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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
UNITED STATES DEPARTMENT OF ENERGY	)	Docket No. 50-537
PROJECT MANAGEMENT CORPORATION	)	
TENNESSEE VALLEY AUTHORITY	)	
	)	
(Clinch River Breeder Reactor Plant)	)	

NRC STAFF TESTIMONY OF EDWARD F. BRANAGAN, JR.
REGARDING CONTENTION 11(c)

Q.1 By whom are you employed, and what is your position, and what is the nature of your work?

A.1 My name is Edward Branagan. I am a Radiological Physicist with the Radiological Assessment Branch in the Office of Nuclear Reactor Regulation. My duties include evaluating the environmental radiological impacts from nuclear power reactors and, in particular, the health effects models for use in reactor licensing. A copy of my professional qualifications was received into evidence in this proceeding and appears at Tr. 2527.

Q.2 In regard to Contention 11(c), what is the nature of the responsibilities you have regarding the Clinch River Breeder Reactor ("CRBRP")?

A.2 I was responsible for preparing most parts of Section 5.7, "Radiological Impacts from Routine Operations," of the Supplement to the FES for CRBRP (hereinafter referred to as the "Supplement"). Those parts of Section 5.7 that concerned radiological impacts from transportation and the fuel cycle (i.e., Sections 5.7.2.6 and 5.7.2.7, respectively) were the primary responsibility of another office -- the Office of Nuclear Materials Safety and Safeguards. However, I did estimate doses for some fuel cycle facilities included in Section 5.7.2.7.

Q.3 What is the purpose of your testimony?

A.3 My testimony addresses Contention 11(c), which states:

> The health and safety consequences to the public and plant employees which may occur if the CRBR merely complies with current NRC standards for radiation protection of the public health and safety have not been adequately analyzed by Applicants or Staff.
>
> c) Neither Applicants nor Staff have adequately assessed the induction of cancer from the exposure of plant employees and the public.

Q.4 Did the Staff estimate the risk to the general public as a result of exposure to releases of radioactive effluents from normal operations of CRBRP?

A.4 Yes. The Staff estimated the additional risk of fatal latent cancers to the general public associated with exposure to radioactive effluents from normal operations of CRBRP in the following manner.[1/] First, the Staff conservatively estimated the dose to the total body that a member of the public might receive from exposure to radioactive effluents from one reactor-year of normal operations. Second, the Staff estimated the risk of fatal cancers to the individual by multiplying a conservative estimate of the dose to the total body of an individual exposed to radioactive effluents from one year of reactor operations by somatic (i.e., cancer) risk estimators.

Q.5 Has the Staff calculated doses to the public resulting from exposure to radioactive effluents?

A.5 Yes. Doses to a "maximally exposed" individual (that is, the hypothetical individual potentially subject to maximum exposure) attributable to annual releases of radioactive liquid effluents and radioactive airborne effluents are listed in Tables A 5.2 and A 5.3, respectively, of the Supplement. The dose to the total body of the maximally exposed individual to radioactive liquid effluents or radioactive airborne effluents from 1 year of CRBRP operation is less than 1 mrem. Doses to the general public within 50 miles of the plant attributable to annual releases of radioactive liquid effluents and radioactive airborne effluents from CRBRP are given in Table A 5.5. The average annual dose to the total body of

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1/ Use of the term "additional risk" in this testimony refers to potential latent cancer fatalities due to exposures to radiation associated with the operation of CRBRP. This risk is in addition to the risk of death from other causes.

individuals within 50 miles of CRBRP from exposure to radioactive effluents is much less (by a factor of more than 1000) than 1 mrem.

Q.6 Could you describe the environmental transport and dose models used?

A.6 Yes. In licensing commercial nuclear power reactors, the Staff uses mathematical models that characterize radionuclide movement in the environment to determine the radiological impact from nuclear power plant operations. These models are described in several NRC Regulatory Guides. Regulatory Guide 1.109, entitled, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I," provides models for calculating doses to both the maximum hypothetical individual and the general population from exposure to radioactive liquid and airborne releases.

Q.7 What risk estimators were used by the Staff in estimating potential health effects?

A.7 The risk estimators used by the Staff were based on models described in a National Academy of Sciences report entitled "The Effects on Populations of Exposure to Low Levels of Ionizing Radiation." Section 5.7.2.5 of the Supplement. This report is known as the BEIR I Report after its author, the Committee on the Biological Effects of Ionizing Radiation.[2/] The BEIR I Report

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2/ Advisory Committee on the Biological Effects of Ionizing Radiation, The Effects on Populations of Exposure to Low Levels of Ionizing Radiation, National Academy of Sciences, 1972.

consisted of a comprehensive review and reevaluation of the scientific basis of radiation exposure on humans by scientists who were eminent in their fields. The following risk estimator was used to estimate potential health effects: 135 potential fatal cancers per million person-rems. The cancer facility risk estimators used in this testimony are based on the linear non-threshold dose response model and the "absolute risk" projection model described in BEIR I. In the text of the Supplement (Section 5.7.2.5) it was noted that higher estimates can be developed by use of the "relative risk" model along with the assumption that risk prevails for the duration of life. Use of the "relative risk" model (using the linear non-threshold dose response model) would produce risk estimates up to about four times greater than those used in this testimony. The Staff regards the use of the "relative risk" model values as a reasonable upper limit of the range of uncertainty. The lower limit of the range would be zero because health effects have not been detected at doses in this dose-rate range. The number of potential nonfatal cancers would be approximately 1.5 to 2 times the number of potential fatal cancers.[3/]

Q.8 Is the linear non-threshold model a conservative model to use for evaluating the potential health impacts from radiation associated with CRBRP?

3/ National Academy of Sciences, The Effects on Populations of Exposure to Low Levels of Ionizing Radiation ("BEIR III"), 1980.

A.8 Yes. In regard to the use of the linear non-threshold model, the National Council on Radiation Protection and Measurements (NCRP) cautions that:

> [L]inear interpolation between the naturally occurring spontaneous incidence and the incidence observed following exposure at intermediate-to-high doses and dose rates generally overestimates the risk of low-LET [linear energy transfer] radiation at low doses and low dose rates. This observation has also been incorporated in reports by the ICRP (1977), NCRP (1975), and UNSCEAR (1977).[4/]

Essentially all of the whole body dose to offsite individuals from exposure to radioactive effluents from routine reactor operations is due to low dose rates from low-LET radiation.

Q.9 Are the risk estimators that were used in the Supplement consistent with the values recommended by the major radiation protection organizations?

A.9 Yes. The whole body risk estimators that were used in the Supplement are compared with risk estimators from other sources of information in Table 1 of this testimony. The risk estimators that are compared in Table 1 include values from the BEIR I Report, the National Academy of Sciences BEIR III Report which was published in 1980, the International Commission on Radiological Protection (ICRP), and the United Nations Scientific Committee on the Effects of Atomic Radia-

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4/ National Counsel on Radiation Protection and Measurements, Influence of Dose and Its Distribution in Time on Dose-Response Relationships for Low-LET Radiations, NCRP Report No. 64, April 1980.

tion (UNSCEAR).2-3,5-6/ These organizations, along with the NCRP, represent the views of the overwhelming majority of the members of the scientific community. The risk estimators used in the Supplement are consistent with the values from these other sources of information.

Q.10 What were the Staff estimates of the risks to offsite individuals from exposure to radioactive effluents?

A.10 Multiplying the preceding somatic risk estimator (i.e., 135 potential fatal cancers per million person-rem for a population composed of all age groups) by a conservative dose estimate of 5 mrems (well over 5 times the expected average annual total body dose), the Staff estimated that the risk of potential premature death from cancer to the maximally exposed individual to radioactive effluents from one year of the reactor operations is less than 1 chance in one million, or 6.7×10^{-7}. The average risk of potential premature death from cancer to an individual within 50 miles of CRBRP from exposure to radioactive effluents from the reactor is much less than the risk to the maximally exposed individual. These calculations are also discussed in Section 5.7.3 of the Supplement.

5/ International Commission on Radiological Protection, Recommendations of the International Commission On Radiological Protection, ICRP Publication 26, January 1977.

6/ United Nations Scientific Committee on the Effects of Atomic Radiation, Sources and Effects of Ionizing Radiation, United Nations, 1977.

Q.11 Has the Staff estimated the risks to the exposed work force population at CRBRP?

A.11 Yes. As set forth in Section 5.7.2.5 of the Supplement, the Staff estimated the risk of potential fatal cancers in the exposed work force in the following manner. First, the Staff made a conservative estimate of the average annual plant worker population dose (i.e., 1000 person-rems/reactor-year). The Staff then estimated the risk to the work force population by multiplying the annual plant worker population dose by the somatic risk estimator.

Q.12 What is the Staff's estimate of the risk of potential fatal cancers in the exposed work force population at CRBRP?

A.12 The risk of potential fatal cancers in the exposed work force population at CRBRP is estimated by multiplying the conservative annual plant worker population dose of 1000 person-rems by the somatic risk estimator (135 potential fatal cancers per million person-rems). The Staff estimates that about 0.14 cancer deaths may occur in the total exposed work force population. The value of 0.14 cancer deaths means that the probability of one cancer death over the lifetime of the entire work force due to one reactor year of operations at CRBRP is about one chance in 7.

Q.13 What is the significance of the risks to the work-force population?

A.13 The significance of these risks can be evaluated by comparing them to the normal incidence of cancer deaths in the exposed work-force population. Multiplying the current incidence of actual cancer fatalities (about 16%)[7/] by the estimated number of exposed individuals (i.e., about 1000 persons/reactor-year), about 160 cancer deaths are normally expected in the work-force. The risks to the exposed work-force population from the operation of CRBRP (0.14 cancer deaths) is a small fraction of the estimated normal incidence of cancer fatalities in the exposed work-force.

Q.14 What is the significance of the risk to the maximally exposed individual as a result of exposure to routine releases from CRBRP?

A.14 For comparative purposes, the Staff has estimated the risk of potential premature death from cancer to the general public from one year's exposure to other sources of radiation in the United States in Table 2. The dose estimates in Table 2 were derived primarily from the 1980 BEIR III Report and NCRP Report #56.[8/] These risks have been estimated using conservative assumptions regarding risk estimators similar to those that were used in estimating risks to a maximally exposed individual from exposure to radiation from CRBRP. As shown in Table 2, the risk to a maximally exposed individual to radioactive materials released from one reactor-year of routine operations at CRBRP (a risk of potential premature death due to

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7/ U.S. Department of Health and Human Services, "Vital Statistics of the United States 1977, Volume II - Mortality Part A," 1981.

8/ National Council on Radiation Protection and Measurements, "Radiation Exposure from Consumer Products and Miscellaneous Sources," NCRP Report No. 56, November 1977.

cancer of about 1 chance in a million using a conservative dose estimate of 5 mrems) is much less than the risk from exposure to any of the major sources of radiation (e.g., medical exposure and natural background radiation). The risk is also within the same range as the risks from exposure to many of the other common sources of enhanced radiation exposure, such as increased exposure to cosmic radiation from airline travel, exposure to radon and its daughters from combustion of natural gas for heating, and exposure to byproduct X-rays from television receivers. The risk of potential premature death from cancer to the average individual within 50 miles of the reactor from exposure to radioactive effluents from the reactor is much less than the risk to the maximally exposed individual.

Q.15 What do you conclude with respect to the issue raised in Contention 11(c)?

A.15 I conclude that the Staff adequately assessed the potential cancers that may occur from exposure of plant exployees and the general public. In Section 5.7.2.5 of the Supplement to the FES for CRBRP the Staff presented estimates of potential fatal cancers that may occur among the exposed work force. In Section 5.7.3 of the Supplement to the FES for CRBRP the Staff presented estimates of the risk of potential premature death from cancer to the maximally exposed individual to radioactive effluents from CRBRP. The potential fatal cancer risk estimators that were used in the Supplement were based on models described in the National Academy of Sciences BEIR I

Report, and are consistent with the recommendations of other major radiation portection organizations such as the ICRP, NCRP and UNSCEAR. These organizations represent the views of the overwhelming majority of the members of the scientific community. I conclude that the Staff's estimates of the potential cancers that may occur from exposure of plant employees and the general public are appropriately conservative.

Table 1 Comparison of FES Supplement Whole Body Cancer Mortality Risk Estimators (Per 10^6 person-rem) With Values From Other Sources of Estimates[a]

Source of Estimates	Dose-Response Models[b]	Projection Model Continuous Lifetime Exposure to 1 Rad/Yr (Low-LET)	
		Absolute	Relative
BEIR, 1980	LQ-L, $\overline{\text{LQ-L}}$	67	169
1972 BEIR[c]	Linear	115	568
UNSCEAR 1977	Linear	75-175	
ICRP[d]	Linear	100-125	
Supplement	Linear	135	500

[a] Except where noted all values are taken from Table V-4 of BEIR III.

[b] For BEIR 1980, the first model is used for leukemia, the second for other forms of cancer. The corresponding estimates when the other models are used (thereby providing an envelope of risk estimates) are:

L-L, $\overline{\text{L-L}}$ 158 403

[c] Updated to 1970 U.S. population.

[d] The value for the ICRP is taken from Ref. 5.

Table 2 Approximate ranking of potential risks from various sources of radiation exposure in the United States

Source of Exposure	Exposed Group	Part of Body Exposed	Avg. Annual Dose, mrem[a]	Approx. Risk,[b] Chance of Premature Death in a Million
Medical diagnosis by radiopharama-ceuticals	Patients	Bone marrow	300	40
Medical diagnosis by X-rays	Adult Patients	Bone marrow	103	14
Natural background radiation	Total population	Whole body	80	11
Many types of radioluminous clocks	Users	Whole body	8	1
Radioactive releases from normal reactor operations	Maximally exposed individual	Whole body	$\leq$ 5	$\leq$ 1
Building materials brick and masonry	Total population	Whole body	7	0.9
Atmospheric weapons tests	Total population	Whole body	4	0.5
Unvented heaters using natural gas	Users	Bronchial epithelium	22	0.5
Airline travel	Passen-gers	Whole body	3	0.4
Dental diagnosis	Adult patients	Bone marrow	3	0.4
Many types of luminous wrist-watches	Users	Gonadal dose equivalent	3	0.4

Natural-gas cooking ranges	Users	Bronchial epithelium	7	0.2
Television receivers	Viewers	Gonads	0.8	0.1

[a] Average annual doses for all sources, except the releases from CRBR were taken from either BEIR III, 1980, or NCRP, 1977. The risks associated with the operation of CRBR are on a per reactor-year basis.

[b] Except where noted, risk was calculated by multiplying the average annual dose (in Rem) by risk estimators of 135 and 22.2 potential cancer deaths per million person-rems for total body and lung exposures, respectively. The total-body risk estimator was used to approximate the risk from the dose to the bone marrow from medical exposure.