORE: The Staff has nothing to add.

MR. EDDLEMAN: Judge, before I go on to this, I wanted to make the point that in agreeing to strike out parts of this, we are not saying at all that they are not true, it's just that they don't relate directly to this. And I think that certainly in the first paragraph on page 5 that is still in -- that's the second one on the page -- that begins, "the various routes" could have been detailed much better.

I think it is fairly obvious for anybody who has read the ER or information about this that babies do have a relatively higher rate of breathing through air in their lungs relative to their mass than do grownups. I think everybody knows that the fetus is more susceptible to radiation. I think it could have been spelled out a lot better, but we do think that it does indicate a problem which should have been considered.

Certainly when there is exposure to fetus,

6pb6

certainly the fetus is not killed by the exposure. And then the lifetime after birth could be a very long time. It could be 70 or 80 or even conceivably 90 years. And that would need to be considered.

JUDGE KELLEY: But you are not contending that the contention says anything about the special vulnerability of fetuses, are you?

MR. EDDLEMAN: Well, the original contention did, but I think that's the part that got thrown out. But what I'm saying is, if you are going to adequately consider the health effects of these particles, then you would certainly have to consider the effects on infants. I know that's not in there. I'm saying we should have written it better.

But the population within 50 miles -- I think the straightforward thing about that is that when the plume is coming straight toward a person, and they are actually in the plume, then they are breathing a considerably higher concentration of those particulates.

Also, when the plume is at ground level, it is closer to a lot more sources of particles, although not to a source of coal particles. But again, it relates as other particles to the dose lifetime because carrying those alpha emitters into the lung, that's going to have an effect that is much longer lived. Having them in the dust that can be stirred up is going to have an effect that is much longer

6pb7

lived. And breathing them in gives a much greater exposure. It gives internal exposure and external exposure.

Now, as for Johnson's plea for monitoring on page 6, I'm not sure that it does a great deal to advance the contention. I think it's simply a statement of his concern as an epidemiologist because of what he said about these alpha emitters being able to escape detection. He is talking about carefully monitoring to catch up with those things. We have already conceded that these 500 nuclides.

The ones that we are mainly concerned with in this testimony are those alpha emitters that are subject to alpha recoil. And that's all I have.

JUDGE KELLEY: All right. It would be an appropriate time for a coffee break; ten minutes or so. And we will confer, and hopefully have a decision on the motion after the recess.

end 6.

(Brief recess.)

7pb1

JUDGE KELLEY: We are back on the record. We indicated at the break that we intended to, at the break, deliberate and hopefully decide how we are going to handle this motion to strike. But since we don't have anyplace to deliberate in this building, the snort of it is, we are going to do it over lunch and come back and deliver the ruling then, because we don't have it right now.

We have a few more procedural matters, and the parties may have some points that they want to raise. But our expectation would be that we will be moving very soon, certainly in the next 15 or 20 minutes or less, to ask Mr. Baxter to put his first witness on.

But let us just go over these few other points first. First of all, we had served on this morning a stipulation signed by Mr. Eddleman for himself and Joint Intervenors, and Mr. Baxter for the Applicants, and Mr. Barth for the NRC Staff. And I'll just read it into the record.

Wells Eddleman on his behalf and on behalf of Joint Intervenors, Thomas A. Baxter on behalf of Carolina Power & Light Company and North Carolina Eastern Municipal Power Agency, and Charles A. Barth on behalf of the Nuclear Regulatory Commission hereby agree and stipulate as follows:

The Final Environmental Statement related to the operation of Shearon Harris Nuclear Power Plant, Units 1 and

7pb2

2, NUREG-0972, U.S. Nuclear Regulatory Commission, October 1983 (FES) may be offered and received into the evidentiary record in the captioned proceeding without objection or further sponsorship as NRC Exhibit 1 in evidence. The receipt into evidence of the FES shall in now way prejudice the rights of Wells Eddleman and the Joint Intervenors in regard to their contentions 8(f)(1), and II(c) and (e), respectively.

MS. MOORE: Your Honor, we have provided copies of that stipulation to the court reporter, and the Staff is going to request that a stipulation be bound into the record.

JUDGE KELLEY: Yes, so ordered.

(The document referred to follows:)

7pb3

MR. EDDLEMAN: Judge, we just want to say for the record, that in agreeing to this to save time, we are not agreeing that anything else the environmental statement says is necessarily right. But it is a procedural agreement.

JUDGE KELLEY: Understood. There are a couple of other questions that we talked about at the last prehearing, and if my recollection serves me, we envisioned the Applicants going first and presenting their case. The Intervenors on this particular contention -- you don't have witnesses, do you, Mr. Eddleman?

MR. EDDLEMAN: No, we do not, Judge.

JUDGE KELLEY: Right. The Staff does have witnesses. So I would envision the witnesses first for the Applicants, followed by the witnesses for the Staff.

Now in terms of sequence of cross-examination, I don't recall if we discussed that. Can you refresh my recollection whether we did or did not?

MR. BAXTER: Yes, I thought we did. And that the understanding was the that the sponsoring Intervenor would cross-examine first, followed by the Staff and then redirect, if any.

JUDGE KELLEY: The Board after the Staff I would think, followed by -- followed by redirect, interjecting, if you were moved to do so.

MR. EDDLEMAN: Sir, we had a little disagreement

7pb4

about that. I don't think it will apply to this, but on the one where we have a witness we thought that the order of cross ought to be -- well, actually on all of them -- that the order of cross ought to be that whatever party puts forward a position, those parties whose positions are friendliest should cross before the ones who are less friendly.

JUDGE KELLEY: Well, it wouldn't arise until you have a witness in Dr. Johnson, correct?

MR. EDDLEMAN: Well, if the Staff has any cross for the Applicant's witness it would arise in this 8(f)(1).

JUDGE KELLEY: I frankly have a dim recollection of that being discussed at the last prehearing, and I don't recall whether that was resolved.

JUDGE FOREMAN: I don't think the Board wants to be put in a position of making a judgment of who is more friendly or less friendly. I think the decision should be made on some other basis. Namely, on just deciding ahead of time and letting it go at that. But not on the basis of who is friendly and who is not.

JUDGE KELLEY: Can I get clear first whether we decided this a month ago.

MR. EDDLEMAN: As to best I recall, Judge, we did not decide it.

MS. MOORE: Your Honor, it has been the usual procedure in our proceedings as a general rule, that the

7pb5

presents its case last and cross-examines last. I see no reason why that procedure should be varied in this case.

JUDGE KELLEY: That's the procedure that I am somewhat familiar with. Apart from its being a procedure, can you think of a good reason why that should be the way we do it?

MS. MOORE: Well, I think that it isn't really correct to characterize the Staff as friendly to one party or other. The function of the Staff is to make sure that the record is as complete as possible in this case. So the Staff's cross-examination may in fact, be geared to the completeness of the record. And as such it is probably more valuable for the Staff to go last after all the other cross-examination has been completed. So that if there are, what Staff believes unclear parts of the record, they can at that time try to clear them up.

JUDGE KELLEY: Okay.

MR. EDDLEMAN: The problem I see with that, you know, whatever Ms. Moore may in good faith believe is that effectively the Intervenor here would be sandwiched between two parties who are in very close agreement. And the practice of the North Carolina Utilities Commission is that when the parties are in fact in close agreement, I don't think it has to be made as a Board judgment, but I think the parties usually just agree to it to go so that the parties who are

7pb6

taking the closest positions cross-examine. And I think that's constructive in the sense that since they are taking close positions, then any differences between them are illuminated before you get to the ones who are challenging the position more strongly.

JUDGE KELLEY: Any comments, Mr. Baxter?

MR. BAXTER: No. I mean, it's my understanding of the Staff's role as Ms. Moore described it. I don't know whether there is a comparable body in the NCUC proceedings and the regulatory staff here.

MR. EDDLEMAN: There is.

JUDGE KELLEY: Well, it is the usual practice, insofar as I'm familiar with it, in the case of the Applicant's case for them to put their people on, followed by Intervenor questioning, and followed by the Staff. I think as Ms. Moore stated, the theory that lies behind that, Staff has the responsibility to try to ensure that the record is complete, and they attempt to do that.

Very often on say a motion, if the Applicants make a motion and the Staff is just supporting it, it makes sense to hear from the applicants and Staff first, and then the intervenor. But in a evidentiary case, the procedure is a little bit different.

Well, let us just confer here for a moment.

(Board conferring.)

7pb7

JUDGE KELLEY: The Board has decided to follow the usual practice with the Applicant leading off here with the witness, then we'll follow with the Intervenor's cross-examination. Following that, the Staff would have their questioning.

The Board may interject at one point or another through this process, but we also have a time for Board questions, which would normally come after the Staff. Then there is a time for redirect if Mr. Baxter exercises it. And it may be appropriate to give some time for recross.

If, for example, Mr. Eddleman if something new crops up in the course of Ms. Moore's questioning of the witness and you have already had your bite, you can ask to have an opportunity at that point on the grounds that it did come up late, and you didn't have an opportunity to address it.

MR. EDDLEMAN: I understand.

JUDGE KELLEY: We talked a little about whether or not we wanted to impose time limits on cross-examination questioning, and the feeling was at the last prehearing that we would not do that at the outset, at least. And if the case is moving along reasonably well, and it's apparent that we are going to get these contentions tried in the time frame we talked about, namely finishing by next Wednesday, we would not go to the time limit regime.

7pb8

If on the other hand things are dragging and we think that the cause of -- we think that the delay is undue, we will reconsider that. And we might impose time limits in terms of whatever seems fair under the circumstances in terms of hours or half-hours or whatever. But we will not do that right now, and we will see how it goes.

Do I understand correctly that on this first contention at least, 8(f)(1), all of the exhibits that the parties intend to offer have been offered and exchanged?

MS. MOORE: That's correct.

JUDGE KELLEY: And are there any disputes over admissibility of the exhibits?

MR. BAXTER: We have no exhibits, we just have the testimony.

MS. MOORE: The Staff is unaware of any disputes. No one has informed us that there are any objections to the two exhibits we intend to offer.

MR. EDDLEMAN: No objections.

JUDGE KELLEY: Okay, fine. Are there other points or ground rules that we ought to talk about before we go to the first witness?

MR. EDDLEMAN: Judge, there was a question in my mind when in the Applicant's reference document. And I think even the Staff references some that they did not provide a copy of. And I guess these things may be presumed

7pb9

to be available. I didn't have time to dig them out.

My understanding was that the exhibits would be the backup documentation to the testimony. And I'm wondering if there's any way that we could just get a copy of the documentation as a Board exhibit.

JUDGE KELLEY: Comments, Mr. Baxter?

MR. BAXTER: Well, one of the reasons that testimony is prefiled is so that the parties have an opportunity to prepare cross-examination. We have clearly identified references that we relied upon. I would imagine that in most cases, they had already been referred to in Dr. Hamilton's, for example, previous affidavit on summary disposition or in discovery.

Is there anything in particular that you don't have access to?

JUDGE KELLEY: I would just make the comment that the mere fact that a piece of testimony may cite some book doesn't mean you have to provide a copy of the book. You can have lots of citations in testimony.

If you rely very heavily on it, on one particular thing, you might very well want to provide that. But if it's just a citation to a page in some book, then we wouldn't normally expect the book to be produced.

MR. EDDLEMAN: I understand. I apologize for having been so busy with these summary disposition motions and other

7pb10

things to not have prepared as well as I might have.

The one question is this Brookhaven National Lab 51305, which I'm not sure is available in the public literature. It is reference 4 to Dr. Hamilton's testimony. I believe the back page gives a list of the references, which is a good list.

Let me just ask the Applicants if they're willing to let me see a copy of that. If they'll stipulate to it, I don't think there's any problem.

MR. BAXTER: We will lend you a copy, but we would not entertain holding up the proceeding for you to read it at this point.

MR. EDDLEMAN: Thank you, no problem. Do you have a copy available now?

MS. BAUSER: We have one copy with us, and Dr. Hamilton has it with him.

MR. EDDLEMAN: Maybe I can get it duplicated over the lunch.

(Pause.)

MS. MOORE: Your Honor, the Staff may have a copy. I have to wait for one of our people to come back, but we may have a copy that we could loan Mr. Eddleman.

MR. EDDLEMAN: Let's just take care of this at lunch.

JUDGE KELLEY: Yes, let's do it that way. We

7pb11

appreciate your offer, Ms. Moore.

Any other points, Mr. Eddleman?

(No response.)

JUDGE KELLEY: Ms. Moore, anything else that we ought to speak to before we get underway with the evidence?

MS. MOORE: No, I don't believe so.

JUDGE KELLEY: Mr. Baxter?

MR. BAXTER: No.

MS. BAUSER: Applicants call Dr. Leonard Hamilton to the witness stand. We have also distributed to the reporter five copies of Dr. Hamilton's testimony.

Could Dr. Hamilton be sworn in, please?

Whereupon,

LEONARD D. HAMILTON

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

DIRECT EXAMINATION

BY MS. BAUSER:

Q Dr. Hamilton, would you please state your name, position and place of employment?

A My name is Leonard Hamilton; Leonard D. Hamilton. I am head of the biomedical environmental assessment division at Brookhaven National Laboratory.

Q Dr. Hamilton, I draw your attention to a document dated May 31, entitled Applicant's testimony of Leonard D.

7pb12

Hamilton on Wells Eddleman's contention 8(f)(1), Table S-3 coal particulates. This document consists of 17 pages, one attachment and a list of references.

Does this document represent the testimony prepared by you under your supervision for this proceeding?

A It does.

Q Do you have any changes or corrections to make to this testimony?

A Yes. I have a few typographical errors and two additions. On page 7, the formula for concentration the pi signs should have two bars. It is indicated only as a single vertical bar, and of course it should be two bars.

Q Is that the pi sign that is in the denominator of the equation?

A Pi times radius squared. That should be a Greek letter pi.

MR. EDDLEMAN: Oh, you're saying it's a pi and not a tau?

THE WITNESS: Correct. It is obvious that the typewriters have difficulty with Greek letters. There is the mu sign, it is missing its tail many times. And I would just like to give you that as a general thing to watch out for.

On page 13, in the footnote at Table 3, there should be a point between less than 2.5. There should be

7pb13

a point there. It is not 25, it is 2.5.

BY MS. BAUSER:

Q Is that line 6 of the footnote?

A Correct.

And then I just want to bring my personal qualifications up to date. There are two minor matters. On page 5, in the end of that paragraph, the workshop should be workshops plural. And after 1980, it should be and 1984. And at the end of the next paragraph, I would like to add that I have been designated World Health Organization focal point in the United Nations on health and environmental effects management system.

And that means now that I represent the World Health Organization in its meetings on energy, represent considerations on health environmental effects.

Thank you. With those corrections, I think that's all I have.

MS. BAUSER: Mr. Chairman, I would like to move that the direct testimony of Dr. Leonard D. Hamilton be admitted into evidence and physically incorporated into the record as if read.

JUDGE KELLEY: Do you have a number for it? Any objection?

MR. EDDLEMAN: No objection.

MS. MOORE: Before the cross-examination begins,

7pb19

there is a lot of background noises. And we would ask that Dr. Hamilton speak up because it's hard to hear him back here.

JUDGE KELLEY: Dr. Hamilton, okay, they're having difficulty hearing you in the back, so as we get into it --

THE WITNESS: Yes, it's very difficult in this room to judge exactly how to pitch my voice, because I don't want to appear to be lecturing.

(Laughter.)

end 7.

JUDGE KELLEY: They won't mind.

mgc 8-1

(The Board confers.)

JUDGE KELLEY: Dr. Hamilton's testimony is admitted, and you will go first, Mr. Eddleman.

(The written testimony of Dr. Leonard D. Hamilton was received in evidence and follows this portion of the transcript.)

mgc 8-2

CROSS-EXAMINATION

BY MR. EDDLEMAN:

Q Dr. Hamilton, the tone of voice in which you answered Judge Kelley's question is fine.

MS. MOORE: Your Honor, I'm sorry to interrupt again, but is it possible that the light on the camera could be turned off?

JUDGE KELLEY: Yes, ma'am.

MS. MOORE: I apologize for the interruption.

JUDGE KELLEY: Sure.

BY MR. EDDLEMAN:

Q Dr. Hamilton, are you representing the World Health Organization here today?

A No.

Q Are you representing Brookhaven National Lab?

A No.

Q You are appearing as a consultant to CCNL and as their witness?

A Correct.

Q Dr. Hamilton, what is the origin of Brookhaven National Laboratory?

A Brookhaven National Laboratory was begun in 1946 by a group of physicists who returned from the Manhattan Project, and then they came back to the East, were discontented to find that they didn't have the large

mgc 8-3

equipment and machines with which to work on their basic research on particle physics, sometimes called high-energy physics. So there was a group in the New York City area that got together, and as word of this spread -- this was in the beginning of 1946 -- a group in the Cambridge area also got together, and in February of 1946, both groups saw General Groves, who was then in charge of the Manhattan Project, and General Groves was a man of decision, and he said, "Well, I'm not going to give you two laboratories, I will give you one." And the two groups, therefore, coalesced and formed an organization called Associated Universities, Inc., which consisted of the nine northeastern universities at that time most interested in high energy physics. If I can remember them correctly, they were Harvard, MIT, Yale, Princeton, Columbia, Cornell, Rochester, Hopkins and the University of Pennsylvania.

General Groves said he was not prepared to condemn any land for them, and therefore they must choose a site that already belonged to the U.S. Government, and the trustees agreed that they would like to have a site that was within one hour of one of these collaborating universities. And eventually they settled on Camp Hopton. And things moved fast in those days, because the site was chosen and the laboratory began operation in December of 1946. In other words, the Government was approached in February, AUI

mgc 8-4

was formed, Associated Universities was formed as a contracting operation, and it began operation in December at an old Army camp, Camp Hopton, which became Brookhaven National Laboratory.

Each university contributes two trustees. One is a trustee who is an expert in the discipline represented by the work at Brookhaven, and the other is usually a university administrator, a Vice President or a Provost or someone like that, an expert in getting things -- theoretically, anyway -- done. And hence the operation.

At the time the physicists decided that they were thinking in terms of building an accelerator and a reactor, but they also decided that they ought to have at the laboratory people engaged in biological and medical work, people engaged in chemical and mathematics and other disciplines that would relate to the specialized equipment that they were going to have on the site.

And the thrust at Brookhaven, therefore, began as a basic research institute, and it has continued as a basic research institution. In this way, it differs from many of the other national laboratries which have defined missions, similar in a way to the Fermi Laboratory, which has the national accelerator and, of course, the University of California Radiation Lab.

Is that helpful?

mgc 8-5

Q Yes, Doctor, and very detailed. Just out of curiosity, were you present at the creation?

A No. I went to Brookhaven in 1964.

Q I noticed in your statement of qualifications, on Page 2 at the top, it says that you have been involved in assessing the risks of radiation for man, by which I take it you mean human beings, for thirty-seven years. That would be beginning in 1947, correct?

A Yes. That was -- I was at the -- I went from Oxford to Cambridge, and at the University of Cambridge, I first of all worked in the hospital there, and I was partly involved with radiation even then, because I was the Resident Medical Officer to the Radiotherapuetic Center.

But at the end of 1946, I joined the University Department of Radiotherapeutics, and I was working on -- I think I made it clear what I said I was working on a little later on -- the mechanism and action of therapeutic effects on ionizing radiation.

Q Now a therapeutic dose of radiation is artificial or human-controlled radiation that is given to people on purpose for helping to cure them of diseases or conditions; is that correct?

A Correct.

Q And you would have to, in your responsibilities there, assess the health effects to them of that radiation,

mgc 8-6

would you not?

A I took that into account, yes.

Q And you began doing that when you took up this position at the end of 1946?

A Correct.

Q And then from 1950 through 1964, you were on the staff at Sloan Kettering Institute for cancer research and also on the clinical staff at Memorial Hospital in New York?

A Correct.

Q What assessment of the health effects of radiation on human beings did you do during that period, Doctor? It didn't seem quite clear from your statement.

A During that period in my clinical work, in addition to being an assistant attending physician, I was also an assistant attending radiation therapist, and we began a program which was novel for the Memorial Sloan Kettering Cancer Center, which at that time, and still is, one of the forefront centers for cancer treatment in the United States, we began our program on combination chemotherapy and radiation therapy. And I actually began a program in which we treated patients with metastases in the liver with radiation.

In 1957, as I think I mentioned on Page 4, I became associated, at first informally and then formally, with the United Nations Scientific Committee on the Effects of Atomic

mgc 8-7

Radiation. This was a committee that began in 1956 because of the worldwide concern about fallout, and it is a committee that has been responsible for bringing together the available information on the sources, the radiobiology and the risks of all radiation.

In 1957, I became associated with the committee informally, because a colleague of mine who worked at the University of Cambridge with me had become the Scientific Secretary of the committee, and he was a physicist by training, and as I was in the New York area, he leaned very heavily upon me for biological interpretation of -- and a particularly medical interpretation, and I became very intimately interested in the effects of radiation on man, the somatic effect and genetic and radiobiologic effects.

I actually assisted him informally in editing the 1958 report, which was the first comprehensive report of that committee, and then I was hired as a full-time consultant by the Office of the Undersecretary of Special Political Affairs in 1962. And as I stated, I was responsible for the first draft of the somatic effects of radiation in the 1962 report .

I also played a considerable role in revising the radiobiology section of that report. I didn't mention that.

And since 1962, I have maintained a very close

mgc 8-8

relationship with the United Nations Scientific Committee on the Effects of Atomic Radiation, receiving their draft working papers, reviewing them and commenting on them, and receiving, of course, their comprehensive reports on which I relied, to some extent, for my testimony.

Q I don't want to get into too much detail with this, Doctor. I think your answers are very detailed and very helpful, but in this period, you weren't concerned -- or were you? -- let me ask -- with the health effects of coal particles? Didn't that date from more like 1972?

A Correct.

Q And your actual work on radiation health effects directly, apart from your assessment of the effects on patients that you were giving radiotherapy to and were reviewing, began in 1957; is that correct?

A Well, I wouldn't have said that. I would have thought that a Ph.D thesis, which was begun -- work for which was begun in 1946, which was concerned with the mechanism of the action of ionizing radiation, would necessarily involve the consideration of how radiation damages cells, which is fundamental to understanding how radiation affects living things.

Q Okay. So, in fact, I agree with you, but what you are saying is that an understanding of the mechanisms by which ionizing radiation does damage is, in fact, a

mgc 8-9

fundamental part of assessing health effects now; do you agree?

A Yes.

Q Would you likewise agree that an understanding of the fundamental mechanisms whereby coal particulates do damage to human beings would be an important part of understanding and assessing the health effects of coal particulates?

A Yes.

End 8

mgc 9-1

MR. EDDLEMAN: I must confess to the Board that I am in some difficulty here, because this was about as far as I had really prepared, and it is because of my workload, I have all these things to hand out to you. I am willing to go on off the top of my head, or I would ask your indulgence, and maybe we could start our lunch break a little bit early and let me work out the specifics.

I know some of the areas that I am going into, but I think it would be more efficient for all of the parties if I had some time to get my act together.

(The Board confers.)

JUDGE KELLEY: All right.

I think I should say that I am a little distressed to learn that you aren't any further prepared than you are. But be that as it may, let's eat lunch.

It is now 11:30. Let's be back here at quarter of one. We are adjourned.

(Whereupon, at 11:30 a.m., the hearing was recessed, to reconvene at 12:45 p.m. this same day.)

End 9

AFTERNOON SESSION

(1:10 p.m.)

Whereupon,

LEONARD D. HAMILTON

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

JUDGE KELLEY: The Board is now prepared to render a ruling on the motion from the Applicants to reject the proposed testimony of Dr. Johnson, and the motion was supported by the NRC Staff and opposed by Mr. Eddleman and the Joint Intervenors, on behalf of the Joint Intervenors actually.

The proposed Johnson testimony, as we read it and based on the discussion here this morning, which was expanded on a bit, basically seeks to litigate the source term involved in this plant as it relates to the health hazard that the contention looks to. We don't think we need to go through it now paragraph by paragraph and line by line.

The source term theme is the theme that really came out most prominently. We think certainly if we were to reject the source term portions, there really wouldn't be anything of significance left, so we are going to treat it as a single piece.

The argument from the Applicants and Staff essentially is that the source term points are irrelevant.

mgc 10-21

They are said to be outside the scope of the contentions, Roman II E and Roman II C, and the Board agrees with that position.

We did have some source term contentions in this case earlier. They were argued in the summary disposition context and were rejected in order dated January 27th.

II E and II C, as we read them, are relatively narrow. The source term under those constentions is to be treated essentially as given in the FES, the environmental report, but the elements or quantities of effluents are taken as established. It is an elementary rule that we follow here, and indeed we have to in order to make the proceeding move forward, that proposed testimony must be within the scope of the contention that is being litigated.

The proposed testimony from Dr. Johnson, in our judgment, is not within the scope of II E and II C, and therefore the motion to reject that testimony is granted.

It seems to us that if the Intervenors are saying that they have some new and pertinent information, that the proper approach is not to bring it up in testimony under a contention that does not encompass it, but if anything, the petition for the admission of a late contention. When that is done, of course, it is subject to the balancing under the five factors in 10 CFR 2.714, if memory serves me.

mgc 10-3

I would just note here that one major factor in that approach is that you must -- the proponent of a late contention must show that they have good cause for filing late, and I would just observe that the fact that certain information may have come to an Intervenor a month ago or a week ago is not dispositive, if the information has been in the public domain for some time. Then there would have to be some explanation of why it wasn't found earlier.

I note that at least the article here relating to alpha recoil, dated 1977, -- in referring to that option, I don't necesssary suggest that it is a promising avenue, but that seems to us to be the only way that we could get through this matter of source term.

In addition, Dr. Foreman has a comment.

JUDGE FOREMAN: I think that the recoil phenomenon really doesn't change the considerations of the source term anyway, because as this article states -- and I am reading a couple of lines now from the second column of the article, the third full paragraph, and it reads, "The conclusion should not be drawn from this work that more alpha active material has been released through air filters than was known." And then it goes on to discuss the matter.

And so then, source terms are based upon measurements that have been made through the filters. That's all I have to say.

mgc 10-41

JUDGE KELLEY: Well, that is the Board's ruling on that matter.

When we adjourned for lunch, Mr. Eddleman was cross-examining Dr. Hamilton, and we can resume at this point.

CROSS-EXAMINATION (RESUMED)

BY MR. EDDLEMAN :

Q Dr. Hamilton, would you agree that -- well, let me ask you this.

Are you familiar with the meaning of the term, "source term"?

A Source term? Reasonably familiar, yes.

Q Is it your opinion that the 1154 metric tons of coal particulates emissions given in Table S-3 of the Nuclear Regulatory Commission Rules -- and if you don't have a copy of it with you, I could show it to you --

JUDGE KELLEY: What page?

MR. EDDLEMAN: This is Page 519 of the 1984 edition, the red one.

(Pause.)

BY MR. EDDLEMAN:

Q I believe the 1154 metric ton number is in the middle of the page under "Effluents, Chemical (MT)."

Would it be your opinion that the effluents here, gases and entrapment, $SO_x$, $NO_x$, hydrocarbon CO, and

mgc 10-51

particulates, are in the nature of a source term?

A I think I would agree that they are in the nature of a source term.

Q Thank you.

The Footnote 3 to that section appears on Page 520, after the end of the table toward the bottom of the fine print.

Can you locate that in your copy? It's on Page 520. It's in fir print under the end of the table. Note 3 is almost down to the bottom.

A Yes.

Q These are estimated points based on combustion of equivalent coal for power generation. That is what that note says, is it not?

A Correct.

Q So that's what it is a source term of?

A Correct.

Q Okay. Thank you.

I noticed in your resume, I believe it's the fourth page, down toward the bottom of the large paragraph that takes up most of that page, you mentioned that you are a member of the NRC NAS panel on trace element geochemistry of coal resource development related to health from 1976 to 1980.

A Yes.

mgc 10-61

Q Doctor, first the NRC referred to there is the National Research Council, is it not?

A Correct.

Q Is this panel still in existence, or did it complete its work?

A No. It completed its work with the publication of its report.

Q And was that report published in 1980?

A My memory is that it was.

Q You don't make reference to that report in your testimony, do you?

A No.

Q As a member of the panel, what specific areas were you concerned with on this panel, do you recall?

A My memory is that we did some modeling on the distribution of trace metals from the combustion of coal, and my memory is that we came up with an interesting observation.

When you model the actual distribution of these trace elements that were released, the only trace element that appeared to be relatively high in our modeling exercise was iron, and I remember jokingly saying that perhaps this would be a method of showing anemia in various people who were suffering from iron deficiency. The impressive thing is that when you actually model the trace element

m gc 10-4

distribution, you've got remarkably low levels of trace elements.

Q Okay. When you say "actually modeled," did you model this through a computer?

A Yes. These were, of course, computer models using various methods for distributing the material around power plants.

Q Okay. Do you recall -- and if you don't, it's perfectly okay -- but do you recall what sort of assumptions about the content of the coal that was being combusted that were inputs to that model?

A I do not.

Q Okay. Let me ask you, in making this model, at what point do you start with those trace elements? Do you start with them being burned in the boiler? Do you start with the elements or the particles as they come out of the stack? Where do you start with some real data before you start modeling?

A My recollection is that we started with the emissions, the actual emissions.

Q You used an actual chemical analysis of the emissions?

A That's my memory of it, yes.

Q And that would be reported in this report?

A Yes.

mgc 10-8

Q I would ask you if you would agree or disagree with the following statement, and this is talking about stack-collected fly ash from coal-fired power plants.

"The elements showing pronounced concentration trends of increased concentration with decreasing particle size were lead, thallium, antimony, cadmium, selenium, arsenic, nickel, chromium, zinc and sulfur."

MS. BAUSER: Mr. Chairman, I would ask that the witness be allowed to see the context of the statement that he is reading from. We have no idea what he is reading from.

JUDGE KELLEY: I think that's reasonable.

MR. EDDLEMAN: Okay. I don't know if you have this in your notebook or not, and I will be glad to show it to you. This is from Fisher and Natusch, N A T U S C H (spelling), 1979. I believe it's the same report that you referenced for your testimony.

THE WITNESS: Well, there are several of those in 1979.

BY MR. EDDLEMAN:

Q It says this report reproduces a chapter in Analytical Methods for Coal and Coal Products, Volume III, C. Karr, K A R R (spelling), Editor, Academic Press, Pages 49 and 541, 1979. I believe that is your Reference 1. The title is, "Size Dependence of the Physical and

mgc 10-9

Chemical Properties of Coal Fly Ash."

A It sounds similar, but the first page of my article is 489 in Academic Press.

Q All right. Now this is a typescript, so we may not have the same page. Let me see if I can get you a section number.

This is in Section 4, "Elemental Composition of Coal Fly Ash, Particle Size Dependence," under Section A, "Studies of Specific Concentrations."

End 10

llpbl

A So these are specific concentrations, yes.

Q Now here it has the first paragraph as one fairly long paragraph. And I think it's about the fourth or fifth sentence that states, the elements showing "pronounced" concentration trends of increased concentration with decreasing particle size were -- and then it gives the chemical symbols of lead, thallium, antimony, cadmium, selenium, arsenic, nickel, chromium, zinc and sulfur.

A Yes.

Q My question is do you agree or disagree with that statement?

A I agree with it.

Q Okay. Are any of the metals which are listed in that statement, in your opinion, carcinogenic?

A Well, arsenic and nickel.

Q You say arsenic and nickel are. What about cadmium?

A Well, I'm not sure.

Q Okay. Just for completeness, let me ask you, are you sure that the others that we have not mentioned here are not carcinogenic?

A Well, you cannot be sure that nothing is -- you know, anything can be carcinogenic under certain circumstances, but I wouldn't say they were reasonably recognized carcinogenics.

11pb2

Q Okay. Let me refer you to the second sentence following that which states, iron concentrations decrease with particle size for precipitator ash, while no trend was observed in the stack collected samples.

Now, Dr. Hamilton, do you know what an electrostatic precipitator is? I apologize for asking you an elementary question.

A It's a device for removing particles from the stack. Is that a reasonable knowledge?

Q Well, doctor, that indicates that you know what it is. And it does this, I think we can infer by electrostatic means, doesn't it?

A Yes.

Q The observation is that in the precipitator ash, that is the ash that has been precipitated and did not get out of the plant, the iron concentrations decreased with particle size, while in the samples collected from the stack no trend was observed. That is, of changes in iron concentration with particle size, as I take it.

Let me ask you first, is my reading of that sentence reasonable to you?

A Absolutely.

Q You have stated that in your modeling, starting from observed concentrations in the stack ash, if we may call it that, or the particles being emitted from the plant,

11pb3

you found a relatively high concentration of iron distributed around the plant.

A Higher, yes.

Q That is -- well, let me ask you exactly what that means. Do you mean relative to the concentrations of the other elements which were present in the stack ash? The concentrations --

A Well, I think you're confusing the point. I'm talking about the material that comes out of emissions. Nothing to do with the stuff in the stack. Nothing to do with the stuff that's collected. It's the material that is emitted and distributed.

Now it follows from the sentence you just read that iron concentrations decrease with particle size, the precipitator ash. And if they did so, that means that more was getting out.

Q More iron was escaping.

A That's right.

Q Which would be consistent with your modeling.

A It would be consistent with the results that we found.

Q But the inconsistency -- and this is what I don't quite understand -- it states that no trend was observed in the stack collected samples. Now the stuff that's going up the stack is the stuff that is getting out, isn't it?

llpb4

A Well, frankly I don't know what stack collected samples means.

Q Well, let's back up to the first --

A You're saying that stack collected samples are things that come out before or after the filtration?

Q After. I thought you had agreed with me, but I'll be glad to go back over it with you.

A I didn't think I had on that point. I just agreed with the sentence, but I hadn't agreed with what it meant.

Q I didn't think I was asking you what it meant. Well, I think I asked you what the sentence meant, and I thought you said that my interpretation was reasonable.

But let me just start up at the top of this paragraph and try to establish what we're talking about, because I certainly don't want to get you confused.

It says in the third sentence, two types of fly ash samples were analyzed: (1) fly ash collected by the plant cyclonic precipitator and (2) stack collected material. Now I take that to mean that the precipitator ash was collected in the precipitator, which in this one was a cyclone. And that what was collected in the stack came after the precipitator and was collected from what had gotten past the precipitator.

Now is that a reasonable statement of what you take it to mean?

A No, I don't agree. I mean, it's collected in the stack, or it is not emitted.

Q Okay. So what you're saying is if I take a sample of coal particles inside the stack of a power plant, it hasn't been emitted yet. It is not out of the stack, it's not loose in the environment. Is that what you mean?

A Correct.

Q Now let me see if I can figure this out. When you made your model you said that the basis of your modeling was the real distribution of these metals, trace metals, as they came out of the stack. Is that right?

MS. BAUSER: Objection. I don't know what model he's talking about.

MR. EDDLEMAN: The model that he did for the National Academy of Sciences National Research Council Panel that he was on from 1976 to 1980 on trace element chemistry in coal. The thing I started this line off with.

JUDGE KELLEY: Okay?

MS. BAUSER: Okay. Could he repeat the question?

MR. EDDLEMAN: Could the reporter read it back?

(The reporter read the record as requested.)

THE WITNESS: Is that the question?

BY MR. EDDLEMAN:

Q Yes.

A Well. You asked me about this PECH committee report, as I remember, the panel on something --

11pb6

Q Could you spell PECH?

A I think it was P-E-C-H, PECH. I think that was the name of it.

Now you asked me, and it is now four years ago in my extremely busy existence what I could remember about this. And I told you what I could remember, because the only thing that sticks out in my mind was this rather surprising finding that, you know, of all the trace elements that came out -- and I'm talking about stuff measured just after it has exited the stack in the plume -- the thing that was most conspicuous or surprisingly conspicuous was the iron. And that's just a fact that stuck in my mind.

As for the details on how this was all done, I mean I simply cannot remember. You know, the human brain can only accommodate about 200,000 separate facts.

(Laughter.)

And I know where to look it up. And it is in the literature. And it is easily checked. But I don't remember more details than that.

Q Well, I can understand that, doctor. Let me ask you one other question along this line to maybe clarify my own confusion. Do you know what an Anderson impactor is? It's referred to in that first paragraph under A.

end 11.

12pbl

A I should say, no I do not. I assume it's some specialized piece of equipment for collecting fly ash. But, you know, I'm a physician, I'm not a coal engineer. And I rely on other people for that type of technical information. I don't think I'm a coal engineer, but I have access to people who would know what an Anderson impactor is.

Q Did you say that you did not have a coal engineer in your group?

A No, I don't have a coal engineer.

Q Okay. Now I recognize that you are a person of medical background, but there are some things in your testimony that perhaps go beyond strictly medical matters. And I may be asking you about some more of those.

Let me ask you this, and it actually refers to the same section but on a different matter. The analysis of Davison, which is referred to in Section A on the same page of Fisher and Natusch that we've been referring to. The second sentence says it was collected from a power plant using southern Indiana coal.

Dr. Hamilton, in your work on the health effects of various energy sources for the past ten years, have you had occasion to examine or make reference to the trace element compositions in different kinds of coal?

A My group, environmental assessment division, have published a sort of databased modular approach to the

12pb2

analysis of the solid waste of various parts of the coal fuel cycle. And in the process of producing this type of analysis, they have had occasion -- I haven't done this myself -- to analyze the effects of various coals.

In other words, we have assembled a model in which it is possible to put in coal of various characteristics and then process it in a variety of options, and come out with what the waste would be from combusting that type of coal under a variety of conditions.

But I personally have had no -- other than seeing the documents and reviewing them in a general way, I have no firsthand experience in that area.

Q Do I take it then that you did not examine the distribution or concentrations of various trace elements in coals which might be combusted either in the specific power plants that you refer to in your testimony, or in any other power plants in preparing your testimony?

A No, in preparing my testimony I did not look specifically at the trace element content of the coal that was burned in these various plants. I dealt only with the hypothetical emission.

Q Isn't it true, Dr. Hamilton, that the trace elements, particularly the ones that were listed in that first sentence I quoted you from this paper, are concentrated increasingly on a smaller and smaller particles of coal fly

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 LEONARD D. HAMILTON ON WELLS EDDLEMAN'S CONTENTION 8F(1) (TABLE S-3 COAL PARTICULATES)

TABLE OF CONTENTS

## I. Introduction

My name is Leonard D. Hamilton. I am currently, and have been since its inception, the head of the Biomedical and Environmental Assessment Division in the National Center for Analysis of Energy Systems at Brookhaven National Laboratory, Associated Universities, Inc., Upton, New York 11973. The Biomedical and Environmental Assessment Division at Brookhaven National Laboratory is an interdisciplinary group that assesses the health and environmental impacts of all energy sources from exploration to end use. Much of our effort over the past ten years has focused on dose-response relationships for air pollution from fossil fuel combustion for electricity generation. A statement of my background and qualifications is provided in Attachment 1. Statements contained herein are my personal opinion and are not necessarily those of Brookhaven National Laboratory.

Eddleman Contention 8F(1) alleges that Appendix C of the Shearon Harris Final Environmental Statement (FES) underestimates the environmental impact of the effluents in Table S-3 because "the health effects of the coal particulates," quantified at 1,154 MT per year, "are not analyzed nor given sufficient weight" therein. In supporting his contention, Mr. Eddleman states that emissions which "are about two-tenths [sic] of one percent of U.S. emissions" may cause up to 10

deaths per year, a number which is "[n]ot trivial."1/ This testimony will demonstrate that Mr. Eddleman is incorrect and that the health effects of particulate effluents specified in Table S-3 were adequately assessed and given sufficient weight by the NRC Staff.

In the FES, the Staff found that the emissions specified in Table S-3 "constituted an extremely small additional atmospheric loading in comparison with the same emissions for the stationary fuel-combustion and transportation sectors in the U.S.; that is, about 0.02% of the annual national releases for each of these species. The staff believes that such small increases in releases of these pollutants are acceptable." FES, Appendix C at C-2. (Mr. Eddleman misquotes the FES in his statement of support for Contention 8F(1) in that the figure "two tenths of one percent" should actually be "two one hundredths of one percent" or two ten thousandths of the annual U.S. coal particulate emissions.)

## II. Significance of Table S-3 Coal Particulates Issue

Before beginning my analysis of the possible health effects of 1,154 MT of coal particulates associated with the estimated electrical energy needed to support the uranium fuel

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1/ See Wells Eddleman's Response to Staff DEIS, June 20, 1983, at page 14.

cycle for one year, I would like to draw attention to the limited and therefore possibly misleading nature of such an assessment. Operation of a new nuclear power plant, such as the Shearon Harris Plant, will result in the retirement earlier than otherwise possible of old coal-fired plants with much higher rates of particulate emissions and, consequently, greater health and environmental impacts than the Shearon Harris Plant and associated fuel cycle activities. The net result of such a replacement is thus a considerable reduction in health and environmental impacts which is not included in Table S-3 or in my analysis here. With this caveat in mind, this testimony explains why the Staff succinctly and correctly concludes in the FES that there is a miniscule incremental environmental impact from the coal particulates identified in Table S-3.

## III. Basis for Table S-3 Particulate Figure

The emission of 1,154 MT of particulates a year is a hypothetical attribution. It is used in Table S-3 in order to calculate a reasonable estimate of the particulate emissions that might be associated with the electrical energy produced by the equivalent of a hypothetical 45 MWe coal-fired power plant operating for one year; this is the estimated energy needed to support the uranium fuel cycle for one year of the Harris Plant's operation. Most of this energy is used in the uranium enrichment process at gaseous diffusion plants.

The three gaseous diffusion facilities used in the uranium enrichment process are located at (1) Paducah, Kentucky; (2) Oak Ridge, Tennessee; and (3) Portsmouth, Ohio. These facilities are supplied with electricity primarily from power grids. Thus, the impact of the particulates released from coal plants supporting the uranium fuel cycle in fact are distributed in small amounts over large areas. However, for purposes of my calculations to estimate an upper limit of health risks, I have made the following assumptions. From the TVA's grid system, I have assumed the Bull Run Plant to be the only plant serving Oak Ridge, and the Shawnee Plant to be serving Paducah, Kentucky. I have also assumed that the following facilities are dedicated to providing electric power to their respective locations: the Joppa Plant (in addition to the Shawnee Plant), supplying Paducah, Kentucky, and the Kyger and Clifty Plants, supplying Portsmouth, Ohio. I have also assigned the hypothetical 1,154 MT of particulates individually to each of these power plants on the basis of two different assumptions: first, that any one of these coal plants may be singly responsible for the electricity used to produce the entire enrichment of uranium needed to supply the Shearon Harris Nuclear Power Plant; and second, that the source of energy to support the uranium enrichment process may be divided equally among these coal plants (see Section IV.C).

## IV. Particulate Concentration Levels and their Significance

### A. Particulate Concentration Levels

In order to provide an understanding of the upper boundary of any possible risks to health, there are several different ways to analyze the impact of the coal emissions assumed in Table S-3. First, I have estimated the concentration of particulates in the atmosphere produced by the hypothetical 1,154 MT of emitted particulates. This calculation assumes that in the region (50-mile radius) near the coal plant supplying power for each enrichment facility, emissions are uniformly mixed in the volume of air contained in a cylinder with a radius of 50 miles and a height equal to the average height of the mixing layer of air (see Table 1, below). The concentration of particulates in the 50-mile region is a function of the quantity of emissions released by the coal plants and the wind speed. Thus, the total emissions mixed in this volume are related to the time it takes for the wind to blow the particles 50 miles from the stack to the edge of the cylinder. This calculation yields a rough estimate of the long-term average coal particulate exposure over the 50-mile radius area. Of course, on an individual basis, persons closer to the plant would receive greater exposures than those farther away. Similarly, individuals living downwind from the plant would receive larger exposures than those living upwind.

I have calculated the exposure to particulates in the area of each of the coal plants supplying energy for the enrichment facilities, assuming 1,154 MT/yr of particulate emissions and annual average daytime conditions as shown in Table 1.2/

Table 1

Annual Average Daytime Meteorological Conditions
(Holzworth, 1972)

| | Wind Speed (m/sec) | | Mixing Layer (m) | |
|---|---|---|---|---|
| | am | pm | am | pm |
| Paducah, KY | | | | |
| Joppa Plant | 5 | 6.5 | 450 | 1400 |
| Shawnee Plant | 5 | 6.5 | 450 | 1400 |
| Oak Ridge, TN | | | | |
| Bull Run Plant | 5 | 6 | 450 | 1600 |
| Portsmouth, OH | | | | |
| Kyger Plant | 5 | 6 | 520 | 1400 |
| Clifty Plant | 5 | 6.5 | 420 | 1400 |

2/ The small amount of particulates equivalent to the emissions of a hypothetical 45 MWe coal-fired plant actually attributable to the nuclear fuel cycle is in reality much smaller than the 1,154 MT/yr set forth in Table S-3. The allowable emission rate for three of the coal plants that supply power to the uranium enrichment facilities (Shawnee Plant, 0.11 lb/10E6 Btu; Bull Run Plant, 0.10 lb/10E6 Btu; and Kyger Plant, 0.10 lb/10E6 Btu) are roughly one-eighth of the figure given for the particulate emission rate in Table S-3. See 401 Ky. Admin. Reg. § 61:015 (Shawnee Plant); Tenn. Dept. Public Health, Div. of Air Pollu. Control Regs. Ch. 1200-3-16-.02 (Bull Run Plant); Ohio EPA Regs., § 3745-17 (Kyger Plant). The allowable emission rate for the Joppa Plant is 0.19 lb/10E6 Btu, which is roughly four times lower than the figure given for particulates in Table S-3, while the rate at the Clifty Plant of 0.236 lb/10E6 Btu is approximately three times lower. See Ill. Pollu. Control Bd. Rules & Regs., Ch. 2, Pt. II, Rule 203(g)(1)(C) (Joppa Plant); Ind. Control Bd. Regs., § 325 IAC 6-2 (Clifty Plant).

These data are used to calculate particulate concentration using the equation:

$$\text{Concentration } (ug/m^3) = \frac{\text{Emission Rate (ug/sec)} \times \text{Radius(m)}/\text{Wind speed (m/sec)}}{\pi \times \text{Radius}^2(m^2) \times \text{Mixing Height(m)}}$$

(Where a 50-mile radius is $8 \times 10^4$m and 1154 MT particles/yr = $3.6 \times 10^7$ ug/sec.)

Estimated daytime concentrations for the five plants are shown in Table 2.

Table 2

Estimated Average Daytime Concentrations in a Cylinder of Radius 80 km and Height Equal to that of the Mixing Surface Layer of Air

| Location | Concentration ($ug/m^3$) | | |
|---|---|---|---|
| | am | pm | Average |
| Paducah, KY | | | |
| Joppa Plant | 0.064 | 0.016 | 0.040 |
| Shawnee Plant | 0.064 | 0.016 | 0.040 |
| Oak Ridge, TN | | | |
| Bull Run Plant | 0.064 | 0.015 | 0.040 |
| Portsmouth, OH | | | |
| Kyger Plant | 0.055 | 0.017 | 0.036 |
| Cliity Plant | 0.068 | 0.016 | 0.042 |

These simplified concentration estimates depend on both wind speed and depth of the mixing surface layer, which are closely linked. The faster the wind blows, the deeper is the mixing surface layer. Also, faster wind results in reduced residence time, hence lower concentrations. (Holzworth, 1972).

B. Comparative Assessment of Impact of Particulate Concentration Levels

From an uncontrolled pulverized coal-fired power plant -- the type specified in WASH-1248 (see page D-16 at Table D-6), from which the annual particulate emission rate of 1,154 MT was derived -- the respirable particles (<10μm), called "thoracic particles" or "TP", constitute only about 40 percent of the mass of the total particulates (Fisher and Natusch, 1979).3/ Larger particles tend to be deposited in the nose or pharynx and do not reach the lung. Thus, only 40 percent of the particles released potentially are damaging to health. Using the above equation, this means that the concentration of TP that would penetrate the thoracic region, i.e., "both alveolar and tracheobronchial penetration,"4/ would be about

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3/ WASH-1248 states that the 1,154 MT of particulates per year was derived from a particulate emission rate of 22 lb/MT of coal with a heat value of coal of 13,000 Btu/lb. This represents the particulate emission rate of an uncontrolled plant, of which few remain.

4/ United States Environmental Protection Agency (EPA) Office of Air Quality Planning and Standards (OAQPS) Staff Paper in its "Review of the National Ambient Air Quality Standards for Particulate Matter: Assessment of Scientific and Technical Information," January 1982 EPA-450/5-82-001, at page 75.

0.014-0.017 ug/$m^3$. This concentration range is derived using the high and low average concentration estimates specified in Table 2.

For perspective, this concentration of TP (0.014-0.017 ug/$m^3$) should be compared with the EPA's estimate of potentially injurious concentrations of TP. In a critical review of the available scientific and technical information most relevant to the review of primary (health) National Ambient Air Quality Standards (NAAQS) for particulate matter, EPA states:

> Based on a staff assessment of the short-term epidemiological data, the range of 24-hour TP levels of interest are 150 to 350 [micrograms per cubic meter]. Under the conditions prevailing during the London studies, the upper end of the range represents levels at which effects are likely in the sensitive populations studied. Given the uncertainties in translating these results to U.S. conditions and the seriousness of the potential health effects, the upper end of the above range contains no identifiable margin of safety and should not be considered as an appropriate standards alternative. The uncertainties and the nature of the potential effects are important margin-of-safety considerations. Neither the studies used to derive the range nor more qualitative studies of effects in other sensitive population groups (e.g., asthmatics, children), or effects in controlled human or animal studies provide scientific support for health risks of consequence below 150 [micrograms per cubic meter]. . . <u>Based on a staff assessment of the long-term epidemiological data, the range of annual TP levels of interest are 55 to 110 [micrograms per cubic meter]</u>. The upper end of this range overlaps the somewhat uncertain "effects levels" derived from these studies. Due to these uncertainties, the upper end of the range (110 [micrograms per cubic meter]) may not include any margin of safety, and should not be considered as an appropriate standard

> alternative. The lower end (55 [micrograms per cubic meter]) represents a level where some risk of symptomatic effects might remain but no detectable differences in pulmonary function or marked increases in respiratory diseases are expected. Increases in symptomatic effects at the lower levels are uncertain and small in comparison to baseline rates (emphasis added).5/

In other words, EPA has concluded that from both short- and long-term exposures to particulates, the "bottom line" or lowest level of TP at which there may be some risk of health effects is approximately 55 ug/$m^3$. As stated above, the concentration of such particulates in the atmosphere, assuming a reasonable distribution of the entire 1154 MT in a 50-mile radius around a single coal plant, would be 0.014-0.017 ug/$m^3$. This means that even if the 1,154 MT was all distributed by a single coal plant in one place, which obviously is not the case since three different gaseous diffusion plants are used in the enrichment process, the concentration would be approximately 3,000 times smaller than the minimum concentration having some risk of symptomatic effects. While the 0.014-0.017 ug/$m^3$ of TP is an incremental concentration to a pre-existing background concentration of TP, its proportional responsibility for any biological effect is equally miniscule.

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5/ EPA op. cit. pages 112-113.

C. Numerical Assessment of Impact of Particulate Concentration Levels

1. Fifty-Mile Population

In addition to the comparative analysis above, I have calculated some conservative estimates of possible health effects of coal emissions attributable to the Harris Plant's uranium fuel cycle needs. In this calculation, I have used a damage function for respirable particulates in a linear non-threshold way, thereby conservatively assuming that even the smallest incremental particulate dose has an incremental health effect. Moreover, to provide an understanding of the upper boundary of risk from coal particulates emitted in support of the uranium fuel cycle, I also have conservatively assumed that the entire hypothetical 1,154 MT of particulates are emitted and expose the 50-mile population around each of the fossil plants serving the three gaseous diffusion facilities.6/

The calculated health risk relies upon a damage function for fine particles developed recently by the Harvard University Energy and Environmental Policy Center.7/ This study recommends, for quantitative risk assessment, use of only a fine

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6/ This assumption ignores the fact that the 1,154 MT is roughly 3 to 8 times more than the actual particulates those plants emit per 45 MWe equivalent. See note 2, supra.

7/ See "Analysis of Health Effects Resulting from Population Exposures to Ambient Particulate Matter" October 1983 ("Harvard Report"), prepared for the Health and Environmental Risk Analysis Program of the U.S. Department of Energy.

particles (FP) risk coefficient, or particles smaller than 2.5 micrometers.8/ FP represent a small portion of the thoracic particles (TP) previously described. (Fine particles are about 10 percent of the total particulate emissions from an uncontrolled pulverized coal-burning power plant (Fisher and Natusch, 1979).) The FP damage function, which is 1.3 $\pm$ 0.6 deaths/year/$10^5$ persons per ug/$m^3$ FP, is derived from available cross-sectional mortality analyses.9/

Using this damage function, and the 10 percent FP function, I have calculated the expected excess deaths per year from population exposure to 1,154 MT/yr total particulate emissions around each of these plants (Table 3). These estimated excess deaths should be compared with the expected deaths from all causes in the population around each of these plants; this is also shown in Table 3. The estimated excess deaths from particulate exposure are indistinguishable from zero against the background of expected deaths from all causes. The upper limit of estimated expected deaths from particulate exposure corresponds to about one one-thousand of one percent of the mortality rate.

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8/ See Harvard Report at page 8 and Table 1, page 5.

9/ Id. at page 45-50.

Table 3

Estimated excess deaths per year from population exposure to 1,154 MT/yr total particulate emissions and total deaths from all causes.

| Location | Excess Mortality (deaths/yr) | | |
|---|---|---|---|
| | Expected from particulate exposure* | 95% range | Expected from all causes |
| Paducah, KY | | | |
| Joppa Plant | 0.014 | 0.001-0.027 | 2,400 |
| Shawnee Plant | 0.017 | 0.0015-0.032 | 2,800 |
| Oak Ridge, TN | | | |
| Bull Run Plant | 0.044 | 0.004-0.080 | 7,400 |
| Portsmouth, OH | | | |
| Kyger Plant | 0.014 | 0.001-0.027 | 2,600 |
| Clifty Plant | 0.068 | 0.006-0.13 | 11,000 |

* In my original affidavit I conservatively assumed that respirable particles ($< 10\mu m$) or "TP" constituted about one half the mass of the total particulates, while in fact they constitute only about 40% of the mass of the total particulates. I also overly conservatively assumed that the fine particles ($< 25\mu m$) or "FP", as used in the Harvard damage function, were the same as the TP, while in fact FP constitute only 10% of the mass of the total particulate emissions from an uncontrolled pulverized coal-burning power plant (Fisher and Natusch, 1979).

The above estimates are based on the assumption that any one of these plants may be singly responsible for the electricity which supplies the entire enrichment of uranium needed to supply the Shearon Harris plant. Using this assumption, the greatest health risk posed by the coal used to supply uranium enrichment facilities is 0.068 deaths annually for the 50-mile population around the Clifty Plant.

An equally plausible assumption is that uranium enrichment services are being supplied equally by all three facilities to produce fuel for the Shearon Harris plant. Using this assumption, the amount of coal generated for each facility would be divided by three and health risks associated with each site would be similarly reduced.10/ This would result in a worst case health risk of 0.023 deaths annually.

These calculations are conservative estimates. The actual numbers could be zero. As the Harvard Report states:

> [T]he FP coefficient is most representative for an "average" urban aerosol composition and will, to some extent, be subject to the biases noted for sulfates when applied to aerosols having a makeup very different from from the mean composition . . . Although the use of a fine particle mortality coefficient should provide an improvement over previously used cross-sectional indices of particle air pollution, we must emphasize the large uncertainties surrounding any such damage coefficient. Indeed, <u>despite the fact that the coefficient is statistically greater than zero, uncertainties not considered by such analyses (e.g., errors in the measurement of the exposure variable) make it possible that the mortality risk might in fact be zero</u>.

Harvard Report at pages 8, 50 (emphasis added).

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10/ This calculation does not account for different quantities of energy being supplied by more than one coal plant in the vicinity of the uranium enrichment plant.

2. U.S. Population

An alternative way to calculate the health (mortality) effects of coal particulate emissions attributable to the uranium fuel cycle is to consider the health risk for the entire United States due to the long-range transport of these particulates. Based on the Brookhaven National Laboratory's Biomedical and Environmental Assessment Division's matrix results (Rowe, 1981), it is estimated that the average total U.S. exposure to fine particles from all coal power plants is 90 person-ug/$m^3$ per MT emissions. Using the FP damage function cited above,11/ the calculated additional deaths in the entire U.S. population from coal particulates associated with the uranium fuel cycle would be 0.13, with a 95 percent statistical range 0.013-0.26. In the entire U.S., roughly 2 million die annually from all causes.

In assessing the 50-mile and U.S. population risk estimates described above, it is important to keep in mind that linear dose-response functions are not able to distinguish between large doses to a few persons and small doses to many persons. The estimates for health effects of long-range transport are based on exceedingly small exposures to millions of persons. Since the human body has many defenses against low-level exposure to particles, these small doses are probably less harmful per unit exposure than higher doses. The long-range

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11/ The calculation is (90 person-ug/$m^3$ per MT) (1154 MT) (0.1 FP/total emissions) (1.3E-05 deaths-$m^3$/person/ug).

transport health effects estimates therefore probably are biased on the high side.

It also must be recognized that the health-damage function described above links annual average fine particle exposure to increased annual mortality rate. It does not represent the acute effects of exposure but, rather, the long-term impact on the population of a continuing (chronic) environmental exposure. The mortality rates calculated above are based on the assumption that, although the sequence of events leading to its impact on the population is unknown, long-term exposure to fine particles, particularly in childhood, presumably increases the susceptibility to respiratory infection. A history of repeated respiratory infection, possibly coupled with continued fine particle exposure, increases the prevalence of chronic respiratory disease. This leads to more deaths from a broad range of cardiopulmonary diseases. Implicit in this hypothesis, therefore, is the assumption that the exposure to fine particles that eventually is reflected in mortality rate is continuous and long-standing.

## V. Conclusions

In summary, the 1,154 MT of annual particulates referenced in Table S-3 is a hypothetical figure for the sole purpose of calculation of estimates of the level of particulate emissions that might be emitted from a 45 MWe coal-fired plant. This figure essentially is based on the annual quantity of energy

from coal plants needed to support the uranium enrichment facilities that are part of the uranium fuel cycle. Conservative calculations of the upper limit of health risk which may be associated with the 1,154 MT figure indicate that atmospheric concentrations of the amount of particulates attributable to a 45 MWe coal-fired plant reasonably distributed over a 50-mile radius would be 3,000 times smaller than the minimum concentration determined by the EPA to present some health risk. Moreover, conservative calculations of the upper limits of risk of those particulates distributed among the populations around the five fossil plants supplying the uranium enrichment facilities indicate that, at most, a tiny fraction of a death, each year those plants are in operation, could be attributed to the particulate emissions. This quantity is extremely small, particularly when compared to the deaths one would expect in those same populations from all causes. This upper limit of risk is confirmed by an alternative calculation of the impact of the Table S-3 particulates over the population of the entire United States. Moreover, these calculations assume that exposure from particulates is long standing; otherwise, the calculated impact is inapplicable.

## DR. L. D. HAMILTON

## PERSONAL QUALIFICATIONS

My name is Leonard D. Hamilton. My address is: 6 Childs Lane, Setauket, New York, 11733. I am, among other responsibilities, Head of the Biomedical and Environmental Assessment Division in the National Center for Analysis of Energy Systems at Brookhaven National Laboratory, Associated Universities, Inc., Upton, New York, 11973. The Biomedical and Environmental Assessment Division is jointly sponsored by the Department of Energy and Environment and Medical Department at Brookhaven. The Biomedical and Environmental Assessment Division (BEAD) aims at developing a realistic assessment of biomedical and environmental effects of energy production and use. All forms of energy, including electric power generation using fossil fuels, hydro, nuciear, and new technologies, are assessed. The Biomedical Environmental Assessment Division is the lead group in the Health and Environmental Risk Analysis Program, Human Health and Assessment Division, Office of Health and Environmental Research, Office of Energy Research, U. S. Department of Energy, assessing the health and environmental effects of energy production and use and among other responsibilities is harged with producing a comparative health and environmental effects assessment of the different energy systems. The Biomedical and Environmental Assessment Division also has substantial support from the U.S. Environmental Protection Agency and is the lead group for assessing the health effects of complex technologies. The Division is designated a World Health Organization and United Nations Environment Program [WHO & UNEP] Collaborating Centre for the Assessment of Health and Environmental Effects of Energy Systems.

I have been involved in assessing the risks of radiation for man for 37 years, specifically the health effects of nuclear energy for electric power generation for 22 years, and the assessment of the comparative health effects from various energy sources, for the past 10 years. The Biomedical and Environmental Assessment activity formally began in July, 1973; for the past and present year our level of effort is 204 man-months annually.

I received my Bachelor of Arts in 1943 and qualified in medicine from Oxford University in 1945. I am a registered medical practitioner in the United Kingdom and licensed physician in New York State. After several positions in University hospitals, which included a position as Resident Medical Officer at the Radiotherapeutic Centre, Addenbrooke's Hospital, Cambridge, during which time I was concerned with the management of cancer patients undergoing treatment with radiation, I proceeded to research at Cambridge University on histological studies of the mechanism of the action of therapeutic doses of ionizing radiation for which I received my Ph.D. in experimental pathology in 1952. In the meanwhile, in 1951, I had received my Doctor of Medicine degree from Oxford; this is a senior medical qualification in the United Kingdom, roughly equivalent to Diplomate in Internal Medicine in the United States. I am also a Diplomate of the American Board of Pathology (Hematology).

From 1950-1964 I spent 14 years on the research staff of the Sloan-Kettering Institute for Cancer Research and on the clinical staff of Memorial Hospital in New York being Associate Member and Head, Isotope Studies Section at the Institute and Assistant Attending Physician,

Department of Medicine at Memorial. During this time I was also a member of the faculty of Cornell University Medical College and a Visiting Physician, Cornell Division, Bellevue Hospital. Since then I have maintained a continuing association with the Sloan-Kettering Institute as Associate Scientist.

At the Institute my laboratory research was on the molecular structure of the genetic material (DNA) and the cells in man concerned with the immune mechanism. I provided the DNA on which the proof of the double-helical structure of DNA is based, and was one of the first to establish the long life of the immune cells in man. My clinical work in Memorial Hospital involved research on the treatment of patients afflicted with cancer and leukemia with new chemical agents and also with new applications of radiation therapy.

In 1964 I joined the scientific staff of Brookhaven National Laboratory as Senior Scientist and Head, Division of Microbiology, and Attending Physician, Hospital of the Medical Research Center. Since 1973 I have been Head of the Biomedical and Environmental Assessment Group which in 1976 became a Division of the National Center of Analysis of Energy Systems.

At Brookhaven I continued my laboratory research begun at Sloan-Kettering. In addition since my Visiting Fellowship at St. Catherine's College, Oxford 1972-73, I have been concerned with placing all risks in life in perspective; and since becoming Head of the Biomedical and Environmental Assessment activity in 1973, particularly with the assessment of the hazards associated with different energy sources and their use. Our group has the lead responsiblity to DOE for

the assessment of health and environmental effects from various energy systems, and of coordinating such assessments in national laboratories, universities and research institutes in the United States.

My interest in the risks of radiation for man began with my Ph.D. work in Cambridge in 1946 and, since DNA and the immune system are prime targets of radiation damage has continued throughout my laboratory research. I was associated informally with the United Nations Scientific Committee on Effects of Atomic Radiation (UNSCEAR) almost since its inception in 1957, served as Consultant, Office of the Under-Secretaries for Special Political Affairs (UNSCEAR), 1960-62, and was responsible for the first draft of the somatic effects of radiation in the 1962 report. This section covers the effects of radiation in inducing leukemia and cancer in man. I have reviewed most of the working papers of UNSCEAR since then. I was a member of the National Research Council-National Academy of Sciences (NAS-NAS) Committee on Biological Effects of Atomic Radiation, Subcommittee on Hematologic Effects, 1960-64, the NRC-NAS Solar Energy Research Institute Workshop, 1975, the NRC-NAS Committee on Environmental Decision Making, Steering Committee on Environmental Monitoring, Panel on Effects Monitoring 1975-76, the NRC-NAS Health Effects Resource Group, Risk Impact Panel of the Committee on Nuclear and Alternative Energy Systems (CONAES) 1975-80, the NRC-NAS Panel on the Trace Element Geochemistry of Coal Resource Development Related to Health 1976-80, and the NAS-NRC Committee on Research Needs on the Health Effects of Fossil Fuel Combustion Products, 1976-80.

I was a member of the Mayor's Technical Advisory Committee on Radiation, New York City, since 1963 until its end, December, 1977 and

have been a member of the Technical Advisory Committee on Radiation to the Commissioner of Health of the City of New York since August, 1978.

Since 1972, I was a Consultant to the Environment Directorate, Organization for Economic Co-operation and Development; since 1976 served as DOE (formerly ERDA) Representative in the U. S. Delegation to the Environment Committee and U. S. delegate to the Joint Environment-Energy Steering Group. I was a member of the United Nations Environment Programme (UNEP) International Panels of Experts on the Environmental Impacts of Production, Transportation, and Use of Fossil Fuel 1978, on the Environmental Impacts of Nuclear Energy 1978-79, on Renewable Sources of Energy and the Environment 1980, and on the Comparative Assessment of Environmental Impacts of Different Sources of Energy, 1980. I was a member of the Beijer Institute, UNEP, and USSR Commission for UNEP International Workshop on Environmental Implications and Strategies for Expanded Coal Utilization, 1980.

I am currently a member of the U. S. Department of Health and Human Services, Public Health Service Centers for Disease Control, National Institute for Occupational Safety & Health group of consultants advising on the epidemiological study of the employees at the Portsmouth Naval Shipyard where an alleged increase in leukemia was reported by Najarian and Colton in 1978, and a Consultant to the Division of Environmental Health, World Health Organization and the United Nations Environment Programme on the comparative health effects of different energy sources.

I have been Professor of Medicine, Department of Medicine, Health Sciences Center, State University of New York at Stony Brook, New York since 1968 and I am currently a member of the American Association for

Cancer Research, American Society for Clinical Investigation (emeritus), American Association of Pathologists, Inc., the Harvey Society, and the British Medical Association.

I have published more than 150 scientific papers, including many reports assessing the hazards of various energy sources.

## References


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ash?

A That is correct.

Q Okay. You said that your group had published a database on the solid waste in the coal fuel cycle. Now I don't want to take you too far out of your medical field again, but let me just ask you if you know, do these solid wastes include the bottom ash from a boiler?

A I assume so.

Q Would they include the ash collected by any sort of precipitator or pollution control device?

A Yes.

Q You would not consider the stuff that is actually emitted out of the stack to be a solid waste, or would you?

A Well, it's part of -- if you're going to consider sort of a solid waste balance. And I think that's what they did, you would have to take that into account, the emissions that come out. And it's my impression that they did model these.

Q Dr. Hamilton, in making that solid waste balance, you would start off with the various constituents of the coal that is put into the process, would you not?

A Correct.

Q And in a lay person's terms, your balance would be whatever goes in must come out somewhere.

A Correct.

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Q So you could actually take, say, a concentration of arsenic in the coal that would be combusted and figure out in a million tons of coal how much arsenic there was, how much pounds or kilograms of arsenic, could you not?

A Yes.

Q And you could analyze the arsenic content of the bottom ash and the precipitator ash, could you not?

A Yes.

Q And by determining those concentrations on a reasonably representative basis, you could then calculate the amount of arsenic that had been collected in the bottom ash and in the precipitator ash, couldn't you?

A Yes.

Q And by your mass balance, you could figure that any of the arsenic that went in but didn't show up in these ashes that you have sampled came out someplace else, wouldn't you?

A One might reasonably assume that.

Q And one of the obvious places where it might have gone is up the stack, isn't it?

A Correct.

Q I need to refer to my notes.

(Pause.)

Q You referred in your document list to this report, BNL 51305. I believe you referred to that on page

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15 of your testimony. I will probably come back to this, but I just want to ask you because it ties into this line. On page 13 of that report -- do you have a copy?

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A I'm going to get a hold of it.

Q Do you have it in front of you?

A Yes.

Q In the second paragraph it states, "Although organic materials are not necessarily all emitted as ion particulates" -- am I reading correctly?

A Correct.

Q Particles, I am sorry -- "they soon evince, adsorb or otherwise become associated with particulate emissions." Do you agree with that statement?

A Yes.

Q Is there a similar phenomenon to your knowledge with metals in the high temperature output from a coal-fired boiler?

A I believe there is some adsorption of metals on the particles.

Q And would it be possible for a metal which was partly emitted as a vapor under high temperature to then condense and adsorb or otherwise become associated with particulates going up the stack?

A The particles going up the stack, or coming out of the stack.

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Q Well, going up the stack to start out with. The gas stream, I believe, cools as it goes up the stack, does it not?

A I think it's possible.

Q You think it's possible. Do you have, again, in your ten years of being associated with determining the health effects of this, I take it you come from a medical perspective, but have you had any occasion to inquire or have people in your group look into this phenomenon of the association of volatilized metals with particulates?

A No we haven't looked in detail at the physical process of the formation of aerosols, particles, or anything else. We have not really been concerned with that.

We have been concerned with assessing the health impacts of what comes out.

Q Okay. Well, isn't it true, Dr. Hamilton, that when these things come out of the stack, they are entrained together? That is, the particles are flowing in a stream of gas. Is that true?

A Correct, in the plume.

Q Correct, it is a plume. And a plume implies, at least as you come out of the stack some coherence of flood, does it not?

A Yes.

Q Okay. So if I sampled particulates right at the

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top of the stack for example, there might still be volatilized metals in that plume which had not yet condensed upon particles, but which could be associated with them later as the plume cools. That's a possibility, isn't it?

A A possibility.

Q And you don't know yourself of the degree to which this effect takes place, do you?

A No.

Q But for organics as stated on page 13 of BNL 51305 as we just read, this effect does occur, does it not?

A Yes.

Q Now when it says emitted in this Brookhaven National Lab study, do you think the word emitted there is used in the same context that we were discussing emitted before? That is, not emitted until it's out of the stack.

A That's what I was understanding, yes.

Q And in fact, if we refer to page iii, the acknowledgements, the author thanks a certain Leonard D. Hamilton for support and encouragement throughout the project, does he not?

A Yes. That's appropriate.

Q I think it is appropriate.

(Laughter.)

Q Did you engage in any supervision of this project?

A Well, insofar as I am, I sort of head up the

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division when this was going on, I would say that I had what I would call the initiative supervision of the project.

Q You did actually review the document?

A Well, I hardly reviewed these figures in the sense of going over them particularly, checking them all. But the principle of doing the project, in other words the principle that underlies this matrix, I reviewed and approved and encouraged because this represents a considerable simplification on the process of running these long range transport models.

Q The virtue of this in your view is that it simplifies it?

A Well, yes. It avoids running every time all those computer models.

Q In fact, the written text of this report only runs approximately 15 pages, including the references, does it not?

A That is correct.

Q The great bulk of this document is taken up with a large appendix, giving some concentration distributions.

A Correct.

Q I believe I will come back to this later, but I just wanted to establish that while we were on it.

It also says in your qualifications -- wait a second. Pardon me. Do you still have available to you the Fisher and Natusch article that we were referring to

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earlier?

A I haven't disposed of it yet.

Q I hope that we'll dispose of all of these things in a safe manner. Doctor, that first full long paragraph again states toward the end, "Thus, fine particles with their large ratio of surface area to mass will preferentially concentrate volatile, inorganic species."

What do you understand the words volatile, inorganic species to mean?

end 12.

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A I suppose those inorganic elements that are listed above.

Q All right. And he says that because a large surface area of these fine particles -- or they say -- because a large surface area of these fine particles, they will preferentially concentrate volatile inorganic species.

Do you agree with that statement?

A It seems reasonable to me.

Q Okay. It then goes on to state, "In particular, those elements displaying the greatest concentration dependence with particle size generally are associated with elemental forms that booil or sublime at coal combustion temperatures." That is what it says. Do you agree with that statement?

A It seems reasonable, yes.

Q Okay. One moment, please.

(Pause.)

Dr. Hamilton, I believe we supplied to your counsel the identification of a book called Respirable Particles, written by Fredricka P. Ferrera and A. Karim Ahmed.

A Okay.

Q Do you have a copy of it there?

A I hope so. Yes.

Q All right, sir. Does that happen to include a copy of the cover of the book?

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A I don't know what you mean by the cover.

Q That is not a very good reproduction. May I show you the cover of this book, with your counsel's permission?

A Well, show it to me.

(Counsel hands the document to the witness.)

Q Now you have had a chance to look at this --

MS. MOORE: Your Honor, when the witness is through, Staff would like to see a copy of it, too.

MR. EDDLEMAN: I will show it to you right now.

(Pause.)

BY MR. EDDLEMAN:

Q Doctor, do you have any idea what this is a picture of on the cover of this book?

A Well, I would guess it was an electronphotomicrograph of the respirable particle.

Q That's what I would guess also.

A I mean I wouldn't -- you know, I have no basis other than intuition, because I haven't seen that before, but since it has "Respirable Particle" on the top, I know it isn't of the lung.

Q You are familiar with what a photomicrograph of the lung looks like, aren't you?

A Yes.

Q When you say you are not familiar with what a thing like that looks like, do you mean you are not familiar with

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what this particular thing on the cover is?

A Well, I am just deducing that it is an electron-micrograph of a respirable particle. I think that's a reasonable deduction.

Q Have you ever seen an electronmicrograph?

A The answer is no.

Q You have never seen an electronmicrograph of a respirable particle?

A No.

Q Have you ever seen a photomicrograph of a respirable particle?

A I think I must have seen one in some of these papers that I have looked at, photographs of that sort of thing.

Q You are telling me that in ten years of working with health effects of these particles --

A Assessing the health effects, yes. I have never seen an electronmicrograph. Correct.

Q And do I take it, rarely have seen photomicrogaphs of them?

A Only if they have been present in documents that I have reviewed, yes.

Q And perhaps not even until the discovery documents that were produced in connection with this contention were shown to you? Is that possible?

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A No.

Q It is not possible?

A No.

Q Do you recall when specifically you may have seen a photomicrograph of a coal particle?

A I can't fix that in my mind, but I am quite sure, for example, that this article that you furnished, by Natusch or whatever it is, we've been familiar with that for ages.

Q If your counsel will permit me again, let me look into this article and locate some more pictures. Just for the record, this is that same article, "Size and Dependence of the Physical and Chemical Properties of Fly Ash" by Fisher and Natusch, N A T U S C H (spelling), under the sponsorship of the Department of Energy. This is the article that Dr. Hamilton makes reference to on Page 15 of his testimony and which is, I think, No. 4 in his list of references.

You have a copy of that there?

A Yes.

Q I'm not sure if our page numbers are the same, so if I may stick relatively close to you to see if we are matching up, there is a page where Figures A, B, C, D, E and F are shown, way down in a two-by-three grid, fairly early in this article.

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A Yes.

Q Do you have that before you?

A I do, yes.

Q These are photomicrographs of coal particulates, are they not?

A Correct, yes.

Q Some of them appear to have a number of small spheres or spheroids on their surface, do they not?

A Correct. You know, in these Xerox copies of articles, it is extremely difficult to identify what they have on their surfaces. You have to use your imagination.

Q That was one reason why I showed you the book jacket photo, because it is much better quality than what you get out of a Xerox machine.

On the next page, Figures G, H, I, J and K, are they not?

A Correct.

Q And it states in reference to all of these, "Figure 1, light photomicrograph demonstrating the eleven major morphological classes of coal fly ash," does it not?

A It does.

Q And it then lists these eleven classes, doesn't it?

A Yes. I count eleven.

Q You are very thorough, Doctor. You said you are medical person and not necessarily involved with physics

mgc 13-61 or something else, but I wanted to go through with you some kind of common-sense considerations about surface and volume of small particles, if you will.

I want to start off, if we may, with a sphere. Let me ask you if you would accept, if a sphere has a radius, R, that it has a surface area, 4 pi times the radius, $R^2$, and that it has the volume 4/3 pi times the radius, $R^3$, would you accept that?

MS. BAUSWER: I am going to object, just because I don't know where he is leading at 11 in this line of discussion. We have spent about fifteen minutes here.

JUDGE KELLEY: Why don't you do that.

MR. EDDLEMAN: Okay. What we've been going through has a lot to do with adsorption of trace elements and organics, some of which, by the witness' own statement, are carcinogens and some of which may be. I am going to tie some of this back in later, too, but I thought it was an appropriate time to explore the relatioship between the adsorbing surface and the size of the particle, and I can get at it in a lot of ways. I mean, I have done this in my chemistry classes when you explain to people why things react faster when you finally divide them.

What I am trying to do -- and it may be that I could just ask the witness directly some questions about the surface-to-volume relationship, but since he said his

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background was mostly medical, I thought it might be better to just take him through it logically.

MS. BAUSER: I don't understand the relationship with what you described that you are seeking to do to Dr. Hamilton's testimony.

MR. EDDLEMAN: Dr. Hamilton testified earlier before lunch that one should look at the specific mechanisms whereby these things cause harmful effects. Now these are the coal particulates. He is indicating that he is not terribly familiar with their shapes and so on. But what I am getting at is the effect of the shapes, which does to two things.

First, it tends to increase the adsorption of these dangerous materials on these particles, and second, if they were inside the body, it would increase the area over which those things can then be removed by the body -- that is, make it chemically easier to remove them -- and could cause adverse effects.

MS. BAUSER: I still don't know how this relates to this contention. I just don't understand it.

JUDGE KELLEY: Can you point to the portions of the testimony?

MR. EDDLEMAN: It is his conclusion that I am trying to undermine. I don't think he went at it this way, but he said it is a valid way to go at it, to look at the

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specific ways that it operates. That's what I'm trying to do. I'm trying to take him through the mechanics of it.

The basic point I need to establish here is that these particulates in these shapes have an extraordinarily large surface area in comparison to their volume, compared to ordinary visible sized particles or particles that we might deal with in every day life. That's what I'm trying to get at. And if I can establish that -- I mean, I am laying out my case here basically -- but if I could establish that, then I intend to show that both as far as what is on them that is dangerous to people and how it can get off these particles when it is inside people, that increases the danger, and I intend to show it's an effect that Dr. Hamilton has not fully considered in his testimony, if at all, but it is quite relevant to the actual health effects of these emissions.

JUDGE KELLEY: When you say "surface area to volume relationship," the surface area is large in relationship to volume?

MR. EDDLEMAN: That's correct. And as you make the particles smaller, the surface area becomes much larger in relationship to volume. I can show this mathematically, and that is what I was starting to do.

JUDGE KELLEY: Does that help you, Harry?

JUDGE FOREMAN: Yes. But when you are talking about

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the surface that the magnification or at the level that one sees on electron microscopes, there are all sorts of surface characteristics that come to the fore that may or may not be related to particle size, and that is why I'm sort of having trouble following you all the way through after you had shown the electron -- or rather the photoelectromicrographs.

MR. EDDLEMAN: Yes, sir. There is a lot more to this, and I intend to establish a lot of the rest of it, too. Some of these effects are discussed in some of these papers, and I am going to ask him about it. But first I have to get the basics out of the way.

JUDGE KELLEY: Go ahead for the time being.

MR. EDDLEMAN: Judge, it might help, if I'm going to write these things, to use the blackboard, if I might. I would read it while I am writing, of course.

JUDGE KELLEY: I am pausing a bit. There is sometimes a line between cross-examination and testifying that one has to draw. I assume that you will be in the traditional cross-examining --

MR. EDDLEMAN: I am going to ask him if he agrees with the equations that I write, and he can say yes or no or anything he wants.

MS. BAUSER: I am back to my original objection, Mr. Chairman. I don't see how this relates to what

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Dr. Hamilton's testimony is about.

He is attempting to make an independent case that has nothing to do whatsoever with Dr. Hamilton's testimony.

MR. EDDLEMAN: Well, the case is that he is wrong.

JUDGE KELLEY: Well, I think the concern -- that may be the concern that I was expressing. You do have Dr. Hamilton's testimony, and he says what he says. And you may not agree with it, but if you have an entirely different thesis that you want to advance as an evidentiary matter, then you ought to have a witness here prepared to say so.

The scope of your cross-examination is limited to what he has talked about, and that's a rule that I think you're familiar with.

MR. EDDLEMAN: Well, Judge, I'm not a lawyer, and I don't understand that. I thought the scope of cross-examination was to find out whether or not his testimony is accurate, and I thought I could challenge him with other facts.

JUDGE KELLEY: Well, within reason, yes, that too. I am simply saying that if he has -- he has his thesis, and he has put it in this piece of paper. If you have something that you want to -- if you want to come at that from an entirely different angle that he hasn't even spoken to, then -- it's hard to say this in the abstract; let me add

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that.

I think in this particular case we should let this go on a bit longer and see where it takes us. But the normal expectation is that when you have a thesis that's entirely different from the other guy's, you bring in a witness, and you will talk about it. And you are subject to some reasonable limitations in attempting to make a case through cross in that fashion.

MR. EDDLEMAN: Well, I hadn't fully understood it that way. But also, I had always relied on the statements in the NRC appeals that say that the Intervenor is entitled to make their case defensively through cross-examination.

JUDGE KELLEY: Subject to the normal rules on cross-examination. Yes, okay.

MR. EDDLEMAN: Okay, which I'm not sufficiently familiar with, it seems. However, let me try to tie this back into the Doctor's testimony. Let me try to get at what I am challenging.

End 13

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JUDGE KELLEY: All right.

BY MR. EDDLEMAN:

Q Dr. Hamilton, on page 5 of your testimony you say there are several different ways to analyze the impact that the coal emissions assumed in Table S-3, don't you?

A Correct.

Q All right. Would you maintain that the analysis you have made here is the only correct way to analyze those impacts?

A The analysis I made here is the only way in which I know I can come up with a quantitative assessment of the health impacts of particles. At least as far as mortality is concerned. It is not the most exact way, because the Staff has obviously demonstrated that it's possible to go through a more elaborate calculation. But in principle, the way in which I have done it, using what I think is a state of the art damage function is, as far as I know today, is the state of the art method of analyzing in a quantitative way giving you some actual numbers what the health effects of that quantity of particulates would be.

Q You said that the Staff had demonstrated it was possible to go through a more detailed calculation.

A Yes, I have done a simple calculation here, if you read my testimony.

Q I have read it.

A All right. This calculation that I did is to distribute the particles uniformly in a cylinder of 50 miles radius, and a mixing height -- the height of this cylinder is the average height of the mixing layer of that. And I distributed those emissions uniformly. And I distributed them therefore, without regard to real meteorology or the real conditions around these plants, other than some wind speeds that I used.

In addition, I distributed the population uniformly. Now it's possible to improve on this, as the Staff has, by using the real meteorology and the real distribution of the population around these plants. And in that regard, in principle, though they have done very much the same thing that I have done.

Q Wouldn't it also be an improvement in assessing these health effects if you used the real toxicology and the real chemical content, and the real surface characteristics of the particles?

A Well, unfortunately in theory if there was a mechanism of doing that, one might be able to get some more information, if you really knew the real toxicology of the trace metals or the carcinogenics or the surface, and so on and so forth. But in actual fact, the method that we use here, the fine particles is in fact the only approach that one has to put a quantitative sort of bounding estimate on

what these health effects may be.

I mean, our knowledge of the toxicology -- this risk estimate by the way that we use includes the toxic effects of the metals. It includes the toxic effects of the carcinogens. It includes the toxic effects of everything else. And it might include the toxic effects of other pollutants that are present in the atmosphere along with the fine particles, because it is really being used in this context as a surrogate for air pollution in general.

As it is derived, the damage function has been derived from cross-sectional studies. So it is an all-encompassing risk estimate bounding -- an upper bounding of risk estimate that we are making here that is to some extent -- I mean, we would be able to be a little more accurate and a little more precise when we can discern what it is exactly in the particle that's doing the damage and how it comes along. But until we do that, I think we are on very good grounds to say that this is the best sort of upper bound estimate we can give on those health effects.

In my case, as far as mortality is concerned and as far as the Staff has currently made an effort to do this for morbidity.

Q You say this thing constitutes an upper bound. In scientific terms, what does upper bound mean?

A An upper limit of the risk; an upper limit

calculation of the risk, because we're talking here about miniscule quantities of material; miniscule quantities of material. And therefore, the risk is proportionally miniscule that you attribute to these.

Now, of course, these materials by virtue of their surface or chemical composition, you can say well that's a very hazardous surface, or that chemical causes cancer. But I mean, the risks are proportional to the actual quantities. That's the important point.

And a very tiny amount carries with it a very tiny risk. And that's the thrust of this testimony here. And as a matter of fact, we will be able to be more precise about the insignificance of this risk, when in fact we know what the toxicity of some of these things is.

Q This is exactly the point I wanted to challenge when I heard the earlier question, and I would like to take it up now.

JUDGE KELLEY: Why don't you go ahead, Mr. Eddleman. It'll be subject to the right of Ms. Bauser to object, or the Staff to object.

MR. EDDLEMAN: Well, let me explore this upper bound business a little more then.

BY MR. EDDLEMAN:

Q --

JUDGE KELLEY: You can certainly ask when he makes

the statements he just made, you can ask followup questions to find out what that means.

MR. EDDLEMAN: I intend to.

BY MR. EDDLEMAN:

Q When you make an upper bound estimate of a phenomenon, do you believe it is conservative practice to attempt to estimate the various component or contributing factors at or close to their upper bounds?

A I don't understand your question.

Q Let me take a hypothetical example. If I were to estimate the upper bound estimate of something that has three components, and I have a working theory anyway that the thing is the sum of these three components; all right. Now let's say that the first component is between zero and ten, I know, and the second component is between five and 15. And the third component is between 20 and 30.

So those are ranges of the values that the components can take on. Now, if I were to estimate the upper bound of something that is the sum of those components, would it not be sensible to do that by adding the upper bounds of the constituent components in this hypothetical example?

A Well, if they are independent of each other, yes you could add them up. But they would have to be independent, and you'd have to be quite sure that you are not really

adding up the same thing.

Q Okay. Now as to setting an upper bound on health effects, what information do you have as to the independence or interdependence of the components of that damage function that you refer to in your testimony?

A All I know is the following: that the fine particle damage function -- and you can -- eventually you will have a witness who has dealt with it personally -- but that damage function is based on cross-sectional studies of mortality, for example. And it's based on measurements of fine particles in quotes, okay, at a number of stations and measurements of mortality. And there's a correlation between the two.

Now at the same time that they make those correlations -- and that's what this damage function has been derived from -- there are all sorts of other things present in the air apart from the fine particles that could be also responsible. Similarly, there are all sorts of other things that might have caused this mortality.

So that it isn't possible at this stage in the game to separate with any degree of certainty what it is in air pollution that is in actual fact responsible, per se, for the morbidity or the mortality. But there is a working hypothesis. It is possible to get quantitative damage functions which one can tie to fine particles. That's being

done by the Harvard school. Or as we have done it, we've done it for acid sulphates, which is not in contention here.

Let me just say this. The amount that we are dealing with, the attributable amount is so tiny that the incremental effect of this, whichever way you slice it is going to be equally tiny and insignificant. And the reason why I say that I am being very conservative in upper bounds is this. If we are talking about a surrogate damage function for health effects of air pollution, in all fairness I should say that there are two schools of thought now in the United States in this question.

The one group that believes that the ambient concentrations that we now have under the present standards, they're not going to have any health effects on those concentrations. There's another group who still think that you're going to have health effects. So there are really two separate schools.

And one really needs, if you are being realistic about it, to use both models. This is what we recently recommended in our analysis, rather than to use just the one in which you actually quantitate this upper boundary of damage.

When we are dealing with these very tiny doses, the amount of damage that you can realistically attribute to them is so tiny that, you know, I find the whole thing,

the whole exercise a form of medieval scholasticism.

For those of you who are not aware of it, it was in the Middle Ages, monks who had nothing better to do would argue about how many angels can stand on the point of a needle. Or alternatively, whether they could go from point A to point B without going through the middle. And here we are discussing, you know, this tiny, tiny concentration which I agree, the materials themselves in this are hazardous. But when you have a very tiny amount of a hazardous material, it is a very, very proportionate tiny hazard, even under the most conservative circumstances. That's the point I'm trying to get across.

Q Doctor, does that complete your answer?

A Yes.

Q I think I want to come back to some of these tiny amount questions and see about how many devils can get into somebody's lungs later. But right now I'd like to go back to the question in these damage functions and upper bounds.

JUDGE KELLEY: We ought to fairly soon take a little break. We've been on for an hour and 15 minutes. So what's a good point?

MR. EDDLEMAN: Okay. Let me see if I can wrap up one of the loose ends here.

JUDGE KELLEY: Okay.

BY MR. EDDLEMAN:

Q Dr. Hamilton, this damage function that you refer to here, is that damage function made by a form of multi-variate statistic analysis?

A Well, I don't know if it's multi-variable or not. Statistical analysis would be a term I would prefer to use. It is done by regression analysis.

Q Okay, regression analysis. And that is your understanding. I take it you are not a statistician?

A Well, I am trained in medicine in England, I have been exposed therefore to some training in statistics, but I am not a professional statistician. I have published in the Journal of American Statistical Association, but I would not claim to be a professional statistician. But I understand a little of statistics, enough to be a physician.

The commonest things occur most often.

(Laughter.)

Q Doctor, did your statistical publication have anything to do with the health effects of coal particulates by any chance?

A No, my recent one was to do with alternative interpretations of low levels of radiation.

Q Coming back then again to this regression analysis, when you do this regression analysis do you separate out a damage function for particulates or a damage function for

sulfur dioxide, a damage function for nitrogen oxides and so on? Is that how it's done?

A Well, the way the Harvard group did it -- and you will have an opportunity to ask them how they did it -- but they started out with, as far as particles are concerned, they started out with total suspended particles and then they went to thoracic particles. And then they finally got the best sort of relationship when they used this fine particle, the 2.5 micron.

Q By best relationship do you mean a stronger statistical relationship?

A A stronger statistical relationship, yes.

Q So the stronger statistical relationship to health effects comes from the concentration of fine particles. We agree on that.

A Yes.

Q And now you said that many other things could be affecting the health effects that are attributed to particulates by this damage function. The other constituents of the air, possibly other factors. Is that a fair characterization?

A That's fair.

Q Okay. But this damage function only addresses the statistically separated part attributed to particulates; isn't that true?

A That is correct. I mean, it is making a correlation with particulates.

Q Now that means that this upper bound as you characterize it does not necessarily take into effect interactions with other possible causes of morbidity and mortality, does it?

MS. BAUSER: Objection. Interaction of what with what?

MR. EDDLEMAN: Particulates with these other factors that I was talking to him about in three questions ago, sulfur oxides, nitrogen oxides, that sort of thing. Possibly other things.

He's the one who said possibly other factors himself.

JUDGE KELLEY: Does that clarify it?

MS. BAUSER: Yes.

THE WITNESS: Let me just make it very clear because you haven't got the message that I'm trying to give you. The fine particle damage function that I used here, the Harvard people used, all the sulfate damage function that we have used ourselves, these are surrogates for air pollution as a whole. That's the way they are really being used and functioning.

In other words, you could be -- we're relating this to fine particles. But in actual fact, you could not

then go and say, well, the fine particles are doing this, but you know, SO2 is doing something else and sulfates is doing something else as far as air pollution is concerned.

What you're doing here is using fine particles, or as we do, sulfates as a method of calculating what the total mortality effects of air pollution are. And you are using in the Harvard case, fine particles as surrogates. And in our case, we use acid sulfates as the surrogate.

So it encompasses all these other elements, so-called trace metals, carcinogens, the SO2, the nitrates and everything else.

BY MR. EDDLEMAN:

Q You've said that a couple of times. Let me ask you, it doesn't seem consistent with the part of the Harvard report that you quote on page 14, which begins with the words, "The FP coefficient." Now FP stands for fine particulates, doesn't it?

A Where are you reading from?

Q Page 14 of your prefiled testimony.

A The Harvard report says, yes.

Q The FP co-efficient, that FP stands for fine particulate, right?

A Yes.

Q Okay. Now when it says the FP co-efficient that implies that that is one co-efficient, right?

A Yes, but it says -- why don't you go on and read on?

Q Doctor, let me ask the questions please. I'll get to the rest of it in a moment. Now, by distinguishing the FP co-efficient there, isn't that making reference to the fact that there are other co-efficients that take into account these factors that you say are already taken into account?

A No.

Q Why not?

A Because it says here, if you read on, the FP co-efficient is most representative for an average urban aerosol composition, and will to some extent be subject to the biases noted for sulfates when applied to aerosols having a makeup very difficult from the mean composition.

In other words, it's indicating that they are taking it as a sort of representative or surrogate, as I'm saying of a particular type. It doesn't mean because they use the FP co-efficient in the words you can separate FP co-efficient. That is something other than representative of air pollution as a whole.

Q Doctor, integration analysis, when you separate co-efficients aren't you attempting to statistically relate different things to the specific parts for which they are statistically responsible?

A That is correct. But let me just read you something from that testimony. "The range of co-efficients" --

Q Where are reading from your testimony, please?

A I'm going to read you something from the Harvard testimony. I could find it in this book but it would take longer. On page 29 of the testimony of the NRC Staff.

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(Pause.)

JUDGE KELLEY: Okay.

THE WITNESS: Let me read the whole thing because I think this gives you -- gives some explanation of where we are. On page 29, A-47, and this applies to morbidity, but you could say the same thing for mortality too. It says, "The range of co-efficients presented above logically includes zero, because extrapolation below concentrations observed in the studies is not well established. In addition to the extrapolation problem, there are other important contributors to the uncertainties of the morbidity risk estimates. These can be categorized into sampling and non-sampling errors associated with the epidemiologic studies of both morbidity and mortality effects of air pollution.

"Sampling errors refer to the lack of precision of a sample result. If a sample were to be collected without sampling error, then one could reproduce from the sample the results which would have been obtained if the entire population had been included.

"To the extent that this is not true, sampling error exists. Non-sampling errors include a variety of factors that influence the uncertainty of the estimated airborne particle concentration response relationships. They include confounding factors, e.g., cigarette smoking, socio-economic status, occupational exposures, race, prior exposures and residence."

This is an important point that I want to draw to your attention. Co-linearities with other pollutants, e.g., particles and sulfur dioxide. And of course, there could be other pollutants as well. Changing measure of particle pollution that are not entirely comparable, e.g. British smoke and co-efficient of haze versus total suspended particles, TSP. Oversimplifications in estimating personal exposures from data collected at fixed site monitors.

And finally, imbalances due to historical and cross-community differences in particle and source composition.

Now I think that summarizes in a very neat way and succintly all the confounding variables that one has to take into account in using these upper bound damage functions. And I think it makes it very clear that when we are using them, we are using them as a surrogate for air pollution as a whole.

mgc 15-1

BY MR. EDDLEMAN:

Q To follow you, wouldn't errors in the reporting of morbidity and perhaps also of mortality also be a source of error that could be added to that list?

A Well, I think that's in the sampling, yes.

Q Okay. Now you stated that this use of this damage function, as described here with all these sources of error in it, is an upper limit, didn't you?

A I say that the exercise I have done, using the Harvard damage function as a mechanism for trying to get some quantitative idea of the risk, this is an upper limit because I have used it in a linear way. I have made the calculation that even this tiny level of particles, particle concentration, I would assume that when extrapolating down from observations made at very much higher levels, I have assumed that one can make a quantitative estimate.

I have already mentioned to you that there is at least one school of opinion which believes that the effects are definitely zero at current levels, which of course are well above the levels that we're talking about here as a result of 1154 metric tons of particles.

Q Doctor, that's another thing that I want to come back to. But the estimator that you used, this damage function includes all these sources of error, doesn't it?

mgc 15-2

A Absolutely, yes.

Q And are all those sources of error set at their upper limit in that damage function?

A I assume that the errors are distributed in both direction. Wouldn't you? There are so many of them. There is enough to go around both ways, I would have thought.

Q Doctor, I would tend to agree with you about a central limit theorem, but I can't testify. I'm asking you.

A I think it is a reasonable position to take.

Q So your position, without evidence otherwise, is that about half of these would be high and half of these would be low, since there are errors in a lot of them.

A Well, I am using this as a mechanism to get to what the possible health effects of air pollution are in a quantitative way. We've made a very serious effort to do this, and I'm very glad that the Harvard group are making a serious effort to do this also. It is very unlikely to be higher than these figures, because it wouldn't be so difficult to see. It is very difficult to discern the health effects of air pollution, very difficult to discern, and it is most unlikely to be higher, any higher than this. And that is one reason why I believe the figures that we used are reasonable upper bounds.

MR. EDDLEMAN: I think it's a good time for a break.

mgc 15-3

JUDGE KELLEY: All right. Ten minutes.

(Recess.)

mgc 16-1

JUDGE KELLEY: Back on the record. Mr. Eddleman may resume his cross-examination.

BY MR. EDDLEMAN:

Q Dr. Hamilton, one of the many points we touched on in your last series of answers was your idea that if you have a small amount of these particulates that might not be expected to have any effect, is there anyplace that you know of where there is no background of particulates in the air whatsoever?

A No.

Q Did you specifically review the background concentrations of particulates around the coal-fired power plants that you referred to in your testimony?

A I did require some data on that, yes.

Q Is that data stated in your testimony?

A No.

Q It is true, isn't it, that any emissions from those plants would be added to the concentrations around them that are already there?

A Yes, but the important point would be the incremental amounts.

Q That is the amount of the increase, relative to what concentrations are already present?

A Correct.

Q Okay.

mgc 16-2

A Let me just clarify that. The amount that you can attribute to the 1154 metric tons is the amount that, you know, results from that amount of concentration.

Q Okay. Now that amount attributed to the 1154 metric tons would be added to the background concentration of particulates in these areas, would it not?

A Yes.

Q Okay. Can you tell me where in your reference to the Fischer and Natusch paper you figure of 40 percent of the mass of total particulates, which you cite on Page 8 of your testimony, comes from?

A What do you want me to cite?

Q On Page 8, you quote these people as saying that thoracic particles or TP less than ten micrometers constitute only about 40 percent of the mass of the total particulates. Where do they give that figure?

A In the Fisher and Natusch paper.

Q Right. Where in that paper?

A Figure 8.

Q Okay. I have that in front of me.

Now this is a graph, is it not?

A Yes.

Q And it shows some curves, actually lines, although they may be curved a little bit, does it not?

A You can call them curves or lines, whatever you

mgc 16-3

want.

Q Okay. These show a percentage relationship, weight percent less than stated size, I think would be correct.

A Less than stated size is what it says.

Q Well, it would say "than," if the typo was corrected, wouldn't it? It says "then." Maybe the typo has been corrected on your copy, but it is "weight percent less than stated size," isn't it?

A In the copy I have, there is a typo, but I have another copy of the same table in which it is "than."

Q Okay. Then correctly it is "than."

A Yes. That's the one that I used.

Q Okay. Now on the vertical scale, you have a logarithm of particle diameter, correct?

A Particle diameter, correct.

Q Now the 40 percent value is read off that pulverized coal-fired curve, is it not?

A Correct.

Q Okay. And did you, in fact, establish what kind of firing the plants that you referred to in your testimony have?

A No.

Q Do you know if they have cyclones?

A No.

Q Do you know if they are stoker-fired?

mgc 16-4

A No.

Q Okay. It is true, isn't it, that the curve for a cyclone coal-fired plant is something like 70 percent, as I read it, of particles with a diameter of less than ten micrometers?

A Let me just -- cyclone? I find that difficult to believe. But let me just state why I chose the pulverized coal-fired, because WASH-1248 specified pulverized coal-fired, and that's why I used it.

We are dealing with something in Table S-3. We are dealing with something that is in the rule, an actual fact. These plants that we are talking about put out far less emissions. But just for the purpose of making the calculations, I have assumed that they put out the 1154, and I have put it out at that site and assumed that it was a pulverized coal-fired because that was stated in WASH-1248, where that was taken, where the 1154 was taken from.

Q Well, --

A So that's the reason. I didn't bother to inquire whether it was a cyclone or stoker coal-fired plant because reality doesn't enter into it to some extent.

Q You maintain that Table S-3 itself specifies that it is a pulverized coal-fired unit?

JUDGE KELLEY: Just for clarity here, maybe

mgc 16-5

everyone knows this but me, but what's the difference between a cyclone and what is the other one?

MR. EDDLEMAN: Pulverized.

JUDGE KELLEY: Yes. You understand it when you put the question, but what is the differenee?

MR. EDDLEMAN: Well, the easiest distinction is between the stoker and pulverization. The pulverized is broken up much more finely, usually with a hammermill or a ballmill or something like that to a consistency of powder basically.

Then it can be fired horizontally imposed, diagonally, can be fired by certain kinds of burners. One of these is a cyclone. The stoker firing is much simpler. It's just something that ultimately is a screw, but it simply pushes in broken-up coal, and it doesn't have to be nearly as fine.

JUDGE FOREMAN: May I ask a question?

THE WITNESS: I was saying that the reason that I used the 1154 and assumed that it was -- this 1154 was derived from information in WASH-1248, is it says this in the beginning of the table. It also has a footnote, data supporting this table are given in so-and-so, in the survey of the uranium fuel cycle, WASH-1248, April 1974, and I turned to WASH-1248, and I look at Table D-6 on Page D-16, and it says, "Type of Firing, Pulverized Coal."

mgc 16-6

So on that basis, I went back to this Natusch thing and looked at the pulverized coal-fired.

JUDGE FOREMAN: Dr. Hamilton, would your model be very different, or would your results be very different, if you made a distinction between a pulverized and another type, a stoker-fed?

THE WITNESS: Can I show you the histogram on which the particle size is related? It's a little different, but it isn't going to make a great deal of difference.

JUDGE KELLEY: Could you just state what you're pointing to for the sake of the record?

JUDGE FOREMAN: Are we talking about a 50 percent difference or a 10 percent difference?

JUDGE KELLEY: Well, I tried. Can I get into the record what he is pointing at?

THE WITNESS: I am pointing at another reproduction of Figure 8 from Fisher and Natusch, and I am going to show this to Judge Foreman, so that we together can see how much difference it makes.

MS. BAUSER: Fisher and Natusch is a reference to Dr. Hamilton's testimony.

JUDGE KELLEY: Do you have that, Mr. Eddleman?

MR. EDDLEMAN: Yes, I do.

MS. MOORE: Your Honor, could the Staff also see a copy of that document?

mgc 16-6

(Mr. Eddleman tenders the document.)

JUDGE KELLEY: Excuse me, gentlemen. There is a certain awkwardness in having a private conversation between the witness and the Judge.

JUDGE FOREMAN: I apologize.

THE WITNESS: I'm trying to be responsive to the Judge's question.

JUDGE KELLEY: Could you just restate the substance of what was said?

THE WITNESS: Yes. Can I say that I was trying to show the difference between a pulverized coal, where it would be roughly -- we are now talking about the ten micron particle diameter, just to make it clear, and I believe that would correspond to about 40 percent. And then if we move over to the other, it is still below 50. It is certainly not 70. I don't know where you get 70.

BY MR. EDDLEMAN:

Q Havey you checked the cyclone curve, Doctor? Have you tried the cyclone curve?

A For 10, yes.

Q All right. Where do you come down?

A I come down -- I am using a slightly larger diagram. Let me show you the diagram that I'm using.

JUDGE KELLEY: Excuse me, gentlemen. We are going to have a jibberish record unless we have each step

mgc 16-7

of this discussion say what we are referring to.

MR. EDDLEMAN: This is the same Figure 8 in Fisher and Natusch.

THE WITNESS: But you have another version of it.

Let me now try -- I will do this, because I haven't put a mark on this line, and then I will come horizontally down -- or vertically down.

JUDGE KELLEY: While you are doing that, the Fisher and Natusch article that is referenced in Dr. Hamilton's testimony, I don't believe we have that in evidence; is that correct?

MR. EDDLEMAN: I intend to offer it shortly.

JUDGE KELLEY: Okay. Well, there may be an objection to it, I don't know, but it isn't in now, and you do intend to offer it, so we can cross that bridge later.

THE WITNESS: I think I come down about 60.

BY MR. EDDLEMAN:

Q Well, let me show you this version of it. I am using this paper here for my square corner.

JUDGE KELLEY: Which different version is this?

MR. EDDLEMAN: This is in the printed copy, which is the one that I have. I guess this is the prepublication copy, the typescript copy.

mgc 16-8

BY MR. EDDLEMAN:

Q It's on Page 17 of the typescript copy, Figure 8.

A I must admit, on this particular version, it looks different, but I would like for the record to state that this table, by the way, is not original to Fisher and Natusch. In actual fact, it belongs to Vandergriff, A.E. Vandergriff, from the Midwestern Research Institute, in 1961.

It isn't quite accurately reproduced. On one version I have here, it is about 60 percent, and I quite agree on the one you have, it looks more like 70.

Q May I see the one that you are referring to for just a moment? I am going to try to use my method on it and check the results.

(The witness tenders the document to Mr. Eddleman.)

THE WITNESS: Well, it isn't going to make a great deal of difference.

BY MR. EDDLEMAN:

Q Let me mention another difference between these two tables as long as I have them here. The typescript copy has the solid line on the coal-fired cyclone coming down considerably below 10 -- I mean, down to about 5 micrometers.

On the one that Dr. Hamilton has here -- oh, I take it back. It is the same. Right. Okay, it is the same. I'm sorry.

mgc 16-9

JUDGE KELLEY: You mean there is no conflict?

MR. EDDLEMAN: There is no conflict in the parts which are solid and the parts which are dashed. Normally a dashed line means an extrapolation, and they are consistent in that respect. But as to the percent less than stated size, there's a difference between about 65 or 70 percent, depending on which one you look at, for cyclone.

JUDGE KELLEY: I am concerned that the last five minutes may come out less than crystal clear. Is it possible to restate what we are talking about and what we've been looking at?

Do you want to give it a try, Mr. Eddleman, and Dr. Hamilton can comment, and then we can go from there.

BY MR. EDDLEMAN:

Q Dr. Hamilton, you and I both have copies of this Fisher and Natusch paper that appears in "Analytical Methods for Coal and Coal Products," Volume III, Pages 489 to 541, 1979.

I take it that your copy is from the book; is that right?

A Correct.

Q Okay. And mine is a typescript. And both of them have a Figure 8 entitled "Size Distributions for Boiler Particulate Emissions from Coal Combustion and a

chain grate stoker, a pulverized coal-fed unit, and a cyclone-fired unit, reproduced by permission of Southern Research Institute, 1975, and the Electric Power Research Institute.

I have read the title from mine verbatim. Does your title agree with that?

A Well, the Electric Power Research Institute has been cut out in mine.

Q Okay. And this figure consists of a comparison between particle diameter and micrometers on the left or vertical axis and weight percent less than stated size on the horizontal axis.

Yours is the same in those respects?

A I agree, yes.

Q Okay. Now there are three lines or curves, if we may call them that, on this, which -- each has a solid upper end and a dashed lower end that continues all the way to the left margin, don't they?

A Yes.

Q And they are more or less straight as we look at them?

A Yes.

Q More or less straight lines, okay. And these three are the leftmost for a stoker coal-fired, the middle one for pulverized coal-fired, and the rightmost for the

mgc 16-1

cyclone coal-fired.

A Correct.

Q And you said on Page 8 of your testimony that the 40 percent that you quote from this article by Fisher and Natusch comes from this figure.

A Yes.

Q And in fact, your figure and mine agree that at 10 micrometer particle diameter, the weight percent less than that size is 40 percent for pulverized coal-fired.

A Pulverized coal-fired; that's correct.

Q Now the problem is that for cyclone coal-firing, which is the rightmost curve on mine, the weight percent less than stated size of 10 micrometers appears to be about 70 percent, and on yours it appears to be somewhere between 60 and 65; is that right?

A Correct.

End 16

mgc 17-1

MR. EDDLEMAN: I think that describes it.

JUDGE KELLEY: What again is the cyclone-fired?

MR. EDDLEMAN: Judge, I don't know fully enough to describe it.

JUDGE KELLEY: Do you know, Dr. Hamilton?

THE WITNESS: No, not really.

JUDGE KELLEY: Do they both employ pulverized coal, or do we know that either?

MR. EDDLEMAN: I think you about have to to use a cyclone, but I'm not absolutely sure of that, even.

JUDGE KELLEY: Okay.

THE WITNESS: But you appreciate the reason that I chose pulverized coal-fired is that this is what is definitely referred to in WASH-1248 in the table where they specify the characteristics of the coal-fired power plants. It just says, "Type of Firing, Pulverized Coal."

BY MR. EDDLEMAN:

Q Doctor, could I take a look at that page for a second?

(Pause.)

MR. EDDLEMAN: If counsel doesn't object, I would like to read these characteristics.

BY MR. EDDLEMAN:

Q Doctor, would you mind checking me on this?

"Electrical efficiency, 33 percent. Heat rate,

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10,300 Btu per hour per kilowatt. Heat to cooling condensers, 5300 Btu per hour per kilowatt. Heat to stack and elsewhere, 1600 Btu per hour per kilowatt. Heat value of coal, 13,000 Btu per pound. Coal use rate, 363 metric tons per hour. Sulfur content of coal, 2 percent. Ash content of coal, 8 percent. Type of firing, pulverized coal. Particulate emission rate, 22 pounds per metric ton of coal."

Are those correct?

A Those are correct.

Q And it states that this plant is at 100 percent load factor, right under the title of the table, does it not?

A Correct.

Q Okay, thank you.

Now nowhere in this table does it given an emission rate in pounds per million Btu. But I presume that you could calculate that emission rate from the data given, could you not?

A Correct.

Q Okay. And let me see if I can describe to you a method for the calculation.

We know that we have 22 pounds of particulates per metric ton of coal, correct? That's the bottomline of that table?

mgc 17-3

A Yes.

Q And we also know that each pound of coal has 13,000 Btu heat value, do we not?

A Yes.

Q So in a metric ton, having 2204 and a fraction pounds of coal, we would then have that number of pounds times 13,000 Btu per pound, giving the total Btus in one metric ton of that coal, would we not?

A Yes.

Q And if we took the 22 pounds of particulates and divided by the product of 13,000 Btus per pound and 2204 pounds, that would then give us an emission number in the units of pounds per million British thermal units, would it not?

A Correct.

Q Okay. And isn't pounds per million British thermal units a fairly common measure of the emission rate of particulates from coal-fired power plants, Doctor?

A Well, it is the usual rate at which emission standards are expressed. In other words, one usually expresses standards in so many pounds per $10^6$ Btu.

Q Okay. Now did you make any investigation of the pounds per million Btus actual emissions for any of the plants that you referred to in your testimony?

mgc 17-4

A I thought I had stated on Page 6 of my testimony that I listed --

Q Okay. You do have the allowable emission rates. Now those are the current regulations, as best you know them, right?

A Correct.

Q Now for these plants, did you also investigate the actual height of the stacks from which these particulates are emitted?

A I did not.

Q Did you examine the wind rows of wind directions around the power plants in question?

A No.

Q Did you inquire into the characteristics of the plume of the emissions?

A No.

Q And therefore nothing about the dispersion or height of the plume at all.

A No.

Q Now you state, do you not, that you assume that the particulates emitted from these plants are uniformly distributed in a cylinder which is approximately 50 miles in radius and which has a height equal to the average height of the mixing layer of air as expressed in Table 1? That's on Page 5 of your testimony.

mgc 17-5

A That statement is correct.

Q Okay. And you take your mixing layer data from this reference of Holzworth, 1972, as stated in Table 1?

A Correct.

Q Now you stated before that your calculation represents an upper limit.

A No. I said the use of the damage function represents an upper limit, not the overall calculation.

Q On Pages 8 and 9 of your testimony, you state that using the above equation, this means that the concentration of total particulates that would penetrate the thoracic region, and you give a footnote as to what that means, will be about 0.014 to 0.017 micrograms per cubic meter. This concentration range is derived using a high and low average concentration estimate specified in Table 2.

A Yes.

Q So you actually used those uniformly distributed concentration estimates in Table 2 to get this concentration of particulates, did you not?

A Yes.

Q And the "above equation," is that the equation on Page 7 that states, "Concentration micrograms per cubic meter"?

A Yes.

Q Okay. "Equals the emission rate in micrograms

mgc 17-6

per second."

MS. BAUSER: Objection. He has already answered the question. There is no reason to read the whole equation.

MR. EDDLEMAN: All right. I won't read it. No prob em.

BY MR. EDDLEMAN:

Q But that concentration is the concentration, assuming that all the particles are moving out from the center at the wind speed that you use in Table 1, isn't it?

A Correct.

Q Dr. Hamilton, in your experience or your knowledge, have you ever heard of a plume from a coal-fired power plant behaving like that, streaming out a uniform velocity in all directions at once?

A No.

Q And you still maintain that the calculations using this are an upper limit?

A No. I didn't say the calculations using this are an upper limit. I said, as I have said before, that the use of the damage function gives me an upper limit.

Q Well, the damage function is applied to these concentrations, is it not?

A That's right.

Q Okay. Now let's be real clear about this. You say that for a given concentration of particulates, the

mqc 17-7

damage function represents an upper limit of the damage which would be done by that concentration of particulates?

A Correct.

Q Okay. Now as to this mixing, you don't consider the effects of these particles after they have gone past 50 miles from the plant, do you?

A Not in this calculation, but I do later on in my testimony. I considered the long-range distribution throughout the United States.

Q All right. Now let me ask you this hypothetically. Suppose there were two identical coal particles, one of which had been admitted from -- or emitted, pardon me -- from CP&L's Cape Fair plant over to the west of Raleigh, and another of which might have been emitted from a coal plant in Europe or the Soviet Union or China, and let's assume that the two particles are identical.

By breathing either of those particles, either one will have the same effect on me, wouldn't it?

A Well, if they were of similar chemical composition, yes.

Q Okay. So the chemical composition of these particles is important in determining their effect, isn't it?

A Yes.

Q All right. Now if a person were exposed to a

mgc 17-8

higher concentration of particulates, then by this damage function there would be a higher expected effect, would there not?

A Correct.

Q Okay. And I think you already agreed that the plume actually tends to -- I want to say be a plume -- that is, to stream out in basically one direction.

A Well, the plume will vary, of course, depending on the direction of the prevailing wind.

Q Right. It will follow the wind.

A Yes. But this calculation, you have realized, is a simple calculation which I have done in order to get an idea, a bounding idea, of what the risk might be.

Q Well, now, in bounding this risk, don't you effectively assume by making the calculation this way that the plume blows in a given direction with equal probability all the way around the points of the compass?

A Correct.

Q And don't you also assume that the plume is at all times, even when it comes right out of the stack, uniformly mixed from the ground to the top of the mixing layer?

A Correct.

Q And the plume is actually more concentrated than that, at least in the vertical direction, isn't it?

mgc 17-9

A It is concentrated in several directions, but it is more concentrated in some directions and more diluted in others. So I think by averaging it out and using a linear damage function, you're not really -- you know, I don't really think you are underestimating.

Actually, when you talk in terms of real meteorology, you are probably doing an overestimate by this method.

Q Well, Doctor, which direction is it less concentrated in than your model assumes?

A It is less direct -- less concentrated -- if the wind blows in a particular direction, it is less concentrated in my model, or in my thinking anyway -- this isn't a model that I used. I used uniform distribution. But if the wind blows in one direction, the concentration is lower in the opposite direction where the wind is not blowing.

Q But isn't it true that the actual concentration of the plume itself is higher in any given direction because the plume is not, in fact, uniformly distributed in the vertical direction?

MS. BAUSER: Objection. Higher than what? I don't understand the question.

MR. EDDLEMAN: Higher than assumed in his model.

End 17

18pbl

THE WITNESS: I have already said yes, but I am dealing with an average distribution.

BY MR. EDDLEMAN:

Q I understand. Are you through with that ansnwer?

A Yes.

Q Okay. Now, if we take this plume, the real plume, which is more concentrated then you assume in the vertical direction and we average it by swinging it around to all the points of the compass as you assumed, wouldn't you come out with a higher average concentration?

A A plume is more concentrated vertical. Is that what you mean by vertical, something that goes up and down?

Q In other words, it's not completely spread out from the ground to the mixing layer, is it, in reality?

A I see. You mean, you think that it might be more -- I mean, you think it's more concentrated somewhere in the middle area; is that right? It's not uniformly distributed. I'm diluting it out; is that right?

Q That's right.

A Well, the answer to this is, if we have with the good fortune the fact that the NRC actually has people who have actually used the real meteorology and have actually done the models around these various -- used good meteorology -- have actually done the modeling and distribution around these plants. They've actually gone through that exercise

18pb2

and the answers are in that testimony, I believe it's fair to say that they'd come out with lower concentrations than I have, if my memory serves me correct.

Their concentrations using the real meteorology are lower than mine fine particle concentration.

Q Well, Doctor, since you have uniformly distributed all of the particles, both radially and vertically from the ground to the mixing layer, how is it possible to come out with a lower concentration?

(Pause.)

A I am looking now at the Staff's area concentration. I've got the actual figures here.

Q What page are you referring to, Doctor?

A If you look at Table 1 in their testimony.

Q On what page, Doctor?

A Well, it's the end of their testimony. It doesn't have a number, but it would be page 45.

Q All right, I have it.

Now I see that those numbers are lower than what you came out with, but my question is, how is that possible?

A You have got me confused. I'm sorry, what did you say just then?

Q I said, Doctor, I see that these numbers are lower in general than the ones you come out with, the 0.015, but what I am saying is -- well, hang on a second. Let me

18pb3

check these numbers. I'm not sure I have everything. Oh, I see. You have 95 percent confidence intervals also, which they don't give. They are giving annual averages, are they not?

A There can be all sorts of reasons why their figures might be lower than mine, because the real meteorology -- for example, I can give you all sorts of hypothetical reasons. But the real meteorology might distribute these things much faster. The residence time may be lower.

They are dealing with the real thing.

Q They are dealing with a model of it, are they not?

A Yes, I know. But it is closer to the real thing than mine. I made a simplified calculation for the purpose of, you know, arriving -- I thought the effort I put into this was proportional to the -- well, I did it initially to see how it would come out. But I think it was proportional to the, you know, what I thought the size of the problem was.

And to get some idea of the boundary here. And I didn't, you know, from my point of view I personally didn't think it was justified to go into this business of looking at the real meteorology, and really what happens, because I felt the effects were going to be so miniscule that it didn't seem to be warranted.

18pb4

But anyway, the NRC have gone ahead and done this very careful study, which I think answers all these questions that you are raising. And I admit, I have used a very simplified model. You can get all the information about the real meteorology from them. But I think that the model that I used was adequate in order to arrive at a reasonable conclusion about the size of the health effects from these tiny increments of particles.

Q Well, Doctor, if you make an answer about their testimony, I'm not sure I can object to it, and I probably won't. But I believe that if I asked you to defend the NRC Staff's testimony your counsel might object to the question because you didn't write it. And I'm just trying to explain to you why I'm asking you about your testimony and not the Staff's.

A That is not a question, is it?

Q No, it's not a question. Okay, let me ask you a question. What stack height are these concentrations that you calculated predicated on? Any particular one?

A I know it was not predicated on the actual stack heights of these various plants. The actual stack height, I just don't remember what the stack height was. I don't know that we actually assumed any stack height.

Q Well, you wouldn't have to for that uniform distribution that you gave early on, would you?

18pb5

A No.

Q But you stated that if the particulates get out of the 50-mile radius and still have an effect, that you took care of that in your second section where you are calculating a dispersion.

MS. BAUSER: Objection. That is not what he said.

JUDGE KELLEY: Could you restate the question, Mr. Eddleman?

MR. EDDLEMAN: I'm not sure what he said, and I don't even know where I could tell the court reporter to go back to find it. Let me see if I can find something in

side 2 bu

his testimony that I could tie it to.

BY MR. EDDLEMAN:

Q On page 15 of your testimony, Doctor, this is where you are assessing the effects of the particulates if they get any distance from the plant. You know, between zero and the United States borders, correct?

A Correct.

Q And you didn't consider effects outside of the United States, did you?

A Correct.

Q Okay. In doing this you used this Brookhaven National Laboratory biomedical and environmental assessment division matrix result, which is this BNL 51305 by Rowe that we were dealing with earlier.

18pb6

A Correct.

Q Now it is estimated, it says, based on this document that the average total U.S. exposure to fine particulates from all coal power plants is 90 person micrograms per cubic meter per metric ton of emissions.

Can you tell me where in this report that citation comes from, Doctor?

A Yes.

Q Would you please?

A If you look at Table 2 on page 12 you see the cumulative probability distribution of particle concentration and exposures for a randomly located power plant in the continental United States. And you see the cumulative probability.

Q Yes.

A And you see the column labeled cumulative probability and if you cast your eye down to a cumulative probability of 0.50.

Q 50 percent.

A The total population exposure is the next column given in person micrograms per cubic meter per ton.

Q Right.

A And there is a figure there, 92.6.

Q Correct.

A And that has been rounded to 90, and that is the

18pb7

source of that figure.

Q All right. But the actual figure would be 92.6 from this source?

A When you are using this as a damage function, the figure would be rounded to 90.

Q Would be rounded to the nearest ten, Doctor?

A Correct. I mean, to the nearest ten, 90.

Q So what you're saying is only the first digit in any of these things is significant.

A No, I'm not saying that. I'm just saying in that particular thing, when you're going to use this for a general average for the United States, 90 is a correct rounded figure to use.

Q You would not use 92.6 even though it says it?

A No.

MS. BAUSER: Objection. He has answered this question. It's the fourth time you've asked the same question.

BY MR. EDDLEMAN:

Q Doctor, why wouldn't you use 92.6?

(Pause)

A Because I think that when you are going to use -- this is a very average damage function, you would round it off to 90, that's why. I just think that's good scientific practice. To be precise, to use 92.6 would be, you know, precision without accuracy, if you know what I mean.

18pb8

Q Okay. So it is predicated on significant figures then, isn't it?

A Correct.

Q All right. Let me try to get some examples and see how you are rounding. Would you round to the 16.3, the cumulative probability of 0.05 in that same table?

MS. BAUSER: Objection. I don't see any relevance in going through all this, figuring out how the figures --

JUDGE KELLEY: Is the question, would you round 16.3 to 16?

MR. EDDLEMAN: Or to 20, yes.

JUDGE KELLEY: I think the 16 is nitpicking. I'm not sure about the 20. What's the purpose of the 20?

MR. EDDLEMAN: I want to see how big of a range of change in the number. In other words, when you have a significant figure -- well, I could ask him the one that's right above it. Would you round 157 to 150 or 100 or 200?

JUDGE KELLEY: Well, I think it's going to be kind of easy to beat to death, but why don't you try another question or so, and then we'll go on to something else.

MR. EDDLEMAN: Let me try that one.

BY MR. EDDLEMAN:

Q If you were using the 75th percent cumulative probability of 157 and you wanted to apply that to a damage function, what would you round that off to, Doctor?

18pb9

A 160.

Q Okay. Now I'm just a little confused here, Judge. I honestly am. I'm not trying to mess this up. But would you round 16 to 20, or would you round it to 16?

A You know, frankly, I would like to be cooperative, and I want to answer the question, but you know, I don't see what this has got to do with my using this for an average for all U.S. coal plants, this 90 person micrograms per cubic meter. Frankly, it really baffles me. I am really baffled.

I want to be a cooperative witness, but it's quite obvious that when we are dealing with the entire United States and you are dealing with, you know, a damage function that involves the entire population of the United States, what I have done here to round 92.6 to 90 person micrograms for the purpose of this calculation is, you know, perfectly proper thing to do. And it wouldn't make a bit of difference if I used 92.6 as the suggestion.

But it's just -- well, I don't know. I would like to have the guidance of the Board as to whether they really feel this information is going to help them in their deliberations as a licensing body, because, you know, I've put a lot of work into trying to help you.

JUDGE KELLEY: I understand, Doctor. If the difference is de minimus if you use round numbers, why don't we move on?

18pb10

MR. EDDLEMAN: All I was trying to do was trying to understand how he rounds. And I still don't know, but it probably doesn't matter a lot.

Now the difference there would only be 3 percent between 92.6 and 90, wouldn't it?

MS. BAUSER: Objection. I thought we were going to move on here.

JUDGE KELLEY: Let's move on.

MR. EDDLEMAN: All right. You can calculate from the numbers anyway.

BY MR. EDDLEMAN:

Q All right. This is for a randomly located power plant in the continental United States, is it not, Doctor? This Table 2 in this document?

A Correct.

Q Okay. And footnote 8 says, it assumes a uniform probability that the power plant will be located in any air quality control region of the 48 contiguous states.

A Yes.

Q Now what air quality control region are the power plants that you refer to in your testimony, what regions are they located in, Doctor, do you know?

A Well, I would have to study that. Again, I just felt that from the point of view of the United States as a whole, it isn't going to make all that much difference. And

18pb11

I felt that this figure of 90 is a reasonable figure to use therefore.

Q Well, Doctor, apart from the reasonableness of using the figure 90 rather than 92.6, isn't it true that this document has an extensive appendix giving exposure distributions from all the air quality control regions in the country?

A That's correct.

Q Well, so by looking up a few more pages you could have gotten the distributions from the places where these plants are actually located, couldn't you?

MS. BAUSER: Objection. There is no reason for Dr. Hamilton to answer that question. It's not relevant to his analysis.

MR. EDDLEMAN: Well, I want to know what he didn't do it. And first I want to establish --

MS. BAUSER: He has already explained the basis for the calculations that he did. He has repeatedly explained the basis for the calculations that he did.

JUDGE KELLEY: One at a time, please. All right, Mr. Eddleman, your question is why didn't Dr. Hamilton look at the actual data for the areas in which these were located.

MR. EDDLEMAN: Right. If it's in this document, why didn't he look at it?

JUDGE KELLEY: I will overrule the objection.

18pb12

THE WITNESS: Well, I wanted to make as simple calculation as possible. A simple calculation, and one which I think is justified by the size of the problem.

JUDGE KELLEY: Did you think that the actual location was irrelevant for your purposes?

THE WITNESS: Well, yes. From the point of view of making this simple calculation for what the effects would be on the entire United States, yes. And I am willing to explain that to the Board if the Board would like an explanation as to why.

JUDGE KELLEY: Go ahead.

THE WITNESS: All right. Well, the reason is this. I really don't put very much weight on the significance of this figure that I calculated here of 0.13. And the reason I don't put much weight on it is based upon --

JUDGE KELLEY: 0.13 is in the table?

THE WITNESS: No, 0.13 is on page 15 of my testimony. That is the additional deaths that I calculate would be due to this 1154 metric tons. The reason I don't put much weight on this is simply this: this is based on spreading this tiny dose among 200 million people. That's what it is based on. So that essentially you have a very, very tiny increment of this very tiny dose to 200 million people.

Now the damage that I calculated is as a result of adding all these little tiny possibilities together to come

18pb13

up with this figure of 0.13, with a 95 percent range of 0.13 to 0.26. Now that means that for each individual American, the tiny increment, the probability of that doing them any harm is infinitesimally minute, as you realize. It is that divided by 200 million.

And this is where I think the biological reality of the situation, you know, clashes with the statistical analysis and application of the linear hypothesis. I haven't really -- I couldn't give you an analogy. I would like to do it in the radiation area because -- well, yes I can do it in this particle area.

Suppose that we had a calculation that said amongst these 200 million people, as a result of this particle exposure, we had a one in a 100 million chance of having a fatality. Let's exaggerate the odds, okay? According to the linear hypothesis, my calculation which is ten times higher, my calculation is more than that. It is 20 times higher. But my calculation would therefore say we would have two deaths according to this method.

But the odds for each individual American, if the odds were one in 100 million of dying as a result of this particle, would be 999 million to one. The biological reality is such that if everybody has that one in a 100 million chance, in reality they would die of other causes. You know, it is stretching the realms of possibility to consider that

18pb14

to take those figures at all seriously.

I mean, one arrives at them. They are statistical. You know, they are consonant with the statistical results. But just as -- but, I mean statistics don't necessarily correspond to reality and life. Just because something is a statistic. There are other sources of statistics. There are accidental statistics in motor cars and things of this sort. But these hypothetical risk assessments don't fall in that category.

As a matter of fact, what I calculated here is that in 200 million people, you would have .13 death per year. But you see, the odds are that every, you know, each of those people, if those were the particular risks that they were getting from these particles, the odds are so great that they would die of other causes, that I feel this is where, this is the ridiculous application of the linear hypothesis. That's what I feel.

I don't know whether I'm making this clear, because although it is statistically correct, it doesn't correspond to biological reality. And it's particularly true when you're dealing with these very, very tiny risks.

JUDGE KELLEY: Are you saying that in biological reality you see that the risk is zero?

THE WITNESS: Well, it's essentially indistinguishabl from zero.

end 18.

mgc 19-1

BY MR. EDDLEMAN:

Q Doctor, in light of that explanation, isn't part of the analysis you made that the statistical estimate of the risk is a real risk applied equally to every individual?

A Well, that's the way it's done, yes.

Q No. I'm asking you about your explanation.

A Correct, yes.

Q All right. Now, Doctor, you have stated that the odds are vast in favor of someone dying of other causes, even if they were exposed to these things and the damage function were correct, haven't you?

A Correct.

Q Well, isn't it true in your own testimony that you say that it is vastly probable that people are going to die of other causes -- that is, that these deaths are small in comparison to the deaths from all other causes around these plants?

A That is correct, but I haven't given the explanation of why I think that even these aggregated figures possibly are misleading.

Q Well, you cannot exclude the possibility that someone could die as a result of these emissions, can you?

A Attributable to this concentration of emissions?

Q Well, attributable to adding that to background,

mgc 19-2

because I think we agreed it is being added to background, didn't we?

A Yes. But even if you add it to the background, I would find it very difficult to believe, in the areas that we are talking about, the addition of those -- the addition of this increment to either the area around Massa County for Joppa and Shawnee; Anderson County for Bull Run, Jefferson County, et cetera.

You know, I find it difficult to believe that in reality this tiny increment, even to the background that they have, could lead to -- in reality, to a real risk of mortality. That's the answer to your question.

Q But the Harvard study does report that that coefficient is significantly different from zero, doesn't it -- the damage function coefficient?

A Well, it's statistically different from zero, but if you read what they say about it, if you read what the Harvard report says, it is quite clear that an alternative could be zero for a number of reasons. Again, they say quite definitely you can't exclude zero.

Q You couldn't exclude a higher number either, could you, higher than that damage function?

A Well, I think you can, because if it was higher than the damage function or higher than the 95 percent confidence limit of the damage function, it wouldn't be

mgc 19-3

so difficult to identify deaths from air pollution.

Q Are you saying that all those errors that we discussed earlier wouldn't have any effect even if the number were a little bit higher than that damage function, even if the true damage were a little higher than that damage function indicates?

MS. BAUSER: Objection. I don't understand the question. I don't know which earlier errors you are talking about and what implication you are asking Dr. Hamilton to draw.

MR. EDDLEMAN: Dr. Hamilton quoted me a large number of errors out of the Harvard study, the various possible sources of error. Do you recall that?

MS. BAUSER: Yes.

MR. EDDLEMAN: Those are the errors I am asking him about. What I am saying is --

THE WITNESS: It says, "The range of coefficients presented above logically include zero."

BY MR. EDDLEMAN:

Q I understand that. What I'm saying is, given that there are all those errors on the loose, can ycu logically exclude that the damage function might be higher than the number that's given in this study?

A Well, I don't know what you mean by "logically." Reasonably. Obviously, it could be a little higher, but it

mgc 19-4

couldn't be a whole lot higher. That's the point. It wouldn't be greatly higher. Otherwise, one would be able to discern people dying from air pollution.

Q Doctor, let's go back to Table 2 of the BNL Report 51305 for a moment, if we may. This also relates to Page 15 of your testimony.

Let's take your 90 person-micrograms per cubic meter per metric ton of emissions. Now that is an average total U.S. exposure, assuming, as we have gotten out of the report, that the plant m ight be randomly located in any part of the United States whatsoever.

A I said that already.

Q Okay. Again, I am just establishing where I am. I am trying to tie together many threads, and I'm sorry if I'm repetitious.

Now to that, there is some addition. There's 1154 metric tons. And we have agreed, haven't we, that whatever concentration results from that 1154 metric tons would be added to this background? Haven't we?

A I'm afraid you have misunderstood this figure completely, Counsel -- I mean Mr. Eddleman. Sorry.

I mean, I am using that figure --

Q Which figure, Doctor?

A 90 person-micrograms per meter to calculate what the person-micrograms would be in terms of fine particles.

mgc 19-5

To find out -- from 1154 metric tons. I am distributing that, okay?

In other words, I am multiplying the calculation that I did -- this has got nothing to do -- this 90 has nothing to do with background in the United States.

Q I see.

A What I am saying is this. For every metric ton that you put out randomly throughout the United States, you get 90 person-micrograms per cubic meter.

Q Right. Thank you, Doctor.

A So for 1154, you multiply 90 by 1154, by the percentage of fine particles, by the damage function, and then you arrive at the figure. And in this way, I am calculating what 1154 metric tons does to the entire population of the United States.

Q Okay. And isn't that 90 figure based on a uniform distribution which is somewhat analogous to your uniform distribution in and around the radius of the plant that you calculated earlier in your testimony?

A No, it is not. It is based on the cumulative probability distribution of the particle concentration exposure for a randomly located power plant, and it takes into account real, long-range meteorology, because the whole matrix has been constructed on the basis of this meteorology for four seasons of the year from the Pacific

mgc 19-6

Northwest long-term model. And if you want to see what the parameters that were used in this model, you will see that it is Table 1. It is a model. I am not telling you it's the last, you know -- it's absolute reality, but it's the best we can do for the long-range transport of these particles. It doesn't assume uniform distribution at all.

Q But doesn't the fact that the power plant reference in Table 2 could be located at any point randomly in the United States, doesn't that introduce a certain sort of uniformity or averaging into this?

A It introduces an averaging into it, but not uniformity.

Q Okay.

A I say it's average total U.S. exposure.

Q Okay. From a power plant that might be located at any point, not for any specific point.

A Correct.

Q All right. Now let me look at Table 1 here. It states -- and this is on Page 3 -- it states, "The effective source stack height" -- and this is about the middle of the table -- "is 200 meters," does it not, Doctor?

A Correct.

Q Have you made any review of the allowable stack height for sources in the United States?

mgc 19-7

A What do you mean, have I made any review of allowable stack heights? I don't know what you're talking about.

Q Do you know at all, Doctor, whether this compares as higher or lower or equal to the average stack height of a coal-fired power plant in this country?

A I think that's a reasonably good average stack height.

Q Are you familiar with the EPA's practice of not allowing a stack height beyond a certain level, of good engineering practice of not giving credit for air quality concentrations if it is beyond that height?

A I am aware of the whole history of initially building stacks high, so they could dilute out the pollution, and I am aware that the Federal Courts have ruled that they couldn't use that method as a mechanism of accomplishing those requirements.

Q But in using this data from this report, you didn't really make any consideration of stack height, did you?

A In using the data fromthis report, I used all the assumptions that went into this report, all of the assumptions that are built into this matrix model as to the effective source stack height. The effective source stack height is 200 meters, which we believe is a

mgc 19-8
BU 6

reasonable -- a good, reasonable figure. These are reasonable standard figures.

Q Doctor, under source emission rate and these parameters in the same table, it gives the number of 1.0 kiloton per year. Is that 1000 U.S. tons or 1000 metric tons?

MR. BAUSER: Objection. I again don't know where Mr. Eddleman is going with this line of questioning. What relevance it has is very removed at this point, as far as I can tell from the --

MR. EDDLEMAN: We are assuming effectively a very tall stack here; 200 meters is 600-odd feet. And the actual plants may not have stacks that high.

THE WITNESS: Which actual plants?

MR. EDDLEMAN: The ones that are used to emit these particles.

JUDGE KELLEY: If I understood correctly, you did use a figure of 200 meters.

THE WITNESS: Correct.

JUDGE KELLEY: How exactly was that relevant to your conclusions, though?

THE WITNESS: Well, this is all the model parameters that were used for the matrix. They are based on certain factors that go into it, and we used the 200-meter stack, and that is a reasonably good figure.

mgc 19-9

And I might say it is relevant to these power plants that we are discussing here, because again we are indebted to the NRC Staff.

JUDGE KELLEY: They know how high the stacks are.

THE WITNESS: Yes, and they are listed in their testimony on Page 7.

JUDGE KELLEY: Mr. Eddleman, you want to raise the point that the actual stack heights, if the NRC is correct, are different from the stack height assumed by Dr. Hamilton, right?

MR. EDDLEMAN: Well, let me just take that up with the NRC Staff, okay?

BY MR. EDDLEMAN:

Q All I wanted to get here, Doctor, one more question along this line of stack height.

It is generally true, isn't it, that if you make the stack taller, the particles will go farther before they get to the surface of the Earth?

A Yes.

Q Okay. Now the source emission rate in this model is 1.0 kilotons per year, and I believe Counsel objected to my asking that question and wanted to know where I was going.

This emission rate, I think, is 1000 -- let me see if I can find this. Okay. Yes.

Dr. Hamilton, on the first page of this report,

which isn't numbered one, but it follows Page Roman vi, in the middle paragraph, the second paragraph of the introduction -- do you have that?

A Yes.

Q It states that, "The results are expressed per ton (2000 pounds) emissions. Now therefore the emission rate in Table 1 is 1000 U.S. tons per year, isn't it?

A Yes.

Q Did you examine the reasonableness of that emission rate as applied to power plants of the sort that are contemplated in Table S-3 in preparing your testimony?

A This is -- the power plants described in S-3 are -- as a power plant that was described in WASH-1248, which is an analysis of power plants that are existing in the late '60s or late '70s, all right?

We have the 1154 metric tons as a given for working with it, but there is a lot of evidence, you know, that in the contemporary situation, things are different. The actual emissions are less.

But be that as it may, what the assumptions are here and how they are listed and so on are only to make the sort of basis of the whole -- are only given for the basis of making this transparent and not opaque, and it doesn't make a bit of difference to the business of taking -- the only way you can use this matrix and get to the point is,

mgc 19-11

you take our figure of 90 and multiply it out by 1154, and it doesn't make a bit of difference -- that 1154 is metric tons, and it doesn't make, as I say, a bit of difference whether this is done in 2000 -- whether we are talking about here in U.S. tons or metric tons or what.

Essentially what we have arrived at is a matrix and a damage function that we can apply -- not a damage function -- a population exposure function that we can apply for every ton of emission, okay?

Q Doctor, perhaps I didn't make my question clear enough. What I am asking about here is, do you think that a plant like this, Table 1, which emits 1000 U.S. tons per year, okay -- which I agree with you -- it doesn't have anything to do with that 90 number -- is an appropriate model for the type of power plant that is contemplated in Table S-3?

A Well, it is an appropriate model to enable me to calculate what the distributed person-micrograms will be for the entire United States from the emissions of 1154, which is specified in Table S-3.

Q Do these distributions in this model of this report have any dependence on particle size, to your knowledge?

A Well, obviously they are going to be related to particle size.

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Q How are they related, Doctor, to size?

20pb1

A Well, we are talking about respirable particles, aren't we?

Q I believe so, but I'm not even perfectly clear on that in this report yet.

A Well, it says, respirable particles.

Q Okay, I accept that. That's right, respirable particle matrices, Table 1.

JUDGE KELLEY: I think we are approaching another good stretch point. If you have just one or two questions, go ahead.

MR. EDDLEMAN: Okay.

BY MR. EDDLEMAN:

Q Doctor, I'm not sure if I had a question pending or not.

A You had agreed with my statement that I was correct when I said it is respirable particles.

Q Okay, Doctor.

A You asked me a question whether it was related to particle size. And I pointed out to you that you saw it on Table 1. In actual fact, if you begin right away it says respirable particles.

Q All right. I think that's probably the best break point.

JUDGE KELLEY: Let me ask before we break, where do you see yourself at this point in terms of how much ground

you have covered and how much time you think you will need.

MR. EDDLEMAN: I'm only about halfway through, Judge.

JUDGE KELLEY: Well, we will talk about that. Let's take a break, ten minutes.

(Recess.)

JUDGE KELLEY: Back on the record. We would like to take just a few minutes to talk with counsel and Mr. Eddleman about where we are and where we are trying to get. It does seem to the Board that given the relative narrowness of this contention that we are on now, we really ought to be able to finish it, at least by the time we go home tomorrow. Hopefully we can finish up by around 3:00 tomorrow, but we can go a little later if necessary.

We mention 3:00 because it's Friday and there are people who want to catch planes and so on. We are prepared, since we're going to need a little more time than we had thought to start tomorrow morning at 8:30. We're prepared to go until 6:00 tonight. And that gives us a little bit more time also.

But we have to bear in mind that Dr. Hamilton is one now and we have the Staff panel scheduled to testify after him. And with those considerations in mind we did ask you, Mr. Eddleman, before you broke about where you thought you stood in terms of your cross of Dr. Hamilton.

And you have had about two and a half hours of cross. We would like to get a little clearer idea, given the cross that you had, where you think you want to go with him, and what are the major points that you want to explore. How long do you think it would take?

I would just add that in terms of allocating time, and we are not talking now about strict time limits in minutes and that sort of thing, but just getting some guides into place so we can finish up where we want to be. If you, generally speaking, want to spend more time on Dr. Hamilton than on the Staff or vice versa, that's a judgment that you can make. But could you give us a little more specific idea of where you have in mind going, and the time you think that may require?

MR. EDDLEMAN: Okay, Judge. I meant that I had asked about half the questions I wanted to ask, not that I had taken half the time I wanted to take. I want to explore these particulate concentration levels that are real averages in the Brookhaven report. I guess on the order of 10 or 15 minutes on that.

Then I want to go back to this Fisher and Natusch and also to some other Dr. Hamilton's work that he refers to and talk about the organic chemicals relating to fly ash. I want to get some more to the properties of fly ash. I want to come back and cover the size effects that I was getting

at. And I want to talk about the sensitivity of various groups in the population. And I think that's the vast majority of it.

JUDGE KELLEY: What would be your sort of gross estimate of time for that?

MR. EDDLEMAN: I hope I can do it in an hour and a half, maybe a little less.

JUDGE KELLEY: Okay. Well, let's go ahead then. Thank you.

BY MR. EDDLEMAN:

Q Dr. Hamilton, I would like to refer you to page 2 of the same BNL 51305 that we have been discussing. This shows the grid point sources that were used in this model, doesn't it?

A Yes.

Q Now, I am not trying to test your knowledge of geography, but I just want to ask you if you know, in Kentucky is Paduka close to that circle at five from the left-hand column and nine in the bottom line?

A You are beyond me.

Q You know where Portsmouth, Ohio is in relation to the 5, 10 point source.

A That might be reasonable, yes.

Q Reasonably close?

A Yes. I think I have been to Portsmouth, Ohio.

I have never been to Kentucky. My recollection is very roughly that that's roughly where it was.

Q And would you have any idea how close the 4, 10 location might be to Oak Ridge, Tennessee?

A The who?

Q The location at 4 on the left hand and 10 in the bottom. That circle there close to the Tennessee-North Carolina border. Is that anywhere near Oak Ridge?

A I have been to Oak Ridge and I think that looks, you know, from my vague recollection of the maps of the United States, that might be reasonable.

Q Okay. I'll just ask you, for purposes of a question that I'm going to ask in just a second, take a look at the coastline of North Carolina on that map too. Look and see if you see any bumps.

A I'm sorry to admit that I am not familiar with it. I don't know what the coastline of North Carolina is at this time.

Q Try looking between about 3 and 4 and a half on the vertical and 11 to 12 on the horizontal.

A Yes, is that the coastline of North Carolina?

Q Yes, it is.

A All right.

Q Now there's another map here that doesn't show the states. It's figure 7 on page 11 of the same document.

A Say it once again.

Q Figure 7, page 11.

Sort of looping through the southeastern part of the country from a point on the coast of the United States there, there is a dark black line showing the number 100; is there not?

A Yes.

Q And that is an isoplath of sorts, isn't it, of particulate levels?

A Yes.

Q Okay. Now from the fact that the dotted line that kind of wiggles around to the north of there and says 150 is on the north side, we can infer, can we not, that between those two lines you're between 100 and 150 person micrograms per cubic meter per ton emission.

A Right.

Q Okay. Now the reason I asked you to look at the coast is, if you look at the bump where the 100 starts off, I believe that that bump is Cape Fear, which is pretty close to the southern border of North Carolina. And I believe that the bump that sticks directly out into the Atlantic vertically above that corresponds to Cape Hatteras, which is the farthest point of the coast. And then coming back in, I believe the 150 comes in about the northern border of North Carolina.

I don't have a grid to superimpose over this, but does taht seem reasonable to you?

MS. BAUSER: Objection. He already said he's not familiar with the coast of North Carolina. You're asking him to answer --

MR. EDDLEMAN: I'm asking him to compare the two maps.

THE WITNESS: I followed one bump, but there's only one bump that I see. Is that Cape Hatteras?

BY MR. EDDLEMAN:

Q The biggest bump is Cape Hatteras. It's between the 150 and 100.

A All right. Now where is this other bump?

Q It's the little tiny bump right where the 100 line comes to the coast.

A Oh, a little projection. Yes, I see. And what is that.

Q That is Cape Fear, I believe.

A All right. Now I will take your word for it, as you come from North Carolina. Cape Fear and Cape Hatteras, yes.

Q Well, sir, this is a diagram of exposure levels from these coal fired power plants, correct?

A Yes.

Q And if I were correct about where the state of

North Carolina is, then most persons in North Carolina are exposed to between 100 and 150 micrograms per cubic meter per ton of emissions.

MS. BAUSER: Objection.

THE WITNESS: Can I just explain?

JUDGE KELLEY: If counsel wants to object, let's hear what the objection is.

MS. BAUSER: Again, I don't know where he's going. North Carolina, the significance of this is unclear to me with respect to North Carolina. Why you are focused on North Carolina.

MR. EDDLEMAN: Where the zone of interest for Harris around here.

MS. BAUSER: But we're talking about Table S-3. The emissions don't come from the Shearon Harris plant.

MR. EDDLEMAN: That's right. It's not a coal plant. But the levels of coal particulates that people here are exposed to, okay, are at these levels which are higher than the U.S. average. And if you look at a person within 50 miles of Harris, and you added to that the exposure that would result from this hypothetical 1154 metric tons, then you would be increasing that further.

THE WITNESS: Can I explain? You are dead wrong. You misinterpreted what this diagram was about.

JUDGE KELLEY: Just a moment. You could make

the same argument about somebody in Seattle, couldn't you, if they had a lot of coal particulates up there?

MR. EDDLEMAN: Sure I could, Judge.

JUDGE KELLEY: Or Los Angeles. I guess I'm still not clear what this has to do with the witness' testimony.

MR. EDDLEMAN: Well, I can also make the same argument by trying to change those curves to the location of these plants. But it's a lot harder to establish where the states are in the middle of this. Let me show you this thing, and show you what the difficulty is.

There is no state grid on this map. You've got an outline of the whole country.

JUDGE KELLEY: Right.

MR. EDDLEMAN: Now I know where North Carolina is, and I've got a good guess that Tennessee is therefore here, inward (indicating). Now I'm not sure whether the Tennessee border is here or here. I don't know if Kentucky is here or here. If Portsmouth, Ohio is oh, let's see. I would infer that Portsmouth is somewhere around here.

But that's just a guess. You see how hard it is to locate things.

JUDGE KELLEY: Yes.

MR. EDDLEMAN: I'm trying to get a place to take it, and I figure since I can't find these others, that this

is as good as any, right here where we are.

JUDGE KELLEY: And the point that you're driving at is --

MR. EDDLEMAN: With this distribution here, which I haven't asked him about yet, but I'm going to isn't uniform. And the effects of a non-uniform distribution may not be the same as just exposing everybody uniformly to this average.

JUDGE KELLEY: Okay. Objection overruled.

BY MR. EDDLEMAN:

Q Doctor, you were about to give an answer to that question. Do you need the question repeated?

A Well, you'd better repeat the question because I was just saying you had misinterpreted the table.

Q All right. Well, my interpretation of the table is this way: that this table is isoplaths of human exposure to particles from coal-fired power plants in the following units. And that says person per micrograms per cubic meter per ton emission.

And since you have three dividing lines in there, and I'm not sure which one is the major one, I may have misinterpreted it, but let me ask you. I think this means the concentration in micrograms per cubic meter per ton of emission to which a person living in the areas bounded by these isoplaths would be exposed. Is that right?

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A It means that if you plant on those isoplaths for every ton that was emitted by it -- it isn't the levels to which people are actually exposed, which I got the impression was your interpretation of this. You were saying that the current levels in North Carolina are somewhere between 100 and 150 person micrograms per cubic meter. That is not so.

What this says is that if you put a power plant there, for every ton of emission you will get so many person micrograms in the United States. That's what that says.

Q Okay. Now, so if we could actually locate power plants on this map, which doesn't have a state here, but if we could locate them what this figure would tell us is if your power plant is at location X, you could then read off of here, at least between two levels, what the average exposure to people all over the country would be from a power plant located at that point. Is that correct?

A Well, it's what the total exposure in terms of person micrograms per cubic meter for ton emission would be, yes.

Q Okay, thank you, Doctor. That clears me up on that. Now let's refer to Figure 10 --

JUDGE KELLEY: Could I just ask you a question. And it's kind of related to that. In your study, though when you were looking at the deposition of those 1100 and

however many there are -- 1154 metric tons. Did they all fall down in that 50-mile radius?

THE WITNESS: No. I did two studies. The first study is I limited the particles to the 50-mile radius around the plant, and that's the first part of my testimony, and I calculated the concentration and the numbers that would arise from that.

The second study is I took the 1154 metric tons and assumed it was distributed by a standard coal-fired plant, an average standard coal-fired plant. I didn't locate it in the particular regions of these Jopper, Shawnee, Bull Run, Clavery, et cetera. I took an average and I explained why, because it didn't seem to me to be, you know, justified, justify the effort even to run the matrix for the specific sites of these plants.

JUDGE KELLEY: But as to the first part of the study where everything fell down in 50 miles, that figure is irrelevant.

THE WITNESS: This figure is irrelevant to that, yes. This figure is only relevant as part of this matrix method. And it shows you that it is a method for saying that if you put a power plant in a particular spot, for every metric ton of emission, how many person micrograms of respirable particles you will develop. And it's a total for the entire United States, integrated total.

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JUDGE KELLEY: Okay.

BY MR. EDDLEMAN:

Q Doctor, I would like to refer you to Figure 6 on the facing page, page 10 of the same report. This is a graph of total exposure in person micrograms per cubic meter per ton versus the number of these air quality control regions for which you have that total exposure, is it not?

A Correct.

Q All right. The median is shown at 93 in the dashed line going vertically.

A Correct.

Q And that's the number that you rounded to 90 for your study of nationwide emissions, isn't it?

A That's correct.

Q Okay. Now, Doctor, you have stated that exposures at low levels, in your opinion, may not have any health effects. What is your opinion of the effects of exposures at higher levels to particulates? Does that in your view have a definitely established health effect?

A When you are talking about high levels, the sorts of levels you have in the London fog or Donora, which, you know, four or more orders of magnitude higher than the levels we're talking about here, of course they do and can have effects.

Q Doctor, just for clarity of the record, what levels

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would we be talking about, four or five orders of magnitude times 90? Or just give me a number, if you will.

A The 90 person micrograms --

Q Doctor, don't tell me why I'm wrong, just tell me what the right number is.

A Well, it's a completely different unit. You seem to be confused between person microgram and the concentration. I think you've got to distinguish between the concentrational level, which is just so many micrograms per cubic meter.

Q Right.

A And in the London episode we were talking in terms of several hundreds of milligrams of these materials per cubic meter.

Q So you're talking about hundreds of milligrams per cubic meter.

A Yes.

Q Okay. As contrasted to here, concentrations in micrograms per cubic meter.

A Well, we're talking about in my testimony -- I want to remind you what we're talking about. The concentrations in my testimony were average of 0.04 micrograms. We are not even talking about a microgram. We're talking about fractions of micrograms.

Q Well, Doctor, I didn't ask you --

A And I'm talking about figures -- when you asked

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me if they caused health effects, I'm talking about, you know, hundreds of milligrams.

Q All right. So in hundreds of milligrams, would these numbers here show a maximum in the A-Q control region of about 800 person micrograms per cubic meter per ton of emissions over on the bottom right corner of that Figure 6?

A That's right.

Q Okay.

A Can I explain? That could be 800 people exposed to one microgram. Or it could be one person exposed to 800 micrograms.

Q All right. So in other words, this depends on the density of population as well as the concentration in air.

A Right.

Q Okay. And this persons times micrograms per cubic meter per ton is the basic same input of exposure that we used for this damage function throughout your testimony, isn't it?

end 20

A Correct, yes.

mgc 21-1

Q Would you say that it would be more likely that there would be health effects where there are these higher exposures expressed in person-micrograms per cubic meter per ton of emission?

A I don't understand the question.

Q Let me try again. For a given individual, would an exposure to a higher average concentration of fine particulate matter be more likely to lead to some adverse health effect, in your opinion?

MS. BAUSER: Objection. Higher than what? Higher than you might otherwise have been exposed to?

BY MR. EDDLEMAN:

Q Let's say higher than the U.S. median. Is that more likely than exposure to the median?

A Well, I gave you in my testimony on Page 9 and 10 a quotation from what I think is one of the most critical reviews of the available scientific and technical information most relevant to particles, and I gave you the reference to this EPA Staff Paper, which I think is a first-rate piece of work, and I have a quote that I gave you as far as short-term effects.

Q Now, Doctor, what are these short-term effects, just for clarity? Disease rather than death?

A Well, the short-term effects could be disease or they could be a respiratory infection, acute infection

mgc 21-2

or something of this sort, or it could be a death. And again, it gives you figures here. And I say, based on the Staff assessment of short-term epidemiological data, the range of 24-hour TP -- that is the thoracic particles, ten microns or less, not fine particles -- are 150 to 350 micrograms per meter.

And based on the Staff assessment of the long-range epidemiological data, the range of annual TP levels are 55 to 110, which is slightly lower in micrograms per cubic meter.

Now 55 micrograms per cubic meter is a long way from the levels that I calculate you will get from this 1154 metric tons when you distribute it around a power plant. And even taking into account the fact that there is an existing background, it's a long way from where you would be, even with this increment over existing background.

Q Well, Doctor, first let me ask you for clarity, short-term epidemiological data, what does that phrase mean?

A Short-term epidemiological data, those are data of acute effects, either an increase in mortality, though you wouldn't see that -- you wouldn't see much indication of that -- or an increase where you have people going to hospital and things of that sort or having days away from work.

Q These are effects which are manifested in a

mgc 21-3

relatively short time after exposure?

A I suppose that's one way of looking at it. They are acute effects.

I'm going to get to the actual page.

(Pause.)

There is an interesting table here which confirms my memory of what the short-term epidemiological studies refer to. It is daily mortality and aggravation of bronchitis and daily mortality in London, effects likely at levels between -- measured British smoke levels -- these are, you know, comparable or assumed to be comparable to the equivalent range of thoracic particles -- would be 350 to 600 micrograms per cubic meter.

Q Micrograms or milligrams, Doctor?

A Micrograms.

Q Okay.

A The milligram figure that I gave you referred to the London fog episode. I am now referring to daily mortality studies in which people correlate changes in mortality with changes in concentration of pollution. That doesn't mean to say that they have anything necessary to do with each other. It's just a correlation that they make.

Now the effects possible. Those were effects likely. The figure they give here is 150 to 350 micrograms per cubic meter, and that's the figure that I quote in my --

mgc 21-4

as I said, these are the two studies, the daily mortality and the aggravation of bronchitis. Those are the two short-term studies.

Q Okay. Those are the two things that are considered.

A Correct.

Q Does the report say if they considered any other indicators of damage?

A Well, these are the only studies that they feel -- as far as I can see -- and they both happen to be British studies -- fairly short-term epidemiology-- that they want to put any weight on.

Q Just to make sure in my mind, are you quoting the Harvard study or the EPA document that's in your testimony?

A I am quoting the EPA document. I found a few minutes ago -- I had in fact taken this from Pages 112 and 113, and I thought I would clarify the situation by turning to the actual document, which I now have done.

Q Right.

A So I am referring to the EPA study.

Q Okay. So they are considering those two effects only. They have nothing to do with the effects considered in the Harvard study.

A Well, the aggravation of bronchitis presumably has some relationship to hospital visits, which is another

mgc 21-5

which is another end point that the Harvard study used. The Harvard study also used daily mortality. So I don't know -- you asked me to define -- we got into this discussion because you asked me to define "short-term epdiemiological data."

Q That's correct.

A And now I have done that.

Q Okay. Well, let's back up to the question I was trying to get at before.

Based on these numbers, would you say, Doctor, that exposure to a level above 150 micrograms per cubic meter would be more likely to cause adverse health effects than exposure to some lesser figure, say 90 micrograms per cubic meter?

A Yes.

Q Okay. In the Harvard study which your damage function comes from, how are varying sensitivities of different groups in the population taken into account?

A Well, obviously the cross-sectional study from which they derived their fine particle annual mortality figure, 1.3 plus or minus 0.6, is a general population study, so it contains a mixture of people, some of whom are sensitive and some of whom are less sensitive.

Q All right. Would applying that average damage function, if you will, to persons who happen to be in the

mgc 21-6

more sensitive groups in the population be representative of the damage to those persons in those groups?

A Well, when we are applying this, we are applying this to a population within 50 miles, and I presume that it consists of the same mixture on which this population is most representative. The population probably reflects the same population of mixture of more sensitive and less sensitive people than the population for whom the damage function was derived, so it's appropriate to apply that to the particular damage function.

Q In other words, Doctor, if the population to which you apply this damage function has the same distribution or nearly the same of more and less sensitive sorts of people in it as the population from which this function was derived, then it's appropriate to apply the function to that population?

A Correct.

Q All right. If you have a population of people who are more sensitive and out of proportion to this base population for this damage function, if I can call it that, you would expect them to have more health effects from a given level of pollution, wouldn't you?

A Yes. If your hypothesis were correct and one could pick out a population that was more sensitive, then you would expect them to have more health effects.

mgc 21-7

Q All right.

A As a matter of fact, this is an interesting point in the morbidity study of the Harvard report, last year's report. It does look as though as far as their morbidity data are concerned, that you have to have a preexisting cndition in order to demonstrate a morbidity effect of particles. If you don't have a chronic condition, if one were to take the statistics literally, it would look as though exposure to these particles might be good for you, since they got negative -- I mean, they got negative signs for restricted activity days and work lost days. But again, that would be pushing the statistics beyond the realm of plausibility.

And I think the Harvard people in their application of this rightly considered those positive effects as the positive benefits of air pollution as zero.

Q What you are saying is, it doesn't make sense to think that breathing these particles is good for you.

A Correct.

Q Doctor, you made some comparisons of excess deaths compared to people around the country.

Let me ask you, do you have any data on the total mass of coal particulates that are emitted in this country each year?

A I know where to look it up, but I don't remember

mgc 21-8

that sort of thing.

Q All right. Do you have any data that you consider reliable on the morbidity or mortality throughout the country that would result from particulates in a year?

A Well, I don't use fine particulates as a damage function for air pollution. I have some ideas about other surrogates, but I don't use that, so I don't have any notion.

You will find some notion for that in the Staff testimony.

Q All right, sir. Now you have said that in some ways fine particulates -- you use them as a damage function or a surrogate for air pollution in general, have you not?

A Correct.

Q Do you have any data, satisfactory to yourself, that indicates how much morbidity or mortality or both result in the United States each year from air pollution?

A I have some information along those lines, yes.

Q Could you give me some numbers, Doctor?

A Well, if I use the sulfate damage function, the numbers could be ranged all the way from zero to a mean of 50,000. These are the mortality figures that I'm talking about.

Q Okay. From a lower limit of zero to an average of 50,000. Could you put a statistical upper limit?

A I could put 100,000 or so as the upper limit.

mgc 21-9

Q That's caused by air pollutants of all sorts?

A Correct. Throughout the entire United States. But it bears no relationship to the tiny incremental portion. I mean, if you were to calculate -- and there are very similar methods to this, by the way, but you have got to attribute or find out what it is due to 1154 metric tons, and that's a very insignificant part of that.

Q Well, the part of it -- and I think you quote with approval the Staff's analysis and Final Environmental Statement -- that the part is approximately .0002 addition to the total particulate load in the country.

Strike that question. Let me ask the question over, because I asked it wrong.

The Staff FES says, doesn't it, that the coal-fired plant emissions from your Table S-3, plant for enriching fuel for Shearon Harris, are about two parts in 10,000 or .02 percent of the total of such emissions in the United States on an annual basis, doesn't it?

A It is two ten-thousandths of the annual U.S. coal particulate emissions.

Q Right, okay. Now if the Staff had taken your number for damage from air pollution, or let's say your average number of 50,000 deaths --

A Well, that's using another surrogate. It is not the particle surrogate.

mgc 21-10

Q I understand that. But if they had done that, they would get two ten-thousandths as many deaths as being due to all these pollutants taken together from this Table S-3 plant, wouldn't they, by a linear hypothesis?

End 21

mgc 22-1

A Could you repeat that question, because I'm a little lost?

MR. EDDLEMAN: Is the reporter able to find it and read it back?

(The reporter read the record as requested.)

THE WITNESS: If you were to assume your hypothesis -- and I want you to understand that it is a hypothesis that these two surrogates are interchangeable -- your arithmetic would be correct, and you would say that if our mean death is 50,000 and the total number of deaths would be from the total, initial 0.2 percent --

BY MR. EDDLEMAN:

Q You mean .02 percent, don't you?

A Yes, .02. That I -- you know, I think that's -- it is stretching it to do that, because again, I do feel that, you know, you are talking here about what I call the rational application of the linear hypothesis, and it really isn't, you know -- it is not the contention. The contention we are dealing with is the significance of Table S-3, the coal particulate issue.

Q That's correct. And I asked you a hypothetical, and I think you have answered the hypothetical question.

If you want to say some more, go ahead.

A No, I don't want to be led further astray than you have led me.

mgc 22-2

(Laughter.)

Q Well, speaking of leading astray, what analysis of coal particulate impact is there in the Final Environmental Statement for this plant? Can you show me the analysis that's in there?

MS. BAUSER: Objection. The Final Environmental Statement is in evidence, and it speaks for itself. There is no reason for Dr. Hamilton to have to point out to Mr. Eddleman something that Mr. Eddleman already knows.

MR. EDDLEMAN: Well, he says -- and this is on Page 2 -- he says, "Mr. Eddleman is incorrect, and the health effects of particulate effluents specified in Table S-3 were adequately assessed and given sufficient weight by the NRC Staff."

Now what the contention says is, "Are not analyzed nor given sufficient weight." It's a little difference of words.

I want to know if he is saying I'm wrong, where is the analysis?

JUDGE KELLEY: I think that's a fair question. I will overrule the objection.

THE WITNESS: I think my position is that the health effects of the 1154 metric tons, when analyzed by myself, okay --

mgc 22-2

BY MR. EDDLEMAN:

Q Doctor, --

A Let me finish.

Q Okay. Go ahead.

A -- demonstrate on the basis of the fact that the health effects are so trivial that the way the Staff chose to deal with them -- and that is, they found that the emissions specified in Table S-3 constitute an extremely small additional atmospheric loading, et cetera, et cetera -- I don't have to read it out. It is in the testimony.

As I found them so trivial, I believe that my conclusion is justified, that they were given proper weight, and they were adequately assessed and given sufficient weight by the NRC Staff, and I think that's a perfectly justifiable thing.

I am stating here that I feel my judgment is, having done this analysis, that we are dealing with a non-issue from the health point of view, and I think that the Staff are correct in their conclusion that such an extremely small increase is to be acceptable.

That's what I'm saying here.

Q You have given an extensive answer, but I didn't quite hear where the Staff's analysis is.

A Well, it is in that quote.

Q In which quote, Doctor?

mgc 22-4

A In that quote that I gave you, FES Appendix C at C-2.

Q All right.

A If you turn to Page C-2 under "Chemical Effluents" --

Q Yes, I see it, Doctor.

Now it says, "The Staff finds that these emissions constitute an extremely small additional atmospheric loading in comparison with the same emissions," and that's talking about chemical, gaseous, and particulate effluents, including sulfur oxides, nitrogen oxides and particulates -- "an extremely small additional atmospheric loading in comparison with the same emissions from stationary fuel combustion and transportation sectors in the United States. That is about 0.02 percent of the annual national releases for each of these species. The Staff believes that such small increases in releases of these pollutants are acceptable."

Doctor, is there any further analysis, to your knowledge, of these issues in this statement?

A No.

Q You contend that this is adequate analysis?

A As a result of my examination of wh t the concentrations would be from 1154 metric tons and the possible health consequences, I believe the Staff has

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adequately, as I said -- adequately assessed and given sufficient weight.

Q But you had to do a good bit of analysis to come to that conclusion, didn't you?

MS. BAUSER: Objection. He has answered the question.

JUDGE KELLEY: Sustained. I think his answer is clear.

MR. EDDLEMAN: I don't know if I phrased the question very well.

JUDGE KELLEY: Well, I think I understand what the question is. He has said that the Staff is right. They have done this big analysis, and he has concluded that there is nothing to this. Therefore, their two sentences is adequate.

Is that what you are saying, Doctor?

THE WITNESS: Correct.

JUDGE KELLEY: Move on.

BY MR. EDDLEMAN:

Q I guess it's obvious that he had to do the analysis to make the conclusion, but I just don't understand the rules, Judge. I'm sorry.

JUDGE KELLEY: It isn't a question of rules. I just think he's answered the question and he said why he thinks that the Staff's two sentences, if that's what it is,

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is all that it's worth. That is his view.

MR. EDDLEMAN: Never mind.

BY MR. EDDLEMAN:

Q Dr. Hamilton, you cite Fisher and Natusch from their Table 8 for percentages of particles that are fine particulates from a pulverized coal-fired power plant, so I presume that you have seen the article that they wrote; am I correct?

A I have seen it.

Q Have you read it, Doctor?

A Yes.

Q You read the whole thing?

A Well, I skimmed it anyway.

Q Okay. Skimmed the whole thing and read some parts ofit; is that a fair statement?

A Correct.

Q Now this has quite a lot of information in it about these particulates, doesn't it?

A You mean the article as a whole?

Q Yes, sir.

A Correct, yes.

Q You have stated your opinion of various other analyses and documents. Do you have an opinion satisfactory to yourself as to the quality of this work in this report?

A I think on the whole I am impressed by the work of

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Fisher and Natusch. I have seen it, and it seems to be pretty standard, high-quality work.

MR. EDDLEMAN: At this time, I would like to offer this article into evidence as Eddleman Hamilton Cross-Examination Exhibit No. 1.

MS. BAUSER: Applicants have no objection.

MS. MOORE: Staff has no objection.

JUDGE KELLEY: Is there any comment?

(Pause.)

MS. BAUSER: We would prefer that it be referred to as Eddleman or Joint Intervenor Exhibit 1, just for clarity's sake, because the witness --

MR. EDDLEMAN: It is not a Joint Intervenor contention.

MS. BAUSER: Eddleman, okay. Excuse me.

MR. EDDLEMAN: And I wanted to specify that I used it to cross-examine Dr. Hamilton. But if you are saying Eddleman Exhibit 1, that would be fine.

MR. BAXTER: Just Eddleman Exhibit 1. How is that?

JUDGE KELLEY: I would suggest -- it's just a suggestion, but you did use it in cross, but it became rather prominent. There was a lot of discussion. I don't hear any objection to its being in just as substantive evidence -- is that right? -- and then you can cite it for

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any purpose.

Is that satisfactory with you?

MR. EDDLEMAN: It's fine with me.

JUDGE KELLEY: Yes, we did have an understanding -- we put all of our exhibits in in advance. But we've done that, and it seems to me we could have a further understanding that as some pieces of paper or articles come into the case, and there's no objection to it and it's agreed to be useful to have it in, we can put it in, just as we will do right now with respect to this particular article. We will call it Eddleman Exhib it 1.

(The document referred to was marked Eddleman Exhibit No. 1 for Identification and was received in evidence.)

MR. EDDLEMAN: My understanding was that if you had a witness, you had to file all of your exhibits when you had the prefiling deadline. It wasn't my understanding that you had to file all cross-examination exhibits.

JUDGE KELLEY: Let me make a distinction. To me, it's confusing to speak of a cross-examination exhibit for this reason. You can come in and, let's say, you've got some articles,and you want to test the knowledge of the witness. You might prefer just to say, "You know the work of Smith and Jones," and have a question or two to see if the

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witness knows about the article and is familiar with this particular research. It doesn't mean that that is going to go into evidence. It just means that it's used to test the knowledge of the witness. So you may have a big stack of Xeroxed paper that you plan to use that way, and it wouldn't come in as evidence in the case. That's a different kind of thing.

Typically, exhibits as substantive evidence would come in in connection with the witness. They would sponsor a particular piece of evidence and be prepared to answer questions.

I suppose you could come in with some evidence, with some exhibits that are substantive evidence, and you could just offer them at the beginning. We haven't done that here, and if it arises, we can deal with it. But I am just saying that Xeroxes of articles that you may want to refer to, just because you have asked some questions about it doesn't mean that they come in as evidence. They are just used in that limited way.

MR. EDDLEMAN: I understand, Judge. The only reason I was going to call it a cross-examination exhibit is that is where I brought it in. That's a standard practice at the Utilities Commission. That's all it is.

JUDGE KELLEY: Well, you can also let in something for a limited purpose. But I think in this particular case,

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with no objection, it's just simpler to let it in for all purposes.

MR. EDDLEMAN: I understand.

MS. MOORE: Your Honor, might I interrupt for a moment? It was the Staff's understanding at the prehearing conference that if there were exhibits that were going to be introduced into evidence of whatever kind, that copies were going to be provided in advance of their use.

JUDGE KELLEY: Well, that was my understanding. I think what we are saying right now is, if in the course of the case something like this becomes prominent and nobody objects, then there's really nothing to argue about, and we will just put it in.

And we did understand -- and I believe the Board understood -- that evidence being put in as substantive evidence would have been exchanged prior to this time, at the same time as the testimony.

Are we together on that?

MS. MOORE: That was our understanding.

JUDGE KELLEY: Okay. If we run into misunderstanding later on, we will deal with it when it arises. I suspect that we will not have any great problem in this regard.

BY MR. EDDLEMAN:

Q Let me ask you another question. Have you been provided with copies of the various documents which I

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produced on discovery to the Applicants?

A I hope so.

JUDGE KELLEY: Off the record.

(Discussion off the record.)

BY MR. EDDLEMAN:

Q Let me ask you this. Do you have a copy of the Environmental Health Effects, Volume 33, Pages 227 to 247, 1979, Van Hook's paper on potential health and environmental effects of trace elements of radionuclides from increased coal utilization?

A I know I did have that, but I think that's the one I mislaid.

Q I'm sorry, Doctor.

A I have the other two in that series, Goldstein and Falk, and I do recall having the other one as well.

Q All right. The Falk paper, "The Health Effects of Coal Mining and Combustion: Carcinogens and Cofactors," you have that one, don't you, Doctor?

A Yes, I do.

Q Have you reviewed these documents?

A Okay.

Q Do you have an opinion satisfactory to yourself concerning the quality of the Falk and Goldstein paper?

A I think it's a reasonable paper.

Q Do you recall if you had any opinion about the

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quality of the Van Hook paper?

A Yes, I think that was a reasonable paper, too, and I do recall thinking that, at the time, that, you know, if there were any effects of trace metals -- I mean, this is the opinion I had, they are encompassed, of course, in the damage function that we have used.

Q Let me ask you a question about carcinogenicity. Earlier, I believe, you identified arsenic as a carcinogen. This states -- this is Van Hook -- on Page 229 , and I can show it to you if you like --

A Yes.

(Counsel handing document to witness.)

Q -- three elements -- arsenic in the three oxidation state, chromium in the six oxidation state, and nickel carbonol areaccepted as having high carcinogenic importance to man. I think they mean humans.

A Arsenic and nickel....I said arsenic and nickel and chromium. Well, chormium wasn't on the list that we read this morning, if my memory serves me right.

Q Okay. Let me check that. Thank you.

The list -- and I am reading from Section A of Fisher and Natusch again -- as I read it, the last three elements in the list are those elements showing pronounced concentration trends of increased concentration with decreasing particle size -- are chromium, zinc and sulfur.

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MS. BAUSER: Excuse me. Can you tell me what page you are on?

MR. EDDLEMAN: It is Page 25 of the typescript article that we put into evidence, Eddleman Exhibit 1.

End 22

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THE WITNESS: As I recall, my testimony will show that I picked arsenic and nickel and didn't incriminate chromium.

BY MR. EDDLEMAN:

Q Is it your opinion that chromium is culpable as a carcinogen?

MS. BAUSER: I'm going to object again. I don't understand what relevance this has to Dr. Hamilton's testimony. He has already testified that any toxic effects caused by any of these metals would be already included in his analysis. And I think that's the end of the discussion. I don't see what relevance this has.

JUDGE KELLEY: Any response?

MR. EDDLEMAN: Sure. He said early on in cross that the specific mechanism of how the effects happened were relevant. I could tie it up in a minute. In fact, I intend to.

What I want to do is take this and then go back to the question of how these long term effects pick up carcinogenesis from these things and explore that with them. But first I want to get my carcinogens labeled.

JUDGE KELLEY: Let me clear. Could you just restate how you broke out these factors, or whether you disregarded them? And if so, why?

THE WITNESS: I'd say that the fine particle

damage function, particularly the one that I have used for mortality, this correlates a certain level of this material with mortality. And I say we are using that as a surrogate for air pollution, so that it will include all the cancers that are caused by the organics. It includes the cancers caused by the trace metals. It will include the chronic respiratory disease eventually ending in heart failure as a result of emphysema and bronchitis. It includes all those things. All those things that cause mortality.

It is already encompassed in that -- you know, that's total mortality that was analyzed in order to produce this -- from these cross-sectional studies in order to produce this damage function. And fine particles contain within them, as we know, they contain these elements. I mean, that's the point he is just making.

They also contain some of these other carcinogens. They also contain irritating materials such as acid sulfates. So it is really a damage function that is dealing with total mortalities. It includes all the mortality, cancer, and heart and lung disease that might be attributed to air pollution.

And it's from all these possible sources. So to try to -- although the point I was making when I said yes, if we knew the mechanism, when eventually we know the exact mechanism and we can relate it to a particular compound and

a particular agent, we'll say, such as nickel or arsenic, and know that that's what was responsible. Well, then we could calculate more precisely then we are doing at the moment. But we are not in that situation.

(Board conferring.)

JUDGE KELLEY: Our judgment is that it's marginal to make a case for sustaining, but we're going to allow the question anyway.

BY MR. EDDLEMAN:

Q Is chromium a carcinogen, Doctor?

A Well, it doesn't ring any bells with me. But, you know, I always think in terms of chromium as chromium plate and so on, and I don't associate it -- I don't have any knowledge that it's a carcinogen. You say that chapter says it is. But me general impression of it is that is was quite a good article. But my memory of the whole thing was, well, you know, it's all included in the damage function we have used.

So I don't quite see the point of going into the specifics.

Q Well, Doctor, that's the point I'm going to get to. But let me ask you, did you also review an article by Natusch, Potentially Carcinogenic Species Emitted to the Atmosphere by Fossil Fuel Power Plants?

A It seems to have escaped me. Show me that and

I'll tell you.

(Counsel handing document to witness.)

A Oh, yes. I think I must have mislaid those two together, yes.

Q All right, sir. Do you have any opinion satisfactory to yourself as to the quality of that article?

A I think it's a reasonable review of the polycyclics and the organics and so on. Again, I want to emphasize that I was interested to receive these articles from you. But again, I want to emphasize that the carcinogenic properties of all these things and the possible effects on mortality are already included in this damage function that we are using.

Q All right, Doctor. Now that's the point I want to get to. You have this damage function that is made from all the mortality studies. How does the mortality study know if a certain death, say, from lung cancer was caused by chromium on a coal particulate or plutonium from a nuclear particle, or benzene, or any other? How do you know?

A Well, you might to raise the point I pointed out before. You don't. This is an association you get by -- these deaths are not labele . It's a statistical association that you get by taking the levels of the particular surrogate that you're using, in this case we will say fine particles, and you see how well you can explain the fluctuations that

you observe in mortality in relationship to those figures. You do this multiple regression analysis.

And as your dealing, in fact, with the same time that you have -- well, you know fine particles, they are a complex chemical mixture. We don't know what it is in the fine particles that does the damage. There are all these organics that we worry about, and Natusch described. There are all these trace metals. There are acid sulfates and so on. And there are also other neutral sulfates and other salts. It's a complicated business.

And in addition to this, in addition to having fine particles in the air, you have all sorts of other materials in the air, other pollutants. And that's why some people don't put any weight on these cross-sectional studies as a really -- although I think it's the only way you can go in order to be able to arrive at some quantitative damage function. We have no other method of doing it.

If you only have these cross-sectional studies, and no other evidence, I would say that you would forget about it. But you have some other evidence. And this is where your Americanism or toxicology studies help. You have some animal experimental studies which indicate first of all that these chemicals are carcinogenic.

I mean, you haven't got this animal toxicology, you wouldn't know they were carcinogenic. You certainly

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couldn't do it from these cross-sectional studies.

Q So there are carcinogenic effects which might not be picked up in one of these studies, aren't there, Doctor?

A I don't know. Sometimes there's a limit to my ability to exposit to someone and try to explain. I am trying very hard, Mr. Eddleman. When you do these cross-sectional studies, you are doing statistical correlations between a level of something in the air which itself if not there by itself. It's there with a lot of other things.

Fine particles cover a multitude of sins. They've got all these other things that you're worried about. Like things that have been demonstrated to be carcinogens, polycyclic, aromatic hydrocarbons, trace metals. They might have a touch of arsenic, you see? And all you're picking up, you know, change in mortality with the levels of this, that's what the statistics tell you, okay?

Well, the only reason for you to suspect that any of these things may be truly deleterious, because you wouldn't know there could be some other cause, these people might have died from some intrinsic genetic something or other that we know nothing at all about. So the only reason that you believe this is plausible is because there is some experimental evidence where you take animals or human volunteers and you can produce some of these demonstrations of either cancer or respiratory impairment or something else.

And that raises, you know, a suspicion in your mind that these things may be harmful. But there are lots of different lines of evidence that you use to make this association into something that is meaningful.

But none of these cross-sectional studies that we're talking about here, either the surrogate we used or the surrogates that the Harvard people used are anything more than -- you know, they are an association. They are the best state of the art effort that we can now make in order to come up with these numerical bounding estimates.

There is by no means a scientific certainty about them. It's not like the electron micrograph that you showed me this morning of what the shape of a respirable particle is. I said that's a definite fact. These assessments that we make, there's a calculator. It's a definite fact. They are not like that, and they are not like the ordinary scientific experiments even.

In scientific experiments you have to at least go for the 95 percent confidence level at least. And even then you've got a one in 20 chance of being wrong. And that happens far too often in life. We know that even then, that's not absolute certainty, but in science you tend to go for at least the 95.

In this area of assessment that both myself and my group and the Harvard group are in, we are trying to put

our best foot forward, because we know the decision maker has to make decisions now and come up with assessments in which I'm only, say, 60 percent confident, as distinct from 95 percent scientifically confident. And we have to do it with all the uncertainties.

I'm sorry to have gone on. I meant to cut myself short.

JUDGE FOREMAN: I have a question. Those assessments to your mind are highly conservative then. One is being very, very careful then.

THE WITNESS: Yes. We are really giving an upper limit to these things, because as I explained, when I did this, there is another school of very good health epidemiologists who are working in this. And naturally, some of those are closely associated with Mr. Halug, who'd be willing to swear that these didn't do anybody any harm at the current levels. And they would say that very definitely.

So I feel that we have been very conservative in this calculation.

BY MR. EDDLEMAN:

Q Doctor, to back up to where I was when I last had a chance to ask a question, the causing of cancer is a process that can take a long time, isn't it, for the development of the cancer? You have a latency period, don't

you?

A Yes. Latency may cover several things. It may take a long time for the cancer to express itself. Or it may take a long time for the cancer change to actually take place. We don't really know that.

Q But in either case, it could be a long time after one is exposed, or begins to be exposed to a carcinogen before either a cancer or a death shows up.

MS. BAUSER: I'm going to object. I don't see where we're going and it's been a long time.

MR. EDDLEMAN: He says he has pulled all the cancers in these long term studies. What I'm saying is, because you have this latency period, it's going to be really hard to track what levels caused what amount of cancer. And there may, in fact, be more cancers out there that have already been caused. That's what I'm getting at.

JUDGE KELLEY: Well, won't that apply indefinitely back in time?

MR. EDDLEMAN: No, Judge, because the fine particulate production technology was not widely used until after World War II.

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JUDGE KELLEY: I will allow the question.

THE WITNESS: I don't understand this fine particulate production technology.

MR. EDDLEMAN: I will ask you about that in a little while.

THE WITNESS: My understanding is, as along as there have been particles, there's been a mixture of particles. Fine particles, medium particles and big particles, just like the three bears.

(Laughter.)

And let me finish my answer. This business of the latent period and the time it takes -- and somehow or other we may not be seeing things. This is one of the problems that one gets into with these cross-sectional studies, because one is making correlations of mortality in a particular year with levels of pollution. But in actual fact, the mortality that you are seeing represents not the mortality that is due to the year in which you are making the measurement, but to this previous, as the Chairman rightly observed, it is this previous longstanding exposure to those pollutants that have gone on, you know, 30 or 40 years earlier. And that is the result.

And that's the reason why I stressed in my testimony that to some extent if you're thinking in terms of a single year exposure and that effect, well, that's

okay in order for you to be able to make a numerical estimate. But really, as far as these long term effects are concerned, what you are seeing is the effect, either in the induction of cancer or the induction of chronic lung disease are the very long term exposure to these particles in order to get either the cancer or the lung disease manifested.

BY MR. EDDLEMAN:

Q And, Doctor, do these studies track the cancers as they show up, or do they just track the deaths from cancer?

A They just track the deaths, these cross-sectional studies.

Q All right. They just track the deaths. Now, Doctor, let me go into this matter of coal combustion technology.

JUDGE KELLEY: Let me ask a question before you do that. How long would you estimate it will take to get through your questions?

MR. EDDLEMAN: I think I'll be done in 20 minutes, Judge.

JUDGE KELLEY: Okay, go ahead.

BY MR. EDDLEMAN:

Q Do you believe, Doctor, that there were sources of micron size or say less than 10 micron size -- coal particulates in the atmosphere before human beings began to burn coal?

A Well, no, not from coal combustion.

Q All right. And this contention is about the health effects of fine particulates resulting from coal combustion, isn't it?

A Correct.

Q Doctor, are you familiar with the history of coal combustion technology as employed by the electric power industry? Just coal combustion technology.

A Well, in a reasonable way I am.

Q Do you have any idea when pulverized coal firing was first developed?

A No.

Q Do you have any knowledge of when the first large power plants, say, over 100 megawatts, fired by pulverized coal was built in the United States?

A No. I remember when the power station in the U.K. was built, but I wasn't around in the United States until after the war, so you'll forgive me if I'm not familiar with when you had that. Battersea was built immediately after the war. World War II, of course.

Q Well, is it fair to say that you don't know how long pulverized coal-fired power stations have been operating in the United States?

A That's correct. I don't know how long they've been operating in the United States.

Q Now, do you have any knowledge of what pulverization of the coal does to the distribution of particle sizes that come out of the boiler when you combust coal?

A Well, I would have thought, I don't have any direct knowledge but a priori, I would have thought the pulverization helps, you know, improves the combustion, and that's why people go to the trouble of pulverizing it.

Q And that's correct. Let me ask you this. You pulverize the coal so it will burn more efficiently. And it burns more efficiently because it has a greater surface area when it's pulverized, doesn't it?

A Correct.

Q Okay. Now isn't it likewise true that a certain weight of particulate, if it were in the form of extremely fine particulate has a considerably larger surface area, weight for weight than if it were in the form of larger particulates?

A Yes, I agreed with you on that this morning.

Q Do you have any idea what kind of orders of magnitude of increase in surface area to weight ratio we're talking about here?

A No.

Q Well, I can show you again that surface. Well, I'm going to have to go back to this thing with this figure, I'm sorry. If you have a sphere, I represent to you that the

ratio of surface to volume is proportional to one over the radius. Do you think that's right?

A I would take that under advisement. I would be happy to check it out and, you know, if I can do that. I don't know whether it's proper. But I have no means of knowing whether it's right or wrong at this stage off the top of my head. I was never very good at mental arithmetic.

MR. EDDLEMAN: That's why I wanted to sketch it on the board. May I?

JUDGE KELLEY: Go ahead.

BY MR. EDDLEMAN:

Q We agreed earlier, Doctor, that the area of a sphere of radius R is four pi r squared, as I've written up here, did we not?

A The area of sphere?

Q Yes, surface area.

A Okay, I assume that's correct.

Q Okay. And likewise the volume of the sphere of radius R is four-thirds pi times the cube of the radius.

A Well, you say that. I say that I am willing to accept it at the moment. But I want to verify it.

Q I may have to ask for judicial notice to be taken of these formulas, but let me go on with this.

JUDGE KELLEY: You overestimate the judge, but go ahead.

(Laughter.)

BY MR. EDDLEMAN:

Q Well, as I understand the law, anything that is so generally known that you can look it up in a reference book --

JUDGE KELLEY: I think if this could be checked, I would assume if anybody would want to check it, go ahead.

BY MR. EDDLEMAN:

Q What I propose to do, Doctor, is compute the ratio of surface to volume by dividing the volume into the surface. Now, from our algebra we can just cancel out these two pi's, can we not?

A Correct.

Q Okay. And I don't want to go through dividing four by four-thirds, but we get some constant here if we divide those out, don't we?

A Yes.

Q Now as to the radius, if we divide the radius squared by the radius cubed, that is the same as knocking out two from each exponent, is it not?

A Yes.

Q All right. So I have some constant divided by the radius as the ratio of surface area to volume for this sphere, do I not?

A Yes.

Q Now if I make the particle smaller in radius by a factor of 100, then this area to volume ratio increases by a factor of 100, doesn't it?

A That would appear to be so, yes.

Q Well, let me do it here.

A Well, it is. Let's not go through the painful --

Q Okay. If I say 1/R and compare that to 1/.1R, that equals 100/R, doesn't it?

A Yes.

Q All right. That's the main point I want to make. It's proportional to the decrease in radius.

Now, Doctor, is it also true -- this sort of lumpy surface, if I may characterize it, is a micrograph of the coal particle on the cover of this book, respirable particles, just from common sense, wouldn't you say that that lumpy surface actually has a greater surface area than a smooth sphere that just encompassed this particle?

A Yes.

Q Okay. And it's true in general, looking at those other micrographs in light of particles I showed you, that those surfaces are not smooth. They have a lot of lumps and bumps on them.

A You are correct.

Q Okay. Now in the Eddleman Exhibit 1 it says, the Fisher and Natusch paper is what I'm talking about -- it

says that certain of these elements have increasing concentration as the particle size goes down.

MS. BAUSER: Excuse me, could you cite a page that you're referring to?

MR. EDDLEMAN: Page 25 again. There are other places in it where it probably says that, but I'm referring to page 25.

MS. BAUSER: Could you repeat it, I'm sorry?

BY MR. EDDLEMAN:

Q This paper mentions some trends here on page 25 of increased concentration for some elements as the size goes down.

A This is the lead, et cetera.

Q Right. And it also shows some as showing limited concentration trends, and then it shows some that show no concentration trends.

Doctor; without trying to get into details of chemistry, would you say it is true as a general proposition that a certain amount of the substance deposited over a larger surface is more able to interact chemically with the things around it than if it were concentrated so that it had a smaller surface?

A Yes.

Q We discussed a little bit the need to understand mechanisms of carcinogenesis if you really wanted to nail

down this whole question, you know, the total analysis. I'm not just talking about this decision or this case.

It is true, isn't it, that if you're going to have one of these elements, say, that might cause cancer, or one of these particles cause cancer, it actually has to be brought in contact with the person who is going to get the cancer?

A That's correct.

Q Now, Fisher and Natusch talk a little bit about the bringing of these particles into the deep lung. I am reading down at the bottom of page 1 of the printed copy which I hope is the first page of the other copy. It says, fractional deposition in the pulmonary region ranges from 30 to 60 percent of the inhaled aerosol for particles ranging in size from 1.0 to 0.01 micrometers.

Similarly, tracheobronchial deposition ranges from 5 to 30 percent for inhaled aerosols from 1.0 to 0.01 micrometers, respectively. Respiratory tract deposition profiles have been calculated for iron, lead and benzc -a- pyrene in urban aerosols.

Now here we have your iron that is the anomalous element. We have benzoate pyrene. Let me ask you, do you believe that benzoate pyrene is a carcinogen?

A Yes.

MS. BAUSER: Objection. This line of questioning

is the same line we have gone down now numerous times, and I don't see its relevance to Dr. Hamilton's testimony.

MR. EDDLEMAN: When the particles are deposited in the lung, that is bringing the carcinogen into very direct contact with the human body.

BY MR. EDDLEMAN:

Q Isn't it?

A Correct.

Q Now, Doctor, are you at all familiar with the physical properties of fly ash? The particles emitted from coal-fired power plants, if I may say.

A Well, I know some of these -- I don't like the word fly ash, I must admit because it is a somewhat ambiguous word. I tend to think in terms of suspended particles or respirable particles.

Q All right. Particualtes emitted from coal-fired power plants, I think, says what I'm getting at in closer to your terms.

A Thank you. And I would say I'm reasonably familiar with some of the properties of those.

Q All right. Do you have any knowledge about the electrostatic properties of such particles, such as the resistivity?

MS. BAUSER: Objection. I just would like to hear why this is relevant to Dr. Hamilton's testimony. The

same objection posed three questions ago, and I think we went on.

JUDGE KELLEY: Well, I thought you objected that some particular thing was a carcinogen, and Mr. Eddleman dropped the question, I thought.

MR. EDDLEMAN: I think he answered it.

JUDGE KELLEY: Well, now we're on a different question, the electrostatic properties when they get into the deep lung.

MR. EDDLEMAN: Well, there, too, Judge. But it's what's coming out the power plant that I'm trying to get at.

JUDGE KELLEY: Okay. And you're objecting to that?

MS. BAUSER: My objection is that Dr. Hamilton's testimony takes account of the health effects of the particles coming out of the coal plants in question. And Mr. Eddleman, as I understand his questioning, continues to focus on subparts, in fact, of that analysis, which Dr. Hamilton has already taken into account. And he keeps on going back through the same assessment, which doesn't change conclusions that Dr. Hamilton has already made about this.

MR. EDDLEMAN: Well, if I think that Dr. Hamilton may not have taken something into account, I think I have to ask him about it. In this case, where I'm going is that there is a relationship between these electrostatic properties

and the sulfates, the sulphur gases which has been talked about a good bit, and it is a physical relationship.

I want to know what he knows about it.

MS. MOORE: Your Honor, I would join in the objection on the grounds that sulfates are not a subject of this contention. The particulates are the subject of this contention.

JUDGE KELLEY: Well, it just strikes me -- and I asked my colleagues -- it's one thing to ask whether something is a carcinogen. And it's somewhat a different thing to ask how it behaves when it comes out of the stack, whether it's a carcinogen or not.

And if that can have some bearing on the effect of the particle, it seems to me, it's relevant. But I'd like to confer.

(Board conferring.)

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JUDGE KELLEY: My colleagues have persuaded me that the objection is well taken, but given the approach that Dr. Hamilton takes, the answer to the question would not be relevant, so I will sustain the objection.

BY MR. EDDLEMAN:

Q Dr. Hamilton, asbestos is a carcinogen, isn't it?

A Yes.

Q Let me refer you to Page 2 of the Fisher and Natusch typescript.

A Can you read the chapter heading, because I don't have that typescript. I have the printed version.

Q All right, I'm sorry. I had the wrong page here. It is under "Section I: Introduction," and it is the next to the last paragraph in the introduction. It might be the second or third page of your text.

It says, "It should be emphasized, however, that dissolution of surface - associated chemical components need not be a prerequisite for their interaction with the biological system. For example, inhaled particles may be phagecitized by macrophages where direct particle surface/cell interaction will take place. A reasonable comparison of insoluble particle interaction may be made with asbestos."

Now my question is, if you have an insoluble coal particulate, does this statement say to you that that particulate being swallowed up by a white cell in the body,

mgc 25-2

a macrophage, can bring it into interaction with the biological system without disolving any of the possible carcinogens off the surface of the particle?

MS. BAUSER: Objection. I don't understand the question. I'm sorry.

JUDGE KELLEY: Can you restate it, or maybe paraphrase it?

MR. EDDLEMAN: Sure.

BY MR. EDDLEMAN:

Q Dr. Hamilton, I read that paragraph. Do you have it in front of you?

A Yes.

Q Do you agree with those statements?

A Well, I find the last sentence somewhat opaque. I don't know what he means by a "reasonable comparison of insoluble particle interaction may be made with asbestos." I don't understand what he means there. But otherwise, it seems quite reasonable to me.

Q All right. Now focusing, then, on the first two sentences that you say are reasonable, in addition to the mechanism of a carcinogen being carried into the lung on one of these particles and then dissolved off of it, this identifies another mechanism whereby the body's white cells come and swallow the thing up, even though the particle is insoluble; isn't that what it says?

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A That's correct.

Q So another mechanism of possible --

A Carrying it around the body.

Q Right. Taking it into the lymph nodes, for example. All right.

JUDGE KELLEY: About where are you at this point, Mr. Eddleman?

MR. EDDLEMAN: Just about done, Judge.

JUDGE KELLEY: Can you finish in five minutes?

MR. EDDLEMAN: I think so.

JUDGE KELLEY: Okay.

BY MR. EDDLEMAN:

Q Isn't it true that these particulates can kill some of the macrophages that eat them?

A It is conceivable that they might, yes. If they are sufficiently toxic to kill a macrophage, yes.

Q Doesn't one of the papers that I showed you -- it is the cytotoxicity to alveolar macrophages of trace metals adsorbed on fly ash -- See Arunyi, et al., Environmental Research, 20, Pages 14 through 23 of 1979.

This document, I believe, was supplied to you. Do you have that?

A I have it, yes.

Q It described such an effect, didn't it?

A Correct.

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Q What is your opinion of the scientific validity of this paper?

MS. BAUSER: Excuse me. Could you just wait a second while we locate it?

(Pause.)

MS. BAUSER: Could you restate what that paper was?

MR. EDDLEMAN: Cytotoxicity to Alveolar Macrophages of Trace Metals Adsorbed on Fly Ash.

THE WITNESS: I thought it was a reasonable piece of work.

MR. EDDLEMAN: Thank you, Doctor.

BY MR. EDDLEMAN:

Q Isn't it true that among the trace metals found in coal are uranium and thorium?

A In coal, uranium and thorium?

Q Yes. Aren't they trace metals that are found in coal?

A Yes. They can be there.

Q And these are alpha emitters, aren't they?

MS. BAUSER: Objection. I don't see -- I think I know what Dr. Eddleman is trying to do -- Mr. Eddleman is doing -- and it has nothing to do with Dr. Hamilton's testimony. He has focused in on Contention 2-E issues, and he has been pursuing that for some time. But this is

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simply not what Dr. Hamilton's testimony is about.

MR. EDDLEMAN: Counsel is simply wrong. Contention 2-E is about the radionuclides released from the nuclear plants getting on these particles. I am talking abcut the nuclides in the coal.

MS. BAUSER: In that case, it's already included in Dr. Hamilton's analysis, and we are back to the same question. The health effects are already encompassed.

MR. EDDLEMAN: I think I am entitled to know whether he specifically considered it.

JUDGE KELLEY: I understood that Dr. Hamilton counted deaths, and if they are somehow related to air pollution. That's about as far as it went; is that right?

THE WITNESS: Correct.

JUDGE KELLEY: That is his thesis. You are entitled to probe it, as you've been doing, but I think you have to take the thesis he is advancing. I don't see the relevance of that to his approach.

BY MR. EDDLEMAN:

Q Doctor, did you specifically take into account the effects of uranium and thorium and other radiation-emitting trace elements at all in your analysis?

A They are included in the sense that I explained that the fine particle is a surrogate for air pollution, and it includes within it all the chemicals, and it includes

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radioactivity as well -- trace metals, polycylic aeromatic hydrocarbons, radionuclides, sulfates -- I didn't mention radionuclides earlier, and I apologize -- but they are all included in this under this umbrella of this surrogate. And so, you know, they don't have a separate existence, but I am aware of the fact that radionuclides are admitted by coal plants.

Some people, by the way, actually have got some measurements and claim that some sorts of coal and some coal plants put out more radioactivity than do nuclear plants, but I don't want to get into that controversy.

Q Neither do I. But let me ask you this.

You mean included to the extent that the statistics pick up their effects, don't you?

A Correct.

Q All right. Doctor, did you have occasion to take a look at the FES as an analysis of the radiation health effects of Harris in comparison to the coal health effects?

MS. BAUSER: Objection. It is not the subject of Dr. Hamilton's testimony. It is Table S-3.

JUDGE KELLEY: You say the radiation health effects of Harris?

MR. EDDLEMAN: Right.

JUDGE KELLEY: How does that tie into the fuel cycle of coal?

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MR. EDDLEMAN: It goes to the adequacy of the analysis.

JUDGE KELLEY: In what way?

MR. EDDLEMAN: Well, there is a whole pile of analysis in their radiation health effects, and they come out with a smaller number of results than he does for coal. He says the other stuff isn't worth putting a line in on. I want to go after their consistency. I just want to lay a basis for it.

JUDGE KELLEY: I'm going to sustain the objection. I think it's pretty far afield.

MR. EDDLEMAN: All right.

BY MR. EDDLEMAN:

Q Doctor, how is your group at Brookhaven funded?

A We get about two-thirds of our support from the Department of Energy, about one-third from the U.S. Environmental Protection Agency.

Q And is this through grant proposals that you made?

A No. We are the lead -- in the Office of Health and Environmental Research, in the Office of Energy Research, we are the lead group of a group organized called the Health Environmental Risk Assessment Program. We actually support this program. Proportioally, the support seems to fluctuate.

Q Your financial support, you mean?

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A The financial support, because the Department of Energy overall and the Office of Environmental Research has been under some constraints, and that is something which started back in 1973, as I recall, this program, and we were the first group, and we maintain that we are the largest group, and we have about eighteen man-years of effort in our group at the moment. That gives you some idea of the size of our operation. And we were approached on the basis of our work on -- we are charged with assessing the health and environmental impact of all energy sources, and we were approached by EPA to see if we would undertake a study of the health effects of complex technologies, and we have been collaborating with our sister laboratory, Oak Ridge, in a risk assessment program with them in this area. So we have a contract with the EPA, and our work with DOE is, of course, on a contractual basis.

Q It comes up for renewal every year?

A Every year, yes. DOE is funded on a year-to-year basis.

Q Have you ever heard or seen any indication that the Department of Energy has an internal opinion as to what kind of results you should get in your work?

A I would say this. The answer is emphatically no. You know, there are some people in the Department of Energy who like the results we get, and there are some people who

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don't like the results we get. It varies, depending on the prejudices of the people within the Department of Energy.

I do my analysis. I have in my room at Brookhaven an interesting cartoon from a cartoonist called Lowe, a very famous English cartoonist. He dealt with -- he was in the war, and it shows an enormous truck coming out of an enormous factory, loaded with shells, and it says, "For King and County." "Any King, Any Country" is the logo on the front of the truck, and that's precisely how we do our analyses.

(Laughter.)

But we don't change them, whether it's the NRC or DOE or EPA or the Sierra Club. We have done work for Intervenors' groups, such as the Sierra Club, and we have supported the Heart and Lung Association in a number of areas. So we have done some assessment at the request of the U.S. Congress' Office of Technology Assessment. They came to us and asked us to help them in connection with the long-range pollution problem, and we tell it as it is. If you would ask me and wanted to retain me as a consultant, I certainly wouldn't be the slightest bit different from what you've heard today.

Q Well, I saved myself a lot of money, I guess.

(Laughter.)

Doctor, one last little line. How much of your own

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time is spent in your personal consulting work, as distinguished from your work at Brookhaven Laboratory?

A How much time do I spend? That is a difficult question to answer. I have to be quite sure that my professional responsibilities are fully discharged. I would say somewhere around ten, fifteen percent of my time is probably spent on consulting. I'm just giving -- that's my best ballpark estimate. I haven't really sat down -- it does, of course, cut into my spare time. That's where it comes out of. It comes out of my leisure time, unfortunately, weekends and evenings.

Q Well, Doctor, that's all the questions I have. I hope you have much better luck on your flight back than you did on your way down.

A I hope so.

JUDGE KELLEY: Let's maybe pause and take stock. I did check out in the hall about whether we had to leave by a certain hour, and you will be glad to know that we can on indefinitely, Doctor.

(Laughter.)

Maybe we could just check now. We will have some questions from the Staff. The Board will have a few questions, I suppose. I don't know whether we'll have redirect or not.

Ms. Moore, do you have a ballpark guess about the

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time you think you will need?

MS. MOORE: Could I have a moment.

JUDGE KELLEY: Sure.

(Pause.)

Doctor, could you be here tomorrow morning, if need be?

THE WITNESS: Yes. I'm planning to stay over.

MR. RUNKLE: There is one other matter on Dr. Hamilton's testimony that we can clear up, and I can probably do it faster than Mr. Eddleman can. Can I ask one series of questions on his testimony?

JUDGE KELLEY: What are we talking about?

MR. RUNKLE: Another minute.

JUDGE KELLEY: That's all right. Just wait a minute while we get an assessment here.

(Pause.)

End 25

6 p.m.

(6:00 p.m.)

JUDGE KELLEY: Ms. Moore?

MS. MOORE: Your Honor, I am ready if you like.

JUDGE KELLEY: I just wanted a rough guess about time.

MS. MOORE: It's easy. The Staff has no questions.

JUDGE KELLEY: Oh, that is simple. All right.

We are going to go to Mr. Runkel for a short line in just a minute, but let me just talk here.

(Board conferring.)

JUDGE KELLEY: Do you envision redirect?

MS. BAUSER: No.

JUDGE KELLEY: Okay. Well, Mr. Runkel had a few questions he wanted to put. Let's go back to the Intervenors.

BY MR. RUNKEL:

Q Dr. Hamilton, let me draw your attention to page 3 of your testimony, the first full sentence begins operation of a new nuclear power plant will result retirement earlier of coal-fired plants.

Do you have any basis for that statement?

A Well, it has been my experience, the basis for that statement has been -- and it's an argument that I used recently. I was asked a year ago to testify at the Sizewell inquiry in England, where the British are going to be

building for the first time an American designed reactor. And making this an occasion an opportunity of going into the whole nuclear cyle in some depth.

And I was asked to testify comparing the coal and nuclear cycle. And the situation for the central electricity board is that on the need for power point of view, they don't have any need for additional generating. That was a conclusion that I came to on that occasion. They do have some old coal-fired plants in the U.K., and the great advantage of the Sizewell plant is that it would enable them to retire them, these plants, earlier even though they don't have a need for power.

Q But in fact, you have not done any study or know of any study on the Carolina Power & Light service area.

A No. But it was just a general observation that I think it is almost a truism. You know, if you are really worried about coal-fired particulates from the health point of view, merely building a nuclear plant will enable you to get the same energy with about 20 times less particulates.

Q Answer my question please. You have not looked particularly at Carolina Power & Light, the basis for this statement.

MS. BAUSER: Objection. He answered.

MR. RUNKEL: I'm sorry, I missed the answer.

THE WITNESS: I said I had not, but I went on to

explain in general terms.

MR. RUNKEL: Thank you, that's all I wanted to clear up there.

JUDGE KELLEY: Okay, thank you.

I think my first question really goes to Ms. Bauser, rather than the witness, if you will forgive me. I was just wondering, Ms. Bauser, in putting your case on at this point, we had a footnote, as I'm sure you know in our opinion of last January, a footnote on page 44, Footnote number 1. And we simply averted to the fact -- or I'll back up a step. I think I remember seeing some paper in the case earlier about the effect of Shearon Harris going online.

And the effect would be that X number of coal plants would be shut down, or not brought up. Or in other words, there would be a decrease in coal burning in this area. And from an environmental standpoint, our footnote as a matter of fact says, that if you really were going to replace coal with nuclear, you might have a net decrease in the neighborhood of a factor of 20.

I guess the reasoning there was that, if the 1154 metric tons comes from a 45 megawatt plant. And you've got a 900 megawatt nuclear plant that you are putting in instead. Why isn't that the short answer to this contention? And I didn't hear that. Of course, that's not Dr. Hamilton

to present. It's more sort of a lawyer's argument.

But I'm not quite sure I understand why it isn't the short answer. And maybe you can enlighten me.

MS. BAUSER: I can give you my personal legal opinion on the subject, which is that as a practical matter I think it's the answer. But I think that we are left with Table S-3, and the probable need to analyze the health effects of Table S-3, emissions and particulates.

And therefore, I don't think that you can, in effect, avoid the question necessarily by what is in fact, a practical matter.

JUDGE KELLEY: I'm always troubled when somebody says yes, that's a practical answer and it's not the legal answer. Do you know whether the Commission took that factor into account when they came up with the Table S-3 or this particular part of it?

MS. BAUSER: I don't know. I know that Table S-3 was, of course, a rulemaking on the numbers themselves. It left open the issue of the health effects.

JUDGE KELLEY: Which you can litigate. So you can walk in and say, hey, I'm shutting down 20 coal plants. Well, okay, I understand your point. I was just curious as to how that fit in. If anybody else wants to comment on that, feel free to go ahead.

MR. RUNKEL: There is a substantial difference

between a baseload plant and a peaking plant. And I think that the nuclear plant would come in on base, and the coal that generates most of the particulates in North Carolina are those peaking plants that just come on in certain times of the year. And it would be real hard to get that kind of correlation between a nuclear plant and taking coal plants off the line. It's not that easy.

MS. BAUSER: Let me clarify something, too. My answer is the legal answer. It has nothing to do with what in fact is going to happen in this area.

JUDGE KELLEY: I understand. We didn't go down that road, whether we could have or not. But I just thought that since we had written this footnote here, there was some short answer why the footnote was wrong. I was curious to know what it was, and maybe as you point out, maybe it is --

MR. EDDLEMAN: I think there's another problem, too. And that is most of those base load units have the more efficient electrostatic precipitators that the rule doesn't let you consider for Table S-3, and it's a wide open question in my mind whether they could show, even with a very extensive analysis that Harris is going to produce enough electricity to reduce the particulate loading by 1154 metric tons per year, given the performance of the coal plants.

JUDGE KELLEY: Okay. Ms. Moore, any comment?

MS. MOORE: I have no comment.

JUDGE KELLEY: Okay.

BOARD EXAMINATION

BY JUDGE KELLEY:

Q Doctor, you made reference several times to the Staff's analysis, and I have read it and I understand that they took a somewhat different approach, they used some different data. You may have said this, but for the record I just would like to be clear in my own mind, do you basically agree with the Staff's analysis?

A Yes, basically.

Q Would you say that your analysis and theirs are basically compatible?

A Very.

Q Do you have any major reservations about them?

A About the Staff analysis?

Q Yes.

A No, I think it's an excellent effort.

Q This business of pulverized coal that came up toward the latter part of Mr. Eddleman's questioning, and this too, may be pretty well covered in the transcript, but I am not entirely clear on it, Mr. Eddleman was making the point that pulverized coal technology is a relatively recent development. And I don't know anything about the technology

and how recent and how much it has spread. But I guess the point would be, that if it is really quite recent that it has been used in a widespread way, do we really appreciate the impact that coal burning may have?

Could you just respond to that? Do you think that that is a significant factor in your analysis? I understand you to say that you go out and you look at how many people died, and you want to know if what they died of is somehow related to air pollution, and there you stop. So that envelopes a lot of factors. But would it envelope the factor of the recent use of pulverized coal?

A Well, I think it would in the sense that, you know, the actual particles that I read off are taken from pulverized coal which was WASH-1248 said it was. I don't know whether it is in these actual plants. But if I was to say that there was any recent development that has really spread these fine particles around, I think it has been the use of the tall stacks.

And I think from 1950 to 1975, where we have seen the increase in fine particle problem in the northeast of the United States. Now that coincides not so much with pulverized coal but with the use of tall stacks to dilute pollution. And that is the basis, of course, of the fine particle, the acid rain problem that we're having to face up to, and the fine particle problem with many other areas.

So I would say that, you know, I'm sure that pulverized coal has been in existence since World War II, so that is now 30 years, isn't it, or 40 years. The 40th anniversary of D-Day. So you know, that is a long enough time to have seen anything. But there are some effects of fine particles.

I don't know if that's responsive.

Q Yes. I have just one other question. It's kind of a fine point. At one point you were talking about the way you went about your analysis, and if I understood you, you took the 1154 and added to existing background?

A Well, no. The way I did the analysis is as I've done it here. I just took 1154 and diluted it out uniformly in a 50-mile radius. And then I also did the same thing over the entire United States using the 90 micrograms.

I only looked at the background to see if the increment -- you know, if one is concerned that there may be a threshold factor. I looked at the background just to see where this was. I haven't included that in the testimony, but for each of the three areas, I did look at the background and saw that this tiny incremental effect would not under any circumstances bring the background level any closer to the level of concern that EPA, you know, specifies in their -- for their 24-hour or their long term average.

Q My question then is this though, when you look

at the background around Portsmouth and those other slices, I forget the name of them, I would have thought that the background that's there now already has the 1154 in it. And when you add --

A That's a good point. Just for the heck of it I added to it, yes.

Q Okay. But it seems to me that in a sense, it is already there.

A Yes, I think that's an excellent point. It is there. It really isn't contributing a significant amount. It is not being responsible in any way for pushing it up to a level where you might begin to see health effects.

JUDGE KELLEY: All right, thank you. I have nothing else. Mr. Eddleman?

RECROSS-EXAMINATION

BY MR. EDDLEMAN:

Q I have to ask him a couple of questions about those last two things.

Dr. Hamilton, you say the 1154 metric tons is already there in the air around these plants. Have you actually checked the emission levels of those plants to see how much they are emitting?

A No, no. But the point I am making is this: the point that the Chairman is making is the following, that if these plants are responsible for generating electricity

for enriching uranium, and at any one of those plants, if any one of those plants the uranium was going to be the uranium that is supplied to Shearon Harris, then the levels that currently exist around those are the levels that already carry within them the particulate loading associated with the production of that uranium.

Q As actually emitted from the plant.

A As actually emitted from the plant.

Q Not as stated in Table S-3.

A Well, in that case, you see, I actually covered myself by saying that if you add the 1154 -- the level of concentration which you get which I have calculated to the actual levels around the plant, it doesn't make any significance difference to the levels. They still remain well below those at which EPA indicates one would be concerned from the health point of view.

MR. EDDLEMAN: One moment.

end 26.

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(Pause.)

MR. EDDLEMAN: I have a problem. My mind went blank on the thing that he answered before that, and I was going to ask him something about it.

(Pause.)

MR. EDDLEMAN: Well, it may not matter. If I can't remember, it's my own fault.

JUDGE KELLEY: Well, I believe that brings us to the point where we can thank Dr. Hamilton and excuse him.

We appreciate your coming, sir, and we're glad you will be here tomorrow. Thank you very much. You are excused.

(Witness Hamilton excused.)

JUDGE KELLEY: We would like to start tomorrow morning at 8:30 and maybe finish a little earlier than one normally would.

Does everybody know where this is, this 300 Lafayette Mall -- no, Fayetteville -- Fayetteville Street. It is a courtroom, so it should be a little better.

So let's all pick up our Dixie cups and so on. We appreciate that. That's it for tonight.

(Whereupon, at 6:32 p.m., the hearing was recessed to reconvene at 8:30 a.m., Friday, June 15, 1984.)

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# CERTIFICATE OF PROCEEDINGS

This is to certify that the attached proceedings before the

NRC COMMISSION

In the matter of: CP&L and N.C. Eastern Municipal Power Agency, Shearon Harris Units 1 & 2

Date of Proceeding: Thursday, June 14, 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