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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

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

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# NRC STAFF PROPOSED FINDINGS OF FACT AND CONCLUSIONS OF LAW REGARDING EDDLEMAN CONTENTION 8F(1), JOINT CONTENTION II(c), AND JOINT CONTENTION II(e)

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# NRC STAFF PROPOSED FINDINGS OF FACT AND CONCLUSIONS OF LAW REGARDING EDDLEMAN CONTENTION 8F(1), JOINT CONTENTION II(c), AND JOINT CONTENTION II(e)

## I. INTRODUCTION

On June 14-15, 1984, and June 18-19, 1984, hearings were held in the Shearon Harris Operating License Proceeding concerning Eddleman Contention 8F(1), and Joint Contentions II(c) and II(e). Pursuant to the schedule agreed to by the parties and adopted by the Board at the end of the hearing, the Staff of the Nuclear Regulatory Commission (Staff) submits its proposed findings of fact and conclusions of law concerning each of these contentions. Tr. 2150.

## II. PROCEDURAL BACKGROUND

Eddleman Contention 8F(1) was admitted as a matter in controversy in this proceeding by the Board in its Order of August 18, 1983. "Memorandum and Order (Ruling on Wells Eddleman's Contentions on the Staff Draft Environmental Statement)" at 5. Discovery was conducted on

this contention, and motions for summary disposition of the contention were filed by both the Staff and Applicants Carolina Power & Light Company, and North Carolina Eastern Municipal Power Agency [hereinafter Applicants]. "NRC Staff's Motion for Summary Disposition of Wells Eddleman's Contention 8F(1)" (December 2, 1983); "Applicants' Motion for Summary Disposition of Eddleman Contention 8F(1)" (December 6, 1983). The motions for summary disposition were denied by the Board in its Order of January 27, 1984. "Memorandum and Order (Ruling on Motions for Summary Disposition of Health Effects Contentions: Joint Contention II and Eddleman Contentions 37B, 8F(1) and 8F(2))" at 46. Hearings were held on this contention on June 14 and June 15, 1984.

Joint Contention II was originally admitted by the Board in September, 1982. In the Matter of Carolina Power and Light Company and North Carolina Eastern Municipal Power Agency (Shearon Harris Nuclear Power Plant, Units 1 and 2), LBP-82-119A, 16 NRC 2069, 2076 (1982). Joint Contention II was the subject of a motion for summary disposition by the Applicants which was supported by the Staff. "Applicants' Motion for Summary Disposition of Joint Intervenors' Contention II and Wells Eddleman's Contention 37B (Health Effects)" (October 3, 1983); "NRC Staff Response to Applicants' Motion for Summary Disposition of Joint Contention II and Eddleman Contention 37B" (October 31, 1983). The Board granted Applicants' Motion in part and denied it in part. Order of January 27, supra. The Board denied the motion with respect to Joint Contention II(c) and Joint Contention II(e). With respect to Joint Contention II(c), the Board in denying the motion modified the issues to be heard at the hearing. Hearing on these two contentions was held on June 18 and 19, 1984.

## III. FINDINGS OF FACT

### A. Eddleman Contention 8F(1)

1. Eddleman Contention 8F(1) states:

> Appendix C of the DEIS underestimates the environmental impact of the effluents in Table S-3 for the following reasons:
>
> (1) Health effects of the coal particulates 1,154 mt per year, are not analyzed nor given sufficient weight.

2. Evidence was presented on this contention by Applicants,[1/] and the Staff.[2/]

3. Intervenor Eddleman did not present any evidence on this contention.

4. Table S-3 of the Commission's regulations, 10 C.F.R. Part 51, sets forth the amount of particulates which will be generated by coal fired plants used to support the uranium fuel cycle. Table S-3 states that 1,154 metric tons of particulates will be emitted per year in support of the uranium fuel cycle.

5. In its Final Environmental Statement the Staff concluded that the quantities of chemical, gaseous and particulate effluents set forth in Table S-3 constitute an extremely small additional atmospheric loading

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1/ Applicants' witness on Eddleman Contention 8F(1) was Leonard D. Hamilton. "Applicants' Testimony of Leonard D. Hamilton on Wells Eddleman's Contention 8F(1) (Table S-3 Coal Particulates)", ff. Tr. 1178 [hereinafter Hamilton, ff. Tr. 1178].

2/ Staff witnesses on Contention 8F(1) were Dr. Loren J. Habegger, Dr. A. Haluk Ozkaynak, and Mr. Ronald L. Ballard. "NRC Staff Testimony of Dr. Loren J. Habegger, Dr. A. Haluk Ozkaynak and Mr. Ronald L. Ballard Regarding Eddleman Contention 8F(1) (Health Effects of Coal Particulates at the Table S-3 Level)", ff. Tr. 1380 [hereinafter Habegger, et al. ff. Tr. 1380].

in comparison with the same emissions from the stationary fuel combustion and transportation sectors in the U.S. That is, they constitute about 0.02% of the annual national releases for each of these species. The Staff found that such small increases in releases of these pollutants are acceptable. (NRC Staff Exhibit 1, Appendix C at C-2. The Staff also concluded that the nonradiological impacts of the uranium fuel cycle are acceptable. (Id. at 5-88.)

6. Applicants' witness Dr. Hamilton performed an analysis which demonstrated that the health effects of the coal particulate effluents specified in Table S-3 were given sufficient weight in the Staff's Final Environmental Statement (FES). (Hamilton, ff. Tr. 1178 at 1.)

7. Dr. Hamilton is the head of the Biomedical and Environmental Assessment Division in the National Center for Analysis of Energy Systems at Brookhaven National Laboratory. (Hamilton, ff. Tr. 1178 at 1.) This division of Brookhaven National Laboratory assesses the health and environmental impacts of all energy sources from exploration to end use. (Id.) Dr. Hamilton testified that Brookhaven's efforts have focused on dose-response relationships for fossil fuel combustion for the generation of electricity. (Id.)

8. Dr. Hamilton is a physician, and also possesses a Ph.D in experimental pathology. (Id. at Attachment 1.) Dr. Hamilton has long experience in the area of the assessment of health effects from various sources. (Id.)

9. Applicants' witness testified that most of the energy required by the uranium fuel cycle is used in the uranium enrichment process conducted at 3 gaseous diffusion plants. (Hamilton, ff. Tr. 1178 at 3.)

He testified that these gaseous diffusion plants are located at Paducah, Kentucky, Oak Ridge, Tennessee and Portsmouth, Ohio. (Id. at 4.)

10. Applicants' witness testified that these three plants are supported primarily by power grids, so that the impacts from coal particulates released from the plants supporting the fuel cycle would actually be distributed in small amounts over large areas. (Id. at 4.)

11. Applicants' witness assumed that the total amount of particulates listed in Table S-3 were emitted alternatively from each of 5 coal-fired power plants. (Hamilton, ff. Tr. 1178 at 4.) Applicants' witness testified that such an assumption was made in order to estimate an upper limit of health risk. (Id.)

12. Applicants' witness assumed that the Bull Run plant would support the Oak Ridge gaseous diffusion plant. (Hamilton, ff. Tr. 1178 at 4.) He assumed that the Pudacah gaseous diffusion plant was supported by the Shawnee and Joppa plants. (Id.) The Kyger Creek and Clifty Creek plants were assumed to be dedicated to providing electric power to the Portsmouth gaseous diffusion plant. (Id.)

13. Assuming the emission rate of 1,154 metric tons per year, Applicants' witness first estimated the concentration of particulates in the atmosphere around each coal-fired plant. (Hamilton, ff. Tr. 1178 at 5.) Applicants' witness assumed that within a 50-mile radius of each coal-fired plant, the particulate 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. (Id.) 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 particulates 50 miles from the stack to the edge of the cylinder. Such an analysis yields, the witness testified, a rough estimate of the long-term average coal particulate exposure over a 50-mile radius. (Id.)

14. To model the dispersion of particulates, Applicants' witness assumed annual average daytime conditions. (Hamilton, ff. Tr. 1178 at 6.)

15. The average particulate concentrations for the five plants analyzed are as follows: Joppa, 0.040 ug/$m^3$; Shawnee, 0.040 ug/$m^3$; Bull Run, 0.040 ug/$m^3$; Kyger Creek, 0.036 ug/$m^3$; Clifty Creek, 0.042 ug/$m^3$. (Hamilton, ff. Tr. 1178 at 7, Table 2.)

16. Applicants' witness determined that the plant characterized in WASH-1248, the underlying document for Table S-3, is an uncontrolled pulverized coal-fired plant. (Hamilton, ff. Tr. 1178 at 8.)

17. Applicants assumed that respirable particles constituted 40% of the total mass of particulates emitted from such a plant. Applicants' witness assumed that it is this 40% of the total particulates emitted which would be damaging to human health. (Id.) The reason for this stated opinion is that larger particulates tend to deposit in the nose and pharynx, and so do not reach the lung. (Id.)

18. Applicants' analysis predicted the concentration of thoracic particles which would penetrate the thoracic region to be in the range of 0.014 to 0.017 ug/$m^3$. (Hamilton, ff. Tr. 1178 at 8-9.)

19. Applicants' witness pointed out that the Environmental Protection Agency (EPA) has stated that for both short-term and long-term exposures to particulates, the lowest level of thoracic particles at

which there may be some risk of health effects is approximately 55 ug/$m^3$. (Hamilton, ff. Tr. 1178 at 10.) Applicants' calculated concentration of thoracic particles would be approximately 3000 times smaller than this EPA level. (Id. at 10.) Applicants' witness testified that this contribution is a minimal incremental addition to background, and its contribution to health effects is very small. (Id.)

20. In estimating health effects Applicants' witness used a linear nonthreshold approach. (Hamilton, ff. Tr. 1178 at 11.) This approach assumes that even the smallest incremental particulate dose has an incremental health effect. (Id.)

21. Applicants used the damage function for fine particulates developed by the Harvard University Energy and Environmental Policy Center. (Hamilton, ff. Tr. 1178 at 11-12.) Fine particles are particles of a size less than 2.5 micrometers. (Id.) Such fine particulates, according to Applicants' witness, constitute 10% of the total particulate emissions from the witness's hypothetical plant. (Id. at 12.)

22. Applicants' witness calculated the expected excess deaths per year from exposure of the population around each coal plant analyzed to 1,154 mt/yr of total particulate emissions. (Hamilton, ff. Tr. 1178 at 12.)

23. Applicants' witness then compared the excess deaths calculated with deaths from all causes in the population around each plant. (Hamilton, ff. Tr. 1178 at 12.) The upper limit of estimated expected deaths from particulate exposure corresponds to about one one-thousandth of the mortality rate. (Id.)

24. The greatest risk posed by any of the 5 plants is 0.069 deaths per year for the population within 50 miles around the Clifty Creek plant. (Hamilton, ff. Tr. 1178 at 13.)

25. Applicants' witness testified that the estimated excess deaths from particulate exposure are indistinguishable from zero against the background of expected deaths from all causes. (Hamilton, ff. Tr. 1178 at 12.)

26. Applicants also analyzed the effect of coal burning in support of the uranium fuel cycle over the entire United States. In the entire U.S. the additional deaths from coal burned in support of the fuel cycle were calculated to range from 0.013 to 0.26 deaths per year. (Hamilton, ff. Tr. 1178 at 15.) Two million people die annually in the entire U.S. from all causes. (Id.) Applicants' witness testified that these long-range transport health effects estimates are probably biased on the high side. (Id., at 15-16.) This is because the human body has many defenses against low-level exposure to particles, and thus these small doses are probably less harmful per unit exposure than higher doses. (Id. at 15.)

27. As a result of his analysis, Applicants' witness concluded that the risk posed by the emission of 1,154 metric tons of coal particulates per year as part of the uranium fuel cycle is very small. (Hamilton, ff Tr. 1178 at 16-17; Hamilton, Tr. 1126.)

28. Upon cross-examination Applicants' witness testified that the type of analysis which he performed was the only way in which he knew one could arrive at a quantitative assessment of the impact of particulates as far as mortality was concerned. (Hamilton, Tr. 1223-1125.)

It is, the witness testified, a state-of-the-art method of giving some actual numbers concerning health effects. (Hamilton, Tr. 1223.)

29. In cross-examination Intervenor Eddleman raised the question of whether Applicants' analysis accounts for trace metals and other pollutants which could be associated with particulate emissions, and could be carcinogenic. (Tr. 1195; Tr. 1197.) Applicants' witness testified that the damage function he used in his analysis is a surrogate for pollution as a whole. Therefore, the witness testified, this damage function encompasses all elements of pollution. (Hamilton, Tr. 1233-1234; Hamilton, Tr. 1237.)

30. Upon cross-examination Applicants' witness concluded that actual effects were unlikely to be higher than those estimated in his analysis because higher effects were higher they would not be so difficult to see. It was for this reason that the witness considered his figures to be upper bound estimates. (Hamilton, Tr. 1239.)

31. The Staff's analysis was presented in the testimony of Dr. Loren J. Habegger, Dr. A. Haluk Ozkaynak, and Mr. Ronald L. Ballard.

32. Dr. Habegger is the manager of the Environmental and Natural Resources Section of the Energy Environmental Systems Division at Argonne National Laboratory. (Habegger, Tr. 1375.) The Environmental and Natural Resources Section conducts studies of technology development and its relationship to environmental protection. (Habegger, et al., ff. Tr. 1380, at Attachment 1.) Studies include the evaluation of the effects of such technical systems on air, water, and human health. (Id.) Dr. Habegger is a trained engineer, with advanced degrees in nuclear engineering. During

his career he has participated in the evaluation of the environmental impacts of non-conventional coal utilization facilities. (Id. at 2.)

33. Dr. Ozkaynak possesses advanced degrees in air pollution control from the Harvard School of Public Health, and in physics and mathematical physics from Harvard University. (Habegger, et al., ff. Tr. 1380 at Attachment 2.) He is currently employed as a research fellow and project manager in the Harvard University Energy and Environmental Policy Center. (Id.; Ozkaynak, Tr. 1375.) Dr. Ozkaynak is Project Director of a project to study the health effects of exposure to particulates. (Ozkaynak, Tr. 1375.)

34. Mr. Ballard is the Chief of the Environmental and Hydrologic Engineering Branch of the NRC. During his employment in various managerial capacities with the NRC, he has been responsible for the development of guidelines for the contents of environmental reports and for the development of guidelines for the conduct of environmental reviews by the NRC Staff. (Habegger, et al., ff. Tr. 1380, at Attachment 3.)[3/]

35. The Staff used a similar basic approach to that of Dr. Hamilton. (Habegger, Tr. 1590.)

36. The Staff testified that in order to analyze the concentration of particulates, they took the following steps: (1) they identified the specific power plants where the increased emissions would occur; (2) they characterized the various emission parameters that influenced

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3/ Mr. Ballard's professional qualifications were inadvertently omitted from the copies of the Staff's testimony which were bound in the record. Under separate cover the Staff has filed a Motion for Transcript Correction to remedy this omission.

the dispersion and can affect the extent of the impact on human health; (3) they specified the meteorological conditions in the region of the emissions sources; (4) they identified the topography around each source and (5) they estimated the particulate concentrations through the use of data from (1) through (4) above and the Industrial Source Complex computer model. (Habegger, et al., ff. Tr. 1380 at 3, 11-12.)

37. It is the uranium enrichment step which requires the greatest amount of electrical energy of the uranium fuel cycle. (Habegger, et al., ff. Tr. 1380 at 4.)

38. Of the 323 thousand megawatt hours of electricity set forth in Table S-3 as the total annual energy requirements of the fuel cycle to support requirements of the model light water reactor plant, approximately 96% or 310 thousand megawatt hours is required for the uranium isotope enrichment step of the fuel cycle. (Id.)

39. In its first step, the Staff identified the three coal fired power plants constructed primarily to support the uranium enrichment process of the fuel cycle where changes in concentrations of coal particulates were assumed to occur. (Habegger, et al., ff. Tr. 1380 at 3.)

40. Therefore, the Staff selected, as the possible sources of emissions, the following three coal plants: Joppa Steam Electric Station in Massac County, Illinois; Clifty Creek Station in Jefferson County, Indiana; and the Kyger Creek Station in Gallia County, Ohio. (Habegger, et al., ff. Tr. 1380 at 4.) Each of these "dedicated" plants was assumed to provide by itself the total fuel cycle electric energy requirement.

(Id.) Therefore, each plant was assumed to emit 1,154 metric tons of particulates per year. (Id.)

41. The Staff then calculated the changes in ambient air quality in the vicinity of each of these coal-fired plants, and identified the population that would be exposed to this change in air quality. (Habegger, et al., ff. Tr. 1380 at 2.)

42. The Staff testified that the parameters of the emissions source which would have an effect on ambient air concentrations and health effects were the stack height and plume rise above the stack of the emission source, and the distribution of particle size. (Habegger, et al., ff. Tr. 1380 at 6.) The Staff's stack parameters were assumed to be those which currently exist at each of the plants analyzed. (Id. at 7.)

43. Based on information gained from Table S-3 and the references for Table S-3, the Staff determined that the model coal-fired power plant assumed in Table S-3 was a pulverized-coal fired plant with a removal rate efficiency of electrostatic precipitators of 85.4%. (Habegger, et al., ff. Tr. 1380 at 8.)

44. The available data demonstrates that for a pulverized-coal fired boiler without controls, 10% of the particulates emitted have diameters of 2.5 micrometers (um) or less, 35% have diameters of 2.5-15 um, and the rest of the particulates have diameters greater than 15 um. Since the control devices to be used in the coal-fired model plant described in Table S-3 were not specified in detail, the Staff conservatively assumed that all of the least harmful particles (those greater than 15 um) were collected, none of the most harmful particles (those less than 2.5 um) were

collected. The level of control on the mid size 2.5 to 14 um particles was adjusted to give a total emission rate of 1,154 MT/yr. (Id.)

45. The Staff used hourly data concerning wind speed, wind direction, temperature and height of the surface mixing layer obtained from National Weather Service stations near each site. (Habegger, et al., ff. Tr. 1380 at 10.) One year of meteorological data was used for the Clifty Creek and Joppa plants, and five years of meteorological data were used for the Kyger Creek plant. (Id. at 10.) The small difference in estimated concentrations among the five years analyzed for Kyger Creek indicates that the selection of a single year of meteorological records does not change the conclusions of the analysis. (Id. at 11.)

46. The topography used in the dispersion modelling was obtained from area maps compiled by the U.S. Geological Survey. (Habegger, et al., ff. Tr. 1380 at 11.)

47. Ambient increments were estimated using the Industrial Source Complex computer model (ISC). This is a standard model recommended by EPA for use in air quality dispersion analyses for regulatory purposes. The model computes concentrations at different receptor locations for each hour over the simulated time period using the input meteorological data, stack and emission parameters, and receptor elevations. (Habegger, et al., ff. Tr. 1380 at 12.) The basic model is a steady-state down wind movement with Gaussian horizontal and vertical cross-wind dispersion. (Id.)

48. The Staff testified that the particulate concentration and population exposure analysis for each of the three power plants covered a circular area of 50 miles radius with the power plant emission source

at the center. The circular areas were divided into 360 grid cells with boundaries formed by 36 radials at 10° increments and 10 concentric rings. Particulate concentrations for each hour were computed with the ISC model for receptors at the geographic centroid of each of the 360 grid cells surrounding each power plant. (Habegger, et al., ff. Tr. 1380 at 12.)

49. Although the model is capable of doing so, the Staff did not simulate deposition of particulates within the 50 mile radius. (Habegger, et al., ff. Tr. 1380 12; Habegger, Tr. 1568.) The ISC model has the capability to simulate particle removal by deposition, which results in lower concentrations, especially at distant receptor points. (Id. at 12.) This feature of the model was not utilized by the Staff, thus adding conservatism to the Staff's analysis. (Id.)

50. The accuracy of the ISC model has been evaluated in the literature. The Staff testified that this model is generally most accurate in predicting long term average concentrations, such as the annual average concentrations used in the Staff's analysis to estimate the health effects of coal particulates. (Habagger, et al., ff. Tr. 1380 at 13.)

51. Staff witnesses testified that the annual average concentrations of coal particulates at each of the three above-mentioned plants would be as follows: For the Clifty Creek the highest annual average increment at any receptor point was 0.022 ug/$m^3$; for Kyger Creek such increments for each of the five years analyzed were 0.010, 0.009, 0.013, 0.011 and 0.013 ug/$m^3$; for Joppa the highest annual average increment was 0.038 ug/$m^3$. (Habegger, et al., ff. Tr. 1380 at 13.)

52. The Staff also estimated the maximum 24-hour concentrations of particulates for each plant. They are as follows: Clifty Creek, 0.70 ug/$m^3$; Kyger Creek, 0.60, 0.53, 0.51, 0.47, and 0.71 ug/$m^3$; and Joppa, 1.3 ug/$m^3$. (Habegger, et al., ff. Tr. 1380 at 13.)

53. Staff witnesses compared the incremental concentration derived from the Table S-3 emissions to the primary National Ambient Air Quality Standards set forth by the EPA which are intended to protect public health. The NAAQS primary standards for particulates are 75 ug/$m^3$ for annual average concentrations of particulates, and 260 ug/$m^3$ for 24-hour maximum concentrations. (Habegger, et al., ff. Tr. 1380 at 14.) The Staff concluded that the contribution of this increment is insignificant in terms of compliance with these standards. The Staff testified that even for pristine areas, the concentrations derived from the Table S-3 emissions would not be a cause for concern related to those standards. (Id.)

54. The Staff did not estimate the incremental increase in particulate concentration beyond a 50 mile radius around each plant. (Habegger, et al., ff. Tr. 1380 at 15.) The reason for this is that, according to EPA, extending dispersion parameters beyond 50 miles results in great uncertainties as to the accuracy of the estimates. (Id.)

55. Under cross-examination the Staff witnesses testified that they did estimate particulate concentrations at the outer boundary of the 50 mile radius, and that they were very small. These concentrations ranged from .003 to .009 micrograms per cubic meter. (Habegger, Tr. 1566.) The Staff determined that since the concentrations were very very low at the outer boundary of the 50 mile radius around each plant analyzed, it would not

be wise to try to compute the concentrations beyond that radius because of the limitations of the model. (Habegger, Tr. 1569.) Although the analysis did not specifically account for effects beyond 50 miles, a Staff witness testified that since the model shows that the effect is, if not completely negligible, very nearly so at the outer boundary of 50 miles, then it would most certainly be true that the effects would be very small beyond the 50 mile boundary. (Habegger, Tr. 1571-72.) Staff witnesses testified that there would be no reason to believe that the concentration of particulates would be higher beyond 50 miles of these power plants then within 50 miles. (Habegger, Tr. 1572.)

56. The Staff testified that in estimating population exposure, the population in each grid cell was assumed to be exposed to the increment estimated for the cell midpoint. (Habegger, et al., ff. Tr. 1380 at 16.) The cell population estimates were derived from the 1980 census data for geographic units called block groups in urban areas and enumeration districts in rural areas. (Id.) The population for each of the geographic units whose centroid was located in the grid cell was assumed to be totally located within that cell. (Id.)

57. The estimated populations around the three plants analyzed were as follows: Joppa, 528,000; Clifty Creek, 1,460,000 and Kyger Creek, 870,000. (Id.)

58. The Staff's estimates of population exposures within the 50 mile radius of each plant analyzed were 5567 persons-ug/$m^3$ for Joppa, 5625 persons-ug/$m^3$ for Clifty Creek and 2174 persons-ug/$m^3$ for Kyger Creek. (Habegger, et al., ff. Tr. 1380 at 17.)

59. The population weighted average incremental concentration for each plant is: Joppa, 0.011 ug/$m^3$; Clifty Creek 0.0038 ug/$m^3$ and Kyger Creek 0.0025 ug/$m^3$. (Habegger, et al., ff. Tr. 1380 at 17.)

60. The Staff did not estimate the population exposures in the year 2000, since the estimation of population growth rates is somewhat speculative. In fact, a Staff witness agreed one should not necessarily assume that the population would grow in all areas. (Habegger, Tr. 1589-90.)

61. The Staff next performed an analysis to quantify the health risk of the estimated coal particulate concentrations, and to assess the significance of that health risk. (Habegger, et al., ff. Tr. 1380 at 18.)

62. There are three components to any analysis of health effects. First is an analysis of the incremental pollution concentrations in the ambient air in the study area. Second, an analysis is conducted of population exposures to these predicted pollution levels. Third, exposure response formulas are applied to these population exposures. These exposure response formulas are based on toxicologic and epidemiologic data. (Habegger, et al., ff. Tr. 1380 at 19.)

63. During cross-examination the Board raised the issue of whether the Staff had considered the chemical composition of the coal particulate emissions used in their health effects analysis. (Tr. 1384.) The Staff testified that the risk coefficients used in their analysis are derived from a typical ambient mix of particles and, therefore, are not specifically related to the chemical composition of a given particle. (Ozkaynak, Tr. 1385.) However, the Staff testified that the specific consideration of the chemical composition of particulates would not

significantly change their risk estimates. (Ozkaynak, Tr. 1386.) The reason given was that, based on studies which have conducted sampling of plumes of power plants, it has been determined that the chemical composition, and thus the toxicity of particles is very similar after the particles have been transmitted a few kilometers downwind of a power plant. (Id.) The Staff also testified that the possibility that different particles might have different health effects was considered in the uncertainty bounds of their analysis. (Habegger, Tr. 1410.)

64. The Staff analyzed health effects in terms of both morbidity and mortality. For acute morbidity, respiratory disease incidents and hospital respiratory disease emergency admissions were among the morbidity health outcome variables studied. (Habegger, et al., ff. Tr. 1380 at 19-20.) For chronic morbidity, the Staff studied chronic respiratory disease prevalence. (Id. at 20.)

65. To analyze the acute mortality effects, the Staff employed daily long-term (time series) mortality risk coefficients. For chronic mortality effects, the Staff employed cross-sectional mortality coefficients relating annual mortality and annual average pollution in a large number of Standard Metropolitan Statistical Areas (SMSAs). (Habegger, et al., ff. Tr. 1380 at 20.)

66. The approach used by the Staff in its analysis was a risk analytic approach oriented toward providing numerical exposure-response information. (Habegger, et al., ff. Tr. 1380 at 20-21.)

67. Most exposure-response relationships are derived from epidemiologic studies of large human populations. (Habegger, et al., ff. Tr. 1380 at 22.) The models used to quantify exposure-response

associations are almost always statistical in nature. They are generally single or multiple regression analyses relating ambient pollutant concentrations and other socio-demographic factors to observed health outcomes. (Id.) The Staff also estimated standard errors from these coefficients from the regression analyses in order to quantify the range of uncertainties in the Staff's estimates. (Id.) The Staff's risk coefficients are based on information contained in NRC Staff Exhibits 2 and 3 as well as more recent research conducted at Harvard University. (Id. at 24.)

68. The Staff testified that the potential mechanisms by which inhaled particles can lead to human health risks are through inhalation and deposition of particles in different parts of the respiratory tract followed by physiochemical and biological responses to the deposited particles. (Habegger, et al., ff. Tr. 1380 at 24.) The major morbidity effects of concern are effects on the respiratory mechanisms and symptoms, aggravation of existing respiratory and cardiovascular disease, and effects on the clearance mechanisms and immune systems of the body. In addition, there are population subgroups who are likely to be more sensitive than others to particulate effects such as individuals with chronic health limitations, those with influenza, asthmatics, elderly people, children, and smokers. (Id.)

69. In its analysis the Staff selected several well regarded studies that give quantitative estimates of air pollution concentrations and morbidity outcomes. (Habegger, et al., ff. Tr. 1380 at 26-27.) The most relevant study was a study of hospital visits since it addresses concentrations in the ranges that are relevant to pollution in the areas considered in the Staff's analysis. Other studies address high particulate

levels, and thus effects must be extrapolated beyond the range of observed concentrations in these studies to obtain a morbidity risk coefficient. (Id. at 27.) Such extrapolation must be done cautiously, since very little evidence exists concerning whether the relationship observed at higher particulate concentrations holds true at lower concentrations. (Id.)

70. A number of coefficients based on linear exposure-response models were selected and applied to projected particle exposures in the vicinity of the three power plants analyzed. (Habegger, et al., ff. Tr. 1380 at 27.) The total health impacts around each power plant were computed by summing the partial risk estimates for each of the 360 grid cells. (Id.)

71. The risk coefficient used by the Staff to predict emergency room visits for respiratory diseases was 13 ±6.5 case/year/100,000 persons per ug/$m^3$ TSP. (Habegger, et al., ff. Tr. 1380 at 28.) The conservative age-specific coefficients used to predict acute respiratory disease incidents were: 0 - 24 years, 540 acute respiratory disease incidents/year/100,000 per ug/$m^3$ TSP; 25 - 54 years, 100 acute respiratory disease incidents/year/100,000 per ug/$m^3$ TSP and 55+ years, 121 acute respiratory disease incidents/year/100,000 per ug/$m^3$ TSP. (Id.)

72. The Staff determined not to include estimates of chronic morbidity effects because the cited literature does not suggest the application of the chronic morbidity risk coefficients to levels of concentration below 130 ug/$m^3$ annual average. This is because the annual average concentrations of the study on which those coefficients are based were typically greater than 130 ug/$m^3$. (Habegger, et al., ff. Tr. 1380 at 28.) The Staff concluded that based on the concentrations determined

by their analysis, chronic morbidity effects from coal particulates emitted in support of the uranium fuel cycle would be highly unlikely. (Id.)

73. The Staff concluded that the risk of acute morbidity effects in terms of emergency room visits for Joppa and Clifty Creek were three cases in two years. The respiratory disease incidents would be about 30 per year. For Kyger Creek the morbidity risk was determined to be about 1/3 of those for Joppa and Clifty Creek. That is, there would be 0.5 emergency room visits per year, and eleven cases of acute respiratory disease incidents per year. (Hapegger, et al., ff. Tr. 1380 at 31.)

74. The Staff witnesses testified that it is possible to determine the morbidity health risk to the general and sensitive populations associated with the particles at concentrations determined in their analysis, although such a determination presents some difficulty. The Staff testified that the determination of morbidity effects at the concentrations presented in their analysis was hampered by a limited data base. There were several reasons for these limitations. First, the outcomes of morbidity studies are measured with less regularity and precision than those from mortality studies. Second, most observational studies involve relatively few subjects, and thus there was not a sufficient population base to detect slight changes in non-specific disease outcomes resulting from particulate exposures at current levels in the U.S. Third, the majority of the studies were conducted at particulate matter concentrations exceeding levels of concern for standard-setting and risk evaluations, and thus often lead to a low-dose extrapolation problem. Fourth, most studies were not designed to give quantitative estimates so that

many are not useful in quantitative interpretations. Finally, the aerosol mixes on which the data are based are different from the pollution mixes encountered in the United States. (Habegger, et al., ff. Tr. 1380 at 25.) Despite these limitations, the Staff testified that after proper characterization of the mathematical uncertainties they could then project and evaluate the extent of the morbidity health risk of air pollution arising from the emission of coal particulates from the uranium fuel cycle with some confidence. (Id. at 26.)

75. The Staff's estimates of morbidity health risks are bounded on the lower end by zero. The upper bound estimate is either 1.5 or 2 times the central estimates. (Habegger, et al., ff. Tr. 1380 at 31.)

76. In analyzing the mortality risks, the Staff used time series and cross-sectional analyses in NRC Staff Exhibits 2 and 3. The Staff also performed an upgraded cross-sectional mortality analysis using 1980 census data and vital statistics in conjunction with the fine particle data for the same year. (Habegger, et al., ff. Tr. 1380 at 32.) Fine particles (FP) were assumed by the Staff to be particles with an aerodynamic diameter smaller than 2.5 um. (Id.)

77. The Staff testified that the time-series mortality coefficients chosen to represent a range were: 0.02 ± 0.005 deaths/day/100,000 persons per unit COH and 0.046 ± 0.007 deaths/day/100,000 persons per unit COH. (Habegger, et al., ff. Tr. 1380 at 32.) These coefficients were adjusted to a representative level of total suspended particulates by use of a scaling factor of 0.01. These coefficients were also adjusted upward by a factor of 1/0.54 to account for the difference in the size distribution of the projected power plant particle emissions.

This factor was chosen because inhalable particles are on the average 54% of the total suspended particulate (TSP) mass. (Id. at 33.)

78. The Staff considered several sets of coefficients for their cross-sectional mortality analysis. (Habegger, et al., ff. Tr. 1380 at 33.) The final range of cross-sectional mortality coefficients selected by the Staff were 0 to 2.31 ± 0.81 deaths/year/100,000 persons per $ug/m^3$ FP. This range was chosen since all of the other coefficients, if used, would project mortality impacts within the range generated by these risk coefficients. (Id.)

79. The Staff concluded that the most likely annual mortality risk associated with emissions from either the Joppa or Clifty Creek plants is less than 0.09 deaths per year within a 50 mile radius of each plant. The most likely annual mortality risk of the Kyger Creek plant is less than 0.03 deaths per year. (Habegger, et al., ff. Tr. 1380 at 34.) The average daily mortality risk at Joppa or Clifty Creek is $2 \times 10^{-5}$ to $4.8 \times 10^{-5}$ deaths per day. This is equal to 0.01 deaths per year. (Id.) The daily mortality risk at the Kyger Creek plant is $0.8 \times 10^{-5}$ to $1.9 \times 10^{-5}$ deaths per day. (Id. at 35.) These are less than 1/3 of the annual mortality projections of risk calculated from the cross-sectional studies. (Id. at 34-35.)

80. The Staff also estimated the maximum daily mortality impacts around each plant. The highest exposures and daily mortality within the 50-mile radius surrounding these plants would be: Joppa, $8.6 \times 10^{-4}$; Clifty Creek, $8.8 \times 10^{-4}$; and Kyger Creek, $4.2 \times 10^{-4}$.

81. The mortality effects are significantly below the detectable levels in the areas studied. (Habegger, et al., ff. Tr. 1380 at 36.) The

morbidity effects are very small, well below the sampling error in most epidemiological surveys. (Id.; Habegger, Ozkaynak, Tr. 1560-1564.) The Staff testified that even adding these morbidity effects to background they could not be detected because they would be masked by sampling errors in the survey. (Habegger, Tr. 1564.)

82. The Staff, in its analysis, considered the nature and magnitude of uncertainties surrounding its analysis. The Staff testified that any risk estimates must include zero, since extrapolation to concentrations below those observed is not well established. (Habegger, et al., ff. Tr. 1380 at 29.) Other contributors to uncertainties include sampling and non-sampling errors associated with the epidemiological studies supporting the risk coefficients. Sampling errors refer to the lack of precision of a sample result. Non-sampling errors include: confounding factors such as cigarette smoking, socio-economic status, occupational exposures, race, prior exposures and residence; collinearities with other pollutants; changing measures of particle pollution that are not entirely comparable; oversimplifications in estimating personal exposures from data collected at fixed-site monitors; and biases due to historical and cross-community differences in particle and source composition. (Id. at 30.)

83. The Staff has defined the standard errors of the estimates to be half as large as the estimates themselves. (Habegger, et al., ff. Tr. 1380 at 29.) Therefore, the 95% confidence limits are estimated by adding or subtracting twice the standard error to the mean risk estimate. (Id. at 31.) Any negative lower estimates were made zero, since beneficial effects of air pollution were not readily plausible. The Staff has quantified the uncertainties in all of its estimates. (Id. at

Table 3.) During cross-examination Intervenor Eddleman raised the issue of whether the Staff had considered the uncertainty involved in the scaling factor used to adjust the time-series morbidity risk coefficients. The Staff testified that this uncertainty was not considered since it is small, and other uncertainties in the analysis dominated. (Ozkaynak, Tr. 1521-22.)

84. A Staff witness testified that under cross-examination he has a 95% confidence level that the Staff's analysis has captured the actual effects of the particulates emitted in the support of the uranium fuel cycle in the error bounds of the analysis. (Habegger, Tr. 1506-07.)

85. In order to determine the significance of its risk estimates for the Table S-3 emissions, the Staff compared the morbidity and mortality risks associated with the incremental emissions with baseline mortality and morbidity in the areas studied. (Habegger, et al., ff. Tr. 1380 at 36.)

86. In order to achieve such a comparison in terms of morbidity and mortality, the Staff examined the socio-demographic profile of the three areas under study and determined that the population characteristics were typical of the national average. Therefore, the Staff could use the national disease incidents in the regions studied as the basis for the comparison. (Habegger, et al., ff. Tr. 1380 at 36.)

87. The Staff computed the expected total mortality rate for the areas studied using a cross-sectional analysis using 1980 census data. This analysis was checked for consistency with the observed mortality rates in 14 cities in Indiana and Ohio and it was found that the results were in agreement. (Habegger, et al., ff. Tr. 1380 at 36.) The model used

to determine this mortality rate was a multiple regression analysis which accounted separately for the contribution of given variables such as age, race, population density, education, income, etc. (Id. at 37.)

88. The Staff also computed the percentage of change in morbidity and mortality effects due to air pollution caused by the Table S-3 emissions. (Habegger, et al., ff. Tr. 1380 at 39.) Typically the baseline air pollution morbidity effects are 2 to 18 percent of the total annual morbidity predicted for the population bases studies. Mortality effects due to air pollution are about 5 percent of the total mortality from all causes. (Id. at 39.)

89. The Staff calculated that there would be a 0.0001 to 0.005 percent change in the baseline morbidity attributable to incremental emissions of 1154 metric tons of coal particulates per year set forth in Table S-3. The Staff also concluded that the change in baseline air pollution related morbidity would be very small, 0.007 to 0.031 percent. (Habegger, et al., ff. Tr. 1380 at 39.)

90. The change in mortality risks due to the 1154 metric tons per year Table S-3 emissions was also very small. The change in total annual mortality would range from 0 to 0.002 percent over background. Compared to mortality attributed to background air pollution in the areas studied, the likely range of percentage of change caused by incremental change in the ambient particle pollution is 0 to 0.034%. (Habegger, et al., ff. Tr. 1380 at 39-40.)

91. The Staff concluded that the concentrations, as well as the health impacts of the emission of 1154 metric tons per year in support of the uranium fuel cycle are so small that they could not be detected

with state-of-the-art monitoring survey design and analysis techniques. In addition, all of the projected health impacts are much smaller than the associated uncertainties. (Habegger, et al., ff. Tr. 1380 at 40.)

92. The Staff concluded that the results of this analysis confirm the judgments made in the Staff's FES, and that the results do not change the cost-benefit balance. (Habegger, et al., ff. Tr. 1380 at 41.)

93. Intervenors presented no contrary evidence on this issue.

94. Intervenor's cross-examination did not effectively challenge any of the Staff's or Applicants' conclusions relating to the question of the impacts on health of the emission of 1154 metric tons of coal particulates per year in support of the uranium fuel cycle.

95. Based on the record in this proceeding, the Board should find that the Staff has given adequate treatment and sufficient weight to the question of the health effects of 1154 metric tons of coal particulates emitted in support of the uranium fuel cycle.

96. Based on the record in this proceeding, the Board should find that Appendix C of the Staff's FES does not underestimate the environmental impacts of the effluents set forth in Table S-3 of the Commission's regulations.

B. Joint Contention II(e)

97. Joint Contention II states:

> The long term somatic and genetic health effects of radiation releases from the facility during normal operations, even where such releases are within existing guidelines, have been seriously underestimated for the following reasons:

(e) The radionuclide concentration models used by Applicants and the NRC are inadequate because they underestimate or exclude the following means of concentrating radionuclides in the environment. . . radionuclides absorbed in or attached to fly ash from coal plants which are in the air around the SHNPP site. . .

98. Evidence was presented on this contention by Applicants[4/] and the NRC Staff.[5/]

99. Intervenors presented no evidence on this contention.

100. Applicants' witness Dr. John J. Mauro possesses a Doctorate in Biology and Radiological Health and is a certified health physicist. Dr. Mauro is employed as the Director of the Radiological Assessment and Health Physics Department of Envirosphere Company. The Envirosphere Company is a division of Ebasco Services, Inc., the architect-engineer for the Shearon Harris Plant. (Mauro-Schaffer, ff. Tr. 1605 at 1.)

101. Applicants' witness Dr. Steven A. Schaffer possesses a Doctorate in biology and environmental health science. He is employed as a Senior Radiological Assessment Engineer at Envirosphere Company. (Mauro-Schaffer, ff. Tr. 1605 at 1.)

102. Applicants' witnesses testified that the dose conversion factors used by the Staff and Applicants to determine the health effects of radiation due to normal operation of the Shearon Harris facility take

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4/ Applicants' witnesses were Dr. John J. Mauro and Dr. Steven A. Schaffer. "Applicants' Testimony of John J. Mauro and Steven A. Schaffer on Joint Contention II(e) (Fly Ash)" ff. Tr. 1605 [hereinafter Mauro-Schaffer, ff. Tr. 1605].

5/ The Staff's witness was Dr. Edward F. Branagan, Jr. "NRC Staff Testimony of Edward F. Branagan, Jr. on Joint Contention II(e)" ff. Tr. 1865 [hereinafter Branagan, ff. Tr. 1865].

account of attachment of radionuclides to coal fly ash. (Mauro-Schaffer, ff. Tr. 1605 at 15-16; Schaffer, Tr. 1607.) Applicants also testified that calculations for the food pathway appropriately take account of the attachment of radionuclides to coal fly ash and their deposition. (Mauro-Schaffer, ff. Tr. 1605 at 16.)

103. Applicants testified that the phenomenon of attachment of radionuclides to coal fly ash is only applicable to those radionuclides that can take particulate form. (Mauro-Schaffer, ff. Tr. 1605 at 4.) The reason for this is that nuclides which are not particulates will not remain in the lung, but will either be exhaled or absorbed into body fluids. (Id.)

104. Applicants testified that tritium constitutes 98% of the whole body inhalation dose. Tritium is inhaled as water vapor. Therefore, it is either exhaled or absorbed into the body fluids. (Mauro-Schaffer, ff. Tr. 1605 at 4-5.) Therefore, Applicants testified that the inhalation dose of concern is the 2% remaining dose. (Id. at 5.)

105. On cross-examination Intervenors raised the question of the effect on the behavior of tritium once it becomes attached to a particle. (Eddleman, Tr. 1682.) Applicants treated tritium as though when deposited in the lung the body fluids would commingle with the wet particle, take up the tritium, and cause it to behave as though it were not attached. (Mauro, Tr. 1682.) Applicants considered the phenomenon of attachment of tritium to a particle and its consequent behavior as a particle as an unlikely phenomenon. (Mauro, Tr. 1684.) Applicants' witness testified that there was no reason to believe, and no evidence, that tritium would bind tenaciously to a particle. (Mauro, Tr. 1713; Mauro, Tr. 1855.)

Applicants believed that tritium would be absorbed into the body since its nature is that of water vapor whether or not it entered the body by nucleation around a coal particle or as an atom. (Mauro, Tr. 1762-1763.) Therefore Applicants considered the question of the behavior of tritium as a particle and rejected it. (Mauro, Tr. 1750.) Applicants' witnesses testified that due to the dispersion modelled in their analysis, concentrations of radionuclides would be unaffected by those processes raised by Intervenors in cross-examination. (Mauro, Tr. 1779.)

106. Applicants' witnesses testified that the calculation methodology used by both Applicants and the Staff is in accordance with Regulatory Guide 1.109. For these calculations the following information is required: 1) the source term; 2) the atmospheric dispersion factor at the location of the maximally exposed individual; 3) the inhalation rate of the maximally exposed individual; and 4) the inhalation dose conversion factor. (Mauro-Schaffer, ff. Tr. 1605 at 5-6.)

107. Applicants' witnesses testified that the inhalation dose conversion factors in Regulatory Guide 1.109 account for radionuclide lung deposition and clearance. These dose conversion factors represent the 50 year integrated commitment to the specified organ per unit of radionuclide activity inhaled. (Mauro-Schaffer, ff. Tr. 1605 at 6.) Applicants testified that these dose conversion factors were derived by the use of a two-compartment lung model which simulates the behavior of radionuclides once inhaled. (Id.)

108. Applicants' witnesses testified that this model was first described in ICRP-2, 1959. (Mauro-Schaffer, ff. Tr. 1605 at 6.) This model assumes that 75% of the inhaled radionuclides are deposited in the

lung and 25% are immediately exhaled. (Id.) Of the 75% deposited, the model assumes 50% is deposited in the upper respiratory tract and 25% is deposited in the deep lung. (Id. at 7.) The model also assumes that half of the insoluble particles deposited in the deep lung are removed in 24 hours, and half are retained with a half-life of 120 days. (Id.) The model assumes that soluble particles will pass through the lung. (Id.)

109. Applicants' witnesses testified that recent studies measured particle deposition in the lung as a function of aerodynamic diameter. (Mauro-Schaffer, ff. Tr. 1605 at 8.)

110. Applicants' witnesses concluded that a comparison of the experimental data with the assumptions in the lung model for percent deposition and distribution shows that the model used to derive the dose conversion factors is somewhat conservative. (Mauro-Schaffer, ff. Tr. 1605 at 8.)

111. Applicants' witnesses testified that respirable fly ash particles in the ambient atmosphere have a median aerodynamic diameter of about 2.0 um. (Mauro-Schaffer, ff. Tr. 1605 at 8.) The deposition fraction for most particles in the size range of fly ash is about 30 percent but can approach 60 percent for sizes near the 2.0 um diameter. (Id.) The ICRP-2 lung model assumes 75% deposition of particulates. (Id.) Therefore, Applicants' witnesses testified that the model assumes that a larger quantity of particles the size of fly ash will be deposited in the lung than has actually been observed to occur. (Id.)

112. Applicants' witnesses testified that empirical data indicates that 10 to 30 percent of the inhaled particles from 0.1 to 2.0 um are deposited in the deep lung. The observational studies indicate that the

percentage deposition is less for nose breathing. (Mauro-Schaffer, ff. Tr. 1605 at 9.) The model assumes 25% deposition in the deep lung, and so Applicants' witnesses conclude that the model is reasonable if not somewhat conservative. (Id.)

113. Upon cross-examination Intervenors raised the issue of whether, since the curves set forth in the study used by Applicants in their testimony were eye-fit curves, they could be varied depending on the person mapping the curve. (Eddleman, Tr. 1637-38.) Applicants' witness testified that changes in the slope of the curve would not make the model they used any less conservative. The model assumed a 75% deposition rate. The extreme case which is depicted by the study used in their testimony would be between 60 and 70 percent. (Schaffer, Tr. 1648.)

114. Upon cross-examination Intervenors also raised the issue of whether the dose to the lymph nodes achieved by the carrying of particles from the lung to the lymph nodes had been taken into account. (Eddleman, Tr. 1701.) Applicants' witness testified that the lymph nodes near the lung were not counted as part of the lung by ICRP in its model. (Schaffer, Tr. 1702.) Applicants' witness testified that the lymphatic system doses were not calculated in the Applicants' analysis. (Mauro, Tr. 1705.) However, Applicants' witness went on to state that more recent models have treated particles as remaining in lymph nodes indefinitely and only being removed by radioactive decay. (Mauro, Tr. 1705.) Applicants' witness testified that an analysis of the significance of not including dose to the lymph nodes in the earlier model was performed, and that the conclusions of the analysis supported the continuing validity of the older model. (Mauro, Tr. 1709.) The reason for this is that the analysis

concluded that the dose to the lung was more important or comparable to the dose to the lymph nodes. The lymph node dose would not, therefore, be the limiting dose. (Id.) Applicants' witness testified that, had they used a newer model, there would not be a significant difference in Applicants' calculations. (Mauro, Tr. 1711.)

115. Applicants' witnesses also considered the question of whether attachment of noble gases to coal fly ash could have a significant effect on their calculated dose. (Mauro-Schaffer, ff. Tr. 1605 at 10.) They concluded that because of the inert nature of such noble gases they would not bind significantly to particles or absorb to the surface of such particles. (Id.)

116. Applicants' calculated the fraction of Krypton-85, Xenon-133, and Argon-41 absorbed onto fly ash. These three radionuclides were chosen by Applicants' witnesses because they represent the three elemental types released and are the worst case combination of half-life and release quantity. (Mauro-Schaffer, ff. Tr. 1605 at 2-1.) The fractions of these nuclides which are calculated to attach to coal fly ash are as follows: Kr-85, $1.2 \times 10^{-5}$; Xe-133, $2.4 \times 10^{-3}$; Ar-41, $2.0 \times 10^{-9}$. (Id. at Table A-2.)

117. Applicants' witnesses testified that the actual fraction would probably be lower than the quantity calculated, because the calculation assumes a fly ash concentration representative of the maximum total respirable airborne particle load for northeastern cities. Such a concentration is higher than exists in the vicinity of the Harris plant. (Id. at 2-1, 2-2.) In addition, they testified that the calculations were conservative because they assume that all particles have surface absorption

characteristics of activated charcoal, which is manufactured for the specific purpose of efficiently absorbing radionuclides. (Id. at 2-2.)

118. Applicants' witnesses further testified that even if significant binding of noble gases to particles were assumed, it would not be significant due to the source term of gases being significantly decreased by hold up and removal of gases in the HVAC charcoal filtration system. They concluded that the dose effect would be inconsequential. (Mauro-Schaffer, ff. Tr. 1605 at 10.)

119. Applicants' witnesses testified that data collected concerning particle size in the ambient environment demonstrates that the inhalation dosimetry model effectively accounts for particle deposition in the lung of inhaled ambient particles at the Harris site. (Mauro-Schaffer, ff. Tr. 1605 at 12.) This data indicates that there are three modes of particle size. The first mode is below 0.1 um and consists of particles emitted as a result of fuel combustion. (Id. at 11.) Applicants' witnesses testified that such particles only exist in the ambient environment for a short time due to their rapid aggregation. (Id.) The next mode consists of particles in size ranging from 0.1 um to 2.0 um. These particles remain airborne for several days. This mode is known as the accumulation mode. These particles are formed by the coagulation of particles from the smaller mode and aggregation of additional particles. (Id.) Because of the relatively long life of these particles, they are the most easily transported from the point source emissions. (Id.) The third particle size mode involves those particles above 2.0 um and are produced by mechanical action. Such particles are easily removed by washout and

sedimentation. They have been determined to exist in the atmosphere for only a few hours. (Id.)

120. Applicants' witnesses testified that the most prevalent mode of particle size around the Shearon Harris facility would be the accumulation mode. (Mauro-Schaffer, ff. Tr. 1605 at 11.) The reason for this is that the plant is in a forested region with no major industrial combustion sources within five miles of the plant. (Id. at 11-12.) The inhalation dose model assumes a particle deposition fraction representative of particles in the range of 0.1 to 2.0 um. (Id. at 12.) Studies have concluded that fly ash has a median aerodynamic diameter of 2.0 um for plants using electrostatic precipitators. Therefore, Applicants conclude that fly ash falls in the range of particles considered in the model. (Id. at 12.)

121. During cross-examination Intervenors raised the issue of the effect of the presence of the Cape Fear coal units 12 miles southwest of the Shearon Harris facility. (Tr. 1771.) Applicants testified that in their analysis they did not assume the existence of any specific coal plant in the area surrounding Harris. (Mauro, Tr. 1789-90.) Applicants' witness also pointed out in response to questioning concerning the effect of the nucleation of tritiated water with particles from these Cape Fear coal units that Applicants did not use a specific activity approach in their calculations. (Mauro, Tr. 1781.)

122. In response to questioning concerning the effect of nucleation with the particles from the Cape Fear unit with tritium water droplets Applicants' witness testified that nucleation would not influence the calculated deposition rates. The reason for this is, according to Appli-

cants' witness, that when particles nucleate and get above 15 microns, they will settle out. (Mauro, Tr. 1795.) Applicants' witness concluded that, since they did not employ a specific activity approach, their calculations are transparent to the processes raised by Intervenors in questioning concerning such an approach. (Mauro, Tr. 1793-94.)

123. Applicants' witnesses testified that even if one were to assume more deposition or longer retention in the lung of radionuclides attached to coal fly ash, it would not increase the dose calculated using the dose conversion factors in Regulatory Guide 1.109. (Mauro-Schaffer, ff. Tr. 1605 at 13.) The whole body dose was calculated to be 0.075 mrem and the dose to the critical organ, which is the thyroid, is calculated to 0.14 mrem. Using a 60% deposition rate to the deep lung instead of 25%, Applicants determined that the whole body dose stays the same, and the thyroid dose increases from 0.14 to 0.16 mrem. (Id.)

124. Applicants' witnesses also performed an alternative calculation assuming that all radionuclides except for tritium are insoluble. The whole body dose was calculated to be 0.074 mrem. The dose to the critical organ which in this case was the lung was calculated to be 0.084 mrem. (Mauro-Schaffer, ff. Tr. 1605 at 14.) From this calculation Applicants concluded that particle solubility had no significant effect on overall dose. (Id.)

125. Applicants' witnesses also analyzed the effect on deposition velocity of attachment of radionuclides to coal fly ash. They concluded that the calculations for the food pathway appropriately account for the attachment of such radionuclides to coal fly ash and their subsequent deposition. (Mauro-Schaffer, ff. Tr. 1605 at 16.)

126. Under cross-examination Applicants' witness testified that he believed the experimental and observational data showed their deposition velocity values to be reasonable. Such values are within experimental and observed values. (Mauro, Tr. 1797-1798.) In addition, Applicants' witness testified that there is some uncertainty in deposition rate, and that is why Applicants have an environmental surveillance program to verify their model with actual data. (Id.)

127. Intervenors questioned Applicants' knowledge as to the fraction of particles which would be above 10 microns and be in the area surrounding the Harris plant. (Tr. 1799-1800.) Applicants, when questioned, testified that even if a 10 um source were upwind of Harris, it would not alter their analysis since the 10 um particles would never reach Harris. (Mauro, Tr. 1817.) Applicants' witness testified that the particles which stay airborne for 12 miles are the smaller particles. (Mauro, Tr. 1817.)

128. In response to Board questioning, Applicants addressed the question of decay of noble gases into ionized form to attach to coal fly ash. Applicants' witness testified that there are 13 noble gases released from the Shearon Harris facility. Of these 13, the most important are Xenon 133 and Krypton 85. They make up over 93% of the total noble gas quantity released. These two noble gases decay into stable isotopes which are not radioactive. (Mauro, Tr. 1949-1950.) Therefore, these noble gases would not be at issue. (Mauro, Tr. 1950.) Four of the remaining 11 noble gases have daughters which are radioactive. (Mauro, Tr. 1950.) In the development of dose conversion factors, consideration is given to these daughters. Where the daughters do not

contribute significantly to dose the contribution from the daughter is ignored. It is a general practice not to consider nuclides with the releases of below $10^{-4}$ curies. (Mauro, Tr. 1951.) Applicants' witness agreed that once the charge on these 4 radioactive daughter particles was lost, these particular particles would have to compete with all other substances for the site it had been attached to by the charge. (Mauro, Tr. 1965.) Applicants' witness testified that he would expect the daughter to be charged for less than seconds, and thus only be able to attach to coal fly ash for a very short period. (Mauro, Tr. 1952.) Applicants' witness testified that the remaining isotopes are also stable. (Mauro, Tr. 1958.) Applicants' witness also pointed out that the radioactive daughters of the daughters of such noble gases were all stable. (Mauro, Tr. 1968.)

129. Under Board examination, Applicants testified that the micro curies of tritium per gram of water in the air is a bounding calculation and that one could not have a concentration of tritium in the body greater than the concentration in the air. Applicants calculated the upper bound of the dose to the whole body that could occur and that dose would be 4 millirem per year to the whole body. (Mauro, Tr. 1744.) This calculation was based on using the annual average release per year of tritium at the offsite location with the highest potential for airborne levels of radionuclides. (Mauro, Tr. 1746.)

130. The Staff's witness Dr. Edward F. Branagan, Jr. possesses a Doctorate in radiation biophysics. (Branagan, ff. Tr. 1865 at Statement of Professional Qualifications.) Dr. Branagan is employed as a Senior

Radiobiologist in the Radiological Assessment Branch, of the Division of Systems Integration of the NRC. (Branagan, ff. Tr. 1865 at 1.)

131. The Staff, in presenting testimony on this issue, used a somewhat different approach, but agrees with the conclusions reached by Applicants. (Branagan, Tr. 1946.)

132. The Staff calculated the increase in dose to the thyroid of the maximally exposed individual due to the deposition of 100% of radioiodines and particulates in the respiratory tract rather than the 75% deposition rate used in the model employed by the Staff in the FES. (Branagan, ff. Tr. 1865 at 3-4.)

133. The Staff testified that the primary pathway of potential concern would be the exposure through inhalation of radioactive iodines and particulates. (Branagan, ff. Tr. 1865 at 2; Branagan, Tr. 1866.) The inhalation pathway constitutes the most direct means of exposure of a person to radionuclides. (Branagan, Tr. 1866.)

134. The Staff concluded that it would be unlikely that noble gases would attach to coal fly ash to such an extent that it would present pathways of concern not previously analyzed. (Branagan, ff. Tr. 1865 at 2.) This conclusion is consistent with the conclusion and calculations expressed by Applicants. (Mauro-Schaffer, ff. Tr. 1605 at 10, Attachment 2.)

135. The Staff shows the dose to the thyroid because it was the most limiting organ to be exposed in relation to the annual dose design objectives in Appendix I to 10 C.F.R. Part 50. (Branagan, Tr. 1877.) This means that the dose to the thyroid was the highest dose from all pathways of exposure to iodines and particulates, and that the dose to other organs evaluated in the FES was less. (Branagan, Tr. 1905.) This

is because the major contributors to the dose of the thyroid are radioactive iodines. (Branagan, Tr. 1907.) Doses to the thyroid from other nuclides are essentially zero or very close to zero. (Branagan, Tr. 1903-1905.)

136. Under cross-examination Intervenors questioned the Staff witness as to whether he had considered the clearance time for those radionuclides deposited in the deep lung. (Tr. 1873-1874.) The Staff witness testified that the nuclides which are the most important contributors to the dose to the thyroid are soluble radionuclides. They are assumed to be taken up into the circulation system instantaneously. Therefore, it was not necessary for the clearance times to be considered in the Staff's testimony. (Branagan, Tr. 1874.) In addition, the Staff did not consider insoluble radionuclides because they are not important to the dose to the thyroid. (Id.) The Staff also pointed out under cross-examination that in regard to the analysis of the dose to the thyroid, it does not make any difference in which part of the respiratory tract particles are deposited. (Branagan, Tr. 1876.)

137. The Staff concluded that if one assumes that all the radionuclides attached to coal fly ash were deposited in the respiratory tract, the dose to the thyroid would increase by a factor of one-third. This would mean the calculated dose to the thyroid of 0.2 mrems/year would increase to 0.3 mrems/year. (Branagan, ff. Tr. 1865 at 4.)

138. The Staff concluded that the dose to the maximally exposed organ from all pathways would increase from 4.6 mrems/year to 4.7 mrems/year. (Branagan, ff. Tr. 1865 at 4-5.) This is less than 1/3

of the dose design objective of 15 mrems/year set forth in Appendix I to 10 C.F.R. Part 50. (Id. at 5.)

139. Therefore, the Staff concluded that the attachment of radionuclides to coal fly ash would not increase the dose to such an extent that it would exceed the applicable design objectives from Appendix I to 10 C.F.R. Part 50. (Branagan, ff. Tr. 1865 at 5.) Thus, the risks of long-term somatic and genetic health effects of radiation releases from the facility during normal operations have not been seriously underestimated by the Staff. (Id.)

140. Intervenors did not present any contrary evidence on these issues, and the cross-examination did not effectively challenge the conclusions reached by the Staff and Applicants.

141. The Board should find that the dose conversion factors employed by the Staff and Applicants appropriately account for the attachment of radionuclides to particulates, including fly ash.

142. The Board should find that even if the deposition fraction of radionuclides in the lung were increased, the doses to the whole body and the critical organ would not change significantly.

143. Based on the record in this proceeding, the Board should find that the Applicants and Staff have not seriously underestimated the risks of long term somatic and genetic health effects due to the release of radiation during normal operation of the Shearon Harris facility.

C. Joint Contention II(c)

144. Joint Contention II(c) as originally admitted states:

> The long term somatic and genetic health effects of radiation releases from the facility during normal

operations even where such releases are within existing guidelines, have been seriously underestimated for the following reasons:

(c) the work of Gofman and Caldicott shows that the NRC has erroneously estimated the health effects of low-level radiation by examining effects over an arbitrarily short period of time compared to the length of time the radionuclides actually will be causing health and genetic damage.

145. This contention was modified by the Board in its Order of January 27, 1984. "Memorandum and Order (Ruling on Motions for Summary Disposition of Health Effects Contentions: Joint Contention II and Eddleman Contentions 37B, 8F(1) and 8F(2)" at 40-41.

146. The issues litigated under this contention were as follows: (1) whether the environmental impact statement should provide the total risk associated with exposure to radioactive effluents from normal operations for the 40-year life of the plant; and (2) whether the environmental impact statement should take into account the incremental impact on people who live near the plant for many years. (Branagan, ff. Tr. 2058 at 2.)

147. Evidence was presented on this contention by Applicants[6/] and Staff.[7/]

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6/ Applicants' witnesses on Joint Contention II(e) were Dr. John J. Mauro and Stephen F. Marschke. "Applicants' Testimony of John J. Mauro and Stephen F. Marschke on Joint Contention II(c) (Radiological Dose Calculations)" ff. Tr. 1971 [hereinafter Mauro-Marschke, ff. Tr. 1971].

7/ The Staff's witness on Joint Contention II(c) was Edward F. Branagan, Jr. "NRC Staff Testimony of Edward F. Branagan, Jr. on Joint Contention II(c)" ff. Tr. 2058 [hereinafter Branagan, ff. Tr. 2058].

148. Intervenors presented no evidence on this contention.

149. Mr. Marschke is a nuclear engineer who has worked for ten years in the field of radiological assessment. (Mauro-Marschke, ff. Tr. 1971 at 1.) He is currently employed as the Principal Radiological Assessment Engineer at Envirosphere Company. (Id.)

150. In determining whether it was necessary to disclose the plant life time risks in the Final Environmental Statement, Applicants computed a life time individual and population dose, and a life time individual and population risk. (Mauro-Marschke, ff. Tr. 1971 at 3, 12-13, Attachment 6.) Applicants then compared these risks with the background risks. (Id. at 8-9, 13.)

151. Applicants calculated the dose to the population from 40 years of plant operation. The calculation includes consideration of any residual exposures from releases during the life of the plant for a period of 100 years after plant operation ceases. (Mauro-Marschke, ff. Tr. 1971 at 3.)

152. In evaluating residual risk, Applicants chose a 100 year period because by that time all the radionuclides released during plant operation would have decayed to very small fractions of their original quantity. In addition, to calculate doses beyond that period would require speculation as to future land use and population patterns. Such calculations would also assume no medical improvements in the treatment of cancer. (Mauro, Tr. 1992-1993.) Applicants' witness testified that the highest dose to an individual or population will be received during the first 100 year period. (Mauro, Tr. 1993.) Applicants' witness also

testified that the NRC and EPA have used a cutoff for dose calculations at 100 years. (Mauro, Tr. 1993.)

153. Applicants testified that since the annual doses set forth in the FES represent the average annual dose over the life of the plant, the annual dose may be multiplied by 40 to estimate the cumulative dose from the operating life of the plant. (Mauro-Marschke, ff. Tr. 1971 at 5.) If the population doses for the 50-mile radius set forth in the FES were multiplied by 40 to represent the life of the plant, the liquid pathway whole body dose would change to 68 person-rems. The 40-year dose from gaseous effluents would change to 556 person-rems. (Mauro-Marschke, ff. Tr. 1971 at 6, Table 1.)

154. Applicants' witnesses testified, considering that the residual dose is comparatively small, and in light of the many conservatisms in calculating the annual dose, one could simply multiply the annual dose in the FES by 40. (Mauro-Marschke, ff. Tr. 1971 at 6-7.)

155. Applicants testified that there would be no residual liquid pathway dose. (Mauro, Tr. 1988-89.) Upon cross-examination Intervenors raised the issue of whether there were organisms which could swallow bottom sediment and thus release radionuclides bound to that sediment. Applicants testified that once radionuclides were bound to bottom sediment, for all intents and purposes they were gone from the biosphere. Applicants believe that their treatment of the liquid pathway dose was a fair characterization of the environmental behavior of radionuclides. (Mauro, Tr. 1990.)

156. Applicants also calculated the risk to the population within a 50 miles radius of Shearon Harris, and to the U.S. population as a

whole, and compared these risks to background risks. The cumulative risk to the 50 mile population is 0.10 cancer deaths. The risk to the entire U.S. population over the life of the plant is calculated to be 0.25 cancer deaths. (Mauro-Marschke, ff. Tr. 1971 at 8.) Applicants testified that the expected number of cancer fatalities over 40 years is over 10 million. The expected number of cancer fatalities within a 50-mile radius of the Shearon Harris plant over 40 years is over 100,000. (Mauro-Marschke, ff. Tr. 1971 at 8-9.)

157. Applicants' witnesses testified that the cumulative risk to both the 50-mile and U.S. populations is less than one cancer fatality. (Mauro-Marschke, ff. Tr. 1971 at 8.)

158. In calculating the maximum whole body dose to an individual from operation of Shearon Harris, Applicants calculated age specific doses, multiplied these doses by the length of time an individual was in that age group while the plant was operating, and summed the resulting doses over the life of plant. (Mauro-Marschke, ff. Tr. 1971 at 12-13.) Applicants then added the residual dose that an individual would receive after the plant ceases operation from age 41 to 70. (Id. at 13.) In computing this risk Applicants assumed that an individual was born to a family residing at the site boundary which obtains its beef, milk and vegetables at that location. (Id. at 12.) It is also assumed that the individual remains at this location for a period of of 70 years. (Id.)

159. The maximum dose to an individual over the life of the plant was computed to be 130 mrem. (Mauro-Marschke, ff. Tr. 1971 at 12.) Applicants' witnesses testified that this dose appropriately is compared

to that individual's 40-year and lifetime doses from natural background radiation, which are 4,000 and 7,000 mrem, respectively. (Id. at 13.)

160. The risk of cancer mortality from this exposure was calculated using age-specific cancer risk coefficients, and the methodology presented in the report of the Advisory Committee on Biological Effects of Ionizing Radiation (BEIR I). (Mauro-Marschke, ff. Tr. 1971 at 13.) This risk was computed to be 0.00002 deaths. The maximum individual's calculated lifetime risk of dying of cancer from radiation released from the plant and from natural background radiation is 0.001 cancer fatalities. (Id.) Applicants' witnesses testified that the risk posed by operation of the Harris plant also can be compared to the average risk of dying of cancer from other causes of about 0.2. (Id.)

161. During cross-examination Intervenors raised the question of the difference in individual risk which would result if the individual residing at the site boundary were a woman rather than a man. (Mauro, Tr. 1976.) Applicants testified that it would not make a difference if the individual were a woman rather a man. (Id.) Applicants' witness testified that the risk coefficients used were based on exposure of large populations to radiation which included both men and women. Therefore, the risk coefficients were reasonable for either sex. (Mauro, Tr. 1977.)

162. Intervenors also raised the question upon cross-examination of whether Applicants and their calculations had considered the risk to a fetus conceived at the time of the plant's startup. Applicants testified that they did not consider the risk to the fetus in their testimony, but that further analysis showed it would have a very small effect on overall risk. (Mauro, Tr. 1978, 1982.) Applicants concluded that the risk

coefficient for a fetus is 5 times higher than for that for an adult, but that the risk is only delivered for a 9 month period over a 70 year life span. Therefore, the addition of the risk to a fetus would not have a significant effect on the sum of risks over all age groups. (Mauro, Tr. 1982.)

163. Applicants determined that doses could be set forth for the plant's lifetime. However, Applicants testified that annualizing doses from the Harris plant facilitates the assessment of the significance of those doses and provides a reasonable representation of the radiological impacts of plant operation. (Mauro-Marschke, ff. Tr. 1971 at 5.)

164. The NRC Staff testified that the time period for estimating doses in the FES was the total dose that would be received over a 50 year period following intake of radiation for one year under conditions existing 20 years after the station begins operation. The Staff testified that such a dose represents the average exposure over the life of the plant. (Branagan, ff. Tr. 2058 at 2.)

165. The Staff did not present life-of-plant risk in the FES, but rather presented risk on an annual basis, since the applicable regulations contain annual limits or design objectives rather than cumulative limits or design objectives. In addition, the Staff testified that the benefits in the FES are set forth on an annual basis, so integrating costs will be counterbalanced by integrating benefits. (Branagan, ff. Tr. 2058 at 3.)

166. In its testimony the Staff provided an upper bound estimate of the life-of-plant risk. (Branagan, ff. Tr. 2058 at 3-4.) The Staff has estimated the incremental impact on people who live near the plant

for many years. First, the Staff estimated the dose to the total body that a member of the public might receive from exposure to radioactive effluents from one year of normal operations. Second, the Staff multiplied the dose from one year of operations by 40 years of reactor operations to estimate the cumulative dose for 40 years. Finally, the Staff estimated the risk of potential fatal latent cancers to the exposed individual by multiplying the cumulative dose by health risk estimators. (Id.)

167. The Staff assumed that a hypothetical individual would be exposed to 5 millirems per year to the total body for 40 years of operation. thus receiving a cumulative dose of 0.2 rems. The dose estimate of 5 mrems was based on the NRC dose design objectives set forth in Appendix I of 10 C.F.R. Part 50, the dose estimates provided in the Staff's FES and the witness's professional judgment. (Branagan, ff. Tr. 2058 at 4-5; Branagan, Tr. 2090; Branagan, Tr. 2139.) This dose estimate was based on the Staff witness's judgment that it would not be reasonable to assume either that the plant would operate at the dose design objectives for 40 years, or that conditions near the site boundary would not change over that time. (Branagan, Tr. 2138.)

168. The Staff believes that its dose estimate was conservative because it is unlikely that an individual will be simultaneously exposed to radiation at the dose design objective levels for liquid and gaseous effluents to the same body organs for 40 years. (Branagan, ff. Tr. 2058 at 5-6.) The Staff's witness testified that the actual doses are expected to be a fraction of 0.2 rems. To incur such a dose an individual would have to spend almost all of his/her time at the site boundary and receive

almost all of his/her food grown at an offsite location where the concentration of radionuclides is expected to be the highest. (Id. at 6.)

169. The Staff calculated the risk from 0.2 rem of fatal cancers by multiplying the total body dose by a cancer risk estimator of 135 potential deaths from cancer per million person-rems. This risk estimator was based on the absolute risk model from BEIR I. (Branagan, ff. Tr. 2058 at 6.)

170. The Staff also multiplied the total body dose by a genetic risk estimator of 258 cases of all forms of genetic disorders per million person-rems. This estimator is also based on BEIR I. (Branagan, ff. Tr. 2058 at 6.)

171. Potential cancers would be about 1.5 to 2 times the estimate of fatal cancers. (Branagan, ff. Tr. 2058 at 7.)

172. The Staff determined that the cumulative risk to an individual is 3 chances in 100,000 of fatal cancer. This risk is a small fraction of the current incidence of actual cancer fatalities. (Branagan, ff. Tr. 2058 at 7.)

173. The Staff also compared its dose estimates to background doses from natural background radiation. (Branagan, ff. Tr. 2058 at 7.)

174. The Staff testified that higher estimates could be developed through the use of the relative risk model along with the assumption that risk prevails through the duration of life. (Branagan, ff. Tr. 2058 at 6-7.) This would produce risk estimates up to about four times greater than those used in the Staff's analysis. (Id.) The Staff regards this as a reasonable upper limit to the range of uncertainty. (Id.)

175. Under cross-examination Intervenors raised the issue of whether higher risk estimators should be used as a reasonable limit of uncertainty. (Tr. 2116.) The witness testified that he was not in agreement with the work of others who arrived at higher risk estimators and that he preferred to use risk estimators from the range of estimators developed by radiation protection organizations which include scientists from a number of disciplines. (Branagan, Tr. 2117.)

176. The background dose of radiation in the area of the Harris plant is 7 rems over a 70 year lifetime. (Branagan, ff. Tr. 2058 at 8.) The dose to an individual exposed to radioactive effluents for the plant's lifetime is conservatively estimated to be about 3 percent of the dose from exposure to natural background radiation. (Id.)

177. The Staff determined that the cumulative population dose for the life of the Harris facility would be about 620 person-rems. (Branagan, ff. Tr. 2058 at 9.)

178. The Staff testified that 0.16 of a potential genetic disorder may occur. The value of 0.16 is the sum of the number of potential genetic disorders that may occur over all future generations of the exposed population within 50 miles due to exposure to radioactive effluents from 40 reactor-years of operation. This value is small compared with the current incidence of actual genetic ill health in each generation of about 11% of the population of about 1,750,000 persons within 50 miles of the plant. (Branagan, ff. Tr. 2058 at 9.)

179. Under cross-examination Intervenors raised the issue of whether cognitive genetic defects were considered in the Staff analysis. The Staff witness testified that the risk estimators for genetic effects

are based on all genetic effects that would cause some serious handicap during an individual's lifetime. (Branagan, Tr. 2135.) The witness also testified that mongolism is one of the genetic effects considered in the risk estimators employed by the Staff. (Branagan, Tr. 2132.)

180. The Staff concluded that the somatic and genetic effects described in the FES were estimated over an appropriate time, and that the estimation of cumulative risk would not change the Staff's conclusion that they are a small fraction of the current incidence of such effects. (Branagan, ff. Tr. 2058 at 10.)

181. Intervenors presented no contrary evidence on these issues, and did not raise any point on cross-examination which would affect the conclusions reached by the Staff or Applicants.

182. Based on the record in the proceeding, the Board should find that although it is reasonable to disclose cumulative risks in the Final Environmental Statement, it is not necessary to do so.

183. The Board should find that even if cumulative risk were estimated for 40 years of operation of the Harris facility, such risks would be a small fraction of the risk to both the 50-mile and U.S. population of cancer fatalities and genetic ill health.

## IV. CONCLUSION OF LAW

The Board should conclude that the Applicants and Staff have estimated the health effects of the coal particulate emissions set forth in Table S-3 of the Commission's regulations in the manner consistent with the National Environmental Policy Act of 1969, 42 U.S.C.A. § 4321 ad seq. (1970).

The Board should conclude that the Staff has presented the risks posed by the Shearon Harris plant in its FES in a manner consistent with the National Environmental Policy Act of 1969, 42 U.S.C.A. § 4321 ad seq. (1970).

The Board should conclude that the Staff has estimated the effects of the attachment of radionuclides to coal fly ash in a manner consistent with the National Environmental Policy Act of 1969, 42 U.S.C.A. § 4321 ad seq. (1970).

The Board should conclude that the Staff's FES is adequate in these three respects.

Respectfully submitted,

Janice E. Moore
Counsel for NRC Staff

Dated at Bethesda, Maryland
this 20th day of July, 1984

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

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

CERTIFICATE OF SERVICE

I hereby certify that copies of "NRC STAFF PROPOSED FINDINGS OF FACT AND CONCLUSIONS OF LAW REGARDING EDDLEMAN CONTENTION 8F(1), JOINT II(c), AND JOINT CONTENTION II(e)" in the above-captioned proceeding have been served on the following by deposit in the United States mail, first class, or, as indicated by an asterisk, through deposit in the Nuclear Regulatory Commission's internal mail system (*), this 20th day of July, 1984.

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