UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

8/14/78

BEFORE THE ATOMIC SAFETY AND LICENSING APPEAL BOARD

In the Matter of	)	
	)	Docket Nos. 50-400
CAROLINA POWER & LIGHT COMPANY	)	50-401
	)	50-402
(Shearon Harris Nuclear Power Plant, Units 1, 2, 3 and 4)	)	50-403

APPLICANT'S MEMORANDUM IN RESPONSE TO ALAB-480 ON THE PERKINS INITIAL DECISION (IN THE FORM OF PROPOSED FINDINGS AND CONCLUSIONS RELATED TO THE RADON ISSUE)

Background

1. The environmental consequences of the uranium fuel cycle associated with the operation of the Shearon Harris Nuclear Power Plant, Units 1, 2, 3 and 4, were considered in the Licensing Board's Initial Decision of January 23, 1978,[1] which authorized issuance of construction permits for the four units. At the hearing before that Board in September, 1977, the Staff had provided testimony that the figures contained in a revised Table S-3,[2] promulgated by the Commission on March 7, 1977,[3] were sufficiently small that when superimposed upon the other assessed environmental impacts associated with the Shearon Harris Plant,

1/ LBP-78-4, 7 NRC 92 (1978). The Initial Decision is now pending before this Appeal Board.

2/ Table S-3 is part of 10 CFR Part 51 and provides quantified values of environmental impacts associated with the uranium fuel cycle for a typical 1000 MWe light water reactor.

3/ 42 Fed. Reg. 13804 (March 14, 1978).

the overall environmental impacts were not appreciably changed and the overall cost-benefit balance was unaltered from that presented in the March, 1974, Revised Final Environmental Statement for the Harris Plant which supported issuance of construction permits. LBP-78-4, 7 NRC at 116.

2. In addition to presenting the revised Table S-3, the Staff presented an analysis comparing the health effects associated with the coal and nuclear fuel cycles. Id at 118. In making this evaluation, the Staff considered the entire fuel cycle associated with each alternative. The coal fuel cycle consists of mining, processing, transportation, power generation, and waste disposal. The nuclear fuel cycle includes mining, milling, uranium enrichment, fuel preparation, fuel transportation, power generation, irradiated fuel transport, reprocessing (if permitted) and waste disposal.

3. On April 11, 1978, the Commission amended Table S-3 by removing the value contained in the table for radon releases from the uranium fuel cycle. See 43 Fed. Reg. 15613. The Commission directed that in proceedings pending before licensing and appeal boards, the record be reopened for the limited purpose of receiving new evidence on radon releases and on health effects resulting from radon releases.

4. In response to the Commission's directive, the Appeal Board, acting in concert with the appeal boards in sixteen other pending proceedings which are similarly subject to the Commission's April 11 directive, established a procedure for the use of the

ongoing Perkins[4] construction permit proceeding as a "lead case" to resolve the radon issue in each of the seventeen proceedings.[5] To this end, the Appeal Board charged the NRC Staff with responsibility for serving upon each party to this proceeding copies of the Perkins record on the radon issue when that record was closed. Further, it ordered that the record shall be deemed automatically reopened in this proceeding for the receipt of the Perkins record evidence. Finally, it directed that within 14 days after receipt of the Perkins evidentiary record, any party to this proceeding might request in writing that the Appeal Board (a) receive additional written evidence on the radon question; (b) call for a further hearing on the Perkins record; or (c) consider objections to any aspect of the Perkins radon proceeding.

5. In the Perkins proceeding, a public hearing was convened on May 16 and 17, 1978, in Bethesda, Maryland, to receive evidence on the amount of radon that might be released into the environment resulting from the mining and milling of an amount of uranium sufficient to supply the Perkins Nuclear Station during

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4/ DUKE POWER CO. (Perkins Nuclear Station, Units 1, 2 and 3), Docket Nos. STN 50-488, 50-489, 50-490.

5/ See PHILADELPHIA ELECTRIC COMPANY (Peach Bottom Atomic Power Station, Units 2 and 3), et al., ALAB-480, 7 NRC ___ (May 30, 1978).

its years of operation.[6] The subsequent health effects were also considered.

6. In connection with that hearing, the Staff filed with the Perkins Board a series of five affidavits (following Perkins Tr. 2369) which included, as more fully discussed below, the Staff's most recent estimates of radon-222 releases from mining and milling operations and an evaluation of the health effects resulting from such releases. The Perkins Applicant also filed testimony and presented evidence through a panel of witnesses (Lewis, Goldman, Hamilton, following Perkins Tr. 2266).

7. Intervenors in Perkins provided the testimony of Dr. Chauncey Kepford, a former assistant professor of chemistry, who had participated in questions concerning radon-222 emissions in the Three Mile Island proceeding (See LBP-77-70, 6 NRC 185 (1977)). Dr. Kepford's testimony was supplied by a deposition taken on June 8, 1978, in Bethesda, Maryland. At the deposition, Dr. Kepford's prefiled direct testimony was offered (Perkins Tr. 2715).[7] Dr. Kepford also offered a document entitled "Resource Consumption" (Perkins Tr. 2713) and some 11 other documents, or parts of documents (Perkins Tr. 2716-2724) which had not been prefiled.

6/ For purposes of addressing the radon issue, the Perkins Board used 110 annual fuel requirements (AFRs) (Perkins Tr. 2791). In the case of the Harris plant with four units, the number of AFRs would be 4/3 of 110, or about 147 AFRs.

7/ The Perkins Board, in an Order dated June 29, 1978, received the deposition and certain exhibits and ruled on objections and motions made at the time the deposition was taken. That same Order closed the Perkins record on the radon issue.

8. In accordance with the Appeal Board's instruction in ALAB-480, the Perkins record (later corrected in one respect) was served by the NRC Staff on the parties to this proceeding on July 10, 1978. No party objected or sought to supplement the Perkins record for use in this proceeding. The Perkins record on the radon issue therefore becomes a part of the Harris record.

9. ALAB-480 also directed that within 14 days following service on parties in this proceeding by the NRC Staff of the Perkins Licensing Board's initial decision on the radon question, any party might file a memorandum addressing the appropriateness and utility of that decision's findings and conclusions to decide the radon issue in this proceeding. The Perkins initial decision on radon was served by the NRC on July 24, 1978. Following this service of the Perkins initial decision, memoranda were filed pursuant to the schedule set down in Alab-480 by Applicant and . These memoranda have been considered by the Appeal Board in reaching its decision on the radon issue in this proceeding.

Radon Source Terms

A. Radon from Mining

10. Radon-222 is one of the natural products of the decay of uranium-238 which has a half-life of 4.5 billion years. The precursors of radon are all solids, two of them of long half-life, thorium-230 with 80,000 years and radium-226 with 1600 years.

Radon is a gas having a half-life of 3.8 days and readily diffuses through the soil or ore body; the amount reaching the atmosphere depends on the length of the path (and hence the lapse of time) between the origin of the radon (the ore body) and the air interface. Typically 2 feet of soil will hold up the radon long enough to permit about 25% of the radon to decay, allowing 75% to escape. If a body of uranium ore is exposed to the air, radon gas will escape into the air. The process will continue so long as the ore body is exposed, up to billions of years.

11. Staff's witness R. M. Wilde explained how he arrived at an estimated quantity of 4060 Ci of Rn-222/AFR associated with mining. It was calculated from an estimate of the concentration of radon in the ventilating air from an underground mine multiplied by the amount of air pumped from the mine during the time required to extract 2.71×10^5 metric tons of ore (1 annual fuel requirement or AFR) from the mine. Since mine ventilation ceases when the mine is closed down, the mine does not constitute a continuing source of radon. The estimate of 4060 Ci/AFR was accepted as reasonable by Perkins Applicant's witness Lewis (Lewis Testimony, paragraph 2 following Perkins Tr. 2266) and was not challenged by the Perkins Intervenors. This value was used by Gotchy in his estimates of health effects from mining. We adopt it as a reasonable estimate.

12. The Perkins Board was concerned that abandoned underground mines could continue to be a source of radon release to

the atmosphere and questioned Mr. Wilde concerning this. Mr. Wilde indicated that it was industry practice to seal ventilation and hoisting shafts of mines no longer producing uranium. Moreover, even if the shafts were not sealed, when the ventilation fans are shut down, radon releases would essentially go to zero (Perkins Tr. 2541-2542).

13. Mr. Wilde testified that there was insufficient data to predict with certainty the potential rate of radon emission from open-pit mining operations (Wilde, p. 7, following Perkins Tr. 2369). Open-pit mining constitutes about half of the present uranium mining activity (Perkins Tr. 2543). Though this may be anticipated to become a decreasing portion in the future (Perkins Tr. 2550), the Board was concerned by the absence of any estimates of potential radon released from open-pit mining (Perkins Tr. 2543-2558). Failure to include any such estimates (and the associated health effects) appeared to be a major omission that was questioned at length. The Perkins Board insisted that at least an upper bound be placed in the record. Mr. Wilde made a number of conservative assumptions and calculated a value for radon release from open-pit mines of approximately 100 Ci per year per AFR (Perkins Tr. 2609-2613). Perkins Applicant's witness Goldman indicated that he made a similar calculation and estimated bounding values of 100 to 200 Ci/yr (Perkins Tr. 2640).

14. We have assumed that the amount of radon released from mining could be as high as 200 Ci/yr/AFR and that half of the uranium for the Harris plant will be from open-pit mines.[8/] Thus we arrive at a figure of 100 Ci/yr/AFR from unreclaimed open-pit mines. This same figure was adopted by Perkins Intervenors' witness Kepford for purposes of calculations which he subsequently performed in connection with testimony that he gave at his deposition in Perkins (Kepford p. 2).

15. The total amount of radon attributable to open-pit mining depends upon the period of time that the walls and floor of the pit remains open to the atmosphere as well as the concentration of uranium in the soil of the mined out pit. In arriving at the figures in column 4 of Table 1 of his testimony in Perkins, Dr. Kepford assumed that the pits remain open forever. Since U-238 has a very long half-life, he calculates the amount of radon from the open pit mines required to fuel the Perkins plant (110 AFRs) at 6×10^{13} Ci emitted in the following 10^{10} years. We find no error in his mathematics but do have problems with the assumption.

16. If one assumes that an open-pit mine produces enough ore to supply one nuclear plant and that the pit is refilled (or otherwise stabilized) at the end of 20 years of operation,

8/ The same assumption used by the Perkins Board.

then some 4000 Ci of radon would be released per AFR, nearly the same as that estimated for underground mining so it would not matter whether the uranium came from underground or open-pit mines.

17. NRC has no regulatory power over uranium mines; it is entirely a state matter. Therefore the Perkins' Board inquired concerning the present practices of the state regulatory agencies. Mr. Wilde stated that nearly every state has rather stringent reclamation laws governing open-pit mines. Wyoming requires that the land be returned to a condition such that it can be used for an equal or higher purpose after mining than it was used for prior to mining (Perkins Tr. 2556). Dr. Goldman in Perkins stated that of the five states in which significant amounts of uranium are mined, only Arizona has no reclamation requirements.

18. Since the amount of radon expected from the mining operations is determined by the amount of reclamation to be applied to open-pit mines, we necessarily must speculate as to what might occur. We are doubtful that all mines will be reclaimed immediately on the cessation of operations. Neither do we believe that society will permit such open sores on our landscape for all future time. It is our judgment that reclamation will likely occur within 100 years after mining has ceased. This would result in an upper limit of 10,000 Ci/AFR--

2 1/2 times that considered by the Staff but very small compared to that proposed by the Perkins' Intervenors. What if we are wrong? Would radon from this source impose a serious burden on future generations? We think not, as we shall explain when we consider health effects.

B. Radon from Milling

19. After the mining operation, uranium ore is delivered to a mill where it undergoes the various chemical processes which result in the separation of U_3O_8 from the other materials contained in the ore (Perkins Tr. 2502-2505).[9/] At the mill there are a number of potential points of radon release. One point is the stockpile where the ore awaits processing (Perkins Tr. 2502). There will be some generation of radon during this storage period. Staff witness Magno testified that this was considered in developing his estimates but proved to be only a very minor contribution and was not included in the overall estimates (Perkins Tr. 2559-2560). During the course of milling, there will be the release of some radon as a result of crushing and grinding and various chemical processing steps. Staff witness Magno estimated that this release would amount to some 30 curies

9/ About 57 days is required to mill the 2.7×10^5 tons of 0.1% uranium ore required to fuel a 1000 MWe plant operating at 80% capacity for one year.

per AFR (Magno, pp. 2-3, following Perkins Tr. 2369, Perkins Tr. 2560). Thereafter, the tailings or residual material remaining after the uranium has been extracted (which contain substantial amounts of thorium and radium) go to a tailings pile (Perkins Tr. 2505-2506). Mr. Magno provided separate estimates for radon releases from the tailings piles during different periods during and following active milling.

20. Since most of the thorium and radium remain in the ore after the uranium has been removed, radon will continue to be released from the ore and diffuse to the surface of the tailings piles. The rate of emission will be determined primarily by the diffusion constants and will be essentially constant for thousands of years, being chiefly determined by the half-life of the parent Th-230, 80,000 years. Since only 90% of the uranium is recovered in the milling operation, the tailings piles contain about one tenth as much uranium as the ore. Hence even after most of the TH-230 has decayed it will be regenerated from the U-238 and will continue to emit radon at about ten percent of the original level for billions of years.

21. Mr. Magno's testimony provides an estimate of approximately 750 curies of radon per AFR released from the tailings during the period of active mill operation, which he took to be 26 years. During this period of time, a portion of

the tailings pond is composed of wet pond area, wet sandy beach areas, and some dry beach areas. Radon is released principally from the dry beach areas (Magno, pp. 3-4, following Perkins Tr. 2369 and Perkins Tr. 2561-2562). Mr. Magno estimated that during the following period of approximately five years during which the tailings piles dry out and are stabilized, approximately 350 curies per AFR would be generated (Magno, p. 6, following Perkins Tr. 2369).

22. Mr. Magno's values of 750 and 350 curies of radon per AFR emitted from the piles prior to stabilization was accepted by the parties and the Perkins' Board.

23. Mr. Magno estimated that at the end of the 5-year dry out period, the tailings piles would be emitting radon at a rate of about 100 Ci/yr/AFR.[10/] This value was not challenged; indeed it was used by Dr. Kepford in his calculations (Kepford Perkins Testimony, bottom of p. 2).

24. The total amount of radon emitted per AFR depends entirely on the assumptions that are made concerning the stabilization of the tailings piles after they dry out. If the

10/ This value is consistent with that derived in NUREG-0002 which was relied upon by Perkins Board member Jordan, who in a memorandum dated September 21, 1977, had questioned the 74.5 Ci that appeared in Table S-3 at that time.

piles remain uncovered, or are protected only by a foot or two of soil, as has been the practice in the past, the radon will continue to be emitted at a rate of 100 Ci/yr/AFR for tens of thousands of years. The total to infinite time would be about 11 million curies per AFR or nearly 1.3 billion curies for the 110 AFRs required to fuel the Perkins Nuclear Station for 30 years.[11/] This is shown in column 7 of Table 1 of the Kepford Perkins testimony.

25. The Perkins' Board agreed with the Intervenors that the amount of radon that would be emitted from unstabilized tailings piles when integrated far into the future will be very large. This Appeal Board agrees too with that proposition, but not with its application as we discuss infra.

26. Staff witness Gotchy assumed that the tailings piles would emit radon at a rate of 1 Ci/yr/AFR for the first 100 years, 10 Ci/yr/AFR for the next 400 years and 100 Ci/yr/AFR for periods beyond 500 years (Gotchy p. 4). Thus at the end of 10,000 years, he estimated 912,000 Ci/AFR (Gotchy Table 6, p. 15) which would amount to 1×10^8 Ci due to the 110 AFRs required for Perkins.[12/] This agrees with the Kepford figure of 1.06×10^8 Ci. (See Kepford Perkins Testimony, Table 1, column 7 at 10^4 years.)

11/ For Harris the total would be 1.73 billion curies for the 147 AFRs associated with four units.

12/ In the case of Harris, the figure is about 1.3×10^8 Ci due to the 147 AFRs.

27, We question the assumptions on stabilization employed by both Kepford and Gotchy in Perkins. Dr. Kepford assumed no stabilization. Mr. Magno testified that the Staff has recently developed performance objectives for tailings piles management that will require the tailings piles be buried so deep that the radon emission rate will be no more than double the release rate from natural soils in the surrounding environs (Magno p. 6). This will require some 6 to 20 feet of soil over the piles and will reduce the rate to less than 1 Ci/yr/AFR, about 1% of the rate from unstabilized piles.

28. In response to Perkins' Board questions, the Staff produced a witness, Hubert Miller, who described the Staff's Branch Technical Position which required all applicants for a license to operate a uranium mill to commit themselves to a plan of reclamation (Perkins Tr. 2394 et seq.). The fundamental thesis of the Branch Technical Position is that the tailings be reclaimed in such a manner that no on-going active care would be required to maintain stabilization (Perkins Tr. 2395). The Branch Technical Position is applied to new and existing applicants (Perkins Tr. 2401, 2542). By way of example, Mr. Miller stated that the two most recent applicants have committed themselves to dispose of tailings below grade (Perkins Tr. 2396).

29. Since a number of mills may be located in agreement states and thus are not subject to NRC licensing, the Perkins' Board questioned the assumption that all tailings piles would be subject to stabilization requirements such as those described by Mr. Miller as NRC branch positions for NRC licensing purposes. The Staff presented in response to the Board's inquiry, Mr. Kerr, Assistant Director for State Agreements in NRC's Office of State Programs. Mr. Kerr testified that the NRC had been in contact with the states in which uranium milling activities are carried out and each of the responsible states has provided the NRC with commitments to impose stabilization requirements equivalent to those described by the Staff (Perkins Tr. 2477-2480, 2483-2485).

30. There are, of course, some abandoned mills and associated tailings piles from previous milling activities. These abandoned facilities are no longer under license and may not therefore be subject to stabilization requirements as a part of licensing activities, although there is some indication that some effort in this regard may develop in the future (Perkins Tr. 2453-2544, 2480-2481). Nevertheless, since these are abandoned facilities, any radon emission from such tailings piles cannot be attributed to the operation of the Harris facility.

31. The Perkins Board was of the opinion that the situation with respect to tailings piles has changed greatly within the past

year. We agree. We are no longer faced with abandoned and unstabilized piles. The new requirements will assure that they will no longer be a major source of radioactivity. The NRC Staff has recognized the problem and has moved to handle it. Tailings piles stabilized to NRC criteria will emit only 1 Ci/yr/AFR so that the amount of radon from tailings piles associated with the fueling of the Perkins plant will be about 110 Ci/yr.[13/] This is negligibly small compared to the natural emission of radon from the soil of the U.S. (some 10^8 Ci/yr -- see Gotchy, p. 14).

32. Neither the Perkins Intervenors nor the Staff have argued that stabilized piles are a menace. Those intervenors argued that we cannot guarantee that they will be stabilized for all future times. Gotchy conservatively assumed that after 100 years the soil coverings will be eroded to the point that the radon release rate will be 10 Ci/AFR and that after 500 years it will be 100 Ci/AFR. He also assumed that the population of the U.S. will remain stable at 300 million.

33. It appears to us that Dr. Gotchy is being excessively conservative. It is not apparent that piles that meet present NRC standards will be eroded in a matter of a few hundred or a

13/ Or about 147 Ci/yr for the four Harris units.

few thousand years. Furthermore if there are people around to breathe the radon, those people can readily repair any damage to the piles. We see no reason for piling uncertainty on top of uncertainty. There may be another period of glaciation within the next 10,000 years, but we do not have to assume it to project radon emissions into the future. If all the stabilization is destroyed by some catastrophic event, then radon will be a minor problem.

34. The Perkins' Intervenors argued that even if stabilization could be assured for the next few thousand years, it surely could not be guaranteed for millions of years. Most of the impact that they project would occur after the first thousand or 10 thousand years. That impact is cancer deaths to future generations. Before addressing the impact on people to be born tens of thousands of years in the future, we will first explore the relation between radon and cancer.

Radon and Cancer

35. There is good evidence that miners who in the past breathed air containing a large concentration of radon gas (over 100 pCi/liter) for extended periods were much more likely to die of cancer than were members of the public who breathed air containing only the normal background concentration of radon (about 0.1 pCi/liter). Today uranium miners are protected by

regulation which limits radon exposure to 3 WLM/yr;[14/] this results in a maximum dose to the bronchial epithelium of about 15 rem per year (Perkins Tr. 2573).

36. Miners are exposed to air containing a considerable concentration of radon, but no one escapes breathing some radon. Radon seeps from the soil (because the soil contains uranium) and mixes with the air we breath. The amount varies from place to place. It has been estimated that the average concentration of radon in the air over the continental U.S. is about 0.1 pCi/liter which in itself produces a dose to the bronchial epithelium of about 50 rem/yr.[15/] But that isn't all. Modern man lives in houses with concrete floors, stone fireplaces or brick walls. He works in buildings made of concrete. The radon concentration

14/ WLM stands for working level months. One working level (WL) is the exposure to a miner that breathes air with a radon concentration of about 100 pCi/liter. A miner exposed to such a concentration for 8 hours per day for a month (177 hours) would receive an exposure of 1 WLM.

15/ The figures for the concentration of radon in air due to natural background and the lung doses therefrom are subject to a considerable uncertainty. Gotchy, on p. 45 of his Perkins written testimony (quoting from NCRP-45) gives the average Rn-222 concentration in the U.S. as 150 pCi/m which is equivalent to 0.15 pCi/liter. That concentration results in a dose of 450 mrem/yr to the bronchial epithelium. In response to a question, Dr. Hamilton in Perkins relied on a United Nations Scientific Committee Report to arrive at an average dose of 1650 mrem/yr to the bronchial epithelium from natural radon background. The dose from breathing radon inside buildings is 1600 mrem/yr; the figure for radon out of doors is an average of 50 mrem/yr (Perkins Tr. 2275-2276). We recognize that the concentration of radon in the atmosphere varies from place to place and is subject to considerable uncertainty. Differences by a factor of five are not important for our purposes of comparing natural background to the amount that might be due to Harris.

inside such homes and buildings is much larger than it is out of doors. Consequently the average dose to an individual in the U.S. is estimated to be between 210 and 23,000 millirem per year with an average of about 1650 mrem/yr (Hamilton, Perkins Tr. 2276).

37. The question arises as to whether this exposure to background radon produces lung cancer in some people? In other words, do small doses of radiation to large numbers of people produce as many cancer deaths as large doses to fewer people. This is equivalent to asking whether the relation between health effects and dose is a linear one. Science does not provide an unequivocal answer. Many radiation biologists are of the opinion that since body cells have a demonstrated capacity for repair there may well be a threshold dose below which the damage is much below linear, possibly zero (Hamilton, Perkins Tr. 2270, 71). The Perkins Applicant's witness Lewis stated ". . .it is important to note that the linear extrapolation used to calculate health effects at low levels as an estimate of actual health effects may considerably overestimate the actual number of health effects. Various radiation protection standards setting bodies say, in fact, that the real effects are likely very much lower and may, in fact, even be zero" (Lewis, pp. 3 and 4 following Perkins Tr. 2266). He cited a number of government publications as authority for his statement.

38. Since there is no certain evidence for a radiation effects threshold, it is generally agreed that the conservative approach is to assume linearity. Dr. Gotchy's estimates of deaths were based on the linear assumption using risk estimators from WASH-1400 and GESMO (Gotchy p. 7). Although Dr. Kepford made reference in Perkins to some published papers which argue that the linear assumption is not conservative, Intervenors there presented no such evidence. Indeed, Dr. Kepford used the risk estimators of Dr. Gotchy in his calculations in Perkins (Kepford p. 3). We are of the opinion that the linear hypothesis provides a conservative estimate of potential deaths due to small doses of radiation to large populations.

39. Dr. Gotchy adopted a simple wedge model for calculating the dispersion of the radon plume from a mine or tailings piles as it moves across the U.S. He used present population density figures increased by a factor to bring the total U.S. population to 300 million. He relied on the RABGAD computer code developed for NUREG-0002 to calculate the total population doses per curie of radon emitted. Then, using the risk estimators of WASH-1400 and NUREG-0002, he estimated the potential deaths per curie of radon from a source in western U.S. His figure (derived from Table 4 of his Perkins testimony) is about 2×10^{-5} potential cancer deaths per curie. As he stated on p. 7 of his Perkins testimony, this figure is smaller than that used by EPA by about a factor of 2, which is well within the factor of 10 error band of his estimates.

40. Using the foregoing risk conversion factor and his estimates of radon release from mining and milling, Dr. Gotchy calculates the total deaths during the 1000 year period following the mining of 1 AFR to be 1.2 additional deaths (Gotchy p. 8). This number should be multiplied by 110 AFRs to get the total impact of the Perkins plant or approximately 130 deaths in 1000 years.[16/]

41. Dr. Gotchy's testimony discusses at length the reasons for his conclusion that he cannot predict specific health effects into the future beyond 1000 years (Gotchy, pp. 11-13, following Perkins Tr. 2369; Perkins Tr. 2418-2420). Dr. Gotchy further shows that on another basis one can conclude that the radon release from the nuclear fuel cycle does not have a significant adverse impact. He compared radon releases resulting from the mining and milling of uranium with radon naturally occurring on the earth, and provided calculations out to 10,000 years of the comparative population exposure resulting from radon emanation from the nuclear fuel cycle compared to the naturally occurring exposures. These calculations show that exposures due to radon releases from mining and milling are insignificant compared to natural background radiation exposures (Gotchy, pp. 13-16, following Perkins Tr. 2369).

16/ For Harris, about 170 deaths in 1000 years.

42. Out to 1000 years, Dr. Kepford's calculations are somewhat higher than those resulting from the use of Dr. Gotchy's estimates. For 1000 years, Dr. Kepford estimates a total of 489 deaths due to the radon resulting from approximately 110 AFRs required to fuel the three Perkins facilities for a 30-year operating lifetime (Kepford, Table 4, Perkins Tr. 2790, 2791).[17] For the same number of annual fuel requirements, Dr. Gotchy's estimates to 1000 years predict approximately 132 deaths.[18] It should be noted that Dr. Kepford's calculations contain certain radon source estimates greater than those contained in Dr. Gotchy's estimates. These include a source of 100 curies per year per AFR, to account for residual releases from open-pit mines (Kepford, p. 2). Dr. Kepford assumes no stabilization of mill tailings piles and thus assumes a release of approximately 100 curies per year per AFR for the entire period (Kepford, p. 2, Perkins Tr. 2791). As noted above, Dr. Gotchy's estimates for 1000 years are based upon a release from the tailings piles for the first 500 years of approximately 10 curies per AFR and 100 curies per AFR for the 500 years that follow.

43. In contrast to Dr. Gotchy, Dr. Kepford continues his computations of health effects on the same basis for periods to millions and billions of years. On that basis, of course, although the annual increment is small, the total period of time is so

17/ For Harris, the numbers would be 632 deaths, for the 147 AFRs to fuel the four units.

18/ Or about 176 deaths in the case of Harris.

enormous that the total number of deaths summed over this period of time, as computed by Dr. Kepford, is very large, e.g., the impact accumulated for 10,000 years is 4800 computed deaths, for a billion years is 230 million computed deaths (Kepford, Table 4).[19/] It is this impact that Dr. Kepford urges us to debit nuclear power when assessing nuclear power vs. an impact associated with coal (Kepford, p. 6).

44. On the other hand, a third and different point of view was expressed by the Perkins Applicant's witness Dr. Hamilton who, although agreeing that Dr. Gotchy's estimates were reasonable and conservative based upon the data he used (Hamilton testimony, p. 1, following Perkins Tr. 2266, and Perkins Tr. 2270), felt that calculating health effects based upon such extremely low level exposure was not truly meaningful as repair mechanisms were not taken into account. (Perkins Tr. 2271). Dr. Hamilton also decried extrapolations of health effects into the distant future as being misleading (Perkins Tr. 2275).

45. Rather, Dr. Hamilton expressed the view that the problem should be addressed in terms of increase in radon-222 that a person is going to get from the nuclear fuel cycle in terms of the fractional increase in natural background radiation from radon-222 to which every living person is exposed (Perkins Tr. 2275). Dr. Hamilton concluded that the average annual dose

19/ For Harris, 6400 computed deaths for the 10,000 year period and about 307 million computed deaths over a billion years.

to the bronchial epithelium from radon-222 from natural sources is 165 millirad per year (Perkins Tr. 2276). He calculated that one year's operation of a 1000 MWe nuclear power plant for one year at a capacity factor of 0.65 would increase natural background radon by about 1.5 parts in 10 million; the dose to the bronchial epithelium would be increased less than one thousandth of a millirem (2.5×10^{-7} rem) per year. Dr. Hamilton considered that increases in radon-222 of this magnitude "make an additional negligible contribution to annual natural background radiation and consequently, a similarly negligible impact on the health effects associated with the fuel cycle" (Hamilton testimony, pp. 2 and 3, following Perkins Tr. 2266).

46. In response to Perkins Board questioning, Dr. Hamilton testified that variations in normal living style, traveling about the country and going indoors or outdoors results in doses that are many orders of magnitude greater than the increase in dose resulting from radon-222 emanating from tailings and mining (Perkins Tr. pp. 2322 and 2333). Dr. Hamilton concluded that these low levels of exposure are "completely insignificant and without any reality" (Perkins Tr. 2323).

47. The Perkins Applicant's witness Goldman calculated the amount of radon that would seep from the ash pile of a coal fired station that burns coal from various regions of the U.S. Since

the amount of uranium in the coal varies from region to region, as well as the heat content of the coal, his comparison was on the basis of Ci of radon per year per annual coal requirement (Goldman Testimony, Table 2 following Perkins Tr. 2266). He calculates that the amount of radon from a 20 feet deep ash pit would vary from 2 to 14 Ci/yr/AFR. This is more than that expected from uranium mill tailings piles stabilized to NRC criteria. The radon also persists for very long times into the future.

48. Dr. Kepford accepted the Goldman estimates of 2 Ci/yr/AFR as a basis for his calculations of deaths from radon from a coal plant (Kepford Testimony, p. 4 and Table 4). However he reduced the Gotchy risk estimate of deaths per curie of radon by combined factors of 0.05 and 0.17 because of the reduced number of people between a coal plant at the Perkins site and the sea coast and also because of reduced plume residence time.[20/] These reduction factors were strongly questioned at the deposition (Perkins Tr. 2756-2782). Dr. Kepford is certainly correct that a triangle with its apex at Mocksville, N.C. will include many fewer people than a similar triangle with its apex in Utah. On the other hand, he did not take into account such factors as the decay of radon in the plume as it moves across the U.S. and the increase in population density near the east coast. The problem is complicated and it appears that Dr. Kepford's model was oversimplified.

20/ Radon from a coal-fired plant is released at the point of use of the coal and the location of ash piles; uranium is mined and milled in the western United States.

49. It appears to us that if the open uranium mine pits are filled and the milling piles stabilized, then the health effects from the radon from the uranium fuel cycle would not be much larger than the health effects from the radon from coal ash piles. In either case the effects are small; the 110 Ci/yr from stabilized piles caused by Perkins (110 AFRs) would produce only 0.002 deaths per year in the entire U.S.[21/] Dr. Kepford's coal figures are smaller but are suspect for the reason stated in paragraph 48 above. We don't think the difference is important.[22/]

50. This Appeal Board has weighed carefully the views of the Staff, Applicant and Intervenors expressed in the Perkins proceeding. They do not differ greatly on factual evidence but they do differ on the proper treatment of projections of potential effects into a distant future. We believe that we have an obligation to assess the effects of today's actions on future generations. We certainly must consider any known effects on our immediate successors as of importance comparable to effects on those now living. When it comes to balancing adverse impacts to those descendants who may follow a million years from now against the benefits to the present generation, we would weight the benefits to the present population. The benefits are certain -- the impacts hypothetical. The granting of construction permits

21/ For Harris the figure would be .0027.

22/ Similarly it is unimportant for the Harris site as well.

for the Harris units is not an action that presents a serious risk to any future generation due to radon emissions from the mining and milling of uranium to fuel their units. Even if Dr. Kepford's projections were to come about, Harris would result in, at most, 667 deaths per millennium at any time in the future. We believe those estimates are inflated. A possible two-thirds death per year in a population of 300 million people is a minimal impact. Under the NRC stabilization procedures and reasonable regulations on open-pit reclamation, the impact will be 100 times less.

51. The impact on future generations of a coal fired Harris plant is also considerable. A 4-unit coal station would consume more than 400 million tons of coal in 40 years -- coal that will be sorely needed in the future. More than a billion tons of CO_2 that it would put into the atmosphere could have a significant effect on future climate. We believe that future generations will be better off if Harris is nuclear.

52. Based on the record available to this Appeal Board, we find that the best mechanism available to characterize the significance of the radon releases associated with the mining and milling of the nuclear fuel for the Harris facility is to compare such releases with those associated with natural background. The increase in background associated with Harris is so small compared with background and so small in comparison with the

fluctuations in background, as to be completely undetectable. Under such a circumstance, the impact cannot be significant.

CONCLUSION

53. In response to the Commission's directives contained in the statement of consideration issued in connection with the amendment to Table S-3 of 10 CFR Part 51, published in the Federal Register on April 14, 1978, (43 F.R. 15613), this Appeal Board has carefully considered available information concerning the releases of radon-222 associated with the uranium fuel cycle and health effects that can reasonably be deemed associated therewith, and concludes that such releases and impacts are insignificant in striking the cost-benefit balance for the Harris Nuclear Power Plant.

Respectfully submitted,

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Dated: August 14, 1978

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING APPEAL BOARD

In the Matter of	)	
	)	Docket Nos. 50-400
CAROLINA POWER AND LIGHT COMPANY	)	50-401
	)	50-402
(Shearon Harris Nuclear Power Plant, Units 1, 2, 3 and 4)	)	50-403

CERTIFICATE OF SERVICE

I hereby certify that copies of the foregoing "Applicant's Memorandum in Response To ALAB-480 On the Perkins Initial Decision (In the Form of Proposed Findings and Conclusions Related To the Radon Issue)" dated August 14, 1978, were served by deposit in the United States mail, first class, postage prepaid, this 14th day of August, 1978, to all those on the attached Service List.

George F. Trowbridge

Dated: August 14, 1978

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

Before the Atomic Safety and Licensing Appeal Board

In the Matter of	)	
	)	
CAROLINA POWER AND LIGHT COMPANY	)	Docket Nos. 50-400 401
	)	402
(Shearon Harris Nuclear Power Plant, Units 1, 2, 3 & 4)	)	403

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