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Daniel R. Muller, Assistant Director for Environmental Projects, L

REVIEW OF THE PFES FOR INDIAN POINT

Plant name - Indian Point Unit No. 2
Licensing stage - OL
Docket number - 50-247
Responsible branch - Environmental Projects Branch #1
Project leader - M. J. Oestmann
Date request received by RA-L - August 25, 1972
Requested completion date - September 8, 1972
Description of response - Changes in the PFES for final publication
Radiological Assessment Branch review status - Complete

Sections V.D.1, V.E., V.F. and XII.D. of the preliminary Final Environmental Statement prepared by Oak Ridge National Laboratory for Indian Point Unit No. 2 have been reviewed by RA-L. Our suggested modifications, which are included in enclosures 1, 2, 3, and 4, respectively, were transmitted informally to M. J. Oestmann on September 5, 1972.

This material was prepared by A. F. Kluk.

Original signed by
H. R. Denton

Harold R. Denton, Assistant Director
for Site Safety
Directorate of Licensing

Enclosure:
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ENCLOSURE NO. 1

contributions to air pollution are the combustion products listed in Table III-16 discharged from Unit No. 1 through its oil-fired superheaters. In Appendix XII-2, the Department of Agriculture has expressed concern of the effect of sulfur dioxide from fossil-fuels on the vegetation in the area. The incremental addition of sulfur dioxide from Unit No. 2 has been estimated to be about 8 x 10^{-4} ppm or 2.7% of the Federal Quality Air Standards from burning oil (0.3% S) in the package biolers used intermittently. The major source of sulfur dioxide is from the superheater of Unit No. 1 which will produce 25% of the Federal Air Quality Standard. Since Unit No. 1 has been in operation for 10 years it appears that no significant effect on the vegetation has occurred. Furthermore, no chlorine gas will be used to cause any effects on nearby vegetation. Sodium hypochloride solution which produces residual chlorine in solution will be used to clean the condensers.

D. BIOLOGICAL IMPACT OF STATION OPERATION OF UNITS NOS. 1 AND 2

A large quantity of ecological information has been gathered concerning the Hudson River. Much of this information is applicable to the Indian Point site and is briefly summarized in Section II.F and Appendices II-1 and II-2 of this Statement. A significant proportion of this information has been obtained through research sponsored by the applicant through contracts with Raytheon Company, New York University, Ichthyological Associates, Northeastern Biologists, Bechtel Corporation, Alden Research Laboratories, and Quirk, Lawler, and Matusky Engineers. At present, investigators from the NYU Institute of Environmental Medicine and from Texas Instruments, Inc. are conducting biological sampling programs related to the operation of the Indian Point Units.

Information to answer most of the principal ecological questions associated with the operation of Indian Point Units Nos. 1 and 2 is not yet available. The proposed studies as outlined in the applicant's Environmental Report will answer some of these questions. However, other studies should be included, and these are discussed along with their purposes in Section V.D.3 on Non-Radiological Biological Monitoring Program.

The major adverse impact of the Plant including both Units will be on the aquatic environment. Large numbers of fish will likely be killed through impingement on the screens that protect the condensers. A large quantity of plankton will be entrained in the condenser cooling water where they will be exposed to potential physical, chemical, and thermal damage. The release of heated effluent water including chemical and liquid radioactive water will cause a change in the physical environment that may affect the biota. Detrimental effects of Plant operations may be manifested directly by killing organisms or making them less capable of reproduction or indirectly by affecting interactions between species.

Staff evaluation of the probable biological effects of the operation of the Indian Point Units Nos. 1 and 2 is based on an analysis of information from three sources: (1) field studies conducted at other steam generating power plants, (2) laboratory and field investigations of the probable biological effects of Plant effluents, and (3) information that has been gathered in conjunction with the operation of Indian Point Unit No. 1.

The analysis is divided into two sections:

> Section V.D.1 identifies and evaluates the factors that may cause biological damage from the combined operation of Indian Point Units Nos. 1 and 2.

> Section V.D.2 applies the important factors identified in Section V.D.1 to the biological community at Indian Point.

1. Sources of Potential Biological Damage

a. Radiation Effects

Although there is a voluminous amount of literature relating to the effects of radiation on organisms, very few studies have been conducted on the effects of chronic low-level radiation on natural aquatic populations. The more recent and pertinent studies have been reviewed by Auerbach et al.[5] and Templeton, Nakatani, and Held.[6] In general, the results of the studies summarized in these two reviews support the prediction that radiation effects would be difficult to detect at the dose levels normally encountered around power reactors:

> "In assessing the effect of low doses of ionizing radiation, sophisticated means of detection must be used and sensitive biological endpoints are

> necessary as criteria for ascertaining radiation damage. In experimental practice when dose rates are lowered to 1 rad per day or less, the number of factors affecting the organism are sufficient to mask any effects that might be present. Such commonly used endpoints as survivorship, fecundity, growth, development, and susceptibility to infection have not as yet been shown to be unequivocally affected by such low dose rates. Evaluating the impact of doses of less than 1 rad per day on organisms and populations under field conditions is a challenge of considerable magnitude."[5]

Aquatic organisms are exposed to both internal and external radiation.[7,8] The dose from external radiation, termed submersion dose, is due to the radiation from radionuclides in the organisms' surroundings. For planktonic or pelagic organisms, this part of the total dose results from radionuclides dissolved in the water. For benthic and epibenthic organisms, part of the external dose comes from the radionuclides dissolved in the water, and another part comes from radionuclides adsorbed onto or concentrated in their substrate. The radiation dose resulting from dissolved radionuclides can be calculated if the concentrations of the various radionuclides in the water are known.

However, the external dose resulting from radionuclides that are in the substrate of the organism is much more difficult to determine. This difficulty arises from the various behavioral characteristics of the organisms involved which modify the magnitude of the dose from radiation originating in the substrate. In addition, the level of contamination of the substrate by a radionuclide may vary with physical parameters within the environment. For example, manganese-54 adsorbs onto the substrate during periods when fresh water is predominant at Indian Point but is released during periods when salt water moves into the area.[9] As a result of these complications, the external dose from radionuclides concentrated in the substrate is difficult to estimate from the projected releases.

In addition to radiation from external sources, aquatic organisms are exposed to radiation from radionuclides within their tissues. Doses resulting from this source of exposure are potentially much greater (an estimated factor of 100 or more in this case) than doses from external sources, except perhaps for benthic or epibenthic organisms living in association with substrates in which radionuclides have been concentrated. Organisms accumulate radionuclides either directly from the water through epithelial tissue or by assimilation of their food. Transient releases of radionuclides into the environment are followed by transient peaks of radioactivity along the food-chain pathways.[5] Knowledge of these pathways and of the rates of assimilation and turnover of radionuclides is essential for prediction of time-dependent concentrations in the biota. However, chronic releases will result in steady-state concentrations in the biota, and, in these instances, factors can be used to approximate the eventual equilibrium levels of radioactivity.[5]

Radiation doses to aquatic organisms living in the Hudson River at Indian Point and at the discharge have been estimated by the staff. These estimates shown in Table V-1 are based on the assumption of no recycling of released radionuclides through the cooling water intake.

Internal doses in millirads per year for each radionuclide were calculated from Equation (1). The sum of the separate radiation doses for the various radionuclides was used to provide the total internal dose.

$$D = E \cdot k \cdot X \cdot C, \qquad (1)$$

where:

D = dose, millirads per year
E = effective absorbed energy[10] for man, Mev
k = constant = 1.87×10^7
X = bioaccumulation factor
C = concentration of radionuclide in the effluent canal, μCi/ml

The bioaccumulation factors listed in Table V-2 were obtained from the literature and are derived by dividing the radionuclide concentration in the organism per unit wet weight by the radionuclide concentration in the water to which the organism is exposed. Values more suitable to the Hudson River estuary may be obtained by careful analysis of the data gathered in conjunction with the operation of Unit No. 1.[9,11-15] Bioaccumulation factors vary greatly in different environments as a result of changing physical, chemical, and biological conditions. However, in most cases the maximum values obtained from the literature for freshwater ecosystems were used in the dose calculations. These factors often represent extreme cases and very

Table V-1. Internal radiation doses (millirad/year) to aquatic organisms living in the Indian Point effluent canal

(The nuclide concentrations are based on estimated annual releases from Unit No. 2 and continued operation of Unit No. 1 at past levels.)

Radionuclides	Initial Unit No. 2 radwaste treatment				Modified Unit No. 2 radwaste treatment			
	Concentration (μCi/ml)	Aquatic plants	Invertebrates	Fish	Concentration (μCi/ml)	Aquatic plants	Invertebrates	Fish
H-3	1.2E−06	2.3E−01	2.3E−01	2.3E−01	1.2E−06	2.3E−01	2.3E−01	2.3E−01
Na-24					2.5E−09	2.0E+01	3.4E+00	4.1E+00
Cr-51	9.0E−12	4.2E−04	2.1E−04	8.4E−04	6.0E−13	2.8E−05	1.4E−05	5.6E−05
Mn-54	8.2E−10	2.7E+02	1.1E+03	2.0E−01	8.1E−10	2.7E+02	1.1E+03	1.9E−01
Fe-55	2.4E−11	1.5E−02	9.3E−03	8.8E−04	6.5E−12	4.0E−03	2.5E−03	2.4E−04
Fe-59	9.5E−12	7.2E−01	4.6E−01	4.3E−02	2.1E−13	1.6E−02	9.9E−03	9.3E−04
Co-58	8.2E−10	2.4E+01	1.4E+01	4.7E+00	6.0E−10	1.7E+01	1.0E+01	3.4E+00
Co-60	2.6E−10	1.8E+01	1.1E+01	3.6E+00	2.5E−10	1.7E+01	1.0E+01	3.4E+00
Rb-86	9.0E−12	1.2E−01	2.4E−01	2.4E−01	1.7E−12	2.2E−02	4.3E−02	4.3E−02
Sr-89	3.2E−11	1.0E+00	1.3E+00	5.0E−02	2.5E−11	7.8E−01	1.0E+00	3.9E−02
Sr-90	5.2E−12	3.2E−01	4.3E−01	1.6E−02	5.0E−12	3.1E−01	4.1E−01	1.5E−02
Sr-91					7.0E−14	8.2E−03	1.1E−02	4.1E−04
Y-90					5.5E−14	9.2E−03	9.2E−04	9.2E−05
Y-91	9.5E−12	1.0E+00	1.0E−01	1.0E−02	1.7E−11	1.8E+00	1.8E−01	1.8E−02
Zr-95	1.0E−12	3.1E−02	3.1E−03	2.1E−04	3.4E−14	1.0E−03	1.0E−04	7.0E−06
Zr-97					6.5E−15	3.8E−04	3.8E−05	2.6E−06
Nb-95	1.0E−12	9.5E−03	9.5E−04	9.5E−05	3.3E−14	3.1E−04	3.1E−05	3.1E−06
Mo-99	2.8E−09	2.8E+00	2.8E+00	2.8E+00	2.0E−10	2.0E−01	2.0E−01	2.0E−01
Ru-103	1.0E−12	1.6E−02	1.6E−02	8.4E−04	2.5E−14	4.1E−04	4.1E−04	2.1E−05
Ru-106					7.5E−15	3.9E−04	3.9E−04	2.0E−05
Rh-105					7.5E−15	5.0E−05	5.0E−05	2.5E−06
Te-125m					2.1E−14	5.8E−05	3.5E−04	2.3E−05
Te-127m	6.0E−12	4.4E−01	2.7E−01	1.8E−02	1.6E−13	9.6E−04	5.8E−03	3.8E−04
Te-127					2.2E−13	9.9E−04	6.0E−03	3.9E−04
Te-129m	5.5E−11	1.1E+00	6.9E+00	4.5E−01	1.6E−12	3.3E−02	2.0E−01	1.3E−02
Te-131m					6.0E−13	1.8E−02	1.1E−01	7.2E−03
Te-132	3.1E−10	1.0E+01	6.5E+01	4.2E+00	1.1E−11	3.7E−01	2.3E+00	1.5E−01
I-130	8.5E−12	4.1E−02	2.0E−01	1.0E−02	7.5E−13	3.6E−03	1.8E−02	9.1E−04
I-131	1.3E−08	2.2E+01	1.1E+02	5.4E+00	8.2E−09	1.3E+01	6.7E+01	3.4E+00
I-133	6.3E−09	2.0E+01	9.8E+01	4.9E+00	3.5E−09	1.1E+01	5.5E+01	2.8E+00
I-135	2.4E−09	1.2E+01	5.9E+01	2.9E+00	1.8E−09	8.8E+00	4.4E+01	2.2E+00
Cs-134	3.6E−09	1.8E+03	8.0E+02	7.3E+01	5.6E−10	2.9E+02	1.3E+02	1.1E+01
Cs-136	1.0E−09	3.1E+02	1.4E+02	1.3E+01	2.4E−10	7.3E+01	3.2E+01	2.9E+00
Cs-137	3.2E−09	8.9E+02	3.9E+02	3.6E+01	6.5E−10	1.8E+02	7.9E+01	7.2E+00
Ba-140	8.0E−12	1.7E−01	6.9E−02	3.4E−03	2.3E−13	4.9E−03	2.0E−03	9.9E−05
La-140					1.6E−13	5.5E−02	5.5E−03	5.5E−04
Ce-144	1.0E−12	2.4E−01	2.4E−02	2.4E−03	2.2E−14	5.2E−03	5.2E−04	5.2E−05
Pr-143					3.0E−14	1.8E−03	1.8E−04	1.8E−05
Nd-147					1.2E−14	9.0E−04	9.0E−05	9.0E−06
Np-239					2.0E−13	1.1E−03	3.0E−04	1.1E−02
Total dose			2.8E+03	1.6E+02		9.0E+02	1.5E+03	4.2E+01

Table V-2. Bioaccumulation factors for elements in aquatic plants, invertebrates, and fishes

Nuclide	Concentration factor					
	Plants	Reference	Invertebrates	Reference	Fish	Reference
Sr	3,000	7	4,000	7	150	7
Y	10,000	8	1,000	8	100	8
Mo	100	8	100	8	100	8
Tc	100	8	25	8	1	8
Te	1,000	*a*	6,100	*a*	400	*a*
I	200	7	1,000	7	50	7
Cs	25,000	7	11,000	7	1,000	7
Ba	500	8	200	8	10	8
Cr	100	16	50	16	200	16
Mn	35,000	7	140,000	7	25	8
Co	2,500	7	1,500	8	500	8
Zn	4,000	8	40,000	8	1,000	8
H	1	8	1	8	1	8
Ce	10,000	8	1,000	8	100	8
Fe	5,000	8	3,200	8	300	8
Rb	1,000	8	2,000	8	2,000	8
Zr	1,500	16	150	16	10	16
Nb	1,000	8	100	8	10	*b*
Na	160	8	27	8	32	8
Ru	2,000	8	2,000	8	100	8
Rh	2,000	8	2,000	8	100	8
La	10,000	8	1,000	8	100	8
Pr	10,000	8	1,000	8	100	8
Nd	10,000	8	1,000	8	100	8
Np	1,000	8	290	8	10,000	8

[a]Calculated by the staff from stable element analysis listed in the *Farley Nuclear Power Station Environmental Report,* Georgia Power and Light Co., 1972.

[b]Bioaccumulation factor for this radionuclide considered by staff to equal bioaccumulation factor for Zr-95 in fish.

likely overestimate the bioaccumulation of radionuclides and therefore the internal dose that will result from the releases at Indian Point. The use of the effective absorbed energy for man also tends to overestimate the dose.

The bioaccumulation factor multiplied by the radionuclide concentration in the water (in μCi/ml) provides an estimate of the body burden of the radionuclide (in μCi/gm in the organism). The concentration in the organism's body multiplied by the effective absorbed energy and the constant κ gives the internal radiation dose to the organism in mrad/yr for that particular radionuclide. The discharge concentrations and internal radiation doses of Table V-1 were estimated by assuming that the radionuclides released from Indian Point Units Nos. 1 and 2 are diluted by about 2.0×10^{15} cc/yr (2,230 cfs of water) in the discharge canal.

The estimated total doses (see Table V-1) to the aquatic organisms living in the undiluted effluent are higher than those that the organisms would receive from background radiation but considerably less than the levels which would produce observable effects. As a result of these considerations, no discernible radiation effect is expected in the aquatic community of the Hudson River as a result of Indian Point activities.

b. Dissolved Oxygen

In the Hudson River estuary near Indian Point, there is a relatively low load of decomposing organic matter.[17] Raytheon Company[18] found that dissolved oxygen in the Hudson River water in the Indian Point area ranged from low summer values of 3 ppm to high winter values of 11 ppm. The dissolved oxygen concentration in the coolant water discharged from Indian Point Unit No. 1 was found to be slightly less than that in the intake water. Although recent information presented by the applicant during testimony indicates a sampling error in calibration of instrumentation used for dissolved oxygen analysis, Raytheon Company[18] noted a distinct drop in dissolved oxygen across Unit No. 1 and intermittent low levels of dissolved oxygen in the river near the site. As an example, Raytheon cited that in early November 1969, the dissolved oxygen in the effluent (3.7 ppm) was 34% less than that in the intake water. Since the dissolved oxygen intake concentration of 5.3 ppm and the effluent concentration of 3.7 ppm observed in both instances were less than 50% of the theoretical saturation value, the rise in water temperature does not seem to entirely account for the decrease, thus lending credence to the

ENCLOSURE NO. 2

E. RADIOLOGICAL IMPACT OF ROUTINE PLANT OPERATION ON MAN

1. Introduction

Radioactive nuclides will be released during operation under normal conditions as liquids and gases from both Indian Point Unit No. 1 and Unit No. 2. The release of these effluents will be conducted in accordance with the limitations set forth in 10 CFR 20[48] and the guidance of 10 CFR 50[49] to keep the levels of radioactive material in effluents to unrestricted areas "as low as practicable." Operating experience with similar power plants licensed for operation by the Commission has shown that actual releases of radionuclides from these plants have generally been small fractions of the limits set forth in 10 CFR 20, consistent with the Commission's policy of limiting radioactive releases to the lowest practicable level. Information on radioactive releases from operating experience of pressurized power reactors is shown in Appendix III-3.

The limitations set forth in 10 CFR 20 are based upon recommendations of national and international radiation protection groups which represent the consensus of informed and responsible scientific judgment on the radiation exposure limits for occupational workers and the general public. No detectable radiological effects on man are expected to result from releases of radionuclides meeting 10 CFR 20 limitations.

2. General Considerations For Determination of Dose Estimates

Pathways for external (radiation source outside the body) and internal (radiation source inside the body) exposures are schematically illustrated in Fig. V-5. Immersion in the gaseous effluent as it is diluted and dispersed could lead to external exposure, while the dispostion of radioactive particulates on the land surface could lead to direct external exposure and to internal exposure by the ingestion of food products through various food chains. Similarly, swimming in waters in which radionuclides have been discharged could lead to external exposure, while the utilization of these waters for fishing, drinking, irrigation, or food preparation could lead to internal exposures. The doses calculated for the internal exposures are estimates of the total dose an individual will accrue within his lifetime from each pathway.

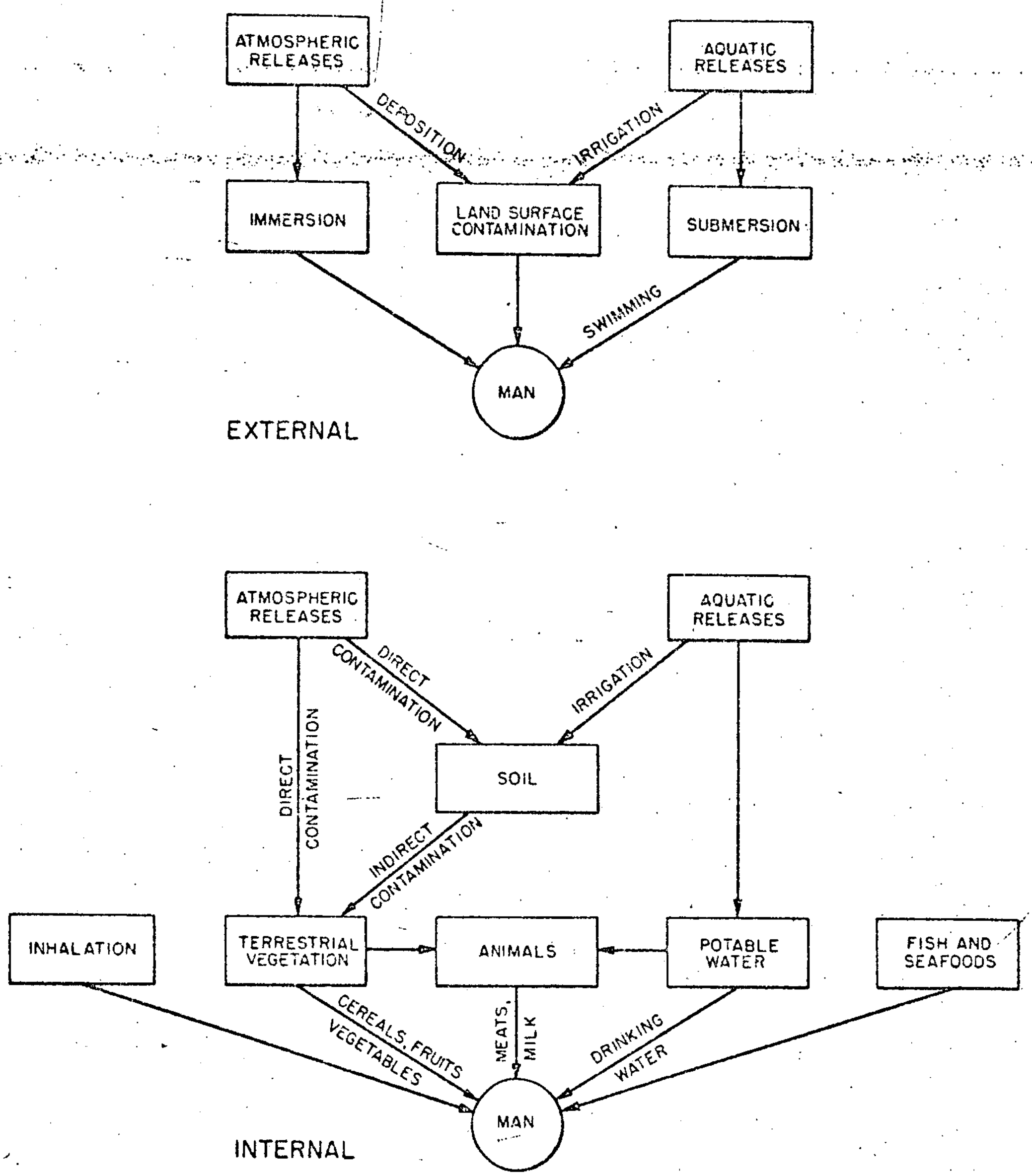

Fig. V-5. Pathways for radiation exposure of man.

Annual radiation doses, both to individuals [in millirem (mrem), where 1 millirem is 1/1000 rem] and the population (in man-rem) near the reactor are estimated. The man-rem or population dose is the sum of the total body doses to all individuals in the population considered. The dose estimates are based on an all adult population. For radioactive iodine in milk, the dose estimated for a 1-year-old child is about 10 times as large as for an average adult.[50,51] Where they are significant, the estimates of dose to organs other than total body are discussed.

Factors for converting internal radiation exposures to dose were obtained with models and data published by the International Commission on Radiation Protection[10] and other recognized authorities.[52] These models and data have been incorporated in computer programs[53] to facilitate estimation of dose. Factors for converting external radiation exposures to dose were obtained with a computer code containing models adapted from standard texts.[54,55]

a. Dispersion of Gaseous Effluents

Average annual concentrations of radionuclides contained in the air and deposited on the ground at distances up to 50 miles from the Plant site were obtained from an atmospheric transport model[56,57] for which a computer program was developed.[58] The deposition velocities used in the calculations for the noble gases (krypton and xenon), methyl iodide (CH_3I), and molecular iodine (I_2), and particulates were 10^{-6}, 10^{-3}, and 1 cm/sec respectively. In this model, the reductions of radionuclide concentrations in the air at ground level by radioactive decay and deposition on the ground are taken into account.

b. Dispersion of Liquid Effluents

The concentration of radionuclides in a body of water receiving liquid effluents depends primarily on the half-lives of the radionuclides and the effective volume of water as well as mixing characteristics. The complex nature of the estuary leads to large variations in the estimates of radionuclide concentrations in the water, on the bottom sediment, and in the biota.

3. Estimates of Dose

Estimates of doses to individuals and the population within 50 miles which result from radionuclide effluents discharged during normal operation of Indian Point Units 1 and 2 are treated below. Estimated doses to an individual for several exposure pathways are given in Table V-8 for radionuclide releases through both the initial and modified radioactive waste systems (see Tables III-6, 7, 8, 10, 12 and 13). The cumulative population dose from immersion in gaseous effluents is given as a function of distance in Table V-9 for both the initial and modified radioactive waste system. The estimates of dose due to gaseous effluents are based on the anticipated radionuclide releases given in Section III.E.2 of the statement and the site specific meteorological data of Indian Point as given in Supplement No. 1 to the Environmental Report on Indian Point Unit No. 2. The anticipated radionuclide releases in liquid effluent as described in Section III.E.2 will be diluted at the point of discharge by a varying factor which depends upon the net fresh water flow and tidal mixing of the Hudson River.

a. Gaseous Effluents

The average concentrations of radionuclides at ground level were estimated in each of sixteen 22.5° sections at various distances from the site. The concentration of gaseous effluent released from Indian Point Unit No. 1 except for the iodines is calculated for release from the 88-meter stack ($X/Q= 2.6 \times 10^{-6}$ sec/m^3, 1000m south). Because of the irregular shape of the property line defining the Indian Point site, estimates of dose are made for several locations.

(1) Dose Estimates for Immersion and Ground Contamination

The highest estimate of total body dose [31. and 3.3 millirem per year (mrem/y) of release respectively for the initial and modified radioactive waste systems] occurs for an individual continuously located at the proposed visitors' center. However, only a small part of this dose would be received by a person present at the visitors' center diving the time of an average visit. If the center has 100,000 visitors per year and each visitor stays for two hours, then an estimate of the annual visitor-population dose is 0.75 man-rem.

TABLE V-8. ESTIMATED DOSES TO INDIVIDUALS PER YEAR OF NORMAL RADIONUCLIDE RELEASE FROM BOTH INDIAN POINT UNITS NOS. 1 AND 2

Pathway	Location or	Total-body dose (millirem)		Thyroid dose (millirem)	
		Initial radioactive waste system	Modified radioactive waste system	Initial radioactive waste system	Modified radioactive waste system
Air immersion and surface contamination. Locations measured from Indian Point Unit No. 2 to:					
Proposed visitor center	107 m E	3.1	3.3	3.1	3.3
Property line	630 m ESE	0.14	0.15	0.14	0.15
Property line	970 m S	0.14	0.15	0.14	0.15
Property line	520 m SW	0.23	0.24	0.23	0.24
Inhalation of contaminated air. Locations measured from Indian Point Unit No. 2 to:					
Proposed visitor center	107 m E	0.02	0.02	14	13
Property line	630 m ESE	<0.01	<0.01	0.57	0.55
Property line	970 m S	<0.01	<0.01	0.52	0.51
Property line	520 m SW	<0.01	<0.01	0.88	0.85
Terrestrial food chain	970 m S	<0.01	<0.01	0.88	<1.0[a]
Aquatic food chain	16 lb of fish per year	0.31	0.054	1.2	0.61
Swimming (Hudson River)	1% of year	<0.01	<0.01	<0.01	<0.01

[a]Based on an upper estimate of the above ground vegetable crops consumed immediately after harvest.

TABLE V-9. SUMMARY OF THE ANNUAL TOTAL-BODY DOSES ESTIMATED FOR IMMERSION IN THE GASEOUS EFFLUENTS FROM BOTH INDIAN POINT UNITS NOS. 1 AND 2

Distance (miles)	Cumulative population (1970)	Initial radioactive waste system		Modified radioactive waste system	
		Cumulative population dose (man-rem)	Individual average dose (millirem)	Cumulative population dose (man-rem)	Individual average dose (millirem)
0-1	2,213	0.16	7.2×10^{-2}	0.17	7.7×10^{-2}
0-2	18,552	0.53	2.9×10^{-2}	0.58	3.1×10^{-2}
0-3	30,175	0.63	2.1×10^{-2}	0.70	2.3×10^{-2}
0-4	39,465	0.69	1.7×10^{-2}	0.75	1.9×10^{-2}
0-5	65,830	0.79	1.2×10^{-2}	0.86	1.2×10^{-2}
0-10	211,373	1.2	5.7×10^{-3}	1.2	5.7×10^{-3}
0-20	916,379	2.0	2.2×10^{-3}	2.1	2.3×10^{-3}
0-30	4,302,799	4.7	1.1×10^{-3}	4.7	1.1×10^{-3}
0-40	10,710,185	8.2	7.7×10^{-4}	7.9	7.4×10^{-4}
0-50	16,507,168	10	6.1×10^{-4}	9.9	6.0×10^{-4}

TABLE V-10. INTEGRATED ANNUAL DOSE TO THE GENERAL POPULATION FROM THE OPERATION OF THE INDIAN POINT STATION[a]

Pathway	People	Initial radioactive waste system (man-rem)	Modified radioactive waste system (man-rem)
Cloud (immersion)	16,000,000	10	9.9
Fish	160,000	5.0	0.87
Swimming	160,000	0.12	0.08
Visitors' center (direct radiation + immersion)	100,000	<7	<7
Transportation of irradiated fuel	300,000[b]	1.8[c]	1.8[c]
Transportation of radioactive waste	180,000	0.9	0.9
Total		<25	<21

[a]Annual exposure dose from natural background is 0.1 rem to the individual and 1,600,000 man-rem to the general population of 16,000,000 (based on 1970 census).

[b]Dose from shipment by rail. Shipment may be made by truck, in which case the dose will be 3.4 man-rem.

[c]This includes ten people close by and two drivers as well as 300,000 people along the route.

Estimates of total body dose are given in Table V-8 for three locations on the property line surrounding the site. A commercial building is located near the intersection of Bleakley and Broadway (630 meters ESE). The nearest sizeable residential areas lie to the south of the site. For the portion of this site not bounded by water, the highest estimate of total body dose is found at 520 meters SW. The adjoining property at this location is owned by Georgia Pacific and is not currently used as a residential area. It is therefore estimated that an annual dose of <0.1 mrem would be received by a person spending 8 hours per day at this location.

The estimates of total body and thyroid doses for both the initial and modified radioactive waste systems are given in Table V-8 for all of these locations. About 5 to 10% of these dose estimates are attributable to ground contamination.

The population dose (see Table V-9) from immersion for persons living within 50 miles (1970 census) of the Station is 10 man-rem for the initial radioactive waste system and 9.9 man-rem for the modified system.

(2) Dose Estimates for Inhalation

The estimates of internal dose for inhalation are based on an inhalation rate of 2×10^7 cc/day.[10] The estimates of the total body and thyroid doses are given in Table V-8 for both the initial and modified waste systems at the same locations for which external doses were estimated. The total dose to the thyroid from external exposure and internal inhalation exposure to the gaseous effluent is the sum of the two separate dose estimates. (For example the estimated annual dose to the thyroid of a person at the visitors' center 8 hours per day would be 5.7 mrem.)

(3) Dose from Radioparticulates and Iodine by Food-Chain Pathways

Deposition of radioparticulates and iodine occurs from the gaseous effluent to crops and soil. Direct ingestion by man of radionuclides deposited on truck crops is possible. Indirect ingestion of radionuclides via meat produced by animals pastured on exposed areas is also possible, and an additional pathway which utilizes all of these mechanisms exists for nuclides carried into the soil by rainfall and subsequently into food plants through their roots. A general purpose environmental model[59] was used to estimate the resulting dose to an individual. The total-body estimate of less than 0.01 mrem/yr of release at 970 meters in the southern direction is based on the assumption that all of the individual's above ground vegetables are produced at this location. The corresponding annual thyroid dose is estimated to be <1.0 mrem.

An estimate of dose from ^{131}I and ^{133}I was made for the pasture-cow-milk-man pathway. The same general environmental model used above[59] converted the deposition rate to a radioiodine concentration in milk. The estimate of dose to the thyroid of an individual drinking 0.6 liters of milk per day was made for milk produced at the dairy approximately 9 miles south of Indian Point. The estimated thyroid dose to an adult drinking this milk is 0.36 mrem/yr of radionuclide release.

b. Liquid Effluents

The anticipated quantities of radionuclides in the liquid effluents discharged from the initial and modified radioactive waste systems of Units Nos. 1 and 2 are listed in Tables III-6, 7, and 8. These effluents will be mixed with an average cooling water flow of 2.0×10^{15} cc/yr (2,230 cfs) and then further diluted by a factor ranging from 2 to 20 after this water is discharged into the Hudson River. Radioactive decay for 1 day and an average river dilution of 10 were used in calculating the concentration of each radionuclide.

(1) Dose Estimates for Ingestion of Fish

The highest total-body dose to an individual from fish consumption is estimated to be 0.31 mrem per year of release. The daily consumption rate for fish was assumed to be 20 gm (16 lb per year is the per capita figure for the United States)[60] all of which came from the Hudson River downstream from the site where the average river dilution of the discharged effluent is assumed to be 10. Radionuclide concentrations in the fish were assumed to be in equilibrium with those in the river and were determined by multiplying the radioactivity levels in water by the respective bioaccumulation factors (radionuclide concentration in fish flesh divided by radionuclide concentration in water). The complexities of estuaries make it difficult to postulate average conditions which will simply take into accound the variations of fresh water flow, salt water intrusion, biota populations, etc. The freshwater bioaccumulation factors shown in Table V-2 were used to obtain the estimates of dose to man from fish consumption.

A population dose from ingestion of fish is difficult to estimate due to the lack of fish harvest data for the Hudson River. If it is assumed that 1% of the approximately 16 million people living within 50 miles of the site obtain 10% of their fish from the Hudson River (a total of 260,000 lb/yr), an annual population dose of 5 man-rem is estimated for the initial radioactive waste system. The estimated population dose reduces to 0.87 man-rem for the modified waste system.

(2) Dose Estimates for Ingestion of Hudson River Water

No estimate of the dose was made for this exposure pathway, since at no place downstream from Indian Point is the river used as a source of municipal drinking water. Table II-2 of Chapter II lists the municipals using water from the Hudson River. All of these cities are north of the Indian Point site. Poughkeepsie which uses the greatest amount of Hudson River for drinking water is 30 miles upstream from Indian Point.

(3) Dose Estimates for Swimming in the Hudson River

Swimming in the river was considered a potential source of external exposure. The estimate of less than 0.01 mrem/yr of radionuclide release for the radiation dose to an individual was calculated under the assumption that he would swim in the river 1% (1 hour per day for three months each year) of the year. The estimated annual population doses of 0.12 and 0.08 man-rem were obtained, respectively, for the initial and modified radioactive waste systems by assuming that 1% of the population living within 50 miles of the site spends 1% of the year swimming in the river.

c. Direct Radiation

The refueling water storage tank, approximately 15 meters NE of the containment of Indian Point Unit 2, is a source of direct radiation due to the storage of excess water received from the primary cooling system upon startup after a refueling cycle. A preliminary estimate of the total body dose rate by the applicant at the visitors' center (approximately 107 meter E) is <0.03 mrem/hr. The corresponding estimated dose rate at the intersection of Bleakley and Broadway would be <0.001 mrem/hr. A radioactive decay period of 6 weeks (normal refueling time) is assumed before the excess refueling water is put into the storage tank without any treatment. These estimates of dose are maximum since shielding and further radionuclide decay in the storage tank would reduce the dose rate.

4. Assessment of Annual Dose Estimates

A summary of estimated annual doses which might be expected by individuals at points of maximum exposure to the gaseous effluents is given in Table V-8. These doses are not reduced by shielding factors or occupancy factors. The sum of the annual total body dose estimates for offsite individuals from immersion, inhalation, and ground surface contamination is less than 1% of natural background dose and less than 0.2% of the exposure limits of 10 CFR 20.

The annual doses expected to result from the liquid releases are summarized in Table V-8. These doses are only very small fractions of natural background for releases from either the initial or modified radioactive waste system.

The estimated population dose from immersion in the gaseous effluents is shown in Table V-9. The average dose within 50 miles of the Station is less than 0.001% of the natural background dose.

Those individuals of the present population distribution who spend all of their time within 2 miles of the reactor would receive on the average less than 0.04% of the typical background dose of 0.1 rem/yr. This is far below the normal variation in background dose and represents no measurable radiological impact on the population from the operation of Indian Point Units Nos. 1 and 2. Similar considerations for the liquid effluents indicate that no discernible radiological impacts are expected. A summary of the annual radiological impact in terms of man-rem from all pathways and the affected population is presented in Table V-10.

5. Radiation Monitoring

The applicant began a preoperational radiological environmental monitoring program in 1958 to determine the levels of radioactivity prior to Plant operations (operation of Indian Point Unit No. 1 began in 1962) and to show the variations in the levels that could be expected from natural sources, fallout from weapons testing, and other sources in the vicinity of Indian Point.[61] The program included measurements of radioactivity in samples of fresh water, river water, rainwater, river bottom sediments, fish, aquatic vegetation, soil, terrestrial vegetation, and air in the environs of the Indian Point Station. In addition, the New York State Department of Environmental Conservation has conducted extensive radiological surveys in the vicinity of the Indian Point Station since 1958, and the New York University Institute of Environmental Medicine has conducted a research program on the ecology of the Hudson River since 1964, which includes radio-ecological studies. Both of these programs are continuing. Although the New York University Institute of Environmental Medicine research program is not characterized as a monitoring program, the results of the study are germane since they provide information about the distribution of radionuclides in the river system.

The radiological environmental monitoring survey program for Indian Point Unit No. 2 will be a continuation of the preoperational studies and Indian Point Unit No. 1 post-operational environmental monitoring surveys.[61] The survey program is designed to be conducted at three different program levels, with the program level in use at any particular time being dictated by the Plant releases for the preceding month. A detailed tabulation of the program levels, criteria which govern the program level to be used, and a map which shows sampling and measurement locations are given in Section 2.3.6.3 of the applicant's Supplement No. 1 to the Environmental Report. Both the applicant's and New York State's radiological environmental monitoring programs are geared to provide more intensive surveillance in the event of a significant increase in radioactive discharge from the plant.

The applicant's radiological environmental monitoring program is well designed to evaluate the radiation levels in the environment resulting from Plant operations.

ENCLOSURE NO. 3

F. TRANSPORTATION OF NON-RADIOACTIVE AND RADIOACTIVE MATERIAL FROM AND TO INDIAN POINT STATION

1. Transportation of Nuclear Fuel and Solid Radioactive Waste

The nuclear fuel for the Indian Point reactors is slightly enriched uranium in the form of sintered uranium oxide pellets encapsulated in stainless steel or zircaloy fuel rods. Each fuel element is made up of 204 fuel rods about 12 feet long. Each year in normal operation, about 40 fuel elements are replaced in Unit No. 1 and 65 fuel elements will be replaced in Unit No. 2.

The applicant has indicated that cold fuel for the reactor will be transported by truck either from Cheswick, Pennsylvania, a distance of 450 miles, or Columbia, South Carolina, a distance of about 800 miles. The applicant has indicated the irradiated fuel will be transported by truck or rail to Morris, Illinois, a distance of about 1,000 miles. The present plans are to transport the irradiated fuel by truck from the site to the nearest railhead (about 1.5 miles from the site boundary) and by rail the remainder of the 1,000 miles to the Midwest Fuel Recovery Plant in Morris, Illinois. Future shipments of irradiated fuel may be by truck only. The solid wastes will be transported by truck to Morehead, Kentucky, for disposal, a distance of about 600 miles. Transport of radioactive material will be conducted under the Commission's regulations 10 CFR 71, and the Department of Transportation's (DOT) regulation's 49 CFR 173.[63] The DOT in its comments in Appendix XII-9 upon the Draft Statement stated that the impact of this project upon transportation is minimal and that it has no objection to the project.

a. Transport of Cold Fuel

The applicant has indicated that cold fuel will be shipped in AEC-DOT approved containers which hold two fuel elements per container. About eight truckloads of seven containers each will be required each year to meet the needs of both reactors.

b. Transport of Irradiated Fuel

Fuel elements removed from the reactor will be unchanged in appearance and will contain about 30 to 50% of the original U-235 (which is recoverable). As a result of the irradiation and fissioning of the uranium, the fuel element will contain large amounts of radioactivity, mostly fission products. As the radioactivity decays, it produces radiation and "decay heat." The amount of radioactivity remaining in the fuel decreases according to the length of time after removal from the reactor. After removal from a reactor, the fuel elements are placed under water in a storage pool for cooling prior to being loaded into a cask for transport.

Although the specific cask design has not been identified, the applicant states that the irradiated fuel elements will be shipped after at least a 90-day cooling period in Federally-approved casks designed for transport by either truck or rail. The cask will weigh perhaps 30 tons for truck or 100 tons for rail. To transport the irradiated fuel from Unit No. 2, the applicant estimates 22 truckload shipments per year with two fuel elements per cask and one cask per truckload; or 10 rail carload shipments per year with seven fuel elements per cask and one cask per carload. With the addition of 13 truckloads or six carloads for transporting the irradiated fuel from Unit No. 1, that would be a total of 35 truckloads or 16 carloads per year from both Units. An equal number of shipments will be required to return the empty casks.

c. Transport of Solid Radioactive Wastes

The applicant estimates that from 100 to 150 drums of solid radioactive wastes will be produced in operating Unit No. 2 each year. Spent resins and waste evaporator bottoms will be solidified in a mixture of vermiculite and cement and soft, solid wastes such as paper, rags, etc., compacted in DOT-approved containers for shipment and disposal. The applicant estimates from five to 10 truckloads of drums of wastes will be shipped out for disposal from Unit No. 2 each year. The staff estimates an equal number of truckloads from Unit No. 1, to average 15 truckloads per year from both Units.

d. Principles of Safety in Transport

Protection of the public and transport workers from radiation during the shipment of nuclear fuel and waste, described above, is achieved by a combination of limitations on the contents (according to the quantities and types of radioactivity), the package design, and the external radiation levels. Shipments move in routine commerce and on conventional transportation equipment. Shipments are therefore subject to normal accident environments, just like other nonradioactive hazardous cargo. The shipper has essentially no control over the likelihood of an accident involving his shipment. Safety in transportation does not depend on special routing.

Packaging and transport of radioactive materials are regulated at the Federal-level by both the AEC and DOT. In addition, certain aspects such as limitations on gross weight of trucks, are regulated by the States.

The probability of accidental releases of low level contaminated material is sufficiently small that, considering the form of the waste, the likelihood of significant exposure is extremely small. Packaging for these materials is designed to remain leakproof under normal transport conditions of temperature, pressure, vibration, rough handling, exposure to rain, etc. The packaging may release its contents in an accident.

For larger quantities of radioactive materials, the packaging design (Type-B packaging) must be capable of withstanding, without loss of contents or shielding, the damage which might result from a severe accident. Test conditions for packaging are specified in the regulations and include tests for high-speed impact, puncture, fire, and immersion in water.

In addition, the packaging must provide adequate radiation shielding to limit the exposure of transport workers and the general public. For irradiated fuel, the package must have heat-dissipation characteristics to protect against overheating from radioactive decay heat. For fresh and irradiated fuel, the shipper must also provide under both normal design basis damage conditions a specified margin of criticality safety.

Each package in transport is identified on two sides by a distinctive radiation label; there are also warning signs on the transport vehicle.

Based on the truck accident statistics for 1969,[63] a shipment of fuel or waste from a reactor may be expected to be involved in an accident about once every six years. In case of an accident, procedures which carriers are required[64] to follow will reduce the consequences of an accident in many cases. The procedures include segregation of damaged and leaking packages from people, and notification of the shipper and DOT. Radiological assistance teams are available through an inter-Governmental program to provide equipped and trained personnel These teams, dispatched in response to calls for emergency assistance, can mitigate the consequences of an accident.

2. Radiological Impact - Transportation Exposures During Normal (No Accident) Conditions

a. Cold Fuel

The transport of cold fuel has been described in Section V.F.1.a. Since the nuclear radiations and heat emitted by cold fuel are small, there will be essentially no effect on the environment during transport under normal conditions. Exposure of individual transport workers is estimated to be less than 1 millirem (mrem) per shipment. For the eight shipments, with two drivers for each vehicle, the total dose would be about 0.02 man-rem*/yr. The radiation level associated with each truckload of cold fuel will be less than 0.1 mrem/hr at 6 feet from the truck. A member of the general public who spends 3 minutes at an average distance of 3 feet from the truck might receive a dose of about 0.005 mrem per shipment. The dose to other persons along the shipping route would be extremely small.

b. Irradiated Fuel[4]

Irradiated fuel will be transported either by truck or by a combination of truck and rail. Based on actual radiation levels associated with shipments of irradiated fuel elements, the staff estimates the radiation level at 3 feet from the truck or rail car will be about 25 mrem/hr. The individual truck driver would be unlikely to receive more than about 30 millirem in the 1,000 mile shipment. For the 35 shipments by truck during the year with two drivers on each vehicle, the total dose would be about 2 man-rem/year.

For the combination truck-rail shipment, the individual truck driver would be unlikely to receive more than 15 mrem in the short trip to the railhead. The staff estimates that during the transfer of the cask from the truck to the rail car, four men might work for an hour at an average distance of 6 feet from the cask and might receive individual doses of about 10 mrem/hr.

Train breakmen might spend a few minutes in the vicinity of the car at an average distance of 3 feet, for an average exposure of about 0.5 rem per shipment. With 10 different brakemen involved along the route, the total dose for 16 shipments during the year is estimated to be about 0.08 man-rem.

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*Man-rem is an expression for the summation of whole body doses to individuals in a group. In some cases, the dose may be fairly uniform and received by only a few persons (e.g., drivers and brakemen) or, in other cases, the dose may vary and be received by a large number of people (e.g., 10^5 persons along the shipping route.

The total dose to transport workers for the 16 shipments by truck and rail, assuming two drivers on each truckload, would be about 1.2 man-rem.

A member of the general public who spends 3 minutes at an average distance of 3 feet from the truck or rail car might receive a dose of as much as 1.3 mrem. If 10 persons were so exposed per shipment, the total annual dose for the 35 shipments by truck would be about 0.5 man-rem and for the 16 shipments by rail, about 0.2 man-rem. Approximately 300,000 persons who reside along the 1,000-mile route over which the irradiated fuel is transported might receive an annual dose of about 0.9 man-rem if transported by truck, and 0.4 man-rem if transported by rail. The regulatory radiation level limit of 10 mrem/hr at a distance of 6 feet from the vehicle was used to calculate the integrated dose to persons in an area between 100 feet and 1/2 mile on both sides of the shipping route. It was assumed that the shipment would travel 200 miles per day and the population density would average 330 persons per square mile along the route.

The amount of heat released to the air from each cask will vary from about 30,000 Btu/hr for truck casks to about 250,000 Btu/hr for rail casks. For comparison, 35,000 Btu/hr is about equal to the heat released from an air conditioner in an average size home. Although the temperature of the air which contacts the loaded cask may be increased a few degrees, because the amount of heat is small and is being released over the entire transportation route, no appreciable thermal effects on the environment will result.

c. Solid Radioactive Wastes

As noted in Section V.F.1.c, about 15 truckloads per year of solid radioactive wastes will be shipped to a disposal site. Under normal conditions, the individual truck driver might receive as much as 15 mrem per shipment. If the same driver were to drive the 15 truckloads in a year, he could receive an estimated annual dose of about 225 mrem during the year. A total dose to all drivers for the year, assuming 2 drivers per vehicle, might be about 0.5 man-rem.

A member of the general public who spends 3 minutes at an average distance of 3 feet from the truck might receive a dose of as much as 1.3 mrem. If 10 persons were so exposed per shipment, the total annual dose for the 15 shipments by truck would be about 0.2 man-rem. Approximately 180,000 persons who reside along the 600-mile route over which the solid radioactive waste is transported might receive an annual dose of about 0.2 man-rem. These doses were calculated for persons in an area between 100 feet and 1/2 mile on either side of the shipping route, assuming 330 persons per square mile, 10 mrem/hr at 6 feet from the vehicle, and the shipment traveling 200 miles per day.

ENCLOSURE NO. 4

D. RADIOACTIVE WASTE TREATMENT, EFFLUENT DISCHARGES, AND ENVIRONMENTAL IMPACT

Comments have been received from EPA, Department of Commerce, the NYS Department of Environmental Conservation (Items 32 - 34), and the applicant (Appendix F of his comments of May 30, 1972) on the amount of radioactive material to be discharged to the environment; the applicant is planning to make a number of modifications to his radioactive waste system. In Section III.E.2, the staff has included source terms related to the present system and to the proposed modified system.

In reply to EPA's comment that the applicant should make full use of the radwaste treatment system to achieve the lowest practicable radioactivity releases, the Commission's regulation, 10 CFR 50.34a, requires the applicant to describe the equipment and procedures for the control of radioactive material in effluents to unrestricted areas. Regulation 10 CFR 50.36a requires that the equipment in the radioactive waste treatment systems be maintained and used to control the releases of radioactive effluents as defined by the Technical Specifications. Detailed records of the radioactive waste system operation along with reporting of its operation are required to be presented to the Commission on a semi-annual basis. Throughout the operating life of Unit No. 2, modification of the operating procedures and equipment utilization will be made to accommodate changing conditions of the reactor and the radioactive waste management systems. In response to EPA's comment on description of the proposed modifications of the radioactive waste system, as stated above, Section III.E.2 has been revised to include additional information regarding design, schedule, operation, and performance of the modified system for Units Nos. 1 and 2. This includes additional information on the steam generator blowdown treatment (filter-demineralizer), an additional demineralizer on the waste evaporator condensate line, and the gaseous waste treatment system (charcoal filters on the Plant vent) to reduce iodine concentrations from the auxiliary building and containment purging.

In response to the NYS Department of Environmental Conservation's comment - Item 32 - on the schedule and performance of the modified liquid radioactive waste system, the applicant is committed to complete the modification of this system before the end of the first fuel cycle, in its testimony before the ASLB Board on July 13, 1971. The schedule is the same for both the liquid and gaseous waste systems. The staff's evaluation of the modified system indicates its performance will be in accordance with 10 CFR 50.36a. Besides information on the source term for Unit No. 2, releases of radioactivity in the liquid and gaseous effluents from Unit No. 1 for calendar year 1971 are shown in Tables III-8 and III-10 (see Item 33 of the NYS DEC comments).

The Department of Commerce has expressed concern regarding the gaseous releases from the four large decay tanks which are filled one at a time and which have a capacity to permit holdup time of at least 45 days. As stated above, the applicant shall be required, according to the Commission's regulation 10 CFR 50.36a, to maintain and utilize the radioactive waste equipment to control the releases of gaseous effluents as defined by the Technical Specifications. The radiation doses were calculated using the annual average diffusion model, which applies for average dispersion conditions. It is possible for the applicant to wait for the meteorological conditions favorable for the best possible dispersion of the gases, thereby reducing the man-rem cumulative doses to the population.

Because of the modified radioactive waste system and in response to EPA's comments on dose assessment of radioactive releases from both the present and the modified system, the radiological doses to biota and man have been recalculated and reevaluated. This revised information is provided in Section V.

The NYS Department of Environmental Conservation, in its comments in Item 45 on page 22, referred to radiation doses of 5 mrem/year and radioactivity releases of 5 Ci/year or 20 pCi/liter limit for as low as practicable limits. Page VII-8 is not referred to on page V-64. Table V-9 referred to is concerned with total body dose (in millirems) and the cumulative population dose (in man-rems) as related to the radial distance from the reactor.

In its comments on radiation doses, the EPA stated:

(a) "A limited number of measurements...direct radiation... condensate storage tank...location of tanks...nearest residence and the visitors' information center...estimates of the population radiation dose should be made." The staff estimates of dose to individuals at the proposed visitors' center and nearest residence for direct radiation from the condensate storage tank located approximately 15 meters NE of Indian Poin Unit No. 2 are given in Table V-8 of the Final Statement.

(b) "The dose computed from release of liquid effluents assumes a dilution flow from the cooling system of approximately 10^6 gal/min...the statement should discuss the effect of reduced flow on the doses involved both on individual and man-rem bases." The reduction of cooling water flow will occur as a result of the installation of cooling towers or during the winter time. Before this installation is accomplished, the steam generator blow-down purification system should be installed, which will reduce the radioactivity released in liquid effluents by a factor of about 10. Although the estimated concentrations of radionuclides in the discharge canal would be higher due to a decreased flow of cooling water, the concentrations as finally dispersed and diluted in the river would be those used in the Final Statement. Fish caught in the discharge canal would undoubtedly have higher concentrations of radionuclides than those caught across the river from Indian Point. However, the number of fish caught here should be quite small. Furthermore, the estimated doses from such fish would be less than a factor of 10 higher than those values given in the Final Statement since it is unlikely that fish would spend their entire life in the canal and be in equilibrium with the radionuclide concentrations found there. The estimated population dose would change only by the added amount of the few individuals eating fish caught in or near the discharge canal.

(c) "The dose estimates for the ingestion of fish as presented in the statement are not consistent with the liquid effluent discharge estimates given. It appears that effluents due to the discharge... The final statement should discuss the assumptions for liquid effluent levels and concentration factors used to calculate the dose due to ingestion of fish."

Inconsistencies in the use of cooling water flow rates, Hudson River dilution factors, and bioaccumulation factors have been eliminated in the Final Statement. The dose estimates for fish ingestion were calculated using the quantities of radioactivity discharged in the liquid effluent as given in Tables III-6, 7, and 8 of the Final Statement. These radionuclides were assumed to be dispersed in an average cooling water flow of 2×10^{15} cc/year and further diluted by a factor of 10 in the tidal mixing zone of Indian Point. Fish caught in the vicinity of the effluent discharge might have higher radionuclide concentrations than estimated with the above assumptions. However, the concentrations would be less than a factor of 10 greater since it is unlikely that the fish would spend their whole life at such a location. The bioaccumulation factors used in the estimates of dose appear in Table V-2.

In response to the Department of Commerce's comment on the meteorological data used to estimate the radiation doses from gaseous effluents, these assumptions and data were taken from applicant's Supplement No. 1 to the Environmental Report as given in Tables 3.1 and 3.2 of Appendix D in Vol. I. Appendices C, E, and G were also used in the meteorological data for the site. The applicant has also provided information on the annual average meteorological model used in the calculations in the FFDSAR in answer to Question 11.1. Corrections to the listing of references have been made in the Final Statement. In response to EPA's comment on meteorology, the study of meteorological conditions reported in its Appendix G for November 1969 through October 1970 on Supplement No. 1 for the Environmental Report indicates no substantial change from conditions of the mid-1950's reported earlier. In both cases conservative models have been used to predict the radiation doses.

In response to comments from the Committee to End Radiological Hazards, the allowable concentrations of radionuclides in air and water released from controlled areas into the public domain as specified in the Commission's regulations in 10 CFR 20, Appendix B, Table II, were chosen to conform to the recommendations of the Federal Radiation Council, the National Commission on Radiological Protection, and the International Commission on

Radiation Protection. These scientific bodies agree that no detectable effects on man are expected to result from exposure to radionuclides at the specified concentrations of 10 CFR 20. In addition, the estimated doses are less than the guides of proposed Appendix I of 10 CFR 50 which requires releases to be ~~further reduces the release concentrations of 10 CFR 20~~ in conformity with the principle ~~that releases should be kept~~ of as low as practicable.

The ~~estimated~~ doses which result from the ~~expected~~ radionuclide releases were determined ~~calculated~~ by methods accepted by a consensus of informed and responsible scientific workers in health physics. The source materials and methods used are referenced in citations starting on page V-116 of the Final Statement. ~~for anyone wishing to confirm that potential radiation exposure to all living things was properly assessed.~~

In regard to the environmental radioactivity monitoring program, the Department of Commerce has expressed concern about the frequency of sample collections and the analysis of benthic animals. The sample frequency and types of samples to be collected are discussed in the applicant's Supplement No. 1 to the Environmental Report and the Technical Specifications. This includes sampling of bottom sediments. The benthic organisms — which include barnacles, clams, polychaete worms and amphipods, and fish species -- will be analyzed for their radioactivity content. The sampling requirements will be spelled out in the Technical Specifications.

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E. ACCIDENTAL RELEASES OF RADIOACTIVITY TO THE ENVIRONMENT

In regard to the question of accidental release of radioactivity, the Department of the Interior (DOI) states on page 6 of its comments that "The environmental effects of accidental releases to water is lacking. Some of the accidents described in Table VI-1 could result in releases to the Hudson River and the effects could last for centuries. As we have stated in comments on previous environmental statements, we do not think that an analysis of only airborne emissions constitutes a complete evaluation of the possible impacts resulting from a major accident." The staff has responded by stating that the doses calculated as consequences of the postulated accidents are based on airborne transport of radioactive materials resulting in both a direct and an inhalation dose. Our evaluation of the accident doses assumes that the applicant's environmental monitroing program and appropriate additional monitoring (which could be initiated subsequent to an incident detected by in-plant monitoring) would detect the presence of radioactivity in the environment in sufficient time for remedial action to be taken