

NRC PUBLIC DOCUMENT ROOM

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD



In the Matter of)

TENNESSEE VALLEY AUTHORITY)

(Yellow Creek Nuclear Plant,)
Units 1 and 2))

Docket Nos. STN 50-566
STN 50-567

NRC STAFF'S SUPPLEMENTAL PROPOSED FINDINGS
OF FACT AND CONCLUSIONS OF LAW CONCERNING
THE URANIUM FUEL CYCLE -- HEALTH EFFECTS
AND RADON-222

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1. On December 20, 1976, pursuant to section 103 of the Atomic Energy Act of 1954, as amended, 42 U.S.C. §§2011 et seq. (1970; Supp. V, 1975) (AEA), the Nuclear Regulatory Commission (Commission docketed^{1/} the final portion of the application^{2/} of the Tennessee Valley Authority (Applicant) to construct two nuclear reactors designed as the proposed Yellow Creek Nuclear Plant, Units 1 and 2 to be located in Tishomingo, County, Mississippi. The plant will employ two identical pressurized

^{1/} 42 Fed. Reg. 1322 (1977).

^{2/} The application also consisted of a segment on antitrust matters docketed November 11, 1975 (40 Fed. Reg. 43, 324), and one including the Preliminary Safety Analysis Report and general and financial information docketed August 2, 1975 (41 Fed. Reg. 33,340).

lightwater reactors, each with a turbine generator net electrical power output of about 1300 megawatts electric (MWe), a rated core power level limited to 3800 megawatts thermal (MW_t) and a design power of approximately 4100 megawatts thermal (MW_t) plus 17 megawatts thermal from pump heat.^{1/}

2. Environmental and site suitability hearings on the application were held in Iuka, Mississippi on December 13-15, 27, 1977. Pursuant to the Partial Initial Decision issued by this Licensing Board (Board) on February 3, 1978, 7 NRC 215 (1978), the Director of Nuclear Reactor Regulation issued limited work authorizations on February 9, 1978 to the Applicant authorizing certain work activities at the plant site.^{2/} As required by 10 CFR s50.10(e) (1977), the Partial Initial Decision constituted the Findings of Fact and Conclusions of Law with respect to site suitability and environmental issues. An evidentiary hearing on radiological health and safety matters involved in this construction permit proceeding was held in Iuka, Mississippi on July 6, 1978, pursuant to the notice of June 5, 1978.^{3/} Proposed findings of fact and conclusions of law were filed by the Applicant on July 21, 1978, and by the NRC Staff on August 19, 1978.

^{1/} Staff Exhibit 3, Safety Evaluation Report (NUREG-0347), relating to construction of Yellow Creek Nuclear Plant, Units 1 and 2, December 1977, U.S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation ("SER"), received into evidence at Tr. 520, at 1-1.

^{2/} 43 Fed. Reg. 7074.

^{3/} 43 Fed. Reg. 24, 750.

3. On April 11, 1978, the Commission amended Interim Table S-3 which summarizes the environmental effects of the uranium fuel cycle to delete the value reported therein for the release of radon-222.^{1/} The reason for deleting radon-222 from Table S-3 was that "new estimates of releases have been devised that require upward revision for the value in Table S-3".^{2/} The Commission directed that in proceedings pending before Licensing Boards, the record on NEPA issues be reopened for the limited purpose of receiving new evidence on radon releases and on health effects resulting from radon releases.^{3/}

4. On May 30, 1978, the Atomic Safety and Licensing Appeal Board (Appeal Board) appointed to review the record of this proceeding issued a joint memorandum and order, along with the appeal boards in 16 other licensing proceedings, establishing a procedure for the consideration of the effect of radon emissions from uranium mining and milling on the

^{1/} Published at 43 Fed. Reg 15613 [April 14, 1978].

^{2/} 43 Fed. Reg. 15614.

^{3/} 43 Fed. Reg. 15616.

NEPA benefit-cost balance in each of the 17 applications. That memorandum and order, ALAB-480,^{1/} inter alia, (1) directed that the evidentiary record on the radon issued in the Perkins proceeding be served on the parties to each of the 17 proceedings and that the record in each of those 17 proceedings be reopened for receipt of the Perkins record as evidence; (2) authorized each party to request the Appeal Board to receive additional written evidence, call for a further hearing, or consider objections to any aspect of the Perkins radon proceeding; and (3) directed that the Licensing Board's decision on the radon question in Perkins be served on every party and authorized each party to file a memorandum addressed to two specified questions:

...(a) whether the Perkins evidentiary record supports the generic findings and conclusions of the Licensing Board respecting the amount of the radon emissions in the mining and milling process and resultant health effects; and (b) whether the radon emissions and resultant health effects are such as to tip the NEPA balance against construction (or operation)^{2/} of the particular facility in question.

^{1/} Philadelphia Electric Company, et al. (Peach Bottom Atomic Power Station), ALAB-480, 7 NRC 796 (1978).

^{2/} Ibid., at 806, (footnote omitted)

5. The Perkins record was closed on June 29, 1978, and on July 10, 1978, the NRC Staff served that record on the parties to the 17 proceedings. On July 18, 1978, the NRC Staff served corrected copies of certain portions of the Perkins record. No party to this proceeding requested the Appeal Board to receive additional written evidence, to hold further hearings, or to consider objections to any aspect of the Perkins radon proceeding.

6. On July 14, 1978, the Licensing Board in the Perkins proceeding issued a partial initial decision ("Perkins P.I.D.") on the environmental consequences of the uranium fuel cycle deciding the radon issues.

7. The Perkins Licensing Board found that releases of radon-222 associated with the uranium fuel cycle and health effects that can be reasonably associated with those releases are insignificant in striking the cost-benefit balance for the Perkins Nuclear Station. ^{1/} TVA and the NRC Staff on August 10, 1978, and August 14, 1978, respectively, presented their positions to the Appeal Board on the questions specified in ALAB-480. Both agreed that (1) the Perkins evidentiary record amply supported the generic findings and conclusions of the Perkins Licensing Board respecting the amount of the radon emissions in the mining and milling process and the resultant health effects; (2) the radon emissions from mining and milling were clearly so small in comparison with the fluctuations in background as to be completely undetectable; and (3) the resultant impact would be insignificant and could not alter the NEPA benefit-cost balance already determined in this proceeding.

^{1/} Perkins P.I.D., p. 29.

8. On September 26, 1978, the Staff filed a motion to the Appeal Board requesting that the radon issue be remanded to us for consideration along with the remaining construction permit issues.^{1/} This motion was granted on September 27, 1978.^{2/} No party to this proceeding requested this Licensing Board to receive additional evidence, to hold a further hearing, or to consider objections to any aspect of the Perkins radon proceeding.^{3/}

^{1/} "NRC Staff Motion for Remand of the Partial Initial Decision to the Licensing Board for the Limited Purpose for Consideration of the Radon Issue," September 26, 1978.

^{2/} Order, September 27, 1978.

^{3/} The NRC Staff's position, as set forth before the Appeal Board, is (1) that in all material respects the Perkins PID is applicable to the Yellow Creek proceeding; and (2) that the cost/benefit balance in this proceeding is not tipped because the benefits of construction and operation of Yellow Creek, Units 1 and 2 clearly outweigh the environmental and economic costs which will necessarily be incurred. Tennessee Valley Authority (Yellow Creek Nuclear Plant, Units 1 and 2) Partial Initial Decision, LBP-78-7, 7 NRC 215, 238, para. 58 (1978). "NRC Staff Memorandum on Applicability and Effect of Perkins Partial Initial Decision" (August 14, 1978), at 2-3.

9. Because of the remand of the radon-222 by the Appeal Board on September 27, 1978, the Licensing Board did not issue the initial decision it had prepared for issuance on September 27, 1978.^{1/} Rather, we sought the comments of the parties on our view of the Staff's evidence on the issue of generic safety problems.^{2/} On October 10, 1978, the Applicant filed supplemental proposed findings of fact and conclusions of law concerning radon-222 emissions. The NRC Staff filed supplemental proposed findings of fact and conclusions of law on the radon-222 matter on November 1978.^{3/}

^{1/} Memorandum and Order, September 28, 1978.

^{2/} Ibid.

^{3/} The NRC Staff indicated to the Licensing Board, however, that it had additional material to submit to the Board on generic items to be considered under Riverbend, ALAB-444 (6 NRC 760(1977)) criteria. These additional generic items will be reported to the Board based on the Staff's risk assessment of the various generic tasks. See Staff affidavit, August 18, 1978, pp. 16-17.

10. In connection with the Perkins hearing, the Staff filed a series of five affidavits,^{1/} 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. At the Perkins hearing, in addition to the evidence of the Staff witnesses, the Perkins Applicant presented evidence through a panel of witnesses.^{2/} The Applicant and Staff witnesses who appeared and testified are well-qualified experts in their respective disciplines and the Board accords substantial probative weight to their testimony.

11. The Perkins Intervenors obtained the services 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. Dr. Kepford's evidence was obtained at a deposition held on June 8, 1978 in Bethesda, Maryland. At the deposition, Dr. Kepford's prefiled

^{1/} Fg. P-Tr. 2369. Reference to "P-Tr" refer to the transcript page in the Perkins record.

^{2/} Lewis, Goldman, Hamilton, Fg. P-Tr. 2266.

direct testimony was accepted into evidence.^{1/} Dr. Kepford also introduced a handwritten document entitled, "Resource Consumption",^{2/} and some 11 other documents, or parts of documents^{3/} which had not been prefiled. The Resources Consumption document projects uranium availability and consumption. Exhibits H, I, and J are NRC Staff documents relating to amendments of the values set forth in Table S-3. Four documents relate to health as affected by radiation. One concerns earth science problems associated with the disposal of radioactive wastes and another is an extract from the Reactor Safety Study, WASH-1400. Since Dr. Kepford has no expertise in the substantive fields covered by the exhibits he offered, no cross-examination of Dr. Kepford upon his exhibits was made by the other parties. The Perkins Applicant objected to receipt into evidence of "Resources Consumption" and the 11 exhibits, marked for identification as Exhibits A-J, upon the basis of untimely filing, as being beyond the scope of the Perkins Board's reopening of the record which is to establish a Radon-222 value for the uranium fuel cycle as it related to the proposed Perkins facility.^{4/} The Staff also opposed admitting these documents as evidence.^{5/}

^{1/} P-Tr. 2715

^{2/} P-Tr. 2713

^{3/} P-Tr. 2716-2724

^{4/} P-Tr. 2726

^{5/} P-Tr. 2728

12. This Board accepts Dr. Kepford's prefiled direct testimony, as corrected at the Perkins deposition, as evidence. We also admit all other exhibits proffered by Dr. Kepford as evidence insofar as they relate to the amount of Radon-222 emitted into the environment as a consequence of the nuclear fuel cycle.^{1/}

13. Among the Staff affidavits submitted in the Perkins record were two affidavits, those of Rothfleisch and Lowenberg, which principally described how the earlier (erroneous) value of 74.5 curies per AFR was derived for the documents which formed the background for the original promulgation of Table S-3. The Perkins Board inquired into these background matters to some degree. However, except for Dr. Kepford's assertions related to the Nuclear Regulatory Commission as a whole--there was no assertion that the prior incorrect value adversely reflected on the the credibility of the evidence and witnesses offered by the Staff in this reconvened proceeding.

Radon Source Terms

14. The questions posed by the inquiry into overall impact and overall cost-benefit considerations associated with potential radon release

^{1/}See, Illinois Power Co. (Clinton Power Station, Unit Nos. 1 and 2), ALAB-340, 4 NRC 27, at 31, July 29, 1976.

from the nuclear fuel cycle raise a number of difficult questions for this Licensing Board. The first questions relate to the various sources of radon in the fuel cycle. Radon is one of the natural products of the radioactive decay of uranium-238 precursors including a number of long-lived isotopes: uranium-238, half life 4.5 billion years; thorium-230, half-life 80,000 years; and radium-226, half-life 1600 years. The radon-222 itself once generated has a short half-life, approximately 4 days.^{1/}

15. One source of radon release to the atmosphere is the mining process. The Staff witness, Wilde, in his affidavit, estimated the radon release from underground mining operation to amount to some 4,060 curies per AFR.^{2/} This value was accepted as reasonable by Applicant's witnesses^{3/} and was not challenged by Intervenors. The background and qualifications of Mr. Wilde and of Perkins Applicants' witnesses who have accepted Mr. Wilde's value as reasonable give the Board a confident basis for accepting this value as an estimate of the release rate from underground mining.

16. The Perkins Board, however, was concerned that abandoned mines could continue to be a source of radon release to the atmosphere and questioned Mr. Wilde concerning this. Mr. Wilde, however, indicated that it was

^{1/} Fig. 3, Supplemental Affidavit of R.L. Gotchy, dated May 10, 1978. (Fg. P-Tr. 2425).

^{2/} Wilde, p. 5, fg. P-Tr. 2369.

^{3/} Goldman testimony, para. 1 following P-Tr. 2266 and Tr. 2281.

industry practice to seal ventilation and hoisting shafts for mines no longer producing uranium. Moreover, even if the shafts were not sealed when the ventilation fans are shut down, radon release would essentially go to zero.^{1/} Mr. Wilde's affidavit indicated that there was insufficient data to predict with certainty the potential rate of radon emission from open-pit mining operations.^{2/} Although open-pit mining operations constitute about half of the present uranium mining activity,^{3/} and may be anticipated to become a decreasing portion in the future,^{4/} the Perkins Board was nevertheless concerned by the absence of any estimates of potential radon released from open-pit mining operations.^{5/} At the request of the Perkins Board, 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.^{6/} Perkins Applicants' witness Goldman indicated he made similar calculations and reached similar results.^{7/} However he testified that of the states in which significant open pit uranium mining takes place, a number have requirements for reclamation and recontouring.^{8/}

^{1/} P-Tr. 2541-2542.

^{2/} Wilde, p. 7, fg. P-Tr. 2369.

^{3/} P-Tr. 2543.

^{4/} P-Tr. 2551.

^{5/} P-Tr. 2543-2558.

^{6/} P-Tr. 2609-2613.

^{7/} P-Tr. 2604.

^{8/} P-Tr. 2639.

17. Mr. Wilde's estimate was not challenged by Perkins Intervenor's witness Kepford or by any party Intervenor in this proceeding. Indeed, it appears to have been adopted by Dr. Kepford for purposes of calculations which he subsequently performed in connection with testimony he gave at his deposition.^{1/}

18. Giving consideration to the conservative value of the assumptions used by Mr. Wilde, and giving due consideration to Mr. Wilde's qualifications and qualifications of Perkins Applicant's witnesses who have agreed with Mr. Wilde's testimony, the Board finds that an estimate of potential radon releases from open-pit mining of 100 Ci per year per AFR represents a conservative estimate of the potential radon release from the process of open-pit mining.

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 uranium from the other materials contained in the ore.^{2/} At the mill there are a number of potential points of radon release. One point is the stockpile where the ore awaits processing.^{3/} There will be some generation of radon during this storage period. Staff witness Magno

^{1/} Kepford, p. 2.

^{2/} P-Tr. 2502-2505.

^{3/} P-Tr. 2502.

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.^{1/} 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 per AFR.^{2/} Thereafter, the tailings or residual material remaining after the uranium has been extracted (which contain substantial amounts of the thorium and radium) go to a tailings pile.^{3/} Mr. Magno provided separate estimates for radon release from the tailings piles during different periods during and following active milling.

20. 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 as 26 years of mill operation. 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.^{4/}

^{1/} P-Tr. 2559-2560.

^{2/} Magno, p. 2-3, fg. P-Tr. 2369, Tr. 2560.

^{3/} P-Tr. 2505-2506.

^{4/} Magno, p. 3-4, fg. P-Tr. 2369 and P-Tr. 2561-2562.

21. 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.^{1/}
22. Mr. Magno's values of 750 and 350 curies per AFR for these activities were accepted as reasonable estimates by Perkins Applicant's witness,^{2/} and were not challenged by Intervenor's witness in the Perkins proceeding.
23. The principal discussion concerning radon release from tailings piles dealt with the period after plant operation ceased and concerned radon emanating from the dried tailings piles. Mr. Magno estimated the releases from dried stabilized tailings piles to be between 1 and 10 curies per AFR. The tailings pile assumed by Mr. Magno is a pile covered with sufficient overburden to achieve an overall release rate of about twice natural background in surrounding environment. This assumption was based upon a recently developed NRC Staff branch position.
24. 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

^{1/} Magno, p. 6, fg. P-Tr. 2369.

^{2/} Goldman, p. 1, fg. P-Tr. 2266.

as those described by Mr. Miller as NRC branch positions for NRC licensing purposes. The Staff presented in response to that 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.^{1/}

25. There are, of course, some abandoned mills in which there are 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.^{2/} Nevertheless, since these are abandoned facilities, any radon emission from such tailings piles cannot be attributed to the operation of the Perkins facility.
26. In light of the testimony provided to the Perkins Board by the Staff, this Board finds that it is reasonable to assume, for purposes of estimating radon release from uranium milling activities that may be associated with

^{1/} P-Tr. 2477-2480, 2483-2485.

^{2/} P-Tr. 2453-2455, 2480-2481.

the production of fuel for the Yellow Creek facility that mills will be subject to stabilization requirements and that the estimate of from 1 to 10 curies per year per AFR for radon releases from stabilized tailings piles provided by Mr. Magno is reasonable.^{1/}

27. Of course, as indicated by Mr. Magno and Mr. Miller, there may be some uncertainty as to stability over very long periods of time. Mr. Magno indicated that stabilized piles will retain integrity over periods of "at least several hundreds of years...."^{2/} Mr. Miller mentions uncertainty involving "thousands and thousands of years."^{3/} To provide information concerning potential radon release from a tailings pile if all of its cover material were removed as a result of erosion processes over long periods of time, such as a thousand years, Mr. Magno estimated a release rate of some 110 curies per year per AFR.^{4/} These values were accepted as reasonable by Perkins Applicants' witness,^{5/} and were not challenged by Dr. Kepford. Indeed, Dr. Kepford appears to use this value for purposes of his computations.^{6/} Dr. Kepford, however, assumed no stabilization at all and assumed the higher rate mentioned by Mr. Magno from the outset of his computation period.^{7/}

^{1/} Since the Perkins units will have a greater AFR requirement than the Yellow Creek units, the Board has utilized the Perkins record as an upper bound for purposes of reaching its conclusions as applied to this proceeding.

^{2/} Magno, p. 9, fg. P-Tr. 2369.

^{3/} P-Tr. 2402, see also Tr. 2396.

^{4/} Magno, p. 10, fg. P-Tr. 2369.

^{5/} Goldman p. 1, fg. P-Tr. 2266.

^{6/} Kepford, pp. 2-3.

^{7/} Kepford, p. 2.

Projection of Impact into the Future

28. The most difficult question posed by the radon inquiry is the determination of how long into the future must one attempt to predict effects of present actions for NEPA purposes and how long into the future can one reasonably predict impact potential.
29. As pointed out above, uranium-238 and other elements in the radioactive decay chain leading to the emanation of radon are very long-lived radioactive materials. There is no dispute that radon emanation will continue for many eons into the future from such activities as an abandoned open pit which is not backfilled or flooded. Similarly, the tailings pile (unless deeply buried) may emanate radon for many thousands of years into the future supported by the decay of 80,000-year, half-life thorium-230. The rate which it will diffuse to the atmosphere is dependent upon the specific conditions of stabilization assumed.^{1/} Of course, as Dr. Gotchy's testimony points out, the potential for intervening climatic changes over very long periods of time, tens of thousands of years to hundreds of thousands of years, (or perhaps, sooner), which can have significant effect upon the earth environment and can indeed cover over, disperse, or otherwise affect the sources of radon released to the environment.^{2/} However, outside of these

^{1/} See Magno, p. 8 and 10, fg. P-Tr. 2369.

^{2/} Gotchy, p. 13, fg. P-Tr. 2396, Gotchy Supplemental Testimony IV-6, IV 13, fig. 4, fg. P-Tr. 2425, P-Tr. 2426-2434.

serious climatic changes, what we are faced with is essentially a permanent, albeit small, continuing release of radon to the atmosphere resulting from the milling and mining of uranium for the operation of the Yellow Creek facility or any other uranium fueled lightwater power reactor. This low-level release can be the source of an increase, albeit extremely small, in overall radiation exposure to populations living now and populations living in the future, including those living in the very distant future. The difficult question which faces us is how to assess these future potential exposures. The record in this case we think provides an ample exposition of three very different points of view.

30. On the one hand, the Staff offered the testimony of Dr. Reginald Gotchy. Dr. Gotchy, using the release values derived from the evidence of Messrs. Wilde and Magno, made some simplifying assumptions for ease of calculation. For example, as outlined above, Mr. Magno's testimony indicates that the tailings piles will be stable for periods of hundreds of years with release rates of approximately 1 to 10 curies per year. Mr. Magno also indicated that release rates, in the event that the covering material were eroded, could be as much as 110 curies per year per AFR. Dr. Gotchy, for his calculation, assumed that the pile remains stable for its first 500-year period releasing 1 Ci per year per AFR for the first 100 years. He then assumed loss of some overburden covering the tailings then released 10 curies per year per AFR for the next 400 years. Then promptly at the

end of that 500-year period, Dr. Gotchy assumed as a step change the essentially complete loss of overburden resulting in a release rate thereafter of 100 curies per year per AFR.^{1/} Based on these rates of release, Dr. Gotchy then calculated the dose to a stable U.S. population of approximately 300 million for various periods of time after the stabilization of the pile out to 1,000 years.^{2/} Dr. Gotchy also calculated the population doses assuming releases as described for the periods up to 10,000 years into the future for purposes of comparing potential doses with background doses for radon.^{3/}

31. Dr. Gotchy, using identified dose conversion factors, then computed a projected risk of cancer mortality which would be attributable to additional radiation exposure associated with this additional radon burden in the atmosphere out to 1,000 years into the future. Dr. Gotchy estimates that the additional risk of cancer mortality deaths resulting from the cumulative assumed radon release for 1,000 years will cumulatively total 1.2 additional deaths per AFR.—/

32. Dr. Gotchy subsequently added this additional risk to his previous estimate of health effects associated with the nuclear fuel cycle and compares them with his previous estimate of health effects associated with the coal fuel cycle.—/ Dr. Gotchy estimates that, considering the impact of radon at the higher release rates presently estimated by the Staff for a period of 1,000 years, the overall estimate of excess

—/ Gotchy, p. 4, fg. P-Tr. 2369 and Tr. 2405.

—/ Gotchy, p. 3-5, fg. P-Tr. 2369.

—/ Gotchy, p. 15, fg. P-Tr. 2369.

—/ Gotchy, p. 8, fg. P-Tr. 2369

—/ Gotchy Supplemental Affidavit, Table 1, 1a, 2, 2a, fg. P-Tr. 2425.

mortality associated with one AFR for the all nuclear fuel cycle would range from 0.59 to 1.7 per year. This is contrasted with the estimate of excess mortalities for AFR for the coal fuel cycle ranging from 15-120 per year.^{1/}

33. Dr. Gotchy concludes that the increase in health effects due to radon out to 1,000 years into the future does not significantly alter his conclusion that the nuclear fuel cycle, even considering these effects, has far fewer adverse health effects than a comparable coal fuel cycle.^{2/}
34. Dr. Gotchy's testimony discusses at length his reasons for his conclusion that he cannot predict specific health effects into the future beyond 1,000 years.^{3/} 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. Dr.

^{1/} Gotchy Supplemental Affidavit, Table 1, fg. P-Tr. 2425.

^{2/} Gotchy Supplemental Affidavit, Enclosure 5, fg. P-Tr. 2425; P-Tr. 2592-99.

^{3/} Gotchy, p. 11-13, fg. P-Tr. 2369. Gotchy Supplemental Affidavit IV-1-IV-20, fg. Tr. 2425.

Gotchy 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 exposure due to radon release from mining and milling are insignificant compared to natural background radiation exposures.^{1/}

35. In sharp contrast is the position of Dr. Kepford. Dr. Kepford agreed that "These problems [famines, plagues, nuclear wars, major technological advances, the collapse of technologies, ice ages, and a myriad of other unknowns] make any attempt at an accurate prediction of what our society will resemble 20, 50 or 100 years from now sheer fantasy."^{2/} Nevertheless, using Dr. Gotchy's health effects values^{3/} and using radon release rates somewhat different from Dr. Gotchy's, but basically derived from the Staff's testimony.^{4/} Dr. Kepford projects numbers of deaths from future radon emanations from uranium mining and milling far into the future: 10,000 years, 100,000 years; millions of years and billions of years into the future.^{5/} Dr. Kepford's calculations are based on his model "which freezes the present society as we know it, with its habits and characteristics and extends this society, for better or worse, off to infinity."^{6/}

^{1/} Gotchy, p. 13-16, fg. P-Tr. 2369.

^{2/} Kepford, p. 2.

^{3/} Kepford, pp. 3 and 5.

^{4/} Kepford, p. 2, P-Tr. 2788-2789.

^{5/} Kepford, Table 4.

^{6/} Kepford, p. 1.

36. Out to 1,000 years, Dr. Kepford's calculations are somewhat higher than those resulting from the use of Dr. Gotchy's estimates. For 1,000 years, Dr. Kepford estimates a total of 489 deaths due to the radon resulting from approximately 110 AFR's required to fuel the three Perkins facilities [or the two Yellow Creek plants] for a 30-year operating lifetime.^{1/} For the same number of annual fuel requirements, Dr. Gotchy's estimates to 1,000 years predict approximately 132 deaths. 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. Dr. Kepford assumes no stabilization of mill tailings piles and thus assumes a release of approximately 110 curies per year per AFR for the entire period.^{2/} As noted above, Dr. Gotchy's estimates for 1,000 years are based upon a release from the tailings piles for the first 500 years of approximately 1-10 curies per AFR and 100 curies per AFR for the 500 years that follow (consistent with Magno's affidavit).

37. 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 this basis, of course, although annual increment is small, the total period of time is so enormous that the total number of impacts summed over this period of time, as computed by Dr. Kepford, seems large,

^{1/} Kepford, Table 4, P-Tr. 2790, 2791.

^{2/} Kepford, p. 2.

^{3/} Kepford, p. 2, P-Tr. 2791.

e.g., the impact accumulated for 10,000 years is 4800 computed deaths, for a billion years it is 230 million computed deaths.^{1/} It is this impact that Dr. Kepford urges us to debit nuclear power when assessing nuclear power vs. an impact associated with coal.^{2/}

38. On the other hand, a third and different point of view was expressed by Perkins Applicant's witness Dr. Hamilton who, although agreeing that Dr. Gotchy's estimates were reasonable and conservative based upon the data he used,^{3/} felt that calculating health effects based upon such extremely low level exposure was not truly meaningful as repair mechanisms were not taken into account. Dr. Hamilton also decried extrapolation of health effects into the distant future as being misleading.^{4/}

39. 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.^{5/} Dr. Hamilton concluded that the average annual dose to the bronchial epithelium from Radon-222 from natural sources is 165 millirad per year.^{6/} Dr. Hamilton calculated that one year's operation of a 1000 MWe nuclear power plant at 0.65 capacity factor would increase natural background

^{1/} Kepford, Table 4.

^{2/} Kepford, p. 6.

^{3/} Hamilton testimony page 1 following P-Tr. p. 2256, and Tr. p. 2270.

^{4/} P-Tr. p. 2271.

^{5/} P-Tr. p. 2275.

^{6/} P-Tr. p. 2275.

^{7/} P-Tr. p. 2276.

Radon-222 by $1.5E-7$ or an increased dose to the bronchial epithelium of $2.5E-4$ millirem per year.^{1/} 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."^{2/}

40. In response to questioning by the Perkins Board, Dr. Hamilton testified that variations in normal living style, traveling about the country; going indoors or outdoors result in doses that are many orders of magnitude greater than the increase in dose resulting from Radon-222 emanating from tailings.^{3/} Dr. Hamilton concluded that these low levels of exposure are "completely insignificant and without any reality"^{4/} For comparison, Dr. Hamilton^{5/} referred to some calculations provided by Mr. Goldman which compared radon exposure from natural outdoor background radiation to that from background to persons indoors. These calculations show that the entire lung dose projected for 500 years could be offset by reducing the average time spent indoors by the U.S. population by less than 10 minutes over a 500-year period.^{6/} Dr. Hamilton's main thrust was to consider each individual person over the years of his lifetime and consider the insignificant additional dose due to Radon-222 from the uranium fuel cycle.^{7/} He clearly stated that increasing natural radon dose by $10E-7$ was not creating an additional health hazard.

^{1/} P-Tr. p. 2277.

^{2/} Hamilton testimony pp. 2 and 3 following P-Tr. p. 2266.

^{3/} P-Tr. pp. 2322 and 2333.

^{4/} P-Tr. 2323.

^{5/} P-Tr. 2322.

^{6/} Goldman, p. 8-10, fg. P-Tr. 2266.

^{7/} P-Tr. pp. 2278, 2280 and 2323.

^{8/} P-Tr. p. 2323.

41. This Board has weighed carefully these views, which basically are not different presentations of factual evidence but basically constitute different views as to the proper treatment of projections of potential effects into a distant future. On the basis of the evidence considered by this Board, we conclude that attempts to project health effects into a distant future. On the basis of the evidence considered by this Board, we conclude that attempts to project health effects into the very distant future in terms of quantitative estimates of specific incidence of various diseases or mortality are not truly meaningful. An element of the Board's conclusion derives from the fact that while there are extensive attempts on the record to calculate in minute detail the potential impact from minute radon releases from the nuclear fuel cycle into the very distant future, there remains an unknown of unquantified portions, based upon the record available to this Board, concerning long-term impacts attributable to releases of toxic materials over long periods of time from the coal fuel cycle,^{1/} and other uncertainties, such as long-term transport of acid sulfates.^{2/} In light of these uncertainties in the impacts associated with the coal fuel cycle, it appears to have little meaning to make concededly artificial assumptions concerning the potential for future long-range impacts associated with the nuclear fuel cycle.

^{1/} Goldman, 8 fg. P-Tr. 2266, P-Tr. 2640, 2641.

^{2/} P-Tr. 2316.

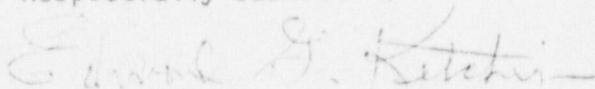
42. Based on the record available to the Board, indeed, we find that the best mechanism available to characterize the significance of the radon releases associated with mining and milling the nuclear fuel for the Yellow Creek facility is to compare such releases with those associated with natural radon background. In this connection, the Board finds that the evidence demonstrates that the exposures associated with the radon release from the mining and milling of the uranium are insignificant. We do, however, believe that the attempt by the Staff to quantify these impacts for at least a period of time for which reasonable future projections can be made; that is, a period of approximately 100 to 1,000 years into the future is desirable for the purposes of assessing relative health impacts of the nuclear and coal fuel cycle. Dr. Gotchy's effort to carry out these calculations out to approximately 1,000 years into the future is useful and, until a definitive determination can be made by the Commission, we believe that the use of a 1,000-year figure for purposes of estimating the potential health impacts associated with the release of radon for purposes of comparison with the available information concerning impacts associated with the coal fuel cycle has been beneficial.

Conclusion as to Health Effects of
Radon-222 (and Carbon 14) Released by
the Uranium Fuel Cycle

43. In response to the Commission's directives contained in the statement of consideration issued in connection with the clarifying amendment to Table S-3 of 10 CFR Part 51, published in the Federal Register on April 14, 1978, (43 F.R. 15613), this Board has carefully considered available information concerning the releases of radon 222 (and Carbon 14) 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 Yellow Creek Nuclear Plant, Units 1 and 2.

Accordingly, our findings and conclusions of law made following the environmental and site suitability hearings with respect to the cost-benefit balance for the Yellow Creek facility remain unchanged. Tennessee Valley Authority (Yellow Creek Nuclear Plant, Units 1 and 2), Partial Initial Decision (Limited Work Authorization), LBP-78-7, 7 NRC 215, 238, para. 58 (1978).

Respectfully submitted,



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Dated at Bethesda, Maryland
this 2nd day of November, 1978