NUREG-75/002

Final

environmental statement

related to operation of

INDIAN POINT NUCLEAR GENERATING PLANT UNIT NO. 3

CONSOLIDATED EDISON COMPANY OF NEW YORK, INC.

DOCKET NO. 50-286

February 1975

Volume I

UNITED STATES NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION

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SUMMARY AND CONCLUSIONS

This Environmental Statement was prepared by the U. S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation.

1. This action is administrative.

2. The proposed action is the issuance of a license to Consolidated Edison Company of New York, Inc., for the operation of the Indian Point Nuclear Generating Plant, Unit No. 3 (Docket No. 50-286), located in the State of New York, Westchester County, Village of Buchanan, 24 miles north of the New York City boundary line.

   The Indian Point Station will have three Units, with each employing a pressurized water reactor to produce a total of 6,675 megawatts thermal (MWt). Indian Point Unit No. 3 will produce up to 3,025 MWt. A steam turbine-electrical generator will use this heat to provide 965 net megawatts of electrical power (MWe). A design power level of 3,216 MWt (1,033 MWe) is anticipated at a future date and is considered in the assessment in this Statement. Just north of Unit No. 3 is Indian Point Unit No. 1 (Docket No. 50-3), which produces 890 MWt (net 265 MWe) and Unit No. 2 (Docket No. 50-247), which yields 2,758 MWt (net 873 MWe).

   During initial operation, the exhaust steam from each Unit will be condensed by once-through cooling water withdrawn from the Hudson River through separate intakes and discharged into the river via a common discharge canal and submerged multiport outfall structure.

   Although the present action is the issuance of an operating license for Unit No. 3, this Statement considers the environmental impacts from simultaneous operation of all three Units. A Final Environmental Statement has been issued for Unit No. 2. Furthermore, in view of the proximity to the Indian Point site of existing and presently proposed power plants on the Hudson River, the cumulative environmental benefits and impacts of the plants within a 30-mile reach of the river have been assessed. The proposed action is interrelated to other actions taken by other Federal agencies such as the Environmental Protection Agency, in regard to granting or denying application for discharge permits under the National Pollutant Discharge Elimination System (NPDES) instituted through the Federal Water Pollution Control Act Amendments of 1972, and the Federal Power Commission, in licensing of other facilities on the Hudson River. The States that will be affected by this proposed action include New York, New Jersey, and possibly Connecticut and other New England states. In New York State, Westchester and Rockland Counties, and in New Jersey, Bergen County are the counties particularly affected by this proposed action.

Since issuance of the Draft Environmental Statement (DES) on Indian Point Unit No. 3 (October 1973), the Atomic Safety and Licensing Appeal Board ruled on the environmental issues requiring closed-cycle cooling for Indian Point Unit No. 2 (ALAB-188). This Board required the licensee to terminate once-through cooling at Unit No. 2 by May 1, 1979, and thereafter to operate Unit No. 2 with a closed-cycle cooling system. However, it required the staff to take a fresh look at certain of the staff's positions and reconsider portions (ecological sections) of the Final Environmental Statement (for Unit No. 2) to which they relate. Such a reassessment of the issues in contention relative to the staff's recommendation on closed-cycle cooling was made in preparing this Final Statement and included holding several meetings with the applicant, its consultants, the State of New York, and intervenors in order to exchange information about current ecological research results which have been utilized in this Statement.

3. Summary of principal environmental impacts, including beneficial and adverse effects, follows:

   a. Indian Point Unit No. 3 will produce an average annual generation of 6.26×10^9 kWhr of electricity, which will provide support of $8.8 billion of regional product in 1980. (pp. XI-45 to 58)

   b. About 35 acres of 239 acres of land formerly used as an amusement park, and later zoned for heavy industry, have been converted to industrial use. (p. V-1)

   c. The applicant's plans to develop an 80-acre forested park with a freshwater lake and to build a new visitors' center, nature trails, gardens and public facilities will enhance the value of the site to the general public. A 14-acre area, transferred by the applicant to the Village of Buchanan, now includes a playing field and the remainder will be developed into a marina. (pp. V-1 to 2)

   d. No additional land area was used for the right-of-way of the transmission lines from Unit No. 3 to the nearby Buchanan Substation from which the power is distributed to the applicant's service system; however, the present transmission facilities will be upgraded to improve the applicant's capability of distributing power to its customers. Transmission towers from Unit No. 3 of the Buchanan Substation were designed in accordance with Federal guidelines. (pp. IV-3 to 4)

e. Areas disturbed during construction will be improved by landscaping and planting after Unit No. 3 is built. (p. V-2)

f. About 4,585 cubic feet per second (cfs) or 2,058,000 gallons per minute (gpm) of water for cooling and service water systems will be withdrawn from the Hudson River and increased in temperature by about 15F° during passage through the steam condensers and heat exchangers of Units Nos. 1, 2 and 3. This heated water from all the Units will be combined and released into the Hudson River at a velocity of about 10 feet per second (fps) through a 270-foot long, submerged multiport discharge structure. Unit No. 3 will use a total of 1,933 cfs of river water for once-through cooling which will be raised in temperature by about 17F°. (pp. III-3 to 14)

g. The staff assessment of thermal discharges from once-through cooling of all three Units, based on mathematical modeling for the near and far field, and utilizing the New York State thermal criteria, indicates that: (pp. V-37 to 41)

(1) When the ambient temperature is about 80°F, compliance with the New York State 90°F maximum surface temperature criterion is possible but is marginal.

(2) Under certain conditions, the thermal discharges in the vicinity of Indian Point, on a tidal average basis, will exceed the New York State thermal criterion requiring that no more than one half of the vertical cross-sectional area of the river shall experience a temperature rise of 4F°.

(3) Under certain conditions, the thermal discharges in the vicinity of Indian Point, on a tidal average basis, will exceed the New York State criterion requiring that no more than two-thirds of the surface width of the river shall experience a temperature rise of 4F°.

(4) Based on a statistical analysis of hydrological and meteorological conditions, the staff estimated that the New York State 4F° surface temperature rise criterion may be exceeded for as many as 30 consecutive days during one out of every

two years, particularly during the time when there is low fresh water flow and the ambient temperature reaches 80°F.

The above assessment indicates that it is likely that under certain conditions, the thermal discharges will exceed part of the New York State thermal criteria. If the thermal discharges from Danskammer, Roseton, Lovett, and Bowline plants are included with those from Indian Point Plants, the staff studies indicate that the chances of violating the 90°F criterion will increase and that the estimated cross-sectional average temperature rise in the vicinity of Indian Point, under certain conditions, will be about 6F°, thereby violating the New York State thermal criteria unless the heat rejected is reduced.

h. The dissolved oxygen concentration in the river in the vicinity of Indian Point may be reduced to levels deterimental to aquatic life, principally in late summer and early fall. (pp. V-110 to 111)

i. During the operation of Units No. 1, 2 and 3, small quantities of phosphate, hydrazine, amines, boric acid, and chromate solutions discharged into the Hudson River are not expected to produce important biological effects. Chromium discharges will be processed to minimize the amount released. Acids or bases will be neutralized prior to release. (pp. V-41 to 48)

j. Chlorination of the once-through cooling system for either Unit No. 2 or Units Nos. 1 and 3 on alternate days three times per week for a total of nine hours per week, may result in discharging cooling water containing up to 0.5 parts per million (ppm) of total residual chlorine. Concentrations of residual chlorine and any chlorinated compounds formed at this level can have adverse effects on aquatic biota in the thermal plume in the immediate vicinity of the cooling water outfall. No chlorination will occur when the river temperature is less than 45°F. (pp. V-47 to 48, 111 to 115)

k. A detailed staff assessment of the biological impact of the once-through cooling system of Indian Point Units Nos. 1, 2 and 3, using available information on the hydraulics and biota of the Hudson River estuary, shows that: (pp. V-213 to 222)

(1) Unless the applicant finds better means of preventing fish from entering the intake structure, impingement of fish on the intake screens can result, as estimated by the applicant, in an annual loss of about 2.6 million

fish (2- to 4-inches long), approximately 70% of which will be white perch. Although the staff does not place great confidence in the estimated numbers or weight of fish killed because of lack of reliable information on impingement losses from past experience at the intakes of Unit No. 1 and limited experience of operating the circulating pumps at Unit No. 2, the staff believes the fish kill from impingement will be of the same order of magnitude as that estimated by the applicant. (pp. V-51 to 66)

(2) Aquatic organisms, including phytoplankton, planktonic crustaceans, larval stages of benthic invertebrates, and eggs, larvae, and juveniles of many of the fish populations, particularly striped bass, blueback herring, alewife, tomcod, bay anchovy, and white perch, will be subject to entrainment in the cooling water withdrawn by the Indian Point Plants and thereby will be exposed to mechanical shock, pressure changes, and thermal and chemical (chlorine) effects. (pp. V-66 to 221)

(a) The staff's analysis shows that entrainment of phytoplankton, microzooplankton, and macrozooplankton, except Neomysis, is not expected to have any measureable effect on the aquatic ecosystem in the vicinity of Indian Point. When the salt front is in the vicinity of Indian Point for most of June through October, entrainment of Neomysis at Indian Point, Lovett, and Bowline may well reduce the standing crop of this mysid crustacean and have an adverse effect on the growth and survival of striped bass and white perch young-of-the-year. (pp. V-214 to 215)

(b) The staff has estimated that for striped bass ichthyoplankters the probability of short-term survival following passage through the Indian Point Plant is 0.2 for eggs, 0.4 for yolk-sac larvae and post yolk-sac larvae, and 0.3 for nonscreenable juveniles. The probability of long-term survival is estimated to be 10% lower than the above estimates for each life stage. (pp. V-215)

(3) Based on a thorough evaluation of striped bass data from the applicant's research program, on the results from the staff's improved young-of-the-year striped bass model, which includes a rigorous treatment of river hydrology

and biological behavior of striped bass through different life stages, and on the results from the staff's new striped bass life-cycle model, the staff has concluded that the combined effects of impingement and entrainment losses each year of striped bass eggs, larvae, and juveniles are likely to result in a substantial decrease in the Hudson River spawned striped bass population.

(a) Percent reduction values of juveniles per spawning season range from 21 to 32% with once-through cooling at Indian Point Units Nos. 1, 2 and 3, alone, but these values increase in the range from 34 to 50% reduction if the effects of once-through cooling at Bowline, Lovett, Danskammer and Roseton plants are included in the calculation. The percent reduction values are increased to 47 to 64% by also including the Cornwall Pumped Storage Facility in the calculation. These annual percent reduction values are relative to the "clean" river (i.e., no power plants withdrawing water from the Hudson River) as the baseline. (p. V-218)

(b) Using the percent reduction values as input into the staff's striped bass life-cycle model, the results show that for a period of 15 to 36 years the relative fishery yield from the Hudson River spawned striped bass population would be less than 50% of the pre-1974 level. The calculations included the effects of Bowline, Lovett, Danskammer, and Roseton plants. If Cornwall is also included in the calculations, the relative fishery yield would be less than 50%, for a period of 41 to 55 years. (pp. V-218 to 219)

(c) The staff estimates that the Hudson River striped bass population is the major source (90%) of striped bass caught in an Inner Zone, which is made up of the Hudson River, the western half of Long Island Sound (Port Jefferson, Long Island to Bridgeport, Connecticut), and the New York Bight (Barnegat Inlet, New Jersey, to Moriches Inlet, Long Island). In light of the uncertainty concerning the percentage contribution of the Hudson stock to the Outer Zone of influence (extending from Maine to Cape May County, New Jersey, inclusive, less the Inner Zone just defined), the staff assumed values of both 10% and 50% contribution of Hudson River spawned striped bass to the Outer Zone. These values served as a basis of estimating the economic impact of Plant operation on striped bass. (pp. V-219)

(4) The cumulative effects could result in substantial decreases in the population of other fish species in the Hudson River. (pp. V-178 to 183)

(5) Populations of aquatic organisms residing near the outfall of the discharge structure will not be adversely affected by radioactive discharges. (pp. V-115 to 118)

l. Operation of Units Nos. 1, 2 and 3 will not cause contamination of groundwater from either chemical or sanitary wastes. No discharges from the septic system to the river are expected. (pp. V-48 to 49)

m. Small amounts of radioactive gaseous and liquid effluents will be released to the environment from the radioactive waste treatment system, which will be modified with the steam generator blowdown intertie between Unit No. 3 and Unit No. 1 and charcoal adsorbers in the containment Plant vent and in ventilation systems in the primary auxiliary and fuel handling buildings by May 1, 1975 or initial criticality, whichever occurs later. The combined gaseous and liquid discharges from all three Units will meet the requirements given in 10 CFR 20 and 50. No significant environmental impact on man will result from normal operational releases of radioactive materials within 50 miles of the site. The estimated dose to the general population living within 50 miles of the site from simultaneous operation of Unit No. 3 with Units Nos. 1 and 2 - will be 42 man-rem/yr, which is less than normal fluctuations in a 2 million man-rem/yr background dose which this population would receive. (pp. V-222 to 263)

n. The risk of accidental radiation exposure during abnormal operating conditions and during transport of radioactive material is very low. (pp. VI-1 to 11)

o. Operation of Unit No. 3 will allow the applicant to shut down or reduce the use of older oil-burning plants, thereby decreasing the air pollution near the plants, and to save about 10 million barrels of oil each year, thereby reducing the problems associated with the shortage of oil. (pp. X-41, XI-58 to 59)

p. The local economy will be stimulated through local taxes, direct employment, and visitors. A short-term economic benefit on the local economy has resulted due to construction activities. (p. XI-57)

4. Principal alternatives considered:

   a. Purchase of power from outside sources.

   b. Use of fossil fuel at the same site and other sites.

   c. Use of hydroelectric pumped-storage facilities and gas turbines for peaking purposes.

   d. Heat dissipation with wet evaporative, natural-draft and mechanical-draft cooling towers, cooling ponds or lakes, and spray ponds or canals operated in the closed-cycle mode.

   e. Heat dissipation with dry and wet/dry combined cooling towers.

   f. Reduction of biological damage of biota from entrainment and impingement by (1) operation with air bubble curtains at the intakes as at Units No. 1 and 2; (2) recirculation to reduce intake flows during the winter months; (3) installation of a new off-shore screening structure sized to maintain intake velocities through the screens below 0.3 fps during the winter season; and (4) reduction of cooling water withdrawn by means of a closed-cycle cooling system.

   g. Means of reducing amount and frequency of use of sodium hypochlorite and alternate devices that would reduce the adverse effects of residual chlorine and chlorinated compounds on aquatic biota.

   h. Replacement of aquatic species damaged by operation of the once-through cooling system through fish hatcheries.

   i. Alternate routes for transport of radioactive waste.

   j. Alternate routes for transmission lines.

5. The following Federal, State, and local agencies and interested parties have commented on the Draft Environmental Statement of October 1973:

   Department of Agriculture (AGR)
   Department of Commerce (COM)
   Department of Health, Education, and Welfare (HEW)
   Department of the Interior (DOI)
   Department of Transportation (DOT)
   Environmental Protection Agency (EPA)
   Federal Power Commission (FPC)
   New York State Department of Environmental Conservation (DEC)
   Hudson River Fishermen's Association (HRFA)
   Save Our Stripers (SOS)
   Consolidated Edison Company of New York, Inc. (CONED)
   Federated Conservationists of Westchester County, Inc. (FCWC)

Rockland County Conservation Association, Inc. (RCA)
Environmental Defense Fund (EDF)
North Brookhaven Sport Fishermen's Club, Inc. (NBSFC)
Great South Beach Mobile Sportfishermen (GSBMS)
West Branch Conservation Association (WBCA)
Connecticut Coastal Anglers Assocation (CCAA)
Mr. Kenneth E. Bay
Mrs. Harold Cooper
Mr. Don McLean
Mr. John Nicholas, Jr.
Mr. Robert J. Rance
Mr. Dennis Zaccardi

Comments from these agencies and other interested parties may be found in Appendix I of this Statement.

6. This Environmental Statement was made available to the Council on Environmental Quality, the public, the applicant, the above-mentioned agencies and interested persons in February 1975.

7. From review and evaluation of the applicant's Environmental Report and Supplements thereto, and from independent observations and analyses discussed in this Statement, the Regulatory staff has reached the following conclusions concerning the environmental impact of once-through cooling of Unit No. 3 in addition to Indian Point Units Nos. 1 and 2 and the other power plants on the Hudson River:

   a. The conclusions of the staff's assessment of the effects of thermal discharges from the Indian Point Plants are that the most difficult part of the New York State thermal criteria to be satisfied is the limit of 4 F° on the excess surface temperature and that this criterion will be violated marginally. The applicant may have to reduce power to limit thermal discharges from the Indian Point Plants to assure that these discharges will not violate applicable thermal criteria. Measurement of the thermal plume during operation of Units Nos. 1 and 2 will be used to provide field data to improve and verify mathematical and physical models in order to predict more accurately the thermal plume characteristics during full power operation of the three Units during various seasons. Operation of Indian Point Units Nos. 2 and 3 with a closed-cycle cooling system will insure meeting the thermal criteria throughout the year. (pp. V-39 to 41)

   b. The staff's evaluation remains in disagreement with the applicant's assessment on the key issue of the extent of damage from once-through cooling to the young-of-the-year striped bass population and, subsequently, to the adult striped bass population. The primary reasons for the difference in model predictions of the impact on the striped bass population are the values selected for the intake factor f_I (which accounts for differences that may exist between the average density of organisms in the river in the vicinity of a plant and the average density at the intakes of the plants) and for compensation.

(1) The staff's analysis of field data supports a f_I value of less than 1.0 but not less than 0.5 for striped bass eggs, larvae and nonscreenable juveniles at Indian Point, Bowline, Lovett, Roseton, and Danskammer. These values were used in sensitivity runs of the staff's young-of-the-year striped bass model to determine the effect of f_I on forecasts of percent reduction values of the young-of-the-year population. Upon careful examination of all available data, the staff cannot agree with the applicant's very low values for the intake f factor. (pp. V-89 to 101)

(2) From the staff's point of view, the major issue in controversy on the topic of natural compensation is not the concept of natural compensation nor whether it is occurring and will continue to occur to some degree. Rather, the major issue is the extent to which the parties rely on compensatory decreases in natural mortality to offset the increased mortality due to Plant operation. Given that the applicant has not and will not be able to quantify the degree of natural compensation, the staff has assumed that natural compensation of early life stages and older age classes is not likely to be of major importance in offsetting the increased mortality due to the power plants. However, the staff has included a compensation function in its young-of-the-year model in order to determine the effects of changes in the compensation parameters on the results of the model used to assess the impact of Plant operation on the striped bass young-of-the-year population. On the other hand, considering that: (a) fishing mortality appears to be a more important source of mortality than natural causes for adult striped bass once they enter the fishery; (b) the striped bass sport catch substantially exceeds the commercial catch; and (c) the fishing effort, particularly the sport fishing effort, is dependent in part on the size of the striped bass population, the staff assumed that the combined fishery will respond in a compensatory manner, with or without new fishing regulations, so as to partially offset the increased mortality due to the power plants. On the basis of this assumption, the staff has included a density dependent, fishing mortality function in its life-cycle model. (pp. V-217 to 218)

c. Based on the staff's thorough analysis of the results of the applicant's research program, on the results of the analysis of impacts from the staff's striped bass young-of-the-year model and the new life-cycle model, the staff concludes that a significant yearly reduction in the striped bass young-of-the-year is likely to occur from operation with once-through cooling. The predicted effects of Indian Point alone are appreciable, and the combined effects of Indian Point, Roseton, Bowline, Lovett and Danskammer power plants are very extensive. The staff, however, believes that during the short term (less than 5 to 7 years) the risk of doing irreversible damage to the Hudson River spawned striped bass population because of operation with once-through cooling is sufficiently small to be acceptable, provided appropriate environmental monitoring and mitigating measures are taken by the applicant to minimize the biological damage. (pp. XI-107 to 108)

d. The results of the staff's striped bass life-cycle model indicate that the impacts from operation with once-through cooling each year during the spawning season will likely be reflected in comparable long-term significant reductions in the yields in the Hudson River spawned striped bass population. The cumulative effects of operation of Indian Point and the other power plants on the Hudson River can decrease the striped bass population yield substantially and for long periods of time. Although the probability that irreversible damage to the striped bass population will occur cannot be estimated with certainty, the risk increases with the magnitude of reduction of the striped bass population and with increases in the length of the time that the population will be substantially reduced. Therefore, the staff has concluded that the risk of causing severe and permanent ecological damage to the Hudson River spawned striped bass population in the Hudson River, western half of Long Island Sound, New Jersey Coast, New York Bight and New England regions, by long-term (greater than 5 to 7 years) operation of Units Nos. 2 and 3 with once-through cooling, in concert with Unit No. 1 and the other power plants on the river, is unacceptable. This is particularly true because the fish population present in the Hudson River, such as the striped bass, are resources valuable to the present and future generations of our country. (pp. V-150 to 166)

e. The applicant's ecological studies, designed to provide only two years of postoperational data from Units Nos. 2 and 3, cannot demonstrate long-term impacts. Long-term field studies would have to last through several generations (i.e., years) of fish species of importance in order to predict accurately long-term impacts of once-through cooling, but by that time unacceptable damage may have occurred. However, the applicant's studies have the potential for determining short-term effects of the once-through cooling system and for assuring that the short-term impacts will be kept to an acceptable limits. Furthermore, these studies may be of value in further quantifying the intake factor f_I and in providing data for validating ecological models that are useful in predicting long-term, as well as short-term, impacts on the striped bass population. The applicant will be able to complete its ecological studies prior to commencement of construction of alternate cooling system. (pp. V-199 to 213)

f. Based on information presently available from the applicant and other sources, replacement of striped bass by stocking the Hudson River from fish hatcheries cannot be accepted as a feasible method of replacing all of the striped bass the staff expects the Plants will kill during operation with once-through cooling over the lifetime of Units Nos. 1, 2, and 3. (p. XI-48)

g. Alternatives to the applicant's proposed method of once-through cooling operation are available which would result in a sizeable reduction of long-term aquatic environmental impacts, primarily on the Hudson River spawned striped bass population, without jeopardizing the needed base-load capacity and reliability of the applicant's service system in the New York area. A balancing of generating costs and environmental costs and risks indicates that operation of Units Nos. 2 and 3 with closed-cycle cooling (i.e., costing the consumer in the applicant's service system about 0.3 mills per kWhr based on a natural draft cooling tower), is preferred over the once-through cooling system over the long-term. The staff evaluation indicates that this alternative mode of cooling operation will significantly reduce the biological damage, including the number of fish impinged and ichthyoplankton entrained, and will significantly reduce thermal discharges to the river. (pp. XI-48 to 51, 106)

h. In the short-term (e.g., the next five years, which is the staff's estimate of the time required to design and install an alternative cooling system), the benefits of meeting an urgent need for power in the New York area outweigh the estimated corresponding environmental costs incurred over this short time period. The need for power for the metropolitan New York area has been adequately demonstrated in terms of the decreasing reserve margins and increasing frequency of brownouts during peak load periods of the past several summers. Indian Point Unit No. 3 will add needed new baseload capacity to the applicant's system and improve the reliability of service in the metropolitan New York area. (App. G, pp. X-41, 107 to 109)

i. Modifications to the radioactive waste treatment system are needed to assure that the radioactive wastes released will be "as low as practicable" in accordance with 10 CFR 50.

8. On the basis of the evaluation and analysis set forth in this Statement and after weighing the environmental, economic, technical, and other benefits against environmental costs and risks and considering available alternatives, the staff concludes that the action called for under the National Environmental Policy Act of 1969 (NEPA) and the former Appendix D to 10 CFR 50, is issuance of an operating license for Indian Point Unit No. 3, subject to the following conditions for the protection of the environment:

a. <u>License Conditions</u>

(1) Operation of Indian Point Unit No. 3 with the once-through cooling system will be permitted in accordance with the license condition agreed to by the parties and which is set forth in the stipulation dated December 1974.

(2) Evaluation of the economic and environmental impacts of alternative closed-cycle cooling systems shall be made by the applicant in order to determine a preferred system for installation. This evaluation shall be submitted to the U.S. Nuclear Regulatory Commission for approval in accordance with the conditions of the stipulation reached among the parties.

(3) Installation of modified radioactive waste treatment facilities will be needed by May 1, 1975, or by initial criticality, whichever occurs later. Radiological process monitoring of all principal release points will be required in accordance with Criterion 64 of Appendix A of 10 CFR 50, by May 1, 1975, or by initial criticality, whichever occurs later.

(4) The applicant shall operate Indian Point Unit No. 3 within applicable Federal and State air and water quality standards and the Environmental Technical Specifications which will include nonradiological and radiological monitoring programs, limits on effluent releases, an appropriate comprehensive ecological surveillance study, and reporting requirements.

(5) The applicant shall develop a Plan of Action of operating procedures and design modifications of the once-through cooling system for Indian Point Unit No. 3 in order to

take corrective actions to minimize detrimental effects on aquatic biota in the Hudson River to a practicable minimum during the interim period prior to installation of a closed-cycle cooling system. The Plan shall include means of reducing thermal shock; impingement on the intake structure; entrainment of fish eggs, larvae, and plankton; chemical and thermal discharges; and loss of dissolved oxygen below 4.5 ppm; and shall include other mitigating measures available. The Plan shall be submitted to the U.S. Nuclear Regulatory Commission one month after receipt of the operating license, and upon approval by the Commission, the Plan shall be implemented so as to eliminate or substantially reduce such adverse effects as are revealed by the monitoring and ecological surveillance study program presented in the Environmental Technical Specifications for once-through cooling.

b. Significant Environmental Technical Specification Requirements

The Technical Specifications will include the following:

(1) Measurement of entrainment mortality of aquatic organisms after passage through the condenser by using sampling procedures which will permit statistically valid estimates of that mortality during the first year of Plant operation; and measurement of eggs and larvae concentration in the vicinity of the Indian Point intakes of the river to determine statistically valid values for the intake f_I factor during two spawning seasons.

(2) Throughout the period of once-through cooling, determination of the number, species, and sizes of fish collected on the screens and trash racks of the intake structures by using sampling procedures which will permit statistically valid estimates of that mortality, and estimation of the number of fish killed on the screens but are forced off into the river by backflushing the screens and are not collected.

(3) Based on the foregoing determinations, an analysis of the biological significance of impingement and entrainment mortality in relation to fish population in the river; to be reported annually and then revised each year depending on new data obtained during once-through cooling operation.

(4) Measurement of concentrations of total residual chlorine, free and combined, at the point of discharge into the river during each chlorination period during the first year of Plant operation; thereafter, the amount used will be controlled to assure concentrations of total residual

chlorine released will not exceed 0.5 ppm. The study to evaluate effects of chlorine residuals and chlorinated compounds on aquatic biota in the vicinity of Indian Point shall be continued for one year after Plant operation begins.

(5) Measurement of concentration of dissolved oxygen in the vicinity of Indian Point and determination of the significance of effects of any low concentration levels during two years of once-through cooling operation.

(6) Measurement of concentrations of heavy metals, especially copper and chromium (VI), at the point of discharge into the river during the first year of Plant operation.

(7) Measurement of radiation levels of radioactive releases and radionuclide content of samples exposed to radioactive releases from the reactors through a radiological environmental monitoring program during the lifetime of Plant operation.

(8) Measurement of concentrations of radioiodine in fresh milk obtained from cows pastured on nearby dairy farms as part of the radiological environmental monitoring program during the lifetime of Plant operation.

(9) Measurement of temperature of thermal discharges at the outfall during the summer months and determination during the first three years of Plant operation of the size, shape, and location of isotherms of the thermal plume with different freshwater flows over complete tidal cycles during different seasons of the year to demonstrate compliance with the New York State thermal criteria at all times of the year, particularly during periods of anticipated potential violations of the State's limits, and to verify thermal models to predict future plume behavior under different seasonal and tidal influences.

(10) Determination of the effects of thermal discharges on biota during different life stage during Plant operation with once-through cooling.

(11) Determination of any changes in aquatic life in the Hudson River during operation of the Plant with once-through cooling.

UNITED STATES OF AMERICA

ATOMIC ENERGY COMMISSION

In the Matter of CONSOLIDATED EDISON COMPANY OF NEW YORK, INC. (Indian Point Station, Unit No. 3)	))))))	Docket No. 50-286

STIPULATION

WHEREAS the Atomic Energy Commission has recognized that the public interest may be served through the fair and reasonable settlement of contested licensing proceedings;

WHEREAS the Hudson River Fishermen's Association ("HRFA"), Save Our Stripers ("SOS"), the Atomic Energy Council of the State of New York, the Attorney General of the State of New York, the Regulatory Staff of the Atomic Energy Commission ("the Regulatory Staff"), and the Consolidated Edison Company of New York, Inc. ("Applicant"), wish to settle all matters in controversy among them relating to the cooling system of Indian Point Unit No. 3 ("the Plant") and the protection of the aquatic biota of the Hudson River; and

WHEREAS the Atomic Safety and Licensing Appeal Board has ruled on related licensing conditions in Consolidated Edison Company of New York, Inc. (Indian Point Station, Unit No. 2), ALAB-188, RAI-74-4 323 (Apr. 4, 1974);

IT IS HEREBY STIPULATED by and among the attorneys for the parties to the above-captioned proceeding that:

1. The requests for a hearing in this proceeding are withdrawn.

2. HRFA, SOS, the Atomic Energy Council of the State of New York, the Attorney General of the State of New York, and Applicant agree that the Director of Regulation may issue to Applicant or its successor in interest an operating license for a term of 40 years for operation of the Plant at steady-state power levels not to exceed 3,025 megawatts thermal ("rated power"), provided that such license and any other operating license that may be issued earlier (for such purposes as fuel-loading, testing and limited power operation) shall contain the following condition:

Operation of Indian Point Unit No. 3 ("the Plant") with the once-through cooling system will be permitted during an interim period, the termination date for which will be September 15, 1980 ("the September 15 date"). Thereafter, except as hereinafter provided or as ordered by the Atomic Energy Commission, the Plant shall be operated with an approved closed-cycle cooling system. Such interim operation is subject to the following conditions, none of which shall be interpreted to limit or to affect in any way such other conditions as are imposed by the Atomic Energy Commission or any other governmental body (including, but not limited to, the State of New York) in accord with applicable law:

(a) Interim operation shall only be permitted to the extent that the requirements of this license (including such technical specifications as may be imposed by the Director of Regulation) to protect the aquatic biota of the Hudson River from any significant adverse impacts are satisfied; any necessary mitigating measure shall be promptly taken; such measures to include any authorized remedy deemed to be appropriate by the Atomic Energy

Commission, including an acceleration of the September 15 date to an earlier date which is deemed reasonable and warranted by the circumstances.

(b) The September 15 date is subject to acceleration or extension depending upon whether the Licensee, acting with due diligence, obtains all governmental approvals required to proceed with the construction of the closed-cycle cooling system by the end of the twelfth month following submission of the evaluation required by subparagraph (g) ("the twelve-month deadline"). In the event all such government approvals are obtained a month or more prior to the twelve-month deadline, then the September 15 date shall be accelerated accordingly. In the event the Licensee has acted with due diligence in seeking all such governmental approvals, but has not obtained such approvals by the twelve-month deadline, then the September 15 date shall be extended accordingly. If this license is issued before May 1, 1975, the twelve-month deadline shall be June 1, 1976.

(c) If the Licensee believes that the empirical data collected during this interim operation justify an extension of the interim operation period, or other relief, it may make an application to the Atomic Energy Commission. The filing of such application in and of itself shall not warrant an extension of the interim operation period.

(d) After the commencement of construction of a closed-cycle cooling system, a request for an extension of the interim operation period will be considered by the Atomic Energy Commission on the basis of a showing of good cause by the Licensee which also includes a showing that the aquatic biota of the Hudson River will continue to be protected from any significant adverse impacts as a result of operation of the Plant during the period for which an extension is sought. The filing of such application in and of itself shall not warrant an extension of the interim operation period.

(e) The September 15 date is subject to extension if the empirical data referred to in subparagraph (c) are insufficient solely because the Plant has not operated at at least 40% of rated power for 45 or more full days (8:00 a.m. to 7:59 a.m.) during the period from May 15 to July 31 in each calendar year, commencing January 1, 1975. The September 15 date will be extended one year for each calendar year in which such operation is not achieved. However, no such extension shall be granted after the Plant has achieved such operation in two calendar years, and no more than two such extensions shall be granted. This subparagraph shall not bar an application for an extension under subparagraph (c) because of lack of operation. As long as an extension of the September 15 date is possible pursuant to this subparagraph, whenever the Plant operates at less than 20% of rated power for more than 12 consecutive hours during the May 15 to July 31 period, no more than three circulating water pumps shall be used.

(f) In addition to the reporting requirements otherwise imposed by this license, the Licensee is directed to file with the Commission and serve on the parties reports of its analysis of data collected during interim operation which bear on the environmental effects of once-through cooling on the aquatic biota of the Hudson River. Such reports shall be made publicly available. The first such report shall be made as soon as is feasible after the end of the 1975 striped bass spawning season but no later than July 31, 1976, and thereafter as significant new data become available.

(g) Evaluation of the economic and environmental impact of alternative closed-cycle cooling systems shall be made by the Licensee in order to determine a preferred system for installation. This evaluation shall be submitted to the Atomic Energy Commission by one month following the receipt of the full-term, full-power operating license, for review and approval prior to construction.

(h) The September 15 date assumes that the installation of a closed-cycle cooling system for the plant will require the relocation of the natural gas pipeline owned by Algonquin Gas Pipeline Company. If the final determination as to the location of the closed-cycle cooling system does not require the relocation of the pipeline, the date for the termination of the interim period of operation with the once-through cooling system will be May 1, 1980, and all dates in this condition shall be deemed changed to reflect those circumstances by substituting "May 1, 1980 ('the May 1 date')" for "September 15, 1980 ('the September 15 date')" and "the May 1 date" for "the September 15 date" throughout this condition and subparagraph (j)(1) of this condition shall be ineffective.

(i) No acceleration of the September 15 date shall be made pursuant to subparagraph (b) or (h) to the extent that such acceleration would result in the simultaneous excavation or outage for the construction of closed-cycle cooling systems for both Indian Point Unit Nos. 2 and 3.

(j) In construing and applying this condition, the following definitions shall govern:

(1) "governmental approvals" shall include, among others, approval by the Federal Power Commission of a certificate of public convenience and necessity, or amendment thereto, authorizing relocation of the natural gas pipeline owned by Algonquin Gas Pipeline Company and crossing the Plant site in order to permit excavation for a cooling tower adjacent to the Plant;

(2) "Licensee" shall include Applicant or any successor to its interest in the license to operate the Plant or any joint holder of the license to operate the Plant.

3. The Regulatory Staff agrees that the foregoing license condition is appropriate and that it will not require or recommend any conditions or provisions in its technical specifications or otherwise in the operating license with respect to operation of the Plant with once-through cooling inconsistent with said license condition.

4. (a) In the event that the Licensee applies for an extension of the interim operation period or other relief pursuant to subparagraph (c) or (d) of the license condition set forth in paragraph 2 of this stipulation, the Licensee shall serve such application on each party as provided in paragraph 7(a) hereof. The Regulatory Staff shall promptly review said application and shall issue a report stating the Regulatory Staff's findings and conclusions concerning said application and a recommendation that the relief requested be approved, modified,

or denied. A copy of such report shall be served on each party to this stipulation.

(b) Within 30 days following such service, any party to this stipulation may serve upon the other parties and file with the Commission a request for a hearing concerning the Regulatory Staff's recommendation. Each party, including the Regulatory Staff, hereby agrees to support any request for a hearing made by any party pursuant to this subparagraph (b). Such support for a request for hearing by any party to this stipulation shall not be construed as agreement with the substantive position of the party initiating the request for hearing. Any hearing and all subsequent proceedings held pursuant to this paragraph shall be governed by the Rules of Practice of the Atomic Energy Commission, or any successor agency, as such rules may then be in effect pursuant to the Atomic Energy Act of 1954 as now or hereafter amended, and to any other applicable laws. If no request for hearing is made, the Director of Regulation or his successor may amend the license condition as recommended by the Regulatory Staff.

5. In the event that the Regulatory Staff proposes any modification of the license condition set forth in paragraph 2 of this stipulation, pursuant to subparagraph (a) of said condition or otherwise, the Regulatory Staff shall issue a report setting forth the proposed change and the basis therefor. A copy of such report shall be served on each party to this stipulation. Following service, the procedure set forth in paragraph 4(b) of this stipulation shall govern.

6. Acceptance of this stipulation shall not be deemed a waiver by any party hereto of the right, in any future hearing or other proceeding, to advance or to oppose any contention not expressly barred by this stipulation, including but not limited to the contention that the analysis and statement required by section 102 of the National Environmental Policy Act of 1969 must include: (a) analysis of the effects on the fisheries of the Hudson River of all power plants situated on the Hudson River or whose design or construction on the Hudson River is imminent as of the time of the hearing, and (b) analysis of the need for power generated by the Plant and the availability of power from other sources.

7. The Licensee will serve on the other parties to this stipulation:

(a) any request for modification of the September 15 date, pursuant to paragraph 2(c) or 2(d) hereof;

(b) a notice of any modification of the twelve-month deadline, with the reasons therefor; and

(c) a notice that the September 15 date has been advanced or set back pursuant to paragraph 2 hereof, with the reasons therefor.

The request referred to in subparagraph (a) above shall be served at the same time it is submitted to the Atomic Energy Commission, and the notices referred to in subparagraphs (b) and (c) above shall be served as soon as possible after the circumstances giving rise to the modification have occurred. If the twelve-month deadline is extended more than eight months pursuant to subparagraph (b) of paragraph 2 of this stipulation, any further extension shall be subject to the approval of the Regulatory Staff. The Licensee shall submit any such request for a postponement and the Staff shall review such request and issue within 30 days of receipt of such request a written determination whether due diligence has been exercised by the Licensee. A copy of said determination shall be served on each party to this stipulation. Within 30 days following such service, any party to this stipulation may serve a request for a hearing on the Secretary of the Atomic Energy Commission and all other parties. Each party, including the Regulatory Staff, hereby agrees to support any request for a hearing made by any party pursuant to this subparagraph. Such support for a request for hearing by any party to this stipulation shall not be construed as agreement with the substantive position of the party initiating the request for hearing. Any hearing and all subsequent proceedings held pursuant to this subparagraph shall be governed by the Rules of Practice of the Atomic Energy Commission, or any successor agency, as such rules may then be in effect pursuant to the Atomic Energy Act of 1954 as now or hereafter amended, and to any other applicable laws. In any hearing involving subparagraph (b) of paragraph 2 of this stipulation, the Licensee shall have the burden of proof on the issue of due diligence, and in any hearing involving subparagraph

(d) of said paragraph 2, the Licensee shall have the burden of proof on the issue of good cause. Nothing herein shall be construed to limit any party's rights to relief under the Rules of Practice or otherwise should it wish to maintain that a necessary governmental approval has been substantially granted or denied by passage of time or otherwise.

8. All parties agree to exercise due diligence in the performance of their various responsibilities under this stipulation. All parties also agree to cooperate in the expeditious processing of any applications for the various governmental approvals required under subparagraph (b) of paragraph 2 of this stipulation, and further agree not to object to the participation of any party to this stipulation in any proceeding relating to any such application.

9. Each party to this stipulation, other than the Regulatory Staff, expressly reserves the right to seek judicial review of any final order of the Atomic Energy Commission following a hearing under paragraph 4, 5, or 7 of this stipulation.

10. All parties, including the Regulatory Staff, shall serve on the other parties to this stipulation all correspondence, papers, and documents exchanged between them which relate to matters in controversy among the parties concerning the cooling system of the Plant or the protection of the aquatic biota of the Hudson River.

11. This stipulation shall be binding upon any successor-in-interest to the Applicant or any future co-applicant who shall come to hold or have any interest whatsoever in the operating license, and shall be binding upon any successor-in-interest to any of the parties hereto who has notice of the terms hereof as if such successor-in-interest had been an original party hereto, and shall remain in effect among the parties hereto and their successors-in-interest regardless of the addition or substitution of parties to the proceeding.

12. The license condition provisions of this stipulation shall not be final and binding on the parties hereto until this stipulation has been approved by the Atomic Safety and Licensing Board and the Atomic Safety and Licensing Appeal Board.

For the Applicant: For the Regulatory Staff:

xxx

Harry H. Voigt Joseph Gallo

For the Attorney General
of the State of New York:

For the New York State
Atomic Energy Council:

For the Hudson River
Fishermen's Association:

For Save our Stripers:

Dated: December , 1974

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FOREWORD

This Environmental Statement was prepared by the U.S. Nuclear Regulatory Commission Office of Nuclear Reactor Regulation (staff) in accordance with the Commission's regulation 10 CFR 50, the former Appendix D,* which implements the requirements of the National Environmental Policy Act of 1969 (NEPA) (P.L. 91-190, 83 Stat. 852).

The NEPA states, among other things, that it is the continuing responsibility of the Federal Government to use all practicable means, consistent with other essential considerations of national policy, to improve and coordinate Federal plans, functions, programs, and resources to the end that the Nation may:

- Fulfill the responsibilities of each generation as trustee of the environment for succeeding generations.
- Assure for all Americans safe, healthful, productive, and esthetically and culturally pleasing surroundings.
- Attain the widest range of beneficial uses of the environment without degradation, risk to health or safety, or other undesirable and unintended consequences.
- Preserve important historic, cultural, and natural aspects of our national heritage and maintain, wherever possible, an environment which supports diversity and variety of individual choice.
- Achieve a balance between population and resource use that will permit high standards of living and a wide sharing of life's amenities.
- Enhance the quality of renewable resources and approach the maximum attainable recycling of depletable resources.

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*The Commission's regulation 10 CFR 51, "Licensing and Regulatory Policy and Procedures For Environmental Protection," superseded Appendix D to 10 CFR 50 on August 19, 1974. In accordance with §51.56, facility licensing proceedings in which notice of hearing was published in the *Federal Register* on or before August 19, 1974, shall be subject to provisions of Appendix D of Part 50 of this chapter applicable to the proceeding in effect on August 19, 1974 [*Federal Register* 39: 26279-26286 (July 18, 1974].

Futher, with respect to major Federal actions significantly affecting the quality of the human environment, Section 102(2)(C) of the NEPA calls for preparation of a detailed statement on:

(i) the environmental impact of the proposed action,

(ii) any adverse environmental effects which cannot be avoided should the proposal be implemented,

(iii) alternatives to the proposed action,

(iv) the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and

(v) any irreversible and irretrievable commitments of resources that would be involved in the proposed action should it be implemented.

Pursuant to the former Appendix D of 10 CFR 50, the NRC Office of Nuclear Reactor Regulation prepares a detailed statement on the foregoing considerations with respect to each application for a construction permit or full-power operating license for a nuclear power reactor.

When application is made for a construction permit or a full-power operating license, the applicant submits an environmental report to the NRC. In conducting the required NEPA review, the staff meets with the applicant to discuss items of information in the environmental report, to seek new information from the applicant that might be needed for an adequate assessment, and generally to ensure that the staff has a thorough understanding of the proposed project. In addition, the staff seeks information from other sources that will assist in the evaluation and visits and inspects the project site and surrounding vicinity. Members of the staff may meet with State and local officials who are charged with protecting State and local interests. On the basis of all the foregoing, and other such activities or inquiries as are deemed useful and appropriate, the staff makes an independent assessment of the considerations specified in Section 102(2)(C) of the NEPA and the former Appendix D of 10 CFR 50.

This evaluation leads to the publication of a draft environmental statement prepared by the NRC Office of Nuclear Reactor Regulation, which is then circulated to Federal, State, and local governmental agencies for comment. Interested persons are also invited to comment on the draft statement.

After receipt and consideration of comments on the draft statement, the staff prepares a final environmental statement, which includes a discussion of questions and objections raised by the comments and the disposition thereof; a final benefit-cost analysis, which considers and balances the environmental effects of the facility and the alternatives available for reducing or avoiding adverse environmental effects with the environmental, economic, technical, and other benefits of the facility; and a conclusion as to whether — after the environmental, economic, technical, and other benefits are weighed against environmental costs and after available alternatives have been considered — the action called for, with respect to environmental issues, is the issuance or denial of the proposed permit or license or its appropriate conditioning to protect environmental values.

In addition, in a proceeding such as this, which is subject to Section C of the former Appendix D of 10 CFR 50, the final detailed statement includes a conclusion as to whether — after the environmental, economic, technical, and other benefits are weighed against environmental costs and available alternatives have been considered — the action called for as regards the previously issued construction permit is the continuation, modification, or termination of the permit or its appropriate conditioning to protect environmental issues.

Single copies of this Statement may be obtained by writing the Division of Reactor Licensing, Office of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555. Dr. Mary Jane Oestmann is the NRC Environmental Project Manager for this Statement. She may be contacted at 301-443-6951 if there are questions regarding the contents of this Statement.

Effective January 19, 1975, activities under the U.S. Atomic Energy Commission regulatory program were assumed by the U.S. Nuclear Regulatory Commission in accordance with the Energy Reorganization Act of 1974. Any references to the Atomic Energy Commission (AEC) contained herein should be interpreted as Nuclear Regulatory Commission (NRC).

I. INTRODUCTION

The Consolidated Edison Company of New York, Inc. (applicant) has applied to the Atomic Energy Commission for an operating license for Unit No. 3 (Docket No. 50-286) of the Indian Point Nuclear Generating Plant (or Station). The 239-acre site, on the eastern bank of the Hudson River in an industrial area near Peekskill, and about 24 miles north of the New York City northern boundary line, is located in the Village of Buchanan in upper Westchester County, New York, and contains two existing nuclear-powered Units. Unit No. 1 produces 265 megawatts electrical (MWe) and Unit No. 2 produces 873 MWe. Unit No. 3 will use a Westinghouse pressurized-water reactor, rated at 3,025 megawatts thermal (MWt), to produce a net rated output of 965 MWe. A design power level of 3,216 MWt or 1,033 MWe is anticipated in the future. Important information related to Unit No. 3 is given in Table I-1. Additional data regarding the thermal and electrical power for the Plants are given in Table III-1. All three Units will initially use the Hudson River for once-through cooling. In addition, the power output from the three Units will be transmitted to the Buchanan substation, 2,100 ft east of the Units, and from there onto existing transmission facilities owned by the applicant.

In regard to the status of the construction and operation of the three Units on the site, the applicant received a Provisional Operating License DPR-5 for Unit No. 1 on March 26, 1962, and applied for a full-term license on November 10, 1969. Unit No. 1 has been shut down since October 31, 1974, in order to have an emergency core cooling system installed. On September 28, 1973, the applicant received Amendment No. 4 to the Facility Operating License No. DPR-26 to operate Unit No. 2 at 100% steady-state power. This license has since been amended by Amendment No. 5 in accordance with the Atomic Safety and Licensing Appeal Board's Memorandum and Order (ALAB-174) dated January 29, 1974, and Amendment No. 6 in accordance with the Appeal Board's Decision (ALAB-188) dated April 4, 1974. A construction permit CPPR-62 for Unit No. 3 was issued to the applicant on August 13, 1969. The applicant resubmitted to the Commission an amended application for an operating license for Unit No. 3 on April 13, 1973. Construction of Unit No. 3 will be completed in the early part of 1975 and commercial power operation is anticipated during the latter half of 1975.

This Statement has been prepared with consideration of the incremental impacts on the Hudson River ecosystem produced by operation of Indian Point Unit No. 3 with the applicant's proposed once-through cooling system over those produced by existing power plants, including Indian Point Units Nos. 1 and 2.

Table I-1. Important parameters related to Indian Point Nuclear Generating Plant Unit No. 3

Power plant	
Thermal power, MWt	
Rated	3,025
Maximum calculated	3,216
Electrical output, MWe	
Rated gross turbine-generator	1,001
Rated net	965
Maximum calculated net	1,033
Heat discharge, Btu/hr	
At rated power	6.940×10^9
At maximum calculated power	7.490×10^9
Water flow rates, gpm (cfs)	
Cooling water	840,000 (1,871)
Service water	30,000 (67)
Total	870,000 (1,938)
Water velocities, fps	
Intake	0.8–2.0
Discharge (design velocity at discharge port)	10
Fuel weight, lb UO_2	215,800
Equilibrium fuel enrichment, wt % U-235	3.2
Plant site	
Distance north of New York City boundary line, miles	24
Area, acres	
Site	239
Occupied by plant (all 3 units)	35
Location of plant on Hudson River, mile point	43
Characteristics of Hudson River at plant site	
Width, ft	4,500–5,000
Maximum depth, ft	85
Approximate cross-sectional area, ft^2	170,000
Ambient temperatures, °F	
Maximum	79–81
Minimum	32
Freshwater flow, cfs	
Maximum	68,000
Minimum	3,500
Maximum tidal flow, cfs	300,000
Average tidal range, ft	2.9
Maximum salinity, ppt	8
Population (1970 Census)	
Nearby cities	
Peekskill	18,881
West Haverstraw	8,558
Haverstraw	8,198
Croton-on-Hudson	7,523
Stony Point	6,270
Nearby counties	
Westchester	894,406
Rockland	229,903
Orange	221,657
Putnam	56,696

In this Environmental Statement, the staff's Final Environmental Statement[1] (FES) for Unit No. 2, as amended, and the applicant's Environmental Report[2] (ER) and Supplements for Unit No. 3 are cited extensively. Therefore, their full titles and documentation are given only in the list of references for the Introduction. A third document, the applicant's Environmental Report[3] and Supplements for Unit No. 2, will be treated similarly to prevent ambiguity. Throughout the Statement, these references will be given in the line of text, either in short form or as abbreviations, followed by citations to pages, sections, appendices, etc.:

FES, IP-2	Final Environmental Statement for Unit No. 2
ER, IP-2	Environmental Report and three Supplements for Unit No. 2
ER, IP-3	Environmental Report and twelve Supplements for Unit No. 3

Independent calculations and sources of information were also used as a basis for the assessment of environmental impact. In addition, some of the information was gained from visits by the staff to the Indian Point site and surrounding areas in February and November 1973 and in June and August 1974.

Meetings with the New York State Department of Conservation and other State agencies occurred in February 1973, and discussions with the intervenors have taken place during the same meetings between the applicant and the staff mentioned above. These various discussions among the parties in the hearing have been beneficial in the staff's preparation of the FES. In addition, the various reports on the applicant's research program have provided extensive information on the Hudson River environment.

A. SITE SELECTION

The Indian Point site was committed to nuclear power generation as early as 1956, when the construction permit for Unit No. 1 was issued by the Commission. The site was further committed in 1966 when the construction permit for Unit No. 2 was issued, and in 1969 when the construction permit for Unit No. 3 was issued. This commitment and the following factors were the major considerations in the selection of the Indian Point site for Unit No. 3: (1) low population density in the nearby area; (2) the geology of the site; (3) extremely remote danger of flooding; (4) short distances to load centers; (5) existing transmission rights-of-way; (6) availability of the Hudson River water for cooling purposes; and (7) scarcity of suitable sites. Each Unit utilizes the Hudson River as the water supply and the receiving water body for discharged wastes. Experience had been gained from operation of Unit

No. 1 regarding the discharges of thermal, chemical, and radioactive effluents and their effects on the environment, and studies have been carried out on the impact of incremental amounts of these discharges. All liquid and gaseous effluents discharged from the Units to the environment shall be required to meet Federal, State, and local regulations. Suitable sites for large power plants are becoming increasingly scarce in the New York area. Limitations of the availability of the above-mentioned requirements have restricted the applicant in selecting suitable sites to build power plants to serve the applicant's service area.

B. APPLICATIONS AND APPROVALS

Table I-2 lists the applications filed by the applicant and the approvals received to date from various governing bodies or agencies for Unit No. 3 as well as for the other two Units. For those applications which have been granted, the date of issuance is included. The letters granting the permits are presented in Appendix I of the applicant's Suppl. No. 1 to the Environmental Report for Unit No. 2 and Appendix H in the Environmental Report for Unit No. 3.

1. Past Environmental Approvals

The applicant has also conferred with the Westchester County Department of Planning[4] in establishing the Indian Point site for construction of nuclear power plants. The Department of Planning comments on the fact that the site is zoned for industrial use, including the use of nuclear power generation, which is consistent with the overall land use development planned for Westchester County. It also strongly endorses the applicant's policy of making part of the site available for public use and for recreational purposes. The State of New York Atomic Energy Council has similarly expressed the opinion, consistent with that of the Department of Planning, that nuclear power development may have resulted in an improved land usage (ER, IP-3, p. 6-2).

The Advisory Council on Historic Preservation[5] has commented on the effect of the nuclear power plant undertaking on the Stony Point Battlefield Reservation, a National Register property, and concluded that the probable effect upon this Reservation cannot be judged to be sufficiently adverse to warrant Council comment.

On September 14, 1967, the Hudson River Valley Commission (HRVC),[6] which encourages projects that enhance the preservation and development of the historic, natural, and scenic resources of the Hudson River Valley and recognizes the need for full development of the commercial, industrial, and other resources, stated its unanimous

Table I-2. Approvals related to the Indian Point Station

Agency	Subject	Date of issuance	Approval
Atomic Energy Commission	Unit No. 1 construction permit	May 4, 1956	CPPR-1
	Unit No. 1 provisional operating license	Mar. 26, 1962	DPR-5
	Unit No. 2 construction permit	Oct. 14, 1966	CPPR-21
	Unit No. 2 facility operating license to load fuel and conduct subcritical testing	Oct. 19, 1971	DPR-26
	Unit No. 2 facility operating license to conduct tests up to 50% of rated power	Apr. 20, 1973 Apr. 27, 1973	DPR-26, Amendments 1 and 2
	Unit No. 2 facility operating license to operate up to 50% of rated power	Aug. 9, 1973	DPR-26, Amendment 3
	Unit No. 2 facility operating license for 100% of rated power	Sept. 28, 1973	DPR-26, Amendment 4
	Unit No. 3 construction permit	Aug. 13, 1969	CPPR-62
Department of the Army, Corps of Engineers	Construction of wharf, screenwells, and discharge tunnel; installation of pipes; dredging and placing of fill	Apr. 3, 1957	Permit No. 5236
	Construction of dike in Lents Cove	Jan. 8, 1960	Permit No. 5891
	Placement of fill	Feb. 23, 1966	Permit No. 7184
	Revised plans to place fill; construction of discharge channel extension wall and screenwell structure; dredging and placing of fill	Mar. 15, 1966	Permit No. 7184-A
	Revised plans for discharge structure	Jan. 19, 1967	Permit No. 7184-B
	Installation of screenwell cofferdam and discharge canal	Sept. 29, 1967	Permit No. 7562
	Dredging at Lents Cove	Dec. 11, 1967	Permit No. 7589
	Revised plans for discharge structure and installation of steel outfall section consisting of 12 submerged openings	Nov. 24, 1970	Permit No. 7562-A
	Sect. 13 permit to discharge and control thermal, chemical, and other wastes	Applied for June 24, 1971; converted to Sect. 402 permit	
Hudson River Valley Commission	Installation of screenwell cofferdam and discharge canal	Sept. 14, 1967	Letter of approval
	Dredging at Lents Cove	Dec. 7, 1967	Letter of approval
	Changes in discharge canal	Mar. 26, 1971	Letter of approval

Table I-2 (continued)

Agency	Subject	Date of issuance	Approval
New York State Water Resources Commission	Dumping of rock spoil in Hudson River	Feb. 4, 1966	Permit No. 8-1-66
	Construction of extension of discharge canal to separate discharge from intake to a point 300 ft south of present location	Mar. 2, 1966	Permit No. 8-4-66
	Dredging for concrete screen-well construction	Apr. 13, 1966	Permit No. 8-11-66
	Installation of screenwell cofferdam and discharge canal	June 22, 1967	Permit No. 8-31-67
	Dredging at Lents Cove	Nov. 30, 1967	Permit No. 8-78-67
	Extension of discharge canal 98 ft downriver and protection with sheet piling	June 30, 1970	Permit No. 8-22-70
New York State Department of Environmental Conservation	Redesigned outfall structure including sluice gates	Dec. 10, 1970	
	Construction of modified outfall structure to change openings from 18-ft depth to 12-ft depth	Nov. 4, 1971	
	Discharge of chemical cleaning solutions	Nov. 13, 1970	Temporary; no longer used
	Discharge of chemical cleaning solutions	Feb. 10, 1971	Temporary; no longer used
	Water quality certification for Units Nos. 1 and 2 under Sect. 21(b) of WQIA of 1970	Dec. 7, 1970	
	Water quality certification under Sects. 401 and 402 of FWPCAA of 1972 for testing period for Units Nos. 1 and 2	Apr. 24, 1973	
	Water quality certification under Sect. 401 of FWPCAA of 1972 for full power operation of Units Nos. 1 and 2	Sept. 24, 1973	
New York State Department of Health	Sewage disposal system	June 10, 1959	
	Construction of 214-ft cooling water discharge channel	Aug. 22, 1966 (expired Aug. 22, 1971)	
	Construction of fossil-fired service boilers	Apr. 12, 1968	Permit No. HA-680101
	Construction of an effluent channel with a submerged diffuser	May 19, 1970	

Table I-2 (continued)

Agency	Subject	Date of issuance	Approval
Westchester County Department of Planning	Use of land for industrial purposes	Nov. 9, 1970	
Village of Buchanan, Building Department			
	Unit No. 2		
	Excavation	Dec. 1, 1965	Permit No. 373
	Intake screenwell	May 16, 1965	Permit No. 381
	Turbine room, water bay, and discharge water tunnel	May 24, 1965	Permit No. 387
	Primary auxiliary building and waste holdup tank pit	Sept. 28, 1966	Permit No. 404
	Fuel storage building	Sept. 28, 1966	Permit No. 405
	Containment building	Sept. 28, 1966	Permit No. 406
	Control room	Feb. 18, 1967	Permit No. 411
	Unit No. 3		
	Excavation	June 16, 1967	Permit No. 421
	Demolition of existing storage and office buildings	July 10, 1967	Permit No. 425
	Installation of screenwell cofferdam and discharge canal	July 11, 1967	Permit No. 427
	Control house	May 28, 1968	Permit No. 458
	Containment building	May 28, 1968	Permit No. 459
	Turbine building	May 28, 1968	Permit No. 460
	Fuel-storage building	July 15, 1968	Permit No. 463
	Primary auxiliary building	Feb. 24, 1969	Permit No. 473
	Waste-holdup tank	Aug. 25, 1969	Permit No. 491
	Service building	Aug. 26, 1969	Permit No. 492

approval of the proposed project for the screenwell and discharge lines at Indian Point. However, it noted that future development at Indian Point in connection with the third Unit will require additional review in detail before the screenwell and discharge line are put into operation. The HRVC further commented, in a letter to the applicant dated February 8, 1968,[7] that the HRVC had concurred that impairment of the natural resources of the river would result if the criteria developed by the New York State for the prevention of thermal pollution were not met. It recognizes the need for pre- and post-operational research concerning possible effects on the aquatic life in the area due to radionuclides.

2. Future Environmental Approvals

Future environmental approvals required by the applicant for the operation of Unit No. 3 will include obtaining: (1) Section 401 water quality certification under the Federal Water Pollution Control Act Amendments (FWPCAA) of 1972 from the New York State Department of Environmental Conservation (applicant filed an application for a Section 401 certification for Unit No. 3 on October 4, 1973; on October 4, 1974, the applicant withdrew the application and on the same date reapplied for a new Section 401 certification);[8] (2) Section 402 discharge permit under the National Pollutant Discharge Elimination System (NPDES); and (3) full-power, full-term operating license for Unit No. 3 from the Atomic Energy Commission. The conditions in the 401 certification for Unit No. 3 will become conditions of the operating license to be granted by the Commission.

Application has been filed with the Department of Environmental Conservation for an operating permit to discharge effluents through the discharge structure from Units Nos. 1 and 2. Discussions have been held between the applicant, New York State, and the Environmental Protection Agency (EPA) regarding the issuance of a water quality certification for Unit No. 3 under Section 401 of the FWPCAA of 1972 and under Section 402 of the FWPCAA (similar to the Section 13 permit under the Refuse Act of 1899) for a permit to discharge effluents through the channel and diffuser into the Hudson River. The applicant received a 401 water quality certification for Units Nos. 1 and 2 on September 24, 1973. A draft NPDES permit for Units Nos. 1 and 2 was issued to the applicant on June 28, 1974,[9] by EPA in which closed-cycle cooling is required by July 1983 for Unit No. 1 and by July 1978 for Unit No. 2. This is in accordance with the effluent guidelines and standards issued by EPA [*Federal Register* 39: 36186-36207 (October 8, 1974)].

On December 10, 1970,[10] the Department of Environmental Conservation stated that to obtain an operating permit for Unit No. 3, it would be necessary to verify predictions made from mathematical and hydraulic models to correlate actual operating experience of Units Nos. 1 and 2 to operating conditions postulated for Unit No. 3. In addition, the basis of approval for the discharge permit was the commitment by the applicant not only to complete the installation of adjustable gates prior to Unit No. 2 operation in order to maintain an average discharge velocity of not less than 10 feet per second (fps) but also to investigate, design, and construct a new intake structure for all Units, with intake screens upstream of all Units, as proposed in the Environmental Report, as expeditiously as possible. The intake completion and a demonstration of its efficiency must precede commercial operation of Unit No. 3. Verification studies of river conditions required above to support a Unit No. 3 operating permit application must include data on the new intake structure.

Upon an agreement between the State and the applicant, a State order of February 29, 1972, to shut down the circulating pumps of Units Nos. 1 and 2 after an extensive fish kill on February 24-28, 1972, was rescinded on April 28, 1972.[11] Conditions agreed upon included:

(1) Operation at 60% reduced flow when the river temperature in the area of the Indian Point site is 40°F or less so that the intake velocity is less than 0.5 fps.

(2) Installation of double air bubbler curtains in front of all circulating water intakes at both Units Nos. 1 and 2.

(3) Carrying out hydraulic model studies of a screened lagoon adjacent to the intakes at all three Units by LaSalle Laboratories. If it were determined at public hearings that the air bubble curtains are not satisfactorily protecting the fish population of the Hudson River and that the screened lagoon will provide a level of fish protection significantly higher than the air bubbler system, the applicant shall with due diligence construct and operate said screened lagoon.

The staff has reviewed the above listing of approvals and permits and has consulted with some of the appropriate agencies in an effort to identify any significant environmental issues of concern to the reviewing agencies. The environmentally related issues, particularly involving the intake-discharge structure, of concern to the NYS Department of Environmental Conservation, have been reviewed by the staff in Sections V.C., V.D., and XI.C. Delay in obtaining a Section 401 water quality certificate and discharge permit for Unit No. 3 could preclude operation of the facility.

Upon filing with the Commission an application for an operating license for Unit No. 3 on December 4, 1970, which was later amended and substituted on April 13, 1973, the applicant submitted the following documents:

1. Environmental Report, dated June 14, 1971, with twelve supplements, the last dated December 26, 1974.

2. *Final Facility Description and Safety Analysis Report,* dated December 4, 1970, and amended and substituted on April 13, 1973, along with 28 supplements and 12 amendments, the last dated January 13, 1975.

These documents and the transcripts and testimony of future hearings for the proceedings for Unit No. 3 before the Atomic Safety and Licensing Board (ASLB) related to an operating license for Unit No. 3 are or will be available in the AEC Public Document Room, 1717 H Street, Washington, D.C., and the local public document room that has been established at the Hendrick Hudson Free Library, Montrose, New York. The Draft and Final Environmental Statements and the Safety Evaluation Report and supplement for Unit No. 3 have been filed in these document rooms. These documents for Unit No. 3 and the transcripts with extensive testimony presented at the ASLB and ASLAB hearings related to an operating license for Unit No. 2, which are also in the document room, were the major sources of information for the preparation of this Statement.

Any licenses and permits that would be needed if a closed-cycle cooling system were built on Units Nos. 2 and 3 would include Sections 401/402 permits for the new discharges and a Section 404 permit for any dredging work. Permits would be needed from NYS Department of Conservation, EPA, U.S. Corps of Engineers, Federal Aviation Administration, and the Village of Buchanan. The Commission would provide the applicant with an amended operating license with amended Technical Specifications.

C. THE APPLICANT'S ENVIRONMENTAL STUDIES

Environmental studies of the Hudson River including the vicinity of Indian Point have been sponsored by the applicant over the last nine years. These studies are classified below.

(1) River flow

Quirk, Lawler, and Matusky Engineers
Alden Research Laboratories, Worcester Polytechnic Institute
Metcalf and Eddy Engineers

(2) Meteorology

Geophysical Science Laboratory, New York University

(3) Biology

Texas Instruments, Incorporated
Ichthyological Associates
Institute of Environmental Medicine, New York University Medical Center
Marine Research Laboratory, Raytheon Company
Northeastern Biologists, Incorporated
Boyce Thompson Institute

Other supporting organizations include:

Regional Economic Development Institute, Incorporated
Bechtel Corporation
Norman Porter Associates
Lamont Geological Observatory, Columbia University

Details of the individual surveillance programs sponsored by the applicant are presented in Chap. V of this Statement and in the ER for IP-3 and the Environmental Technical Specifications that accompany the operating license.

The applicant also has a number of consultants in special technical fields to assist it in developing the site for nuclear power. The ecological studies sponsored by the applicant, including financial support, have usually been reviewed by the Hudson River Technical Committee (HRTC), a subordinate committee to the Hudson River Policy Committee (HRPC), that has representatives from State and Federal agencies: New York State Department of Environmental Conservation, New Jersey Division of Fish and Game, U.S. Bureau of Sport Fisheries and Wildlife, and National Marine Fisheries Service.

The HRPC and HRTC were established in the 1960's in accordance with requirements by the Federal Power Commission (FPC) pertaining to the proposed Cornwall Pumped Storage Power Plant. These Committees have been used to review, study, and provide technical advice to the applicant on its ecological studies and environmental monitoring programs, fisheries program, and fish protection methods. The role, function, membership, and organization of the Committees were presented in a letter dated January 11, 1973,[12] from the NYS Department of Environmental Conservation to the applicant. The HRPC did not direct, but it reviewed proposed work as presented to it by the applicant and advised the applicant as to its "quality and importance to providing information on fisheries impact."[12] The Committee also reviewed, commented upon, and made recommendations concerning periodic progress reports and assessed preliminary and final findings and recommendations. The Committee has had onsite a full-time representative from the Department of the Interior whose authority to act for the Committee was determined by the Committee. The HRPC and HRTC have recently been reorganized into the Hudson River Fish and Wildlife Cooperative. This organization represents a formal structuring of concerned fish and wildlife governmental agencies to coordinate planning and management for the fish and wildlife resources of the Hudson River. The Cooperative does not represent any specific agency's point of view. The Cooperative does not and will not take positions on specific issues.[13]

In addition, the applicant has also organized the Fish Advisory Board (FAB), consisting of biologists and engineers from the United States and Great Britain. These include members from New York University, Yale University, University of Washington, Johns Hopkins University, University of Michigan, South Carolina Wildlife Resources Department, New York Aquarium, a member of a private consulting firm, a nonvoting member from the New York State Department of Environmental Conservation, and a nonvoting member from the New York Department of Public Service. The staff attended a meeting of this Board on June 18-20, 1974. The purpose of the FAB is to provide advice to the applicant on methods of reducing fish impingement effects and other ecological impacts and recommending fish protection methods at Indian Point (see ER, IP-3, App. BB).

REFERENCES FOR CHAPTER I

1. Directorate of Licensing, United States Atomic Energy Commission, *Final Environmental Statement Related to Operation of Indian Point Nuclear Generating Plant Unit No. 2*, vols. I and II, Docket No. 50-247, September 1972.

2. Consolidated Edison Company of New York, Inc., *Environmental Report, Indian Point Unit No. 3 and Appendices* (vols. 1 and 2) issued June 14, 1971, including: Suppl. No. 1, December 8, 1971; Suppl. No. 2, September 11, 1972; Suppl. No. 3, November 8, 1972; Suppl. No. 4, February 7, 1973; Suppl. No. 5, March 15 and 30, 1973; Suppl. No. 6, April 6, 1973; Suppl. No. 7, April 18, 1973; Suppl. No. 8, April 30, 1973; Suppl. No. 9, September 12, 1973; Suppl. No. 10, October 29, 1973; Suppl. No. 11, December 26, 1974; and Suppl. No. 12, March 29, 1974.

3. Consolidated Edison Company of New York, Inc., *Environmental Report, Indian Point Unit No. 2*, issued August 6, 1970, including: Suppl. No. 1, September 9, 1971; Suppl. No. 2, October 15, 1971; and Suppl. No. 3, February 15, 1972; Docket No. 50-247.

4. Letter dated November 9, 1970, from P. Q. Eschweiler, Westchester County Department of Planning, to H. L. Price, U.S. Atomic Energy Commission.

5. Letter dated October 10, 1968, from R. R. Garvey, Jr., Advisory Council on Historic Preservation, to H. L. Price, U.S. Atomic Energy Commission.

6. Letter dated September 14, 1967, from A. Aldrich, Hudson River Valley Commission, to E. G. Watkins, Consolidated Edison Company of New York, Inc.

7. Letter dated February 8, 1968, from A. Aldrich, Hudson River Valley Commission, to E. G. Watkins, Consolidated Edison Company of New York, Inc.

8. Letter dated October 4, 1973, from C. Newman, Consolidated Edison Company of New York, Inc., to T. P. Curran, New York State Department of Environmental Conservation, forwarded on October 15, 1973, from W. J. Cahill, Jr., Consolidated Edison Company of New York, Inc., to D. L. Muller, Directorate of Licensing, U.S. Atomic Energy Commission; and letter dated October 4, 1974, from C. Newman, Consolidated Edison Company of New York, Inc., to T. P. Curran, New York State Department of Environmental Conservation.

9. U.S. Environmental Protection Agency, Region II, New York, New York 10007, Public Notice No. NPDES 74-1111, June 28, 1974. NPDES permit for Indian Point Generating Station, Units 1 and 2.

10. Letter dated December 10, 1970, from T. E. Quinn, New York State Department of Environmental Conservation, to H. G. Woodbury, Consolidated Edison Company of New York, Inc.

11. Letter dated May 31, 1972, from F. X. Wallace, New York State Department of Environmental Conservation, to Consolidated Edison Company of New York, Inc., including consent and agreement of State Order dated April 28, 1972, regarding the fish kill of February 1972.

12. Letter dated January 11, 1973, from A. G. Hall, New York State Department of Environmental Conservation, to H. G. Woodbury, Consolidated Edison Company of New York, Inc., regarding the Hudson River Policy Committee.

13. Letter dated August 16, 1974, from H. E. Doig, New York State Department of Environmental Conservation, to K. F. Plumb, Federal Power Commission, regarding the Hudson River Fish and Wildlife Cooperative.

II. THE SITE

A. GENERAL

The Indian Point site, in which Indian Point Unit No. 3 is adjacent to and south of Units Nos. 1 and 2, occupies 239 acres on the east bank of the Hudson River. The site is about 24 miles north of the New York City boundary line in the Village of Buchanan in upper Westchester County of New York. The Indian Point site was formerly an amusement park.

The predominant environmental feature of this site is the Hudson River. The Hudson River at Indian Point cuts through the Hudson Highlands with a channel at the water level nearly a mile wide and with an average depth of more than 30 ft. West of the river at Indian Point is the Palisades Interstate Park with its wooded mountains and recreational facilities. East of the river are mountains of smaller height and several communities, of which Peekskill, located about 2.5 miles northeast from the Plant, is the largest. The nearest site boundary on land is 0.32 mile from Indian Point Unit No. 3. Nearby are the towns of Buchanan, Montrose, Verplanck, West Haverstraw, Stony Point, and Tomkins Cove. The Penn Central Railroad serves both banks of the river; the railhouse at Croton-on-Hudson is an important terminus and has large switching yards. U.S. Highway 9W serves the west bank, and U.S. 9 (Albany Post Road) serves the east bank (Fig. II-1). The river serves to provide commercial shipping and navigation for many large ships up to Albany. Important geographical features within 5 miles of Indian Point, shown in Fig. II-1 and described in Sect. II.E.3., include Prickly Pear Hill, Anthony's Nose, Bear, Dunderberg, South (High Tor), and Hook Mountains; the latter two form the northern extremity of the Palisades diabase.

The estuarine nature of the Hudson River is the environmental factor of major importance. This river, which currently supplies the cooling water for Units Nos. 1 and 2 and which will cool all three Units at Indian Point once Unit No. 3 is in operation, is a tidal estuary at the site. Tidal mixing brings salt water upstream beyond Indian Point part of the year; the saltwater boundary occasionally reaches as far as Poughkeepsie, 30 miles upstream of the site. The upward extent of the intrusion of salt water varies strongly with the input of fresh water into the river (FES, IP-2, pp. II-18 to II-23). At a freshwater flow in excess of 20,800 cubic feet per second (cfs), the salt intrusion front is driven downstream from Indian Point for the entire tidal cycle.

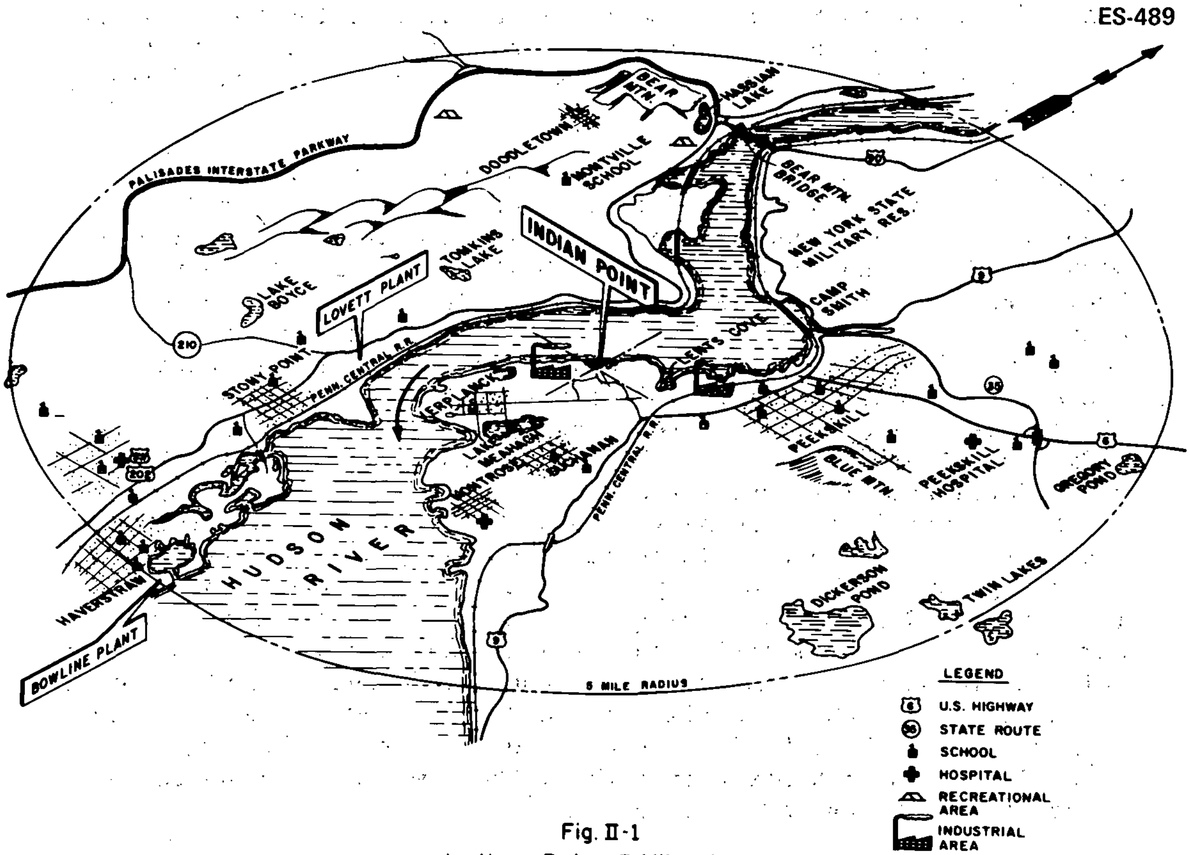

Fig. II-1
Indian Point 5 Mile Area.

Fig. II-1. Important features within a 5-mile radius of the Indian Point site.

The aquatic biota in the river are rich and diverse. The river south of the Troy Dam serves as a major spawning and nursery area for several important resident and anadromous fish, including striped bass.

B. LOCATION OF THE PLANT

The 239-acre site is on a point of land inside a bend in the Hudson River at Mile Point 42.6. Three nuclear reactors, Indian Point Units Nos. 1, 2, and 3, and associated generator buildings are compactly placed on 35 acres of riverbank near the southern end of the site (Fig. II-2). The minimum elevation of the site, 15 ft, is well above the highest recorded flood of 7.5 ft.

About 14 acres at the northern edge of the site have been transferred by the applicant to the Village of Buchanan for development as a marina. The applicant plans to build a new visitors' center near Unit No. 1 (Fig. II-2) and maintain an 80-acre forested area and lake for recreation in the northern portion of the site. Construction is expected to be completed in late 1974 (ER, IP-2, p. 2.3.1-1). The nearest public road (Broadway) forms the southeastern boundary of the site and is about 1,700 ft from the closest Plant building. The property line of the Georgia Pacific Corporation wallboard factory forms the southern boundary of the site and, at its closest, is about 1,100 ft from the Unit No. 3 containment building. South of the reactor facilities is an easement 65 ft wide and 2,800 ft long for two large gas lines of the Algonquin Gas Transmission Company.

C. REGIONAL DEMOGRAPHY AND LAND USE

Westchester County, in which the Indian Point Plant is located, has long had industry along the riverbanks but otherwise serves as suburbia and exurbia for metropolitan New York City. The growth of industrial parks and the distribution and service industries has made the county as a whole a net importer of commuting workers.

The resident population (1970) within a 1-mile radius of the Plant is 745; within a 5-mile radius, 52,700; within a 10-mile radius, 218,400; within a 50-mile radius, 17,500,000 (ER, IP-3, App. F). The projected resident population within a 10-mile radius is 297,000 for 1980 and 735,000 for 2010; within a 50-mile radius, 19,000,000 for 1980 and 26,000,000 for 2010. Table II-1 is a summary of cumulative ring population estimates projected up to the year 2010 (ER, IP-3, App. F). See Chapter X of this Statement for further discussion of population growth. About 50 people reside within a 1,100-meter (3,600-ft) radius of Unit No. 3, all of them to the east-southeast. This has been used as the outer boundary of the

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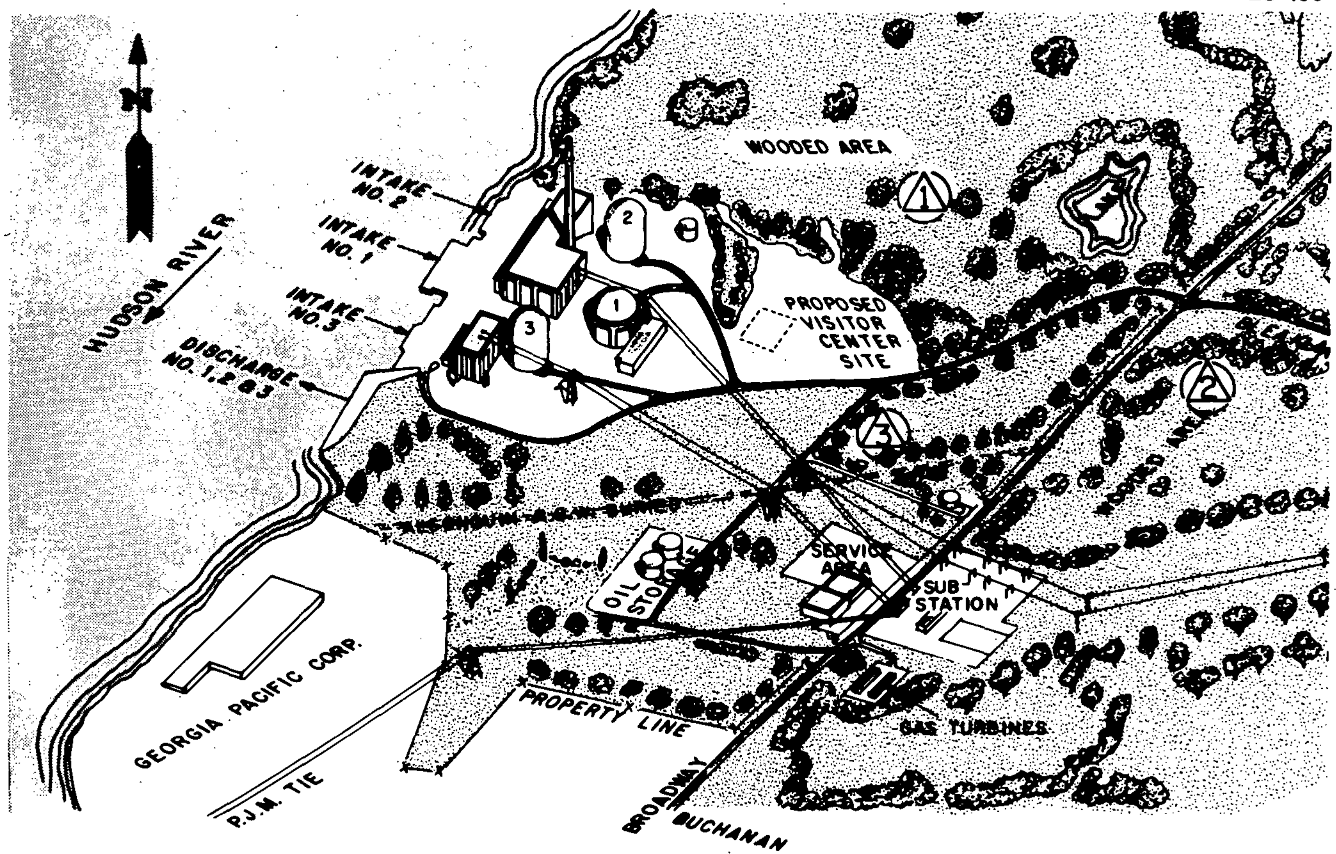

Fig. II-2. Site plan including locations of vegetation sampling plots, Ⓐ.

Table II.1. Summary of cumulative ring population estimates

Radius of the ring (miles)	Cumulative ring population estimates				
	1970	1980	1990	2000	2010
0.5	21	31	45	65	88
1	745	1,008	1,375	1,891	2,453
2	9,255	11,981	15,673	20,698	26,016
3	20,318	25,747	33,045	42,926	53,349
4	34,553	44,338	57,544	75,482	94,451
5	52,683	70,053	94,512	129,397	168,164
10	218,398	297,459	408,198	564,220	734,682
15	450,207	603,035	814,078	1,107,195	1,423,387
20	888,163	1,179,611	1,577,851	2,125,429	2,711,048
30	3,984,844	4,637,627	5,480,207	6,584,630	7,724,505
40	11,659,574	12,882,240	14,403,268	16,333,563	18,276,655
50	17,471,479	18,991,980	20,923,966	23,400,331	25,899,727
60	19,510,656	21,383,172	23,821,556	26,997,743	30,235,074

Source: ER, IP-3, App. F, Table I.

low population zone (ER, IP-3, p. 4-15). The exclusion area for Indian Point Unit No. 3 includes the entire 239-acre site (except for the 14 acres transferred to the Village of Buchanan). The minimum exclusion distance from the centerline of the reactor containment building to the boundary of the exclusion area is 350 meters, which satisfies both 10 CFR 100.3 and 10 CFR 100.11 (FFDSAR, IP-3, p. 2.4-2, Suppl. 7, July 1972).

The closest schools are about 1 mile to the east and 1.5 miles to the south (Fig. II-1). There are about a dozen schools within 2 miles, many of which are small. The closest hospitals are the Peekskill Hospital, about 3 miles northeast of the Plant, and the Veterans' Administration Hospital, about 2.5 miles south of the Plant (Fig. II-1). The nearest commercial airport is at White Plains, about 17 miles south of the Plant. Minor seaplane activity occurs at Green's Cove, about 1.5 miles south of the Plant, and Stewart Airport is located about 16 miles northwest of the site.

The majority of the land to the east of the river within 15 miles of the site is zoned for residential use or for parks. On the west side of the river within 15 miles of the site, the majority of the land is zoned for parks (Palisades Interstate Park) or residential use.

The area immediately around and including Indian Point is zoned for heavy industry. The industries nearest the Plant are a wallboard factory and a yeast plant. Surrounding areas also include stone quarries, water reservoirs, parklands, recreational facilities, the New York State Military Reservation (Camp Smith), the West Point Military Reservation, and a prison at Ossining as well as residential areas.

The Hudson River in this area of the site is used for commercial ship and barge traffic and for pleasure boating with fishermen's landings, parks, and beaches on the east bank of the Hudson River. About 600 to 800 commercial barges and ships on the Hudson River pass the Indian Point site each year. The cargo consists of petroleum products, dry goods, and molasses. The applicant has indicated that no river traffic shipment of toxic materials or explosives currently pass the site. In 1968, the Port of Albany, at the head of seaborne navigation on the Hudson, handled 1,050,000 tons of import-export trade and 2,150,000 tons of coastwise trade.[1]

The major existing and planned power plants on the Hudson River south of Troy are shown in Fig. V-3.

D. HISTORIC SIGNIFICANCE

Except for troop movements in the Revolutionary War, Indian Point has no historic significance. In 1777 the British landed at Lent's Cove to reach Peekskill. The nearest landmarks of consequence are St. Patrick's Church and a cemetery in Verplanck and St. Mary's cemetery along Broadway Road. Some 18 historic places in the vicinity of the Indian Point site are listed in the National Register of Historic Places[2] (ER, IP-3, Table 4-3). The closest of these are the Stony Point Battle Reservation on the west bank of the river about 2 miles downstream (see Fig. II-1) and the Palisades Interstate Park, west of the Stony Point area. The Advisory Council on Historic Preservation commented on the effect of construction and operation of Indian Point Unit No. 3 on historical landmarks and stated "that the probable effect upon the Stony Point Battlefield Reservation cannot be judged to be sufficiently adverse to warrant Council comment."[3] On August 30, 1973, the Council also wrote regarding compliance with Section 106 of the National Historic Preservation Act of 1966 and Executive Order 11593 of May 13, 1971; the Council also questioned whether the State Historic Preservation Office had been contacted to determine if any properties suitable for future inclusion in the National Register would be affected by the proposed Plant operation and extent of their effects. The New York State Parks and Recreation also commented on January 23, 1974, that it would participate in any informational meeting regarding the effect of Plant operation on nearby historical sites listed in the National Register. See Sect. V.A.4 for further discussion of this topic.

The Hudson River Valley Commission has identified 31 sites (mostly buildings) of historic significance within 2 miles of the Plant (ER, IP-3, p. 4-19), but none of the sites have been affected by the Indian Point Plant.

Only two archaeologic sites in Westchester County are mentioned by Ritchie.[4] "Most of the sites spared by construction or other modern activities have been heavily molested by relic collectors over a very long period and relatively few have received attention from competent...archaeologists." For many years before its acquisition by the applicant, Indian Point was a commercial amusement area operated by the Hudson River Day Line.

E. HYDROLOGY AND OTHER ENVIRONMENTAL FEATURES

1. The Hydraulics of the Hudson River Estuary

The dominant environmental feature in the Indian Point area is the Hudson River which flows from the Adirondack Mountains in northern New York to the Atlantic Ocean at New York City.[5] Hilly, forested land along the riverbanks and lakes near the river are predominant features that serve as water reservoirs and recreational facilities. The river geometry in the zone of study is shown in Fig. V-3. The cross-sectional area, surface width, and mean depth are shown in Fig. II-3. The variations of these parameters along the length of the river are significant. The river is 4,500 to 5,000 ft wide at Indian Point but narrows to about 4,000 ft both 2,000 ft upstream and downstream of the Point; about 1 mile downstream the width narrows to about 3,300 ft. The average cross-sectional area at Indian Point is about 160,000 ft^2 and the mean depth is about 40 ft (ER, IP-3, App. EE). The river is more than 100 ft deep at several points.

The water in the Hudson River at Indian Point is principally derived from two sources: fresh water from runoff in the river watershed and ocean water from the Atlantic Ocean. Although the salt concentration of the fresh water is very low, the ocean water contains about 31 or 32 ppt of salt.[6] As a result, determination of the relative proportions of ocean and runoff water in the estuary is possible. The runoff of fresh water supplies all the water in the estuary downstream as far as the saltwater front. Below this point, the upstream flow of saline ocean water becomes a progressively more important source of water within the estuarine system.

Runoff from precipitation-type floods, storm effects along the coastline, or a combination of these types of events can cause high water levels. Similarly, low water levels are affected by tides, runoff, and cyclonic-type storms such as hurricanes that can depress water levels by essentially blowing water downstream. Details of flow characteristics of the Hudson estuary are also discussed in the applicant's appendices to the Environmental Report.

The Hudson River is under tidal influence up to Troy, about 150 miles north of the mouth of the river. The average tidal range is about 3 ft in the Indian Point area with a tidal excursion length of 6 to 8 miles. The highest water level was about 7.5 ft above mean sea level (November 25, 1950).[7] The maximum tidal flow is about 300,000 cfs[8] (see Fig. II-4), which is at least an order of magnitude greater than the average freshwater flow; the average tidal flow is about 180,000 cfs.[5]

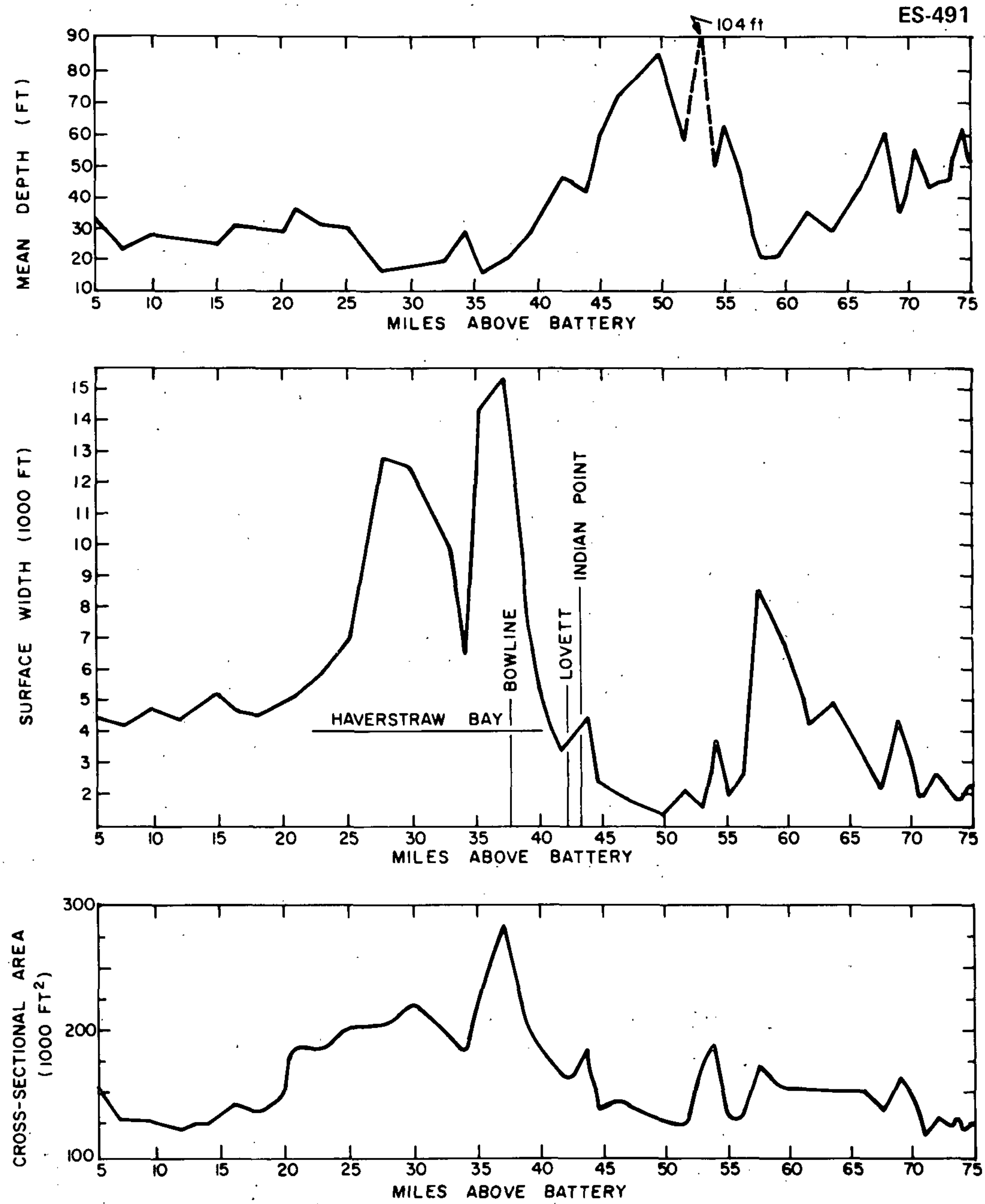

Fig. II-3. Geometry of the Hudson River. Source: ER, IP-3, App. EE(1), Fig. 3.

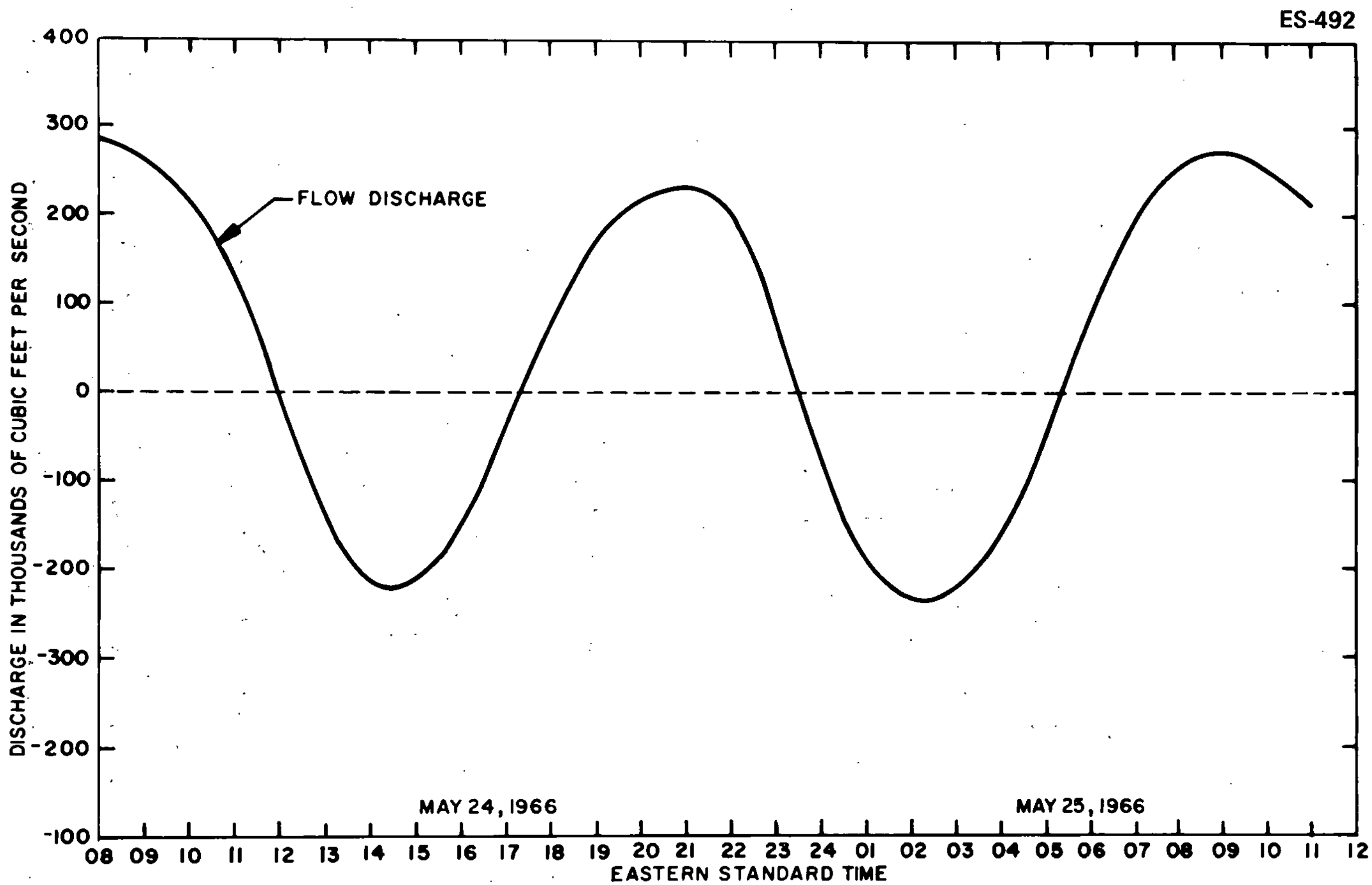

Fig. II-4. Flow discharge during tidal measurement on May 24–25, 1966 — Hudson River near Poughkeepsie, N.Y.

The flow of fresh water in the Hudson River is subject to large variations, with maximum flows of up to 68,000 cfs in the spring and minimum values of 3,000 to 4,000 cfs in the late summer. The applicant furnished monthly average flow data covering a period of 46 years, as shown in Fig. II-5. These data indicate that the average monthly flow for the summer months is about 7,000 cfs, while in 1964 there was a six-month period in which the average flow was 4,000 cfs or less. Table II-2 shows 26 years of monthly average freshwater flow data taken at the mouth of the Hudson River between 1947 and 1972, as supplied by the U.S. Department of Interior. Monthly averages for the 26 years as taken from the data, are also shown. There is fairly good correlation between the two aforementioned sets of data, although the locations of the gaging stations and time of measurement are not necessarily the same. The Department of Interior data were used to estimate the frequency with which the various flow rates could typically be expected during the warm months of May through October, as shown in Fig. II-6. For example, based on these data, a monthly average flow rate of 5,000 cfs, or less, could typically be expected to occur about once every three years in the months of July, August, September, and October. The applicant also furnished the monthly and weekly drought flow duration and frequency data shown in Fig. II-7. These data indicate, for example, that a flow of 4,000 cfs is expected to occur for one week's duration (seven consecutive days) every other year (50% frequency of occurrence), while once every five years one could expect a weekly drought flow of 3,300 cfs or a monthly drought flow of 4,000 cfs.

The salinity at Indian Point varies with magnitude of the freshwater flow and consequent movement of the salt front[8] (see Figs. II-8 and 9). Maximum values of about 7 ppt are observed during periods of low freshwater flow but normally range from 0 to 5.5 ppt[9,10] (Fig. II-10). At a freshwater flow in excess of 20,800 cfs, the salt intrusion front is driven downstream from Indian Point for the entire tidal cycle.

The saline-intruded region of the Hudson River falls into the category of partially stratified estuaries (also called partially mixed).[47] Inclusion of the Hudson within this category is justified because of the nature of the vertical and longitudinal salinity gradients.

The upstream intrusion of salt water is an important characteristic of the river at Indian Point. This phenomenon affects both dilution and dispersion of effluents in the river, both of which increase toward the mouth of the estuary. However, the net effect of this increase in dilution capability depends on a variety of

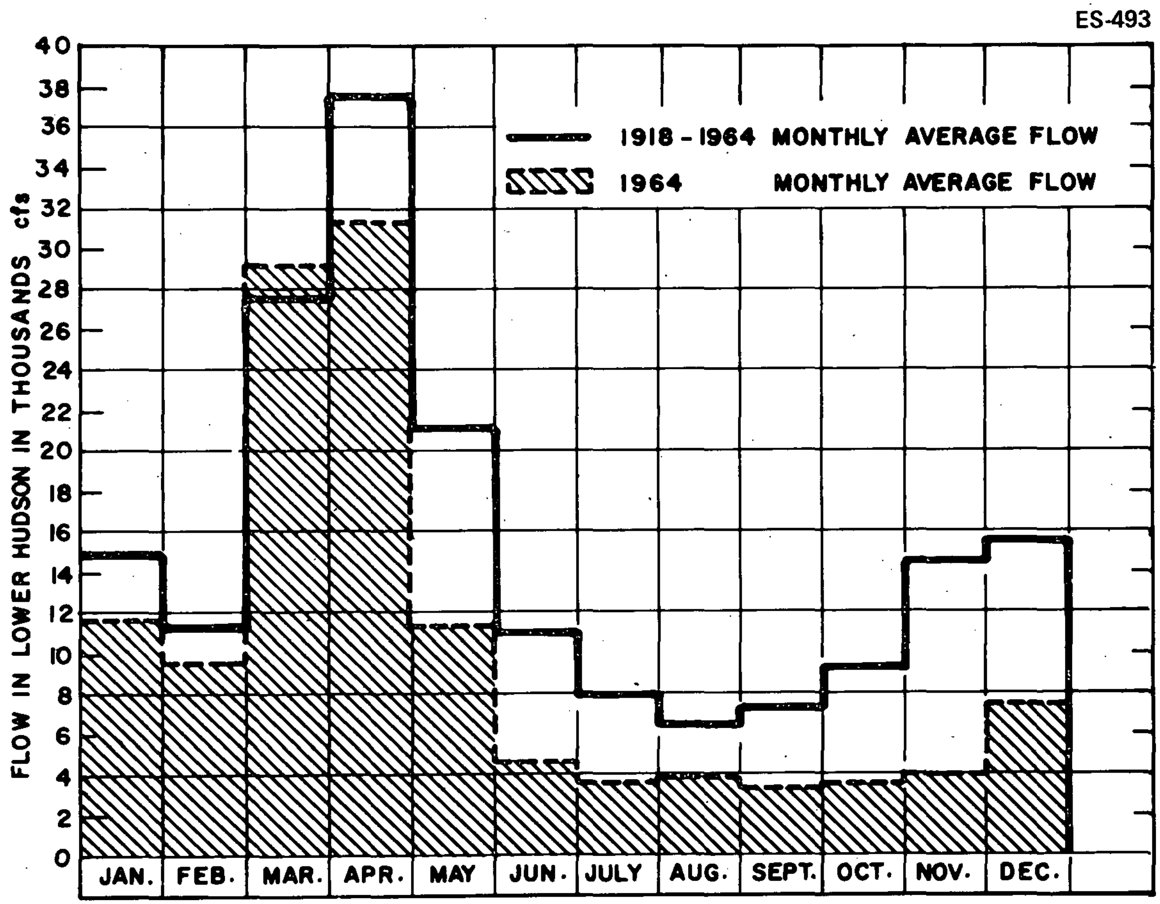

Fig. II-5. Freshwater flow in lower Hudson at Indian Point.
Source: ER, IP-3, App. I, Fig. 2.

Table II.2. Monthly flow rates at mouth of Hudson River

(cfs)

Water year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual
1947	10,000	9,350	10,500	21,700	21,100	34,600	48,500	51,400	32,000	16,400	9,900	6,170	22,700
1948	5,480	16,400	11,200	8,380	18,700	61,700	41,000	31,900	21,900	11,800	7,390	4,390	20,000
1949	4,830	11,000	23,100	57,200	34,100	27,400	24,500	17,200	6,360	4,430	4,470	5,720	18,400
1950	6,310	9,600	18,500	30,600	20,500	39,000	40,800	21,900	15,400	7,610	6,830	11,900	19,100
1951	6,830	17,500	32,200	29,100	44,500	40,200	59,600	15,200	10,300	16,800	11,600	9,910	24,400
1952	14,300	34,900	32,100	42,000	28,400	38,400	66,000	35,600	29,500	10,500	7,860	10,900	29,100
1953	5,820	10,500	25,800	31,500	29,900	52,500	50,200	47,400	8,770	5,280	5,690	4,840	23,100
1954	5,450	7,180	23,100	14,400	31,100	29,500	39,900	38,900	17,400	5,710	4,880	9,350	18,800
1955	6,460	26,100	28,500	17,600	20,200	43,700	49,500	14,500	10,800	5,270	23,600	7,200	21,200
1956	46,800	41,300	16,100	15,000	18,900	32,300	71,100	34,500	17,100	9,180	6,780	10,700	26,500
1957	8,810	12,300	25,700	17,900	18,100	24,200	30,300	14,600	6,840	6,980	5,240	4,490	14,500
1958	5,430	8,200	29,700	24,400	16,900	10,300	63,300	29,000	12,300	7,580	6,350	7,990	20,900
1959	15,800	21,000	14,900	19,800	19,100	32,000	50,700	16,700	8,720	6,240	5,230	5,040	17,900
1960	15,000	32,000	38,400	27,500	32,700	20,500	74,300	19,700	15,100	9,320	13,100	25,800	26,800
1961	11,800	11,600	10,300	7,160	27,300	40,500	39,600	29,500	19,100	9,580	7,430	6,720	18,400
1962	5,420	9,100	10,800	17,800	10,100	33,400	49,300	18,200	6,090	3,890	5,260	4,250	14,500
1963	7,640	13,800	15,000	10,100	9,270	38,800	39,100	18,400	8,180	5,780	5,600	4,280	14,600
1964	4,220	8,360	11,900	20,200	13,200	43,300	36,700	13,200	5,310	3,710	3,610	3,080	13,800
1965	3,350	3,680	7,250	7,090	18,300	14,600	25,400	11,200	4,320	3,520	3,400	4,920	8,810
1966	9,040	12,200	13,500	10,700	19,300	37,300	20,300	23,700	10,500	4,200	4,510	6,560	14,300
1967	8,270	11,000	13,200	17,200	13,700	27,400	48,700	26,600	10,700	8,640	10,300	6,640	16,700
1968	8,880	15,500	26,900	13,200	17,300	39,600	26,800	28,800	30,300	13,000	5,180	5,140	19,200
1969	5,760	19,300	23,200	17,600	18,700	32,600	57,700	26,600	13,100	8,630	11,700	5,810	20,300
1970	6,260	23,500	20,400	11,400	31,600	26,100	59,800	18,900	8,550	6,990	4,820	6,870	18,600
1971	10,800	16,800	15,000	12,100	24,100	42,700	50,100	44,800	10,400	6,980	13,400	18,300	22,100
1972	13,358	12,902	30,988	21,358	17,279	48,828	55,602	54,262	53,751	27,555	9,597	7,197	29,343
Average	10,300	15,500	20,300	20,100	25,300	36,200	46,900	27,000	15,100	8,700	7,800	7,900	

Source: U.S. Dept. of the Interior, Geological Survey, Water Resources Division, New York District.

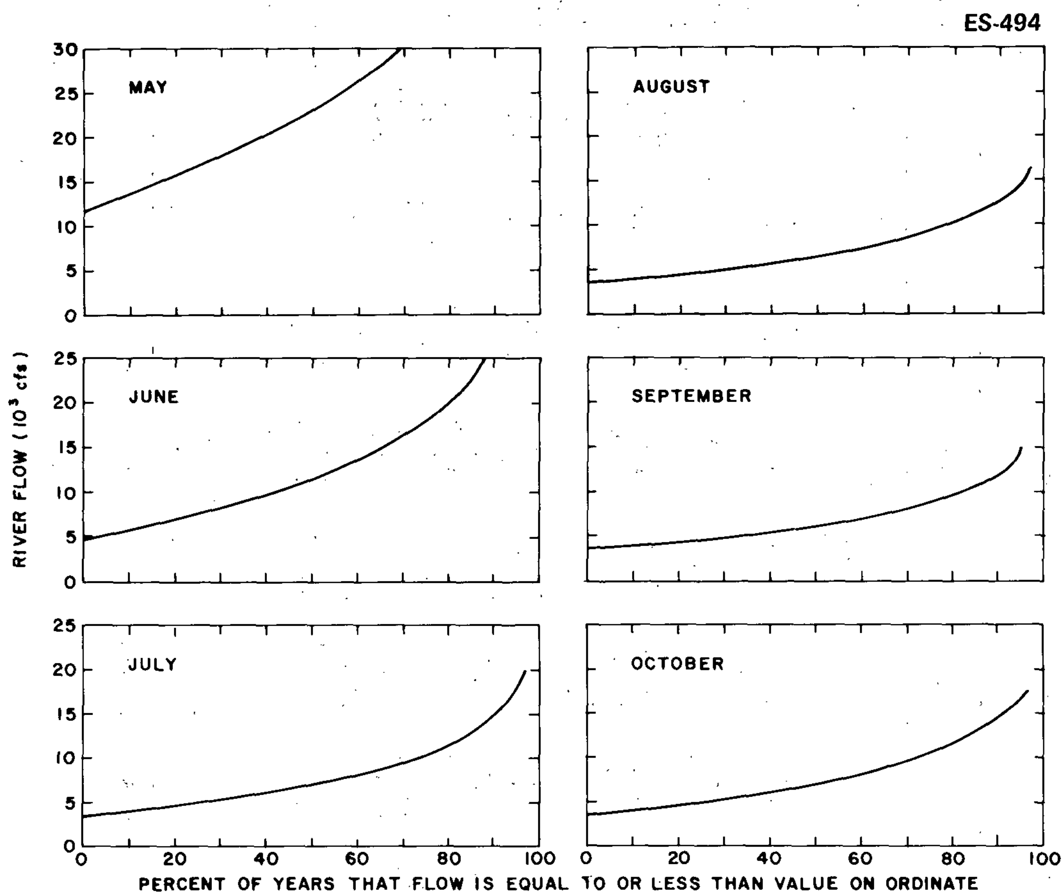

Fig. II-6. Frequency of occurrence of freshwater flow rates in the Hudson River, May–October based on monthly average values.

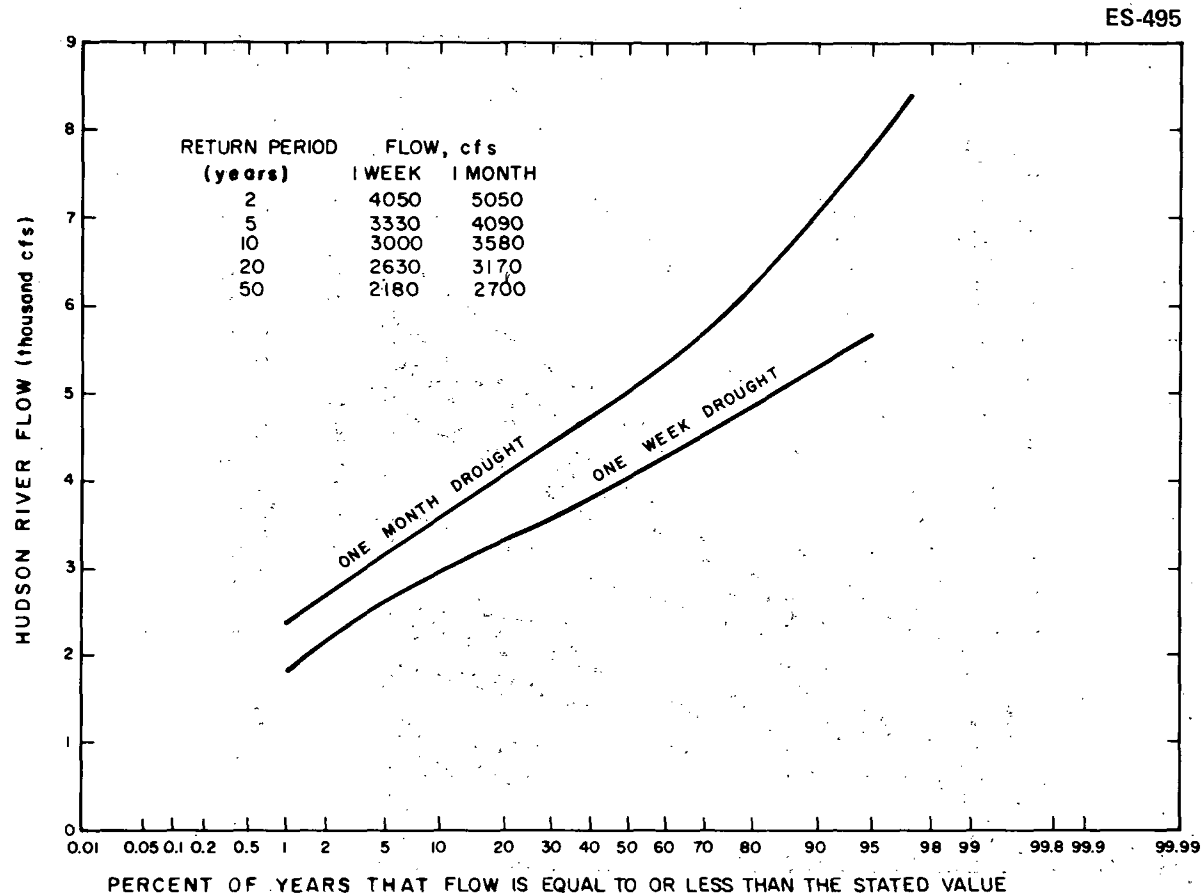

Fig. II-7. Monthly and weekly drought flow frequencies at Indian Point. Source: ER, IP-3, App. I, Fig. B-1.

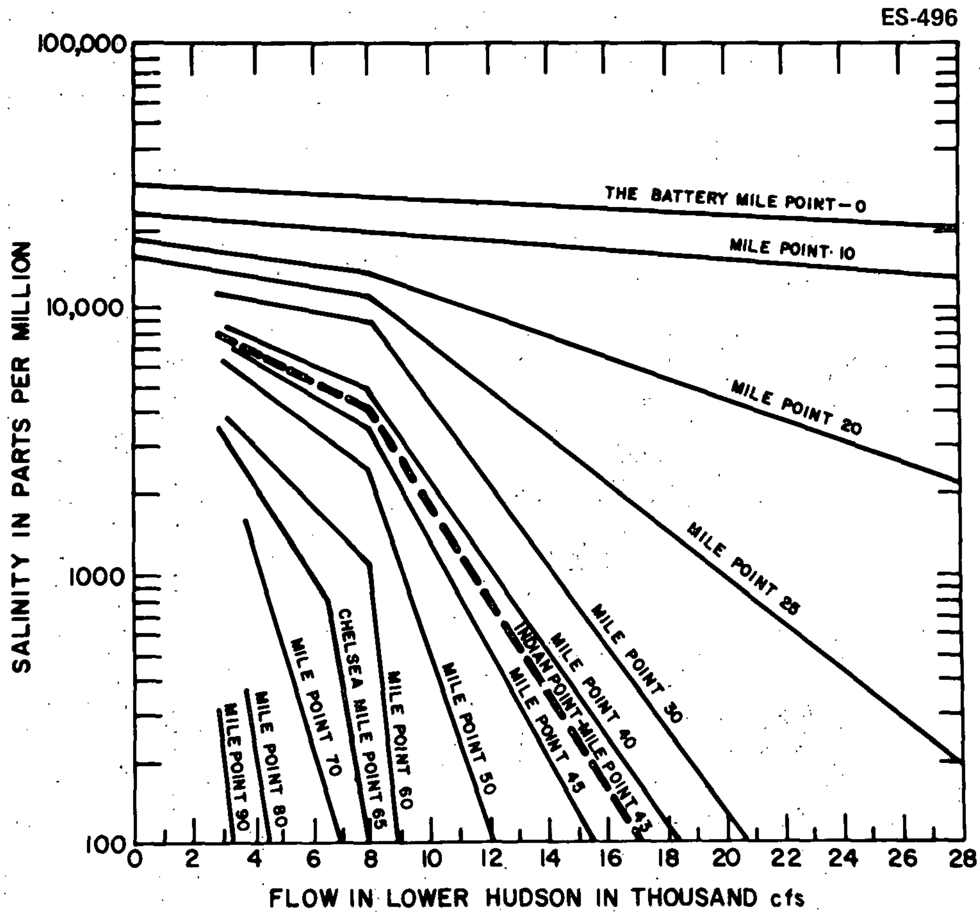

Fig. II-8. Hudson River salt intrusion curves — salinity averaged over tidal cycle and channel cross section. Source: ER, IP-3, App. I, Fig. B-5.

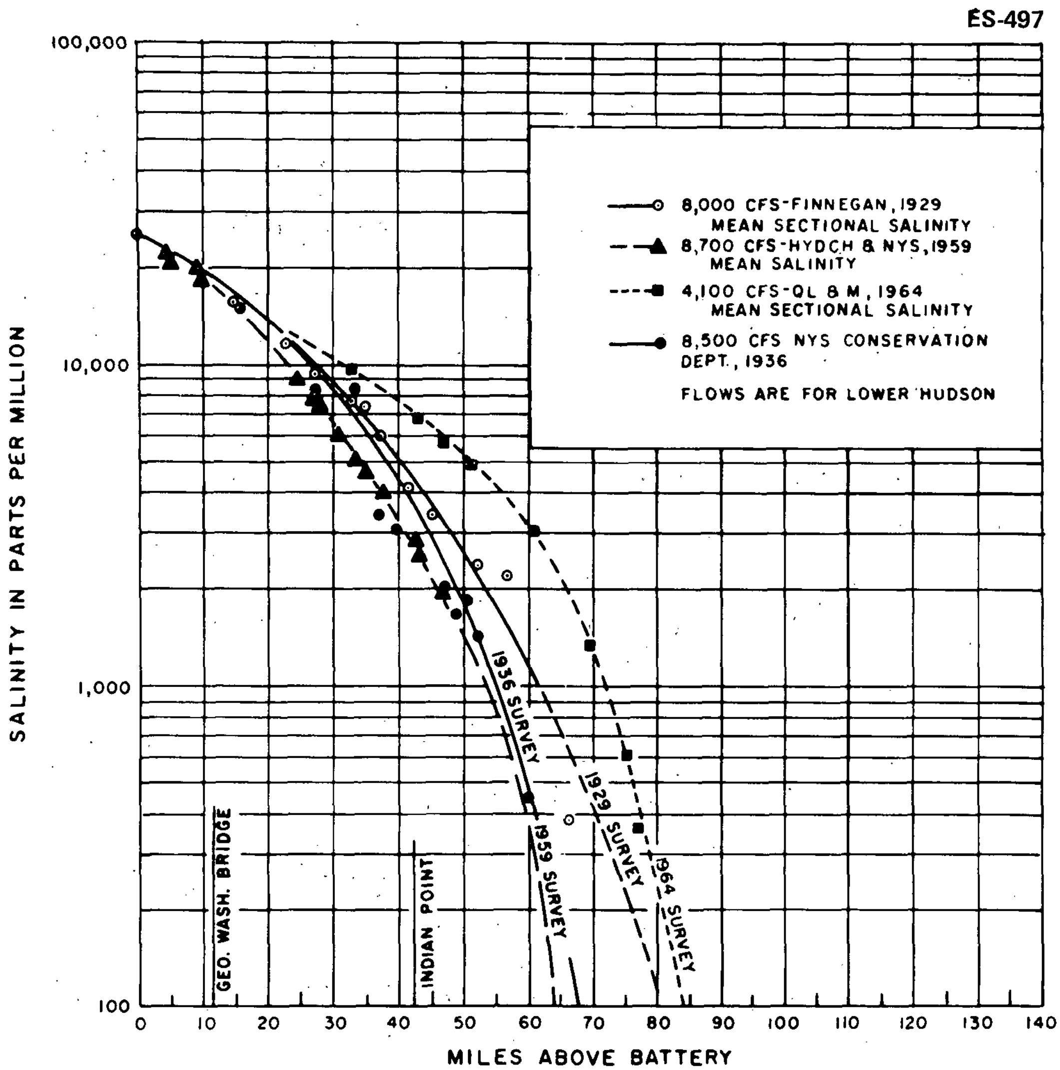

Fig. II-9. Longitudinal salinity distribution in the Hudson. Source: ER, IP-3, App. A, Fig. 11.

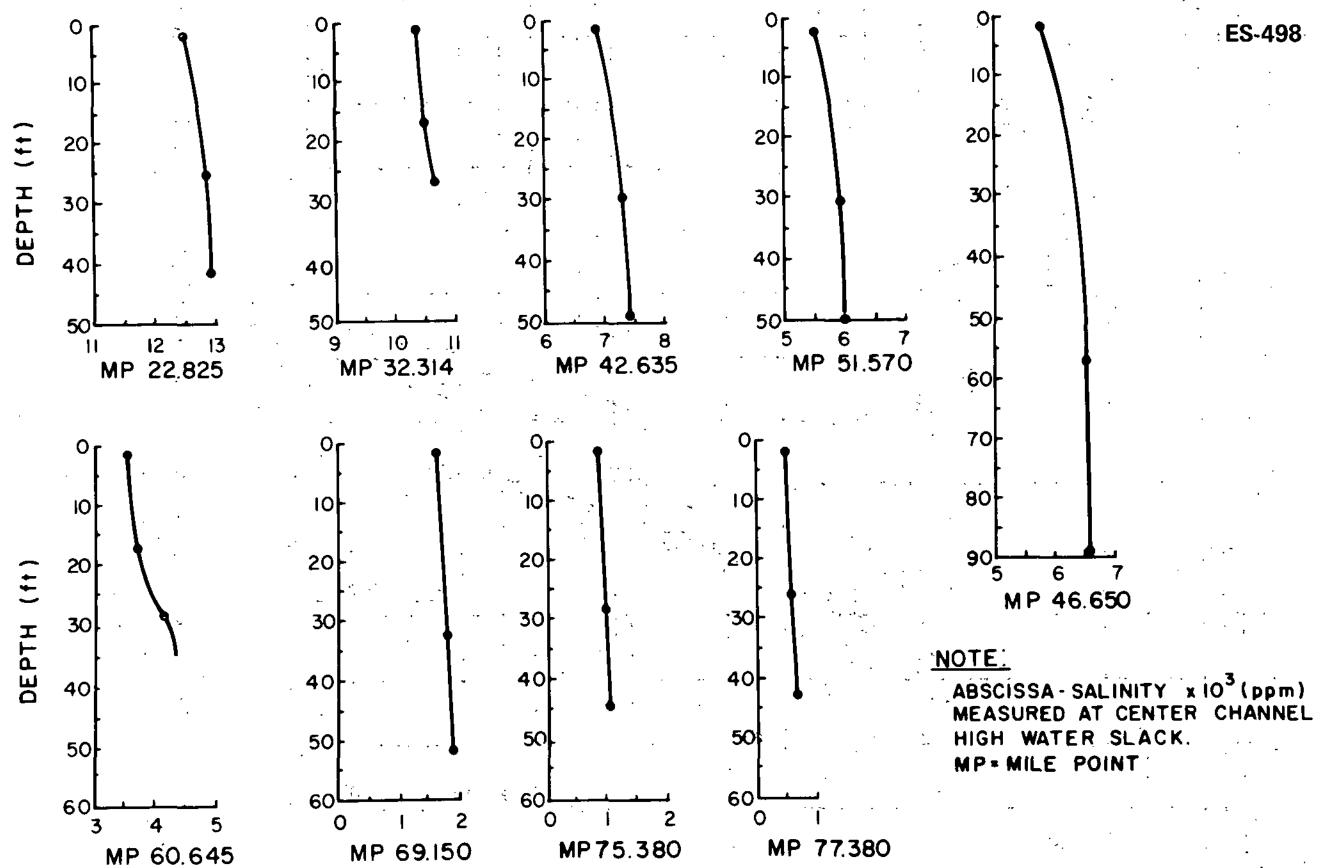

Fig. II-10. Variations of salinity with depth in the Hudson at nine locations. Source: ER, IP-3, App. M, Fig. 6.

factors, many of which are difficult to evaluate. The upstream intrusion of salt water is especially important in relationship to the dissipation of Plant effluents and to the migration of passive planktonic organisms.

The various flows do not, of course, exist independently; they combine to create a very complex flow pattern and velocity structure. In a partially mixed estuary like the Hudson, the major flow patterns involved are: (1) a two-layered horizontal flow with a net-tidal-averaged seaward flow in the upper layer and landward flow of more saline water in the lower layer; (2) a net-tidal-average vertical flow from the lower layer to the upper layer; and (3) vertical mixing in both directions between the two layers. Figure II-11 shows schematically these flow patterns. This concept of the two-layered flow is misleading if looked upon as if it were the description of conditions at any one instant. One must be aware that (1) no distinct interface exists between the two "layers," but vertical mixing extends throughout the depth (see Fig. II-10), mixing the fresher water downward and the more saline water upwards, although there are still two layers as far as the flow is concerned; (2) at no time except maybe at the time when the tidal flow reverses itself do such opposing lower and upper velocities exist at the same time because, as mentioned above, the tidal flow dominates; however, when averaged over a full tidal period, the resultant flows will indeed show such a distinction; and (3) because of the vigorous vertical mixing, the upper layer flows might not be identical with the flow available for removal and transporting conservative effluents introduced into it. Figure II-12 shows horizontal velocity observations throughout a tidal cycle,[11] as a function of depth, for 10% intervals throughout a tidal period. The "two-layer" flow reversal does not really exist as such. Only when the velocity profiles are averaged over a complete tidal period is there a net effect of two-layer flow.

The water temperature in the estuary of the Hudson River varies with the seasons; it falls to a low of 32°F in the winter and reaches high mean temperatures of 81°F, or more, in the flow channel and maximums of 90°F, or more, in the shallow, low-velocity, shoal areas. Temperature measurements taken by the applicant for the water intake of Indian Point Unit No. 1 during the summer months of 1967 showed a range of 74 to 80°F; in 1968 the range was 74 to 79°F.[12] In October 1966, the applicant recorded an intake temperature of 81°F. The applicant also collected temperature data from June to December 1969.[9] During the summer months, river temperatures ranged from 72 to 82°F, with the peak temperatures occurring in August. During 1969-1970, the river temperature ranged from 34°F during the January-March period to 81°F in August.[13] Table II-3 summarizes ten years (1959-1969) of

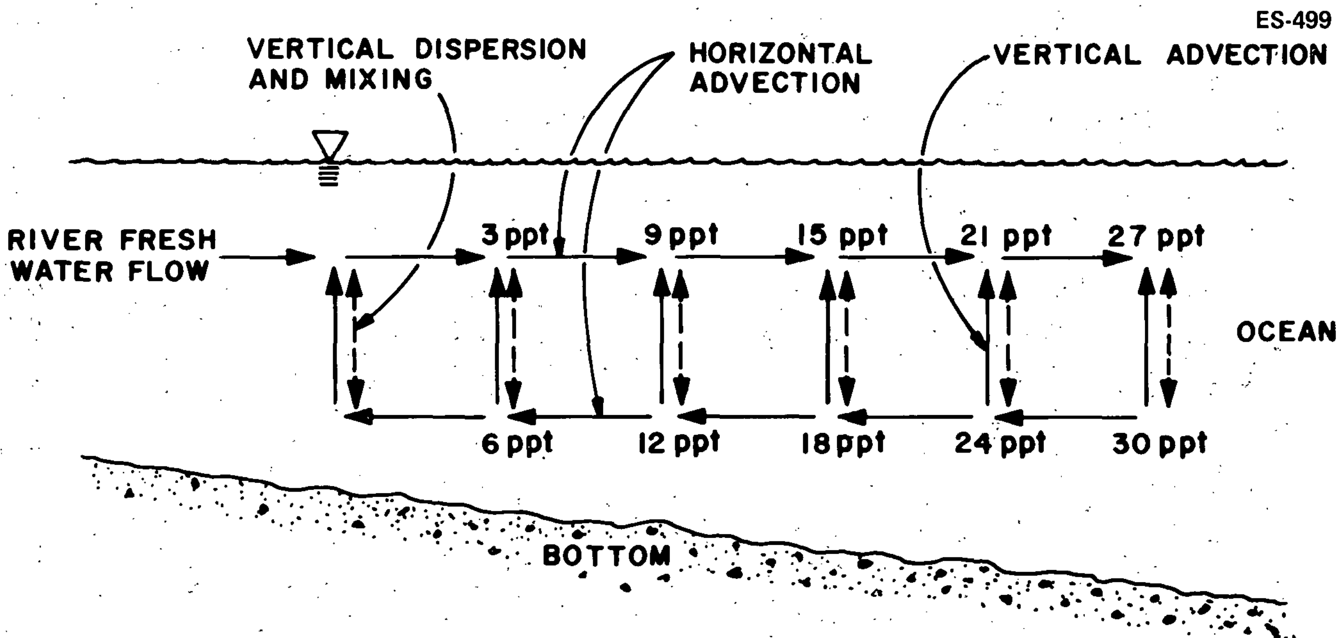

Fig. II-11. Schematic of flow pattern and salinity distribution (ppt) in a partially mixed estuary.

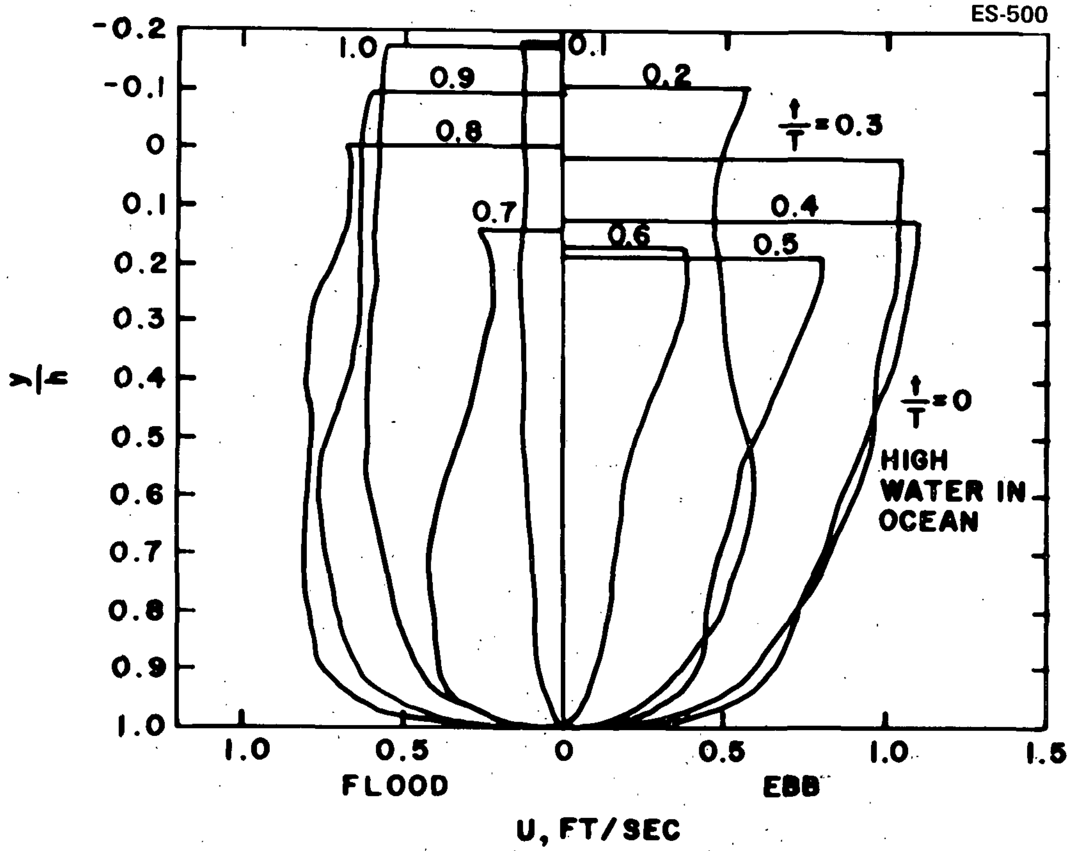

Fig. II-12. Horizontal velocities throughout a tidal cycle. Source: D. R. F. Harleman, "Estuarine Modeling: An Assessment," Environmental Protection Agency, Document 16070 DZV 02/71, February 1971, Chapter 3.

Table II-3. Ten-year (1959–1969) average Hudson River temperatures (°F) in the vicinity of Indian Point

Date	May		June		July		August		September		October	
	Maximum	Mean	Maximum	Mean	Maximum	Mean	Maximum	Mean	Maximum	Mean	Maximum	Mean
1	57.0	51.4	67.0	63.1	79.0	74.4	81.0	77.8	78.0	76.0	73.0	69.3
2	57.0	52.2	67.0	63.7	75.0	74.1	81.0	78.0	78.0	75.9	73.0	68.9
3	59.0	52.2	68.0	63.7	76.0	74.3	81.0	78.0	78.0	75.9	73.0	68.7
4	59.0	52.9	68.0	64.0	76.0	74.1	81.0	77.8	78.0	75.9	72.0	67.9
5	59.0	53.2	67.0	64.4	76.0	74.0	81.0	77.8	79.0	75.5	72.0	67.7
6	59.0	53.4	68.0	64.7	76.0	73.6	81.0	77.4	79.0	75.2	72.0	66.6
7	59.0	54.1	68.0	65.3	76.0	74.0	81.0	77.4	79.0	74.8	71.0	66.6
8	59.0	54.6	68.0	65.9	76.0	74.4	81.0	77.4	79.0	74.8	71.0	66.3
9	59.0	54.7	69.0	66.4	76.0	74.5	81.0	77.5	78.0	74.5	71.0	66.1
10	59.0	55.2	70.0	67.0	77.0	75.1	81.0	77.5	78.0	74.8	71.0	65.9
11	61.0	55.4	70.0	67.5	78.0	75.1	80.0	77.3	79.0	74.8	71.0	65.7
12	61.0	55.7	71.0	67.8	79.0	75.6	80.0	77.3	79.0	74.5	71.0	65.5
13	61.0	55.9	70.0	68.0	79.0	75.8	79.0	76.9	79.0	74.3	70.0	65.2
14	63.0	56.4	70.0	68.4	80.0	75.8	80.0	77.0	79.0	73.8	70.0	65.0
15	63.0	56.6	71.0	68.8	81.0	75.8	80.0	76.8	80.0	73.5	68.0	64.7
16	59.0	56.5	71.0	68.8	81.0	76.0	80.0	76.5	79.0	73.1	68.0	64.6
17	59.0	56.8	72.0	68.9	80.0	76.0	80.0	76.4	78.0	72.8	68.0	64.6
18	63.0	58.1	71.0	69.0	80.0	76.3	80.0	76.4	76.0	72.1	68.0	64.4
19	63.0	58.4	70.0	68.9	80.0	76.4	80.0	76.3	76.0	72.4	67.0	63.6
20	63.0	58.9	71.0	69.1	80.0	76.5	80.0	76.8	76.0	71.9	66.0	63.3
21	63.0	59.1	71.0	69.6	79.0	76.8	81.0	76.5	76.0	71.6	66.0	62.9
22	63.0	59.7	72.0	70.4	79.0	76.9	81.0	76.9	74.0	70.9	64.0	62.2
23	63.0	59.7	72.0	70.5	79.0	77.0	80.0	76.8	75.0	71.1	64.0	62.2
24	63.0	60.3	73.0	71.1	79.0	77.1	79.0	76.3	73.0	70.4	64.0	61.6
25	65.0	61.1	73.0	71.3	80.0	77.4	79.0	76.7	75.0	70.5	64.0	61.4
26	65.0	61.7	73.0	71.2	80.0	77.2	79.0	76.6	75.0	70.3	64.0	60.9
27	65.0	61.9	73.0	71.2	81.0	77.7	79.0	76.2	75.0	69.6	64.0	60.8
28	65.0	62.0	76.0	72.3	79.0	77.2	78.0	76.3	75.0	69.9	63.0	60.5
29	65.0	61.8	76.0	72.8	81.0	77.4	79.0	76.4	74.0	69.3	63.0	60.0
30	67.0	62.6	78.0	73.3	80.0	77.3	78.0	76.0	73.0	68.7	61.0	59.4
31	66.0	62.6			81.0	77.7	78.0	76.1			61.0	59.2

Source: U.S. Geological Survey data supplied by applicant (ER, IP-3, Suppl. 11, Table 9-1).

U.S. Geological Survey daily average river temperature data for the vicinity of Indian Point as supplied by the applicant for the summer months of May through October. Maximums of 81°F and means of 78°F are listed. The applicant stated the opinion, however, that these temperatures may not exactly correspond to temperatures that can be expected at the Indian Point Plant water intakes, because insolation (solar radiation on the water surface) and other effects may have affected the measured temperature (ER, IP-3, Suppl. 11, p. 9-1).

In a Report of Inquiry on Indian Point Unit No. 1, submitted by the Commission's Division of Compliance in October 1971 (see vol. II, Fig. B-4 and attachment B-3[12]), there is detailed information on temperature measurements made by New York University. Portions of these data are given in Table II-4. These measurements indicate that the maximum river temperature at the Indian Point Plant water intakes could be above 81°F in the month of August. The temperatures given in Table II-4 were measured at three stations (east bank, mid-river, and west bank) located across a river section at Indian Point. Since Indian Point Unit No. 1 and the Lovett Station were in operation, this may have affected the water temperature.

Some of the most recent temperature data taken by Texas Instruments and supplied by the applicant were weekly values taken between May 27 and September 23, 1973.[14] A summary of these data is shown in Table II-5. The maximums are undoubtedly in the shallow areas, or perhaps were influenced by thermal discharges into the river. The river mean for about 140 miles upstream of the mouth for the week of August 5 was 81.5°F, and between River Miles 54 and 60 was 82.9°F (the Indian Point Plant is at River Mile 43). The river maximum temperature exceeded 85°F for seven weeks, with a high of 91.4°F for the week of July 29. The New York State Department of Environmental Conservation (NYSDEC) automatic monitoring station located at Verplanck about 1.5 miles downstream of the Indian Point Plant provided some 1973 high readings, as follows:

Week of —	Weekly average (°F)	Maximum daily (°F)
July 29	79.2	79.6
Aug. 5	80.9	81.8
Aug. 12	81.0	81.2
Aug. 20	78.5	81.2
Aug. 26	80.2	81.3
Sept. 2	80.6	82.2

Manual monitoring stations of the NYSDEC in the vicinity of Indian Point at River Miles 40.5 and 46.2 gave readings of 80.6°F on August 1 and on August 8, 1973.

Table II.4. River temperature data taken by New York University

Sampling date	Sampling station	Temperature (°F)		Depth (ft)
		Top	Bottom	
July 16 (1968)	East	77.0	*a*	25
	Mid	77.4	76.8	40
	West	78.1	76.6	20
July 30	East	79.2	78.8	27
	Mid	80.1	79.2	50
	West	78.2	78.4	27
Aug. 14	East	80.2	80.1	12
	Mid	81.3	80.6	45
	West	80.6	80.2	26
Aug. 27	East	80.6	79.9	13
	Mid	81.3	79.7	52
	West	80.4	79.9	20
Sept. 10	East	77.0	76.3	30
	Mid	78.4	76.1	50
	West	76.6	76.1	18
Sept. 27	East	75.6	75.2	50
	Mid	75.4	75.4	60
	West	75.7	75.7	30
Oct. 8	East	79.8	68.9	75
	Mid	70.5	69.6	75
	West	70.3	70.2	32
May 5 (1969)	East	55.0	54.2	42
	Mid	56.3	54.5	54
	West	55.4	54.4	27
June 9	East	70.7	70.0	48
	Mid	70.2	69.4	54
	West	70.2	69.8	22

[a]Not available.

Source: Division of Compliance, "Report of Inquiry into Allegations Concerning Operation of Indian Point-1 Plant of Consolidated Edison Company (for Period of August 1962 to June 1970)," U.S. Atomic Energy Commission, October 1971, Attachment B-3.

Table II-5. Maximum and mean Hudson River temperature (°F) sampled by week, May 27 to Sept. 23, 1973

Week of –	Maximum	Mean[a] for river miles 10–151	Mean[a] for river miles 54–60
May 27	79.7	63.5	59.9
June 3	68.0	65.5	65.3
June 10	80.2	69.7	73.8
June 17	79.3	73.4	71.2
June 24	78.8	75.6	75.4
July 1	79.7	76.6	76.8
July 8	84.2	77.0	76.6
July 15	89.6	77.9	77.0
July 22	87.8	79.7	81.9
July 29	91.4	80.0	79.7
Aug. 5	86.0	81.5	82.9
Aug. 12	84.6	79.3	80.4
Aug. 19	81.5	79.3	77.9
Aug. 26	86.0	81.3	84.2
Sept. 2	85.1	81.3	84.2
Sept. 9	80.4	74.3	79.0
Sept. 16	77.0	80.0	71.1

[a]The Indian Point Station is at river mile 43.

Source: Texas Instruments, Inc., "Fisheries Survey of the Hudson River, March–July 1973," vol. III, prepared for Consolidated Edison Company of New York, Inc., March 1974, Table G-3.

The data available to the staff at the present time are insufficient to serve as a basis for estimating the frequency of occurrence of various temperatures in the Hudson at Indian Point. The applicant provided data for the frequency of occurrence of average temperatures for the month of August at the Lovett Station (located about one mile downstream of Indian Point) for the period 1958 to 1965, as shown in Fig. II-13. Based on Fig. II-13, an average monthly intake temperature of 79.7°F will occur 10% of the time. Frequency data for shorter periods are not currently available to the staff.

Two of the factors most strongly affecting the Hudson River water temperatures are the thermal discharges into the river from power stations and other sources and the rates at which heat is gained or lost from the atmosphere due to solar radiation, back radiation, evaporation, conduction, and convection. The applicant provided an estimate of the coefficient of heat exchange between the river and the atmosphere shown in Fig. II-14. The values range from a minimum of about 80 Btu/day$\cdot$ft$^2\cdot$°F in the winter months to a maximum of about 140 Btu/day$\cdot$ft$^2\cdot$°F in the summer. Table II-6 summarizes the meteorological data used by the applicant to calculate the heat exchange rates for 1964 and 1966 (ER, IP-3, App. I, Table B-5). A statistical evaluation of the occurrence of various values of the heat exchange coefficient is given in Sect. V.C.1.b(3).

2. Groundwater

The closest municipal water supply intakes are the Castle Point Veteran's Hospital and the Chelsea Pumping Station for the City of New York, both of which are located about 20 miles upstream from Indian Point. The Hudson River is not used for drinking water purposes below the Indian Point site due to saltwater intrusion in the tidal estuary. The only public water supply from wells within 5 miles of the site is the Stony Point system on the west bank of the river.[15]

Most of the other local wells take water from the deeper bedrock aquifers. The applicant reports that almost all wells within 2 to 3 miles of Indian Point have been abandoned and connections have been made to public water supply systems. Danger of contamination of the local groundwater supplies is minimal. Leaks and spills near the Plant would largely sink into the ground and be slowly carried to the river by the groundwater flow. Because of the direction of groundwater movement, contamination of offsite groundwater supplies by radioactive materials released in normal operation at the Plant site is very remote.[16]

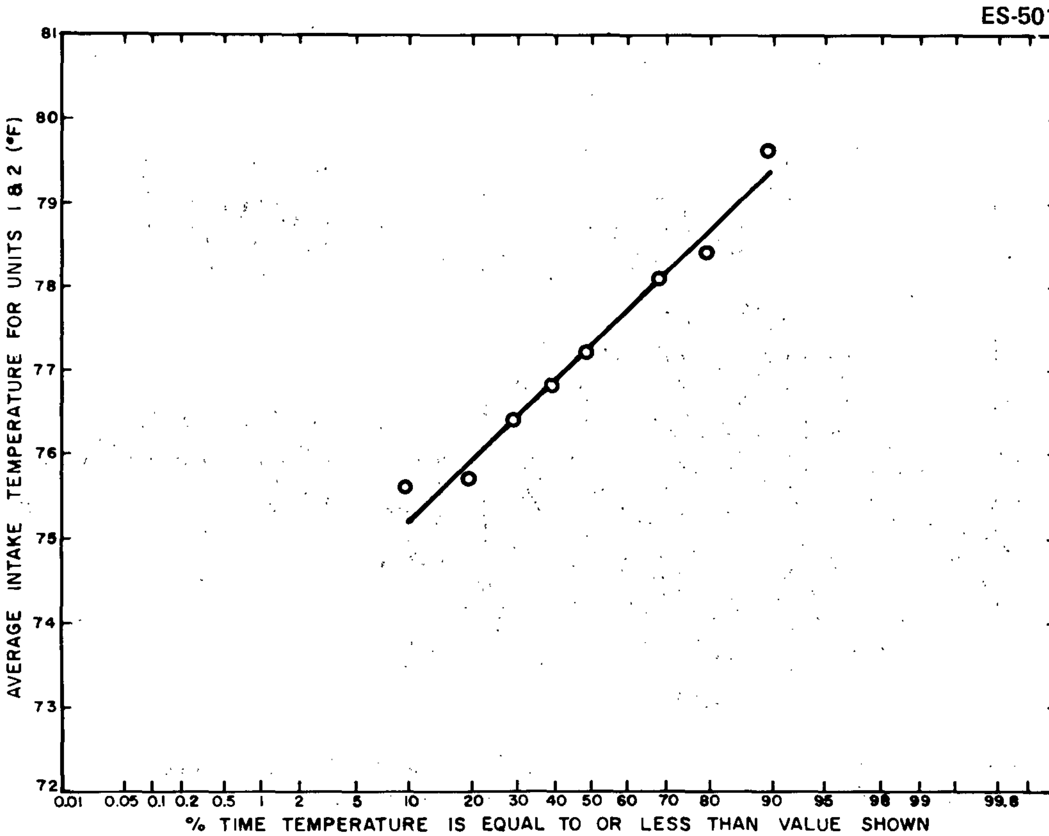

Fig. II-13. Frequency of occurrence of average monthly intake temperature at Lovett, August 1958-1965. Source: ER, IP-3, App. EE(1), Fig. 9A.

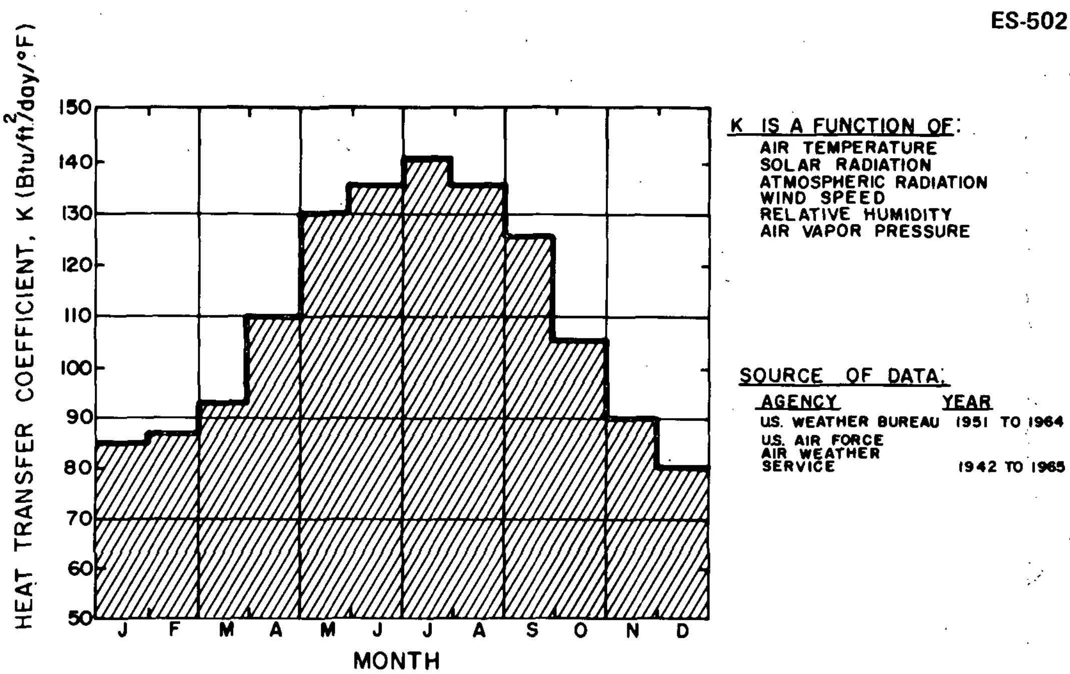

Fig. II-14. Water surface heat transfer in the Hudson River near Indian Point. Source: ER, IP-3, App. EE(1), Fig. 9.

Table II-6. Meteorological data used in heat budget analysis

Parameter	January 1964	March 1964	August 1966	September 1966	October 1966	November 1966
Air temperature, °F	28	36.6	75.3	63.8	53.4	45.3
Relative humidity, %	56	55.8	63	74	68	72.5
Wind speed, mph	10.8	10.4	7.4	8.0	8.8	8.9
Air vapor pressure, mm Hg	4.5	4.75	16.5	12.7	7.9	6.7
Saturation vapor pressure, mm Hg	5	5	24.5	20.8	14.5	9.5
Solar radiation, Btu/ft^2/day	620	1140	1690	1230	1140	577
Water temperature, °F	34.6	35.7	77.8	73	62.5	51

Source: ER, IP-3, App. I, Table B-5.

3. Geology and Geography

The three reactor containment buildings at Indian Point are built on a hard, dark gray, metamorphosed dolomitic limestone;[15] the waste holdup tank pit and east side of the primary auxiliary building are built on caissons. The limestone rock is well bedded and dips steeply to the southeast. It is also much fractured and jointed, which makes it irregularly permeable. There has been little solution along the joints, and the rock is not cavernous. Even without grouting, the rock is very strong and more than capable of carrying any load that will be placed on it at the site. The bedrock was covered with only a few feet of glacial till. This was removed in the construction area, as was the limestone down to grade, and any weak, fractured limestone below grade. The rock surface was then treated with a lean cement mix, and the concrete foundations were poured directly on the treated rock. The rock was not pressure-grouted.

The U.S. Geological Survey, consultants to the Commission, have reported in Appendix D of the Safety Evaluation Report issued on February 20, 1969, that "there are no known active faults or other geologic structures in the area that could be expected to localize earthquakes in the immediate vicinity of the site. Although several ancient faults occur in the area, none appears to have been tectonically active since glacial times, or for at least the past several hundred thousand years."

Although no faults are known to exist on the site,[17] a major fault has been mapped extending into the Hudson River from the eastern shore in a line approximately 3,000 ft northwest of the site. This fault extends over 20 miles to the northeast of the site and may join faults west of the river which extend into New Jersey to the southwest. One of these faults to the southwest, the Ramapo Fault, separates rocks of Precambrian age (over 800 million years old) from those of the Triassic age (200 million years old) and represents considerable displacement. On the east side of the river within 3 miles both north and south of the site are several faults with at least several hundred feet of mappable offset. Earthquakes have been felt in the area, including one of Intensity VII (Modified Mercalli) in New York City in 1737 and 1884.[18] The New York State Atomic Energy Council and the State Geological Survey have expressed concern about the adequacy of the seismic design of the Indian Point Plants with respect to potential earthquakes on the Ramapo Fault, which passes less than 1 mile from the Plant site. A discussion of these concerns and the plans to resolve these concerns are presented in Sect. XII.I.16 and 18. The staff's review indicated that the Ramapo Fault is not "capable" as defined in Appendix A to 10 CFR 100. Detailed discussion of the staff's investigation into the seismic issues of the site is presented in Suppl. 1 to the Safety Evaluation Report.

The Indian Point site is surrounded on all sides by high ground ranging from 600 to 1,000 ft above sea level. Along the winding Hudson River are steep, wooded slopes of the Dunderberg on the west bank and West Mountains to the northwest and Buckberg Mountain to the west-southwest. On the east side of the river where the site is located, the peaks are lower but include Spitzenberg and Blue Mountains. A number of lakes are scattered between the hills and mountains. The site itself is hilly, rising to about 150 ft above the river level. The site will have 80 acres of heavily wooded land and a freshwater lake.

4. Climate and Meteorological Data

Because the Hudson River is in a deep valley at Indian Point, the local microscale meteorological and climatological conditions are different within the valley than on the higher, surrounding ridges. At river level and 100 and 200 ft above river level, the winds are upstream by day and downstream by night more than a third of the time; a usual speed is 5 or 6 mph. The valley winds predominate during the inversions that prevail 42% of the time. The records for Bear Mountain, at 1,301-ft elevation, show winds from all directions during rainstorms; during thunderstorms, south winds are predominant, with few winds being found from north to east.[19] Tornadoes are almost unknown in New York; coastal hurricanes are the storms that bring the most wind.[20] The probability per year of a tornado striking a point in the area of the Plant is 0.00048.[18] Precipitation averages 46 in./year and is rather uniform month by month; the measured annual range is from 36 to 63 in. Because of greater evaporation and soil retentiveness in summer and because of snow in winter, the flow of the Hudson River is not uniform through the year but is high in spring and low in late summer. Mean ambient air temperatures near Indian Point vary from 28°F in January to 75°F in July, with extremes of -19°F and 105°F.

Several meteorological studies of atmospheric diffusion conditions have been based on onsite data. The initial onsite meteorological measurement program was conducted during the years 1956 and 1957.[19,21,22] The program consisted of measurements of wind speed and temperature taken on a 300-ft tower. Data on the joint frequency distribution of wind direction and speed were taken at the 100-ft level and vertical temperature differences between the 150- and 7-ft levels were measured. These data were presented in Exhibit L-5 for Indian Point Unit No. 1 (Docket No. 50-003). The total joint frequency data recovery for this period is not now known, because the data were presented as fractions of recovered data and the original records were not kept.

Another meteorological study was conducted during the years 1969 and 1970. This study was conducted primarily to describe the diurnal wind direction reversals in the Hudson River valley. Measurements of wind and temperature were made on a 100-ft tower in the same location as the now dismantled 300-ft tower and at other stations along the Hudson River located within 5 miles of the site. Data collected in this program were taken for the period November 26, 1969-October 1, 1970, with a recovery rate near 80%. Joint frequency distributions of wind direction and speed by vertical temperature difference class were not presented in this study. The applicant concluded, however, that the annual average statistics of wind direction and speed and of vertical temperature difference were substantially the same as the 1956-1957 data, thereby indicating that meteorological conditions are reasonably consistent from year to year. Diurnal valley flow wind reversals were found whenever the winds aloft were very light.

More recent data were acquired by the applicant during the years 1970-1972 utilizing the 100-ft tower. These data provided the basis for making a meteorological analysis of the site in accordance with current staff practices and verified the representativeness of the 1956-1957 data.

The staff practice is to utilize, for offsite dose calculations, meteorological data that have been collected for at least one continuous year with a data recovery rate of at least 90%. Due to numerous equipment failures, the applicant's meteorological data recovery rate was often below 90% during the 1970-1972 years.

For use in its accident analyses, the staff constructed a composite year of data where the recovery rate was 95%. This composite year consisted of January-July 1970, August 1971, September-October 1972, and November-December 1970. (See Table 2.6-1 of Suppl. 16 to FFDSAR, April 9, 1973.)

Additional modifications of the applicant's data were made to have the data conform with present staff methods. The applicant recorded wind speeds and directions at the 100-ft elevation while temperatures were measured at the 95-ft and 7-ft levels. The wind speed measurements were adjusted (by the staff) to represent wind speeds at a level of 33 ft (the height assumed for ground level release calculations) by use of a power law extrapolation. The temperature differences between the readings at the 95-ft and 7-ft levels were extrapolated to temperature differences simulating recording instruments at 150-ft and 30-ft levels. This new vertical temperature difference calculated by the staff utilized a logarithmic method to extrapolate the measured vertical temperature difference.

Additional data were submitted by the applicant in support of other meteorological models. In Suppl. 14 of the FFDSAR, the applicant presented an analysis of four diffusion conditions: the "split sigma model" to allow for greater wind meander; a procedure to allow for diffusion to the distance of the actual site boundary by direction instead of the minimum site boundary; a procedure to allow for the effect of averaging diffusion conditions over a 2-hr period; and a turbulent building-wake diffusion model developed from New York University wind tunnel tests. The application of any one of these four meteorological models would result in significant reductions in the calculated offsite doses. Although the staff felt that these meteorological models have some merit, they were not accepted at this time. Among the reasons for not accepting these proposed meteorological models was the concern that the instruments that recorded the basic data were not sufficiently accurate in the wind speed range of interest.

The staff concluded that the applicant did not provide sufficient justification for the use of these meteorological models for evaluating the radiological consequences of accidents at this site; consequently, the staff used its own, more conservative meteorological models. Utilizing standard staff practices, an evaluation of the meteorological diffusion characteristics of the site was made for both accident analysis and routine release analysis purposes.

The evaluation of the calculated offsite doses resulting from radioactive releases due to postulated accidents requires calculations of the relative concentration, χ/Q, for the first 30 days following an assumed accident. The impact of routine radioactive releases requires calculations of an annually averaged χ/Q. These relative concentrations were then incorporated into dose analyses.

Accident dose analyses utilize calculated χ/Q values that vary with time. The staff uses its most conservative assumptions when calculating the χ/Q values for the first 8 hr following an assumed accident. Additional credit is given for diffusion and spread of the gaseous plume for time periods beyond the first 8 hr.

The calculated dose at the minimum exclusion radius (350 m) at the end of the first 2 hr and the 30-day dose at the low population zone (1,100 m) must be within the limits of 10 CFR 100.

In the evaluation of the diffusion of short-term (0 to 2 hr) accidental releases from the plant, a ground level release was assumed with a building wake factor, cA, of 1,000 m^2. When using the composite year of data (1970-1972), the relative concentration, χ/Q (which is exceeded 5% of the time), was calculated to be 1.8×10^{-3} sec/m^3 at the minimum exclusion radius of 350 m.

This relative concentration is equivalent to a dispersion condition produced by Pasquill type F stability and a wind speed of 0.7 m/sec, with the building wake effect being limited to a factor of 3 over the diffusion condition produced by a point source. A similar analysis of the 1956-1957 data tends to confirm these results. The staff's meteorological consultant, the National Oceanic and Atmospheric Administration (NOAA), has calculated a similar χ/Q value, and the applicant estimates a value which is 40% lower than staff calculations. (Higher χ/Q values result in larger calculated doses.)

In the staff evaluation of the diffusion conditions associated with routine effluent release, the maximum annual average relative concentration, 2.8×10^{-5} sec/m^3, was calculated to the south-southwest of the Plant at the site boundary (350 m from the center of the containment vessel). Both the applicant and NOAA have presented values which are in essential agreement with the staff's.

As discussed in Sect. V.E of this Environmental Statement concerning effluent releases, the maximum annual average concentration at a location 7 miles south-southwest of the Plant is 2.4×10^{-7} sec/m^3.

The meteorological data used in the calculation of radiological doses and in the calculation of salt deposition from cooling towers, considered as an alternative cooling method as compared with once-through cooling, are given in Appendix E. The applicant is compiling meteorological data at a 400-ft tower and with balloons for determining the meteorological effects from cooling towers. Both the 400-ft and 100-ft towers are located at sites about 100 ft above sea level.

The staff has concluded that the composite year of data presented in the FFDSAR provides a reasonable basis for estimating atmospheric diffusion conditions during accidental and routine gaseous effluent releases from the Plant. Subsequent data collection and analysis are not expected to change staff estimates significantly, because the data from the years 1956, 1957, and 1969 confirm the climatic representativeness of the data for the composite year. The applicant, however, is required to conduct a meteorological monitoring program for compiling continuous data in accordance with Environmental Technical Specifications to satisfy the requirements of the contingency plan for Indian Point as well as for determining the impact of cooling towers.

5. Special Terrestrial Environmental Considerations

The Indian Point site has no unique natural environmental values such as a natural wildlife sanctuary, forested areas, geysers, or caverns. The site is surrounded by geographically interesting terrain such as the forested mountains, but the facility, as currently planned, is not expected to have any influence on the terrain.

F. ECOLOGY OF THE SITE AND ENVIRONS

1. Terrestrial Biota

Clearing for construction purposes, development of parking and staging areas, and erection of temporary and permanent facilities have affected approximately 50% of the 239-acre site (Fig. II-2). Remaining areas are largely wooded, with a well-developed mixed-oak and eastern hemlock stand over the northernmost portion of the site.

The applicant's consultants have recently prepared a floral survey of the site and adjacent areas and have conducted quantitative sampling of the aboveground vegetation at several representative locations within a 2-mile radius of the reactor complex (ER, IP-3, App. FF, p. II-1). Dominant overstory species at sampling point No. 1 (Fig. II-2) include white oak (*Quercus alba*), red oak (*Q. rubra*), eastern hemlock (*Tsuga canadensis*), and river birch (*Betula nigra*). A predominance of red oak, chestnut oak (*Q. prinus*), and shagbark hickory (*Carya ovata*) were noted within sampling area No. 2. Area No. 3 includes planted white pine (*Pinus strobus*), with some black oak (*Fraxinus nigra*), black cherry (*Prunus serotina*), and maple (*Acer* sp.). Understory species common to all areas include yellow poplar (*Liriodendron tulipifera*), sassafras (*Sassafras albidum*), sumac (*Rhus* sp.), catalpa (*Catalpa bignonioides*), and various other species typical of a mixed eastern deciduous stand. Shrub and herbaceous layers include Virginia creeper (*Parthenocissus quinquefolia*), poison ivy (*Rhus radicans*), wild grape (*Vitis aestivalis*), swamp junkberry (*Amelanchier intermedia*), and various perennial weeds.

No surveys of mammalian and avian species have been conducted by the applicant (ER, IP-3, App. FF, p. II-16). Any survey taken would be subject to change because of the construction activity at the site for over the past 20 years. They would be expected to consist of squirrels, chipmunks, and a variety of songbirds common to deciduous forests of the eastern United States (e.g., red-eyed vireo, redstart, eastern wood peewee). No rare and/or endangered species of plants or wildlife have been identified within the immediate area.

2. Aquatic Biota

The aquatic biota of the area is diverse. Aquatic species found in the area by several investigators have been tabulated in Tables II-7 through II-9.[9,10,23-33] The principal aquatic primary producers in the vicinity of Indian Point are phytoplankton. The high turbidity and deep water do not provide a good habitat for the development of extensive communities of periphyton or rooted vascular aquatics in the immediate vicinity of the Plant. Such communities, however, exist within the area that will be affected by operations at Indian Point. Howells and Weaver[23] studied the phytoplankton at Indian Point and found members of some 53 genera of planktonic algae.

The zooplankton of the area includes specimens of most major groups.[34] In general, the zooplanktonic species include protozoans, occasional medusal coelenterates, rotifers, nemertines, and microcrustaceans (including Cladocera, Ostracoda, Mysidacea, Copepoda, Amphipoda, Isopoda, and some Decapoda). The larvae and juveniles of larger pelagic forms are also included. Included in this category are the larval stages of barnacles (Cirrepedia), larger decapods, annelids, and mollusks and early developmental stages of several fish species.

a. Decomposers

Bacterial communities in the Hudson at Indian Point are important constituents of the biological community. These organisms are important in that they are responsible for the decomposition of organic matter, which thereby provides the raw materials for growth of phytoplankton. Thus, bacterial decomposition prevents loss of important materials from biological systems. Bacteria play an additional role by assimilating dissolved organic matter in the water. The bacteria themselves are food for much of the microscopic zooplankton and thereby contribute directly to production at higher trophic levels.[34]

For most bacteria characteristic of waters in the temperate region, the optimum temperature for growth is about 95°F. Temperatures lower than this optimum inhibit growth. If optimal conditions for growth could be maintained and there was no predation, a single minute bacterial cell could produce 2.4×10^{25} bacteria per ton of river water in 48 hr.[35] The generation times of bacteria in natural waters, however, are relatively short and are regulated by available food supplies. The generation times of bacteria in a series of impoundments range from 9 to 120 hr. In comparison, the maximum net production of phytoplankton in Lake Erken is about 150% of the standing crop per day.[34] This indicates that, for short periods, the generation time of the phytoplankton may roughly

Table II-7. Aquatic plants which have been identified in collections from the Hudson River near Indian Point

Chrysophyta (yellow-green algae)
- *Acnanthes*
- *Asterionella formosa*
- *Asterionella gracillima*
- *Asterionella japonica*
- *Bacillaria paradoxa*
- *Bacteriastrum*
- *Campylodiscus*
- *Cocconeis*
- *Coscinodiscus denarius*
- *Coscinodiscus* sp.
- *Cyclotella glomerata*
- *Cyclotella kutzingiana*
- *Cymbella*
- *Diatoma anceps*
- *Diploneis*
- *Ditylium brightwellii*
- *Eunotia*
- *Fragilaria capucina*
- *Fragilaria crotonensis*
- *Gomphonema*
- *Melosira ambigua*
- *Melosira borreri*
- *Melosira crenulata* (*italica*)
- *Melosira granulata*
- *Melosira italica*
- *Melosira varians*
- *Meridion*
- *Navicula*
- *Navicula acicularis*
- *Nitzschia iridula*
- *Nitzschia longissima*
- *Nitzschia paradoxa*
- *Nitzschia sigma*
- *Nitzschia sigmoidea*
- *Pinnularia*
- *Pleurosigma* (*Gyrosigma*)
- *Rhizosolenia*
- *Skeletonema*
- *Stephanodiscus dubins*
- *Surirella brightwellii*
- *Synedra ulva*
- *Tabellaria*

Chlorophyta (green algae)
- *Actinastrum*
- *Characium*
- *Cladophora*
- *Closterium*
- *Coelastrum*
- *Eudorina*
- *Mougeotia*
- *Oedogonium*
- *Pediastrum boryanum*
- *Pediastrum duplex*
- *Pediastrum simplex*
- *Phormidium* (*Sphaerotilus*)
- *Scenedesmus dimorphus*
- *Scenedesmus quadricauda*
- *Spirogyra*
- *Tetraspora*
- *Thallassiothrix longissima*
- *Thallassiothrix nitzschiodes*
- *Ulothrix*

Cyanophyta (blue-green algae)
- *Anabaena*
- *Aphanizomenon*
- *Chaetoceros*
- *Gomphosphaeria*
- *Lyngbya*
- *Microcystis*
- *Microspora*
- *Oscillatoria tenuis*
- *Rivularia*

Vascular plants
- *Chara* sp.
- *Eleocharis* sp. (spike rush)
- *Elodea* sp.
- *Myriophyllum* sp.
- *Najas flexilis*
- *Nitella* sp.
- *Pontederia cordata* (pickerel weed)
- *Potomogeton crispus*
- *Potomogeton pectinatus*
- *Potomogeton perfoliatus*
- *Potomogeton* sp.
- *Spartina* sp.
- *Trapa natans* (water chestnut)
- *Vallisneria americana*

Table II-8. Aquatic animals which have been identified in the Hudson River near Indian Point

- Protozoa
  - Ciliata
    - *Coleps*
    - *Colpidium*
    - *Colpoda*
    - *Epistylis*
    - *Euplotes*
    - *Frontonia*
    - *Glaucoma*
    - *Hypotricha*
    - *Lionotus*
    - *Oxytricha*
    - *Paramecium*
    - *Prorodon discolor*
    - *Stentor*
    - *Stylonychia*
    - *Tetrahymena*
    - *Tentinnidium*
    - *Urostyla*
    - *Vorticella*
    - *Zoothamnium*
  - Flagellata
    - *Astasiid*
    - *Bodo*
    - *Ceratium hirundinella*
    - *Euglena*
    - *Mastigamoeba* sp.
    - *Ochromonas* sp.
    - *Phacus*
    - *Polytomella* sp.
    - *Synura*
  - Sarcodina
    - *Amoeba proteus*
    - *Arcella* sp.
    - *Cyclidium* sp.
    - *Difflugia* sp.
    - Foraminifera
- Coelenterata
    - *Blackfordia manhattensis*
    - *Campanularia calceolifera*
    - *Cordylophora lacustris*
    - *Gonionemus*
    - *Hydra oligactis*
    - *Nemopsis bachei*
    - *Podocoryne*
    - *Sagartia leucolena*
  - Ctenophora
    - *Mnemiopsis leidyi*
- Platyhelminthes
  - Turbellaria
    - *Planaria*
    - *Planocera* sp.
    - Rhabdocoela
  - Nemertinea (Rhynchocoela)
    - *Amphiporous* sp.
  - Rotifera
    - *Asplanchna*
    - *Brachionus calyciflorus*
    - *Brachionus quadridentata*
    - *Filinia* sp.
    - *Hydratina* sp.
    - *Kellicottia longispina*
    - *Keratella cochlearis*
    - *Keratella quadrata*
    - *Notholca*
    - *Philodina* sp.
    - *Platyias* sp.
    - *Rotoria* sp.
    - *Seison*
    - *Trichocerca* sp.
  - Gastrotricha
  - Nematoda
  - Ectoprocta
    - *Ectoprocta crustulenta*
    - *Hyalinella*
  - Tardigrada
- Annelida
  - Hirudinea
    - *Piscicola punctata*
    - *Piscicola milneri*
  - Oligochaeta
    - *Aeolosoma* sp.
    - *Tubifex tubifex*
  - Polychaeta
    - *Hypaniola grayi*
    - *Nectochaete*
    - *Nereis succinea*
    - *Prionospio* sp.
    - *Spio setosa*
- Mollusca
  - Gastropoda
    - *Amnicola limosa*
    - *Bithinia tentaculata*
    - *Lymnaea*
    - *Physa* sp.
  - Pelecypoda
    - *Congeria leucophaeta* (mussel)
    - *Crassostrea virginica*
    - *Elliptio complana*
    - *Macoma balthica*
    - *Mya arenaria*
    - *Pisidium*
    - *Sphaerium* sp.
- Arthropoda
  - Crustacea
    - Cladocera
      - *Bosmina longirostris*
      - *Daphnia pulex*
      - *Diaphanosoma*
      - *Ephippium* sp.
      - *Leptodora kindti*
      - *Sida crystallina*
    - Copepoda
      - *Acartia discaudata*
      - *Acartia tonsa*
      - *Calanoid* sp.
      - *Canthocamptidae* sp.
      - *Canthocamptus microstaphylinus*
      - *Canuella elongata*
      - *Cyclops bicuspidatus*

Table II-8 (continued)

Cyclops vernalis
Diaptomus ashlandi
Diaptomus pallidus
Ectinosoma curticorne
Epischura sp.
Eurytemora copepodid V.
Eurytemora hirundoides
Eurytemora lacustris
Harpactocoid sp.
Laophonte sp.
Microarthridion littorale
Amphipoda
Corophium volutator
Gammarus fasciatus
Leptocherius pinguis
Monoculoides edwardsi
Pontocrates norvegicus
Isopoda
Ancinus depressus
Cyathura carinata
Cyathura polita
Edotea montosa
Edotea triloba
Livoneca ovalis (fantail sowbug)
Mysidacea
Neomysis americana
Neomysis mercedis
Ostracoda
Cypris sp.
Decapoda
Callinectes sapidus (blue crab)
Crangon septemspinosa (brown crab)
Orconectes limosus
Palaemonetes intermedius ("shrimp")
Palaemonetes paludosus ("shrimp")
Rithropanopeus harrisii (mud crab)
Cirrepedia (barnacles)
Balanus improvisus
Insecta
Diptera
Pentaneura monalis
Chaoborus albipes (larvae)

Chordata
Cyclostomata
Petromyzontidae
Petromyzon marinus (sea lamprey)
Osteichthyes
Acipenseridae
Acipenser brevirostrum (shortnose sturgeon)
Acipenser oxyrhynchus (Atlantic sturgeon)
Anguillidae
Anguilla rostrata (American eel)
Atherinidae
Menidia beryllina (tidewater silverside)
Menidia menidia (Atlantic silverside)
Belonidae
Strongylura marina (Atlantic needlefish)
Carangidae
Caranx hippos (crevalle jack)
Catostomidae
Catostomus commersoni (white sucker)
Centrarchidae
Lepomis auritus (redbreast sunfish)
Lepomis gibbosus (pumpkinseed)
Lepomis macrochirus (bluegill)
Micropterus dolomieu (smallmouth bass)
Micropterus salmoides (largemouth bass)
Pomoxis nigromaculatus (black crappie)
Clupeidae
Alosa aestivalis (blueback herring)
Alosa pseudoharengus (alewife)
Alosa sapidissima (American shad)
Brevoortia tyrannus (Atlantic menhaden)
Dorosoma cepedianum (gizzard shad)
Cyprinidae
Carassius auratus (goldfish)
Cyprinus carpio (carp)
Notemigonus crysoleucas (golden shiner)
Notropis atherinoides (emerald shiner)
Notropis cornutus (common shiner)
Notropis hudsonius (spottail shiner)
Semotilus corporalis (fallfish)
Cyprinodontidae
Fundulus diaphanus (banded killifish)
Fundulus heteroclitus (mummichog)
Engraulidae
Anchoa mitchilli (bay anchovy)
Esocidae
Esox niger (chain pickerel)
Esox vermiculatus (grass pickerel)
Gadidae
Merluccius (silver hake)
Microgadus tomcod (Atlantic tomcod)
Urophycis chuss (squirrel hake)
Gasterosteidae
Apeltes quadracus (fourspine stickleback)
Gasterosteus aculeatus (threespine stickleback)
Ictaluridae
Ictalurus catus (white catfish)
Ictalurus melas (black bullhead)
Ictalurus nebulosus (brown bullhead)
Mugilidae
Mugil cephalus (striped mullet)
Mugil curema (white mullet)
Osmeridae
Osmerus mordax (rainbow smelt)
Percidae
Etheostoma nigrum (Johnny darter)
Etheostoma olmstedi (tessellated darter)
Perca flavescens (yellow perch)
Pleuronectidae
Pseudopleuronectes americanus (winter flounder)
Pomatomidae
Pomatomus saltatrix (bluefish)
Salmonidae
Salmo trutta (brown trout)
Sciaenidae
Cynoscion regalis (weakfish)

Table II-8 (continued)

Serranidae
- *Morone americana* (white perch)
- *Morone saxatilis* (striped bass)

Soleidae
- *Trinectes maculatus* (hogchoker)

Sparidae
- *Lagodon rhomboides* (pinfish)
- *Stenotomus chrysops* (scup)

Syngnathidae
- *Syngnathus fuscus* (northern pipefish)

Table II-9. List of free-swimming larvae of major forms at Indian Point which are subject to withdrawal with cooling water

Mollusca
- veliger larvae (gastropod and pelecypod)

Crustacea
- Copepoda
  - nauplii
  - metanauplii
- Decapoda
  - zooea larvae
  - megalops
- Cirrepedia (*Balanus* – barnacles)
  - nauplii
  - cypris

Osteichthyes (fishes)
- *Anguilla rostrata* (American eel)
- *Menidia menidia* (Atlantic silverside)
- *Alosa aestivalis* (blueback herring)
- *Alosa pseudoharengus* (alewife)
- *Anchoa mitchilli* (bay anchovy)
- *Microgadus tomcod* (Atlantic tomcod)
- *Osmerus mordax* (rainbow smelt)
- *Morone americanus* (white perch)
- *Morone saxatilis* (striped bass)

equal that of the bacteria. The growth of bacteria in natural water does not normally outstrip the growth of phytoplankton to such an extent that the bacteria continuously dominate the food supply of the zooplankton. On the contrary, only when the phytoplanktonic organisms die, releasing large quantities of nutrients for bacterial growth, do the bacteria temporarily increase their role as an energy source for the zooplankton.[34]

Bacterial densities in the Hudson River near Indian Point vary with the season. In the winter, the bacterial density may be as low as 1×10^6 per liter or less, while summertime densities may exceed 5×10^7 per liter.[36]

b. Primary Producers

Planktonic algae and organic detritus provide the basis for the food web of aquatic systems and are the principal food of most zooplankton[35] and many fish species as well.[23,37] At Indian Point the dominant algal species most of the year belong to the genus *Melosira* sp., with *Asterionella* sp. as a secondary dominant form. The abundance of these organisms varies from 5×10^5 to 6×10^6 per m^3 of river water. As the salinity builds up in the summer, the species composition changes in favor of more salt-tolerant forms, such as *Rhizosolenia* sp., *Chaetocerus* sp., and *Thalassiosira* sp. About 25 genera of algae (principally diatoms) are present in the area at all times.[23] Some variation in species composition across the river has been observed. When averaged for several months, there was little variability in the percentage composition of the major groups of phytoplankton across the river. Diatoms accounted for about 70% of the phytoplankton, green algae for about 23%, blue-green algae for about 5%, and all others less than 1%.[28]

As indicated above, algae may have a short generation time. Under optimum conditions, some species are capable of producing three generations per day. The normal population growth rate, however, is regulated by temperature, light, grazing by herbivores, and available nutrients.[38]

Many algae are capable of limited movement, but the movement is small in comparison with the movement of the water in their habitat; consequently, the turbulence and current of the river are primarily responsible for their distribution within the water.

In the Hudson, only those algae near the surface are able to capture energy from the sun to grow and reproduce. Since their distribution is largely regulated by the turbulent estuarine water currents, the phytoplanktonic organisms are not always in the upper photosynthetically active zone, which averages about 6 ft deep.[36] Even if all other factors were optimum, the generation time would still be much longer than predicted by laboratory analysis.

c. Consumers

(1) Zooplankton

The zooplankton is a diverse group of organisms that transform their generally less nutritious food (phytoplankton, bacteria, and organic detritus) into a form more readily utilized by larger organisms. These larger organisms include larger zooplankters, larval fish, and adults of several fish species, such as the bay anchovy, which utilize the zooplankton for food throughout their life cycle.

Many reproductive strategies are employed among zooplankton species. Protozoans generally reproduce by division of parent cells into two daughter cells. Under optimum conditions for growth, including food supply and temperature, protozoan populations can double from one to three times per day.[39]

Population growth of small crustaceans such as copepods and cladocerans is also very dependent on temperature, noticeably increasing as the temperature increases. Doubling times of 0.2 to 2.0 days have been observed for these organisms at temperatures of about 77°F. The population turnover rate (100% replacement by a new crop) may be as little as 4 days at 77°F but up to 22 days or longer when temperatures are low. One-quarter of a 28% average loss rate per day at summer temperatures has been attributed to predation.[40]

Many of the larger zooplankters, including amphipods, may reproduce during only one season a year. Their resiliency or capacity to recover from population decimation may be very limited compared with the microscopic forms, which can produce one or more generations per day and reproduce throughout the year.

Heinle[41] found that the upper thermal tolerance of the copepods *Arcatia tonsa* and *Eurytemora affinis* was between 86 and 95°F when the acclimation temperatures were 68 and 77°F. Growth rate and productivity of both species increased with increased temperature up to about 80.6°F. Above that temperature, the growth rate and productivity decreased.

The most abundant invertebrate utilized by fish, in a 1964 survey based upon examination of 190 fish stomachs, was the amphipod

Gammarus.[42] Dipteran larvae and pupae, adult insects, and smaller crustaceans such as cladocerans, copepods, and ostracods were also important components of the stomachs. The individual sizes of the invertebrates in the stomachs, however, varied with the sizes and ages of the fish caught.[42]

(2) Macroinvertebrates

This group of organisms includes bottom fauna, which live in or on the bottom deposits, and organisms that attach themselves to any hard surface. Larval stages of these organisms form a part of the zooplankton. Most of the larger invertebrate organisms (macro-benthos) that live in these habitats reproduce during only one season of the year, so that their ability to recover from a kill would be restricted, compared with many microbenthic forms which reproduce throughout the year.

Little is known about the quantitative aspects of these organisms in the Hudson River. This fauna, generally, appears sparse both in the Indian Point area and throughout the lower part of the estuary.[24,25,42] In deeper portions of the Hudson River north of Indian Point and through the Hudson gorge, grab samples commonly contain no specimens of macrobenthos.[9,10,23-26,28,34-43]

Benthic organisms common in the Indian Point area include *Balanus* sp. (barnacle), *Congeria* sp. (clam), polychaete worms, and *Gammarus* sp. (amphipod), which also occurs as a planktonic species.[9,10,26]

(3) Fish

As is typical of estuarine situations, there are many species of fish (see Table II-9). Included within these species are residents which are found in the area throughout the year. Other species are present in the area only during periods of high discharge of fresh water and the associated low salinity. Another group, composed principally of marine fishes, moves into the area during periods of intrusion of salt water. In addition to the resident species and those that move in and out of the Indian Point area with the salt front, there are seasonal migrants. Both anadromous* and catadromous** species pass the Indian Point area on their way to

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*Anadromous fish is a species that ascends rivers from the sea for spawning.

**Catadromous fish is a species that lives in fresh water but swims to sea water to spawn.

and from spawning grounds. From a biological standpoint, protection of the lower Hudson is most important in relation to the fish species that use the estuarine environment for purposes of reproduction and early development. A more detailed analysis of these species can be found in Appendix F of this Statement. Migratory fish in the area include striped bass, shad, alewife, smelt, sturgeon, blue-back herring, and eels. Principal resident fish are catfish, minnows, white perch, tomcod, and sunfish. The shad and striped bass are the two most important commercial species, and the striped bass is the most important sport fish.

d. Special Ecological Considerations

From an ecological standpoint, the most significant feature of the Hudson River at Indian Point is that it is an estuary. Because of this fact, the lower Hudson, including the Indian Point area, is a spawning and nursery area for species that populate not only the Hudson River but Long Island Sound and the Atlantic Ocean near New York. The most prominent of such species is the striped bass (FES, IP-2, App. V-3). There is considerable evidence that the Hudson River is a major spawning area for the striped bass living in Long Island Sound and in the Atlantic Ocean from New Jersey to New England. Besides being important commercially, the striped bass plays an important ecological role as a predatory fish. Several other anadromous species also use the Indian Point area as a spawning or nursery area or both. The applicant has identified one rare fish species, the Atlantic sturgeon, *Acipenser oxyrhynchus*, and one endangered species, the shortnose sturgeon, *A. brevirostrum*.

G. BACKGROUND RADIOLOGICAL CHARACTERISTICS

The radiological aspects of the area about the Plant are average for the region. The only conspicuous natural source in the area is the uranium ore in the Bear Mountain region. Otherwise, radiation from all other sources is below average for the U.S., as is typical of the northeastern rainbelt. Measured dose rate from natural background for the area is about 125 millirems/year. About one-third is from cosmic radiation, but the background could vary each year because of the variation in K-40 salt content of the estuary water; however, the variation should be very small. The New York State did find excess radiation from the uranium present in Bear Mountain; at one point a measurement taken about 1960 indicated that the background was as high as five times normal background. However, such information was not documented in any report available to the staff. See additional discussion on this subject in Sect. XII.I.21.

The applicant has been carrying out a radiological environmental surveillance program since 1958 prior to startup of Unit No. 1. Consequently, more than 15 years of baseline data that can be used to predict and evaluate the potential radiological effects of operation of Unit No. 3 is available prior to startup of Unit No. 3.

Postoperational values for selected samples from the Indian Point Unit No. 1 monitoring program are summarized in Table II-10 which can serve as preoperational data for Units Nos. 2 and 3.[44] The data were collected over a period from April-September 1972. This large accumulation of available data provides an adequate baseline to which the Units Nos. 2 and 3 impacts can be compared. The New York State Department of Health from 1958 to 1970 and, thereafter, the Department of Environmental Conservation have also carried out periodic checks on samples taken from various locations surrounding the site. Information gathered from this program has been summarized in reports in Appendices V and W in the ER, IP-3 and also Appendix G for the ER, IP-1. Results of preoperational radiological surveys indicated that the dominant factor that contributed to the background radioactive material in samples taken around the Indian Point site was the series of nuclear weapons testing conducted during 1958-1962.[45,46] The radiological environmental monitoring program is discussed in Sect. V.E.2e. The results to date indicate that the quantity of radioactive materials released from the Plants is too small to significantly affect the environs.

Table II-10. Selected representative sample data from the Radiological Environmental Monitoring Program taken in the area of Indian Point Unit No. 1

Samples	Measurement technique	Maximum	Average	Unit
Air particulates	Gross beta	0.59	0.15	pCi/m^3
Precipitation	Gross beta	365.1	208.3	pCi/liter
Well water	Gross beta	39.0	24.2	pCi/liter
Lake water	Gross beta	32.8	10.9	pCi/liter
Reservoir water	Gross beta	12	5.4	pCi/liter
Hudson River water	Gross beta	148.6	25.5	pCi/liter
Terrestrial vegetation	Gross beta	434.4	379.2	pCi/g
Soil	Gross beta	42.4	33.4	pCi/g
Fish	Gross beta	256.8	152.2	pCi/g
River aquatic vegetation	Gross beta	223.7	151.6	pCi/g
External gamma radiation	Gamma scan	12.6	10.7	μR/hr
Water samples	Tritium	8,520	5,335	pCi/liter

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III. THE PLANT

A. GENERAL

The Indian Point Nuclear Generating Plant consists of three Units. Unit No. 1 uses nuclear and oil-fueled components in combination to produce a net output of 265 MWe. It has been in commercial operation since October 1962 and has generated a cumulative total of 13,557,495 MWhr gross (as of December 6, 1974). Unit No. 2 uses nuclear fuel and has a net rated capacity of 873 MWe. On September 28, 1973, the applicant received a license to operate Unit No. 2 up to 100% of steady state power. The gross generation of power has amounted to 10,764,100 MWhr as of December 6, 1974. Unit No. 3, with construction about 92% complete in the fall of 1974, also uses nuclear fuel and has a net rated capacity of 965 MWe.

Waste heat from Units Nos. 1, 2, and 3 is dissipated by once-through cooling with water from the Hudson River. In Unit No. 3, cooling water is withdrawn from the Hudson River at a maximum rate of 840,000 gallons per minute (gpm) through six pumps at full capacity of 140,000 gpm each and six service water pumps of 5,000 gpm each for a total of 30,000 gpm for service water purposes. Upon passing through three condensers, the circulating cooling water is heated to about 15 F° above the background river water temperature and discharged into a common discharge canal with Units Nos. 1 and 2. The heated water is then discharged into the Hudson River through a submerged multiport discharge structure at a minimum velocity of 10 feet per second (fps). Dilution of the thermal discharges takes place by jet entrainment and by diffusion, with heat dissipation eventually occurring by surface heat exchange into the atmosphere.

B. EXTERNAL APPEARANCE

The containment buildings and turbine buildings are the major structures on the site (Fig. III-1). As viewed from the river, the turbine building for Units Nos. 1 and 2 is on the left (north) and that for Unit No. 3 on the right (south). The containment buildings are just behind and extend above the turbine buildings with Unit No. 2 on the left (north), Unit No. 3 on the right (south), and the smaller building for Unit No. 1 in the middle.

Only the Unit No. 1 stack and the upper parts of the three containment vessels are visible from Broadway and parts of Peekskill. For the most part, the Plant structures present an appearance similar to other industrial structures in the area. The appearance

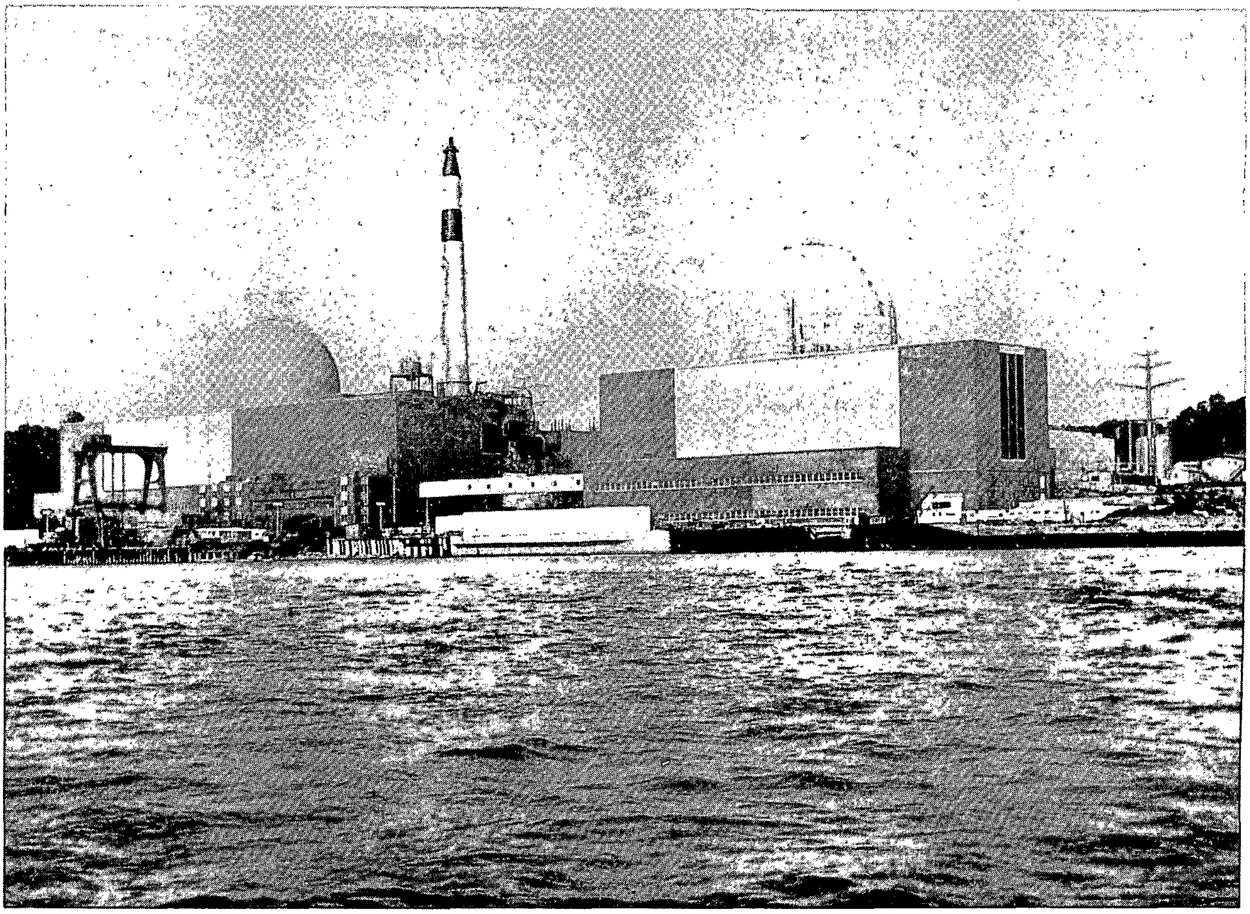

Fig. III-1. Photograph showing construction of Indian Point Unit No. 3.

of the Plants would be decidedly changed if an alternative closed-cycle cooling system as recommended by the staff in Sect. XI were installed.

C. TRANSMISSION LINES

Transmission facilities uniquely identifiable with Unit No. 3 consist of a truss framed into the turbine-generator building, four tubular-steel transmission poles (three double-circuit poles and one single-circuit pole) located within site boundaries, and two tubular-steel terminal structures at the Buchanan substation, 2,100 ft east of the site. Power from Unit No. 3 as well as from Units Nos. 1 and 2 will be transmitted on existing transmission facilities through the Buchanan substation to other substations to the New York City area and other highly populated sections around the metropolitan area in the applicant's service area on transmission lines shown in Fig. X-1 and described in Table X-2.

D. REACTOR AND STEAM-ELECTRIC SYSTEMS

All three Units utilize pressurized light-water nuclear reactors. Their descriptions have been given in detail in the applicant's *Final Facility Description and Safety Analysis Reports*[1,2] and have been summarized in the applicant's Environmental Reports (ER, IP-2, Sect. 2.1.2 and ER, IP-3, Sect. 3) and in the staff's Final Environmental Statement for Unit No. 2 (FES, IP-2, Sect. III.D). The license application for Unit No. 3 is for a power rating of 3,025 MWt as compared with 2,758 MWt for Unit No. 2.. The power levels for the three Units are summarized in Table III-1. The rated capacity is the capacity which is the basis for the license application. The maximum guaranteed capacity is the maximum output for which the vendor guarantees the turbine generators. The maximum calculated (design) capacity is the ultimate capacity that the applicant plans to achieve ("stretch" level).

Steam is generated to drive tandem-compound turbine-generator units located in adjacent secondary-system buildings. There is one turbine-generator for each Unit, and the turbine assemblies for Units Nos. 2 and 3 are essentially identical, each consisting of one high-pressure and three low-pressure turbines on a single shaft. Each of the low-pressure turbines exhausts into a separate single-pass condenser (with divided water boxes) cooled by water from the Hudson River.

Table III-1. Power levels for Indian Point Nuclear Generating Plant

	Unit No. 1	Unit No. 2	Unit No. 3
Rated capacity			
Reactor power, MWt	890[a]	2,758	3,025
Gross electrical power, MWe	285	906	1,001
Net electrical power, MWe	265	873	965
Maximum guaranteed capacity			
Reactor power, MWt	890	3,087	3,087
Gross electrical power, MWe	285	1,021	1,021
Net electrical power, MWe	265	986	986
Maximum calculated capacity			
Reactor power, MWt	890	3,216	3,216
Gross electrical power, MWe	285	1,068	1,068
Net electrical power, MWe	265	1,033	1,033

[a]615 MWt from nuclear component and 275 MWt from fossil-fueled component.

E. CONDENSER COOLING WATER SYSTEMS

1. General

The thermal efficiency of the heat-power cycles for all three Units is approximately 30%; therefore, for each kilowatt of electricity produced, about two kilowatts of heat must be rejected to the environment. The applicant plans to dispose of this heat in the Hudson River by use of once-through cooling water systems. Water will be pumped from the river through intake screen structures, through the turbine exhaust steam condensers, and returned to the river through a discharge canal and a common set of horizontal discharge ports located at the water's edge about 500 ft downstream of the intake openings for Unit No. 3. The general arrangement of the cooling water systems at Indian Point is shown schematically in Fig. III-2.

The amounts of heat rejected by Units Nos. 1, 2, and 3 and the water circulation rates are given in Table III-2. At rated capacity for Units Nos. 1 and 2 and at maximum calculated capacity for Unit No. 3, the total heat rejected to the river from the three Units is about 15.76 x 10^9 Btu/hr. At full circulating water flow of 2,058,000 gpm (4,585 cfs) for the three Units, the total average temperature rise of the water as it flows through the condensers is about 15.3 F°. During periods of low ambient river temperatures (below 40°F), about 40% of the discharge from each circulating

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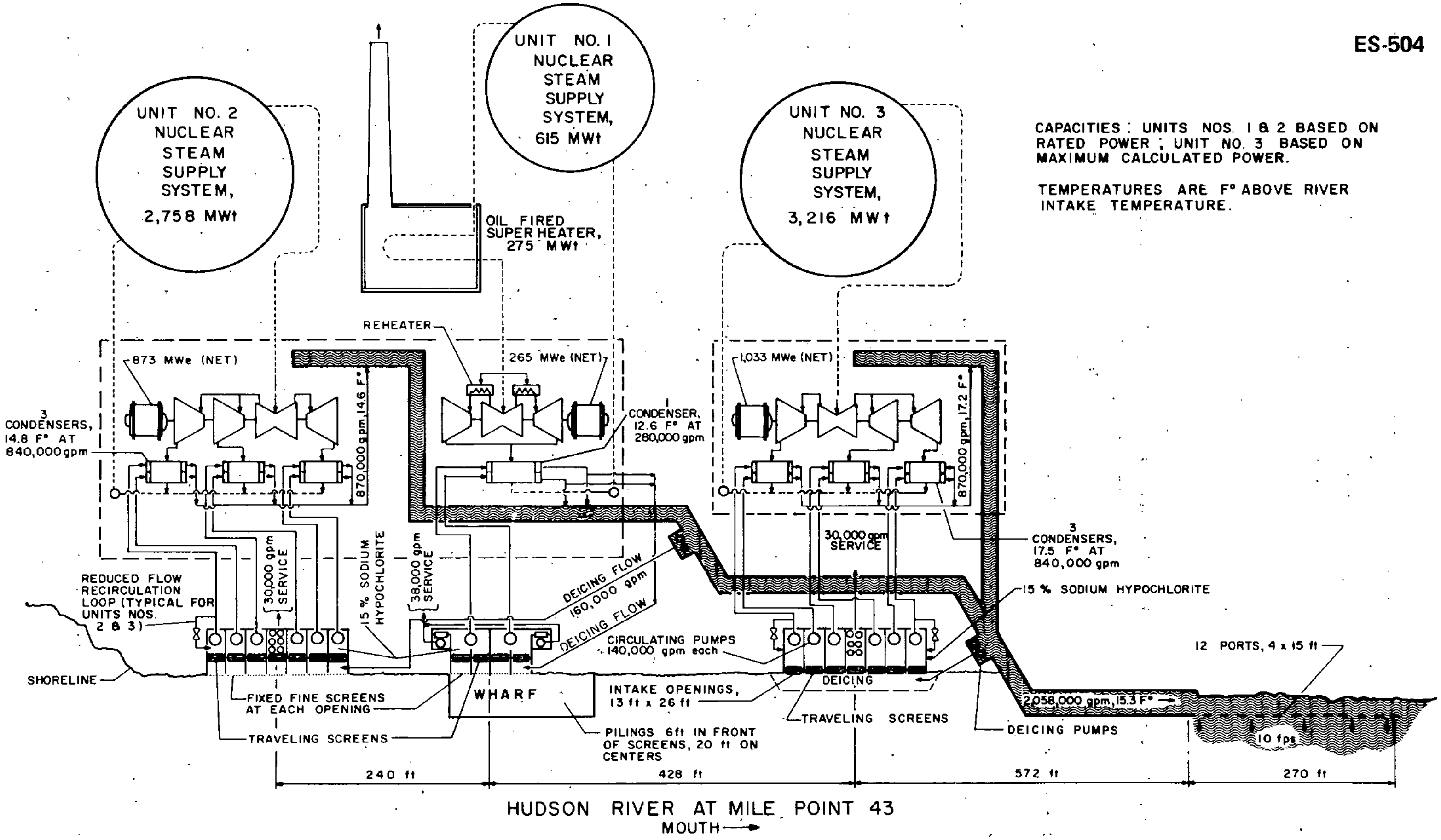

Fig. III-2. Schematic representation of Indian Point Plant cooling water systems.

Table III-2. Heat-rejection and water-circulation rates for Indian Point Nuclear Generating Station

	Unit No. 1	Unit No. 2	Unit No. 3	Total
Net electrical power, MWe[a]	265	873	1,033	2,171
Heat rejection, billions of Btu/hr				
Service water	0.150	0.100	0.140	0.390
Condensing water	1.765	6.250	7.350	15.365
Total	1.915	6.350	7.490	15.755
Normal water circulation rates, gpm				
Service water	38,000	30,000	30,000	98,000
Condensing water	280,000	840,000	840,000	1,960,000
Total	318,000	870,000	870,000	2,058,000
Water circulation rates at 60% flow, gpm				
Service water	38,000	30,000	30,000	98,000
Condensing water	168,000	504,000	504,000	1,176,000
Total	206,000	534,000	534,000	1,274,000
Temperature rise of water, F°				
Normal flow rate	12.0	14.6	17.2	15.3
60% of normal flow rate	18.6	23.8	28.0	24.7

[a]Rated capacity for Units Nos. 1 and 2, maximum calculated capacity for Unit No. 3.

water pump can be returned to the pump suction through a bypass to reduce the flow of water through the intake screens to about 60% of normal and thus reduce impingement and entrainment problems. The average temperature rise of the water in passing through the once-through cooling system under these reduced flow conditions is about 24.7 F°, as shown in Table III-2.

2. Intake System

There are a total of six identical condensing-water intake structures for Unit No. 3, each with a pumping capacity of 140,000 gpm, and one intake structure for service water, with a capacity of 30,000 gpm for the six service water pumps of 5,000-gpm capacity. The general layout of the intakes is shown in Fig. III-2. Unit No. 1 has one condenser with four intakes while Unit No. 2 and No. 3 have three condensers each with six intakes.

A sectional drawing of a condensing water intake structure is shown diagrammatically in Fig. III-3. Each intake opening is 13 ft, 4 in. wide by 26 ft high, with the top elevation about 1 ft below the standard sea level datum* in a "skimmer wall" arrangement to retard entry of floating ice and debris. Water enters the opening and flows through trash racks consisting of 1/2-in. x 3-in. vertical steel bars set on 3-1/2-in. centers. The water velocity through the racks is about 1 fps. (Unit No. 3 does not have bubble curtains and fixed fine screens at the intake structure as required at Units Nos. 1 and 2.) The fixed screens (as at Unit No. 2) are not necessary at Unit No. 3, because the traveling screens at Unit No. 3 are at the river face of the intake structure so that fish cannot be trapped in the forebays as was the case with the Unit No. 2 design. The air curtains are being tested for possible use with the Unit No. 3 intake.

The water then passes through vertical traveling screens having 3/8-in. openings; the screens are rotated periodically as needed to remove debris. The water velocity at the face of the screens is 1.5 to 2 fps under full flow conditions and about 60% of this (0.9 to 1.2 fps) at reduced flow conditions. The upstream portion of the screen moves vertically upwards, and at the top of the travel of the screen, service water jets flush trash from the screen into a discharge trough. (The applicant states that this

*Mean low water is 1 ft below the U.S. Coast and Geodetic Survey sea level datum (FES, IP-2, Vol. II, p. 162).

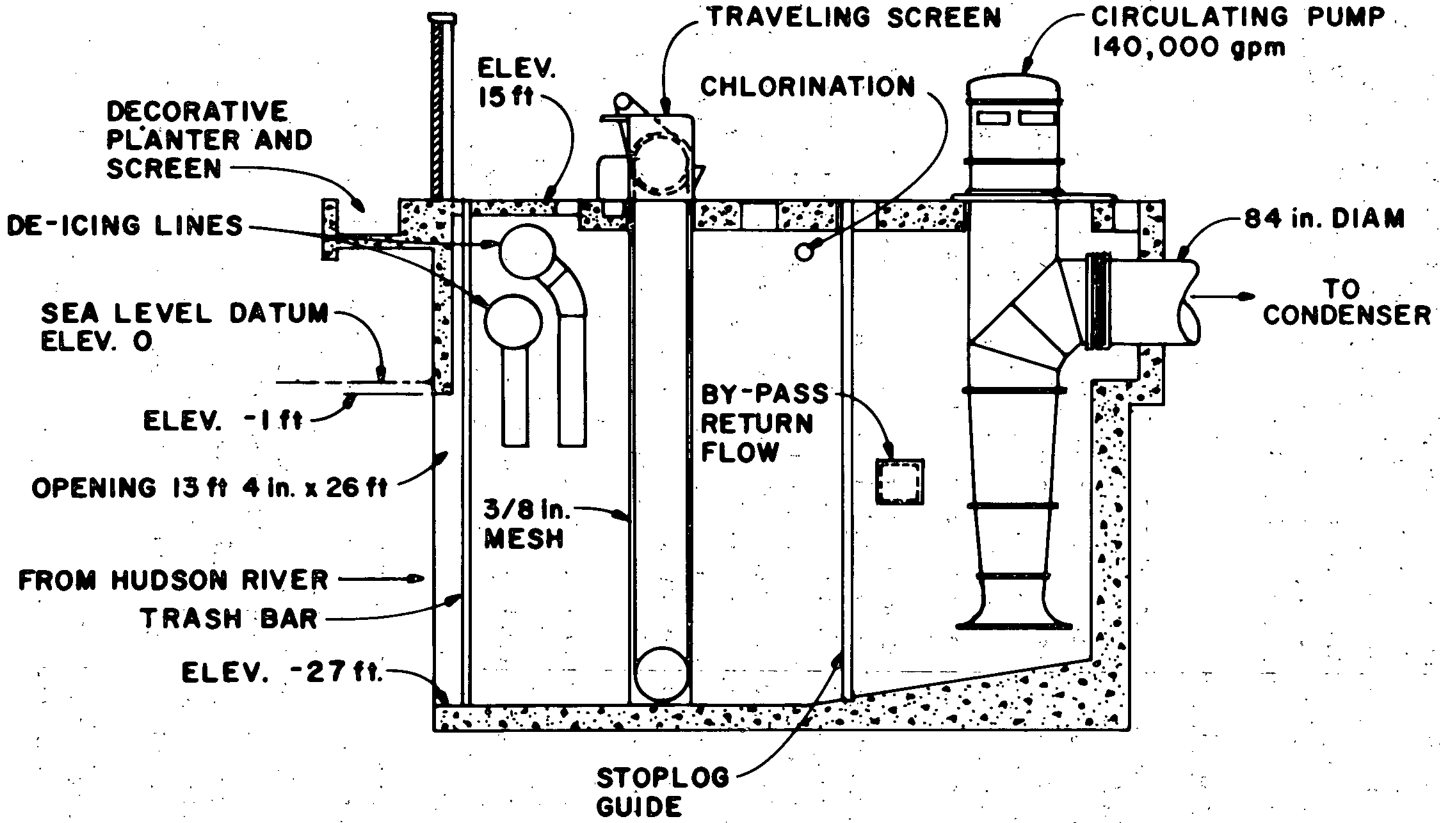

Fig. III-3. Diagrammatic section through condensing water intake structure (total of 6 for Indian Point Unit No. 3).

trash from the Plant will be disposed of by a commercial contractor rather than being returned to the river. The applicant is evaluating fish pumps and determining the proportion of fish expected to survive the fish pump by species, size, and season of the year.) During winter icing conditions, warmed water can be pumped directly from the condenser outlet at Unit No. 1 or from the discharge canal for Units Nos. 2 and 3 back to the intake structure forebay ahead of the traveling screens to help prevent blockage of the screens by ice particles. These de-icing pumps are indicated in Fig. III-2, and the location of the two 54-in.-diam pipes discharging into the intake structure cell are shown in Fig. III-3. The two de-icing pumps per Unit are isolated from the discharge canal by means of individual slide gates. With the two de-icing pumps in operation, a reduced flow to 344,000 gpm with 60% flow through the circulating pumps can occur. The applicant states that the intake structure wall (below elevation 0 ft) between the trash bars and the traveling screens contains openings to provide a lateral escape-way for fish and crustaceans and to allow longitudinal washing of the screen face by river currents (ER, IP-3, p. 9-2).

After leaving the traveling screens, the intake water passes into a cell where a biocide (sodium hypochlorite) is added to prevent excessive fouling of the cooling water system. The rates of chlorination are discussed in Sect. V.C.2. The intake water then passes through an opening provided with vertical guides for "stop logs" that can be inserted during maintenance operations to prevent entry of river water into the pump bay.

The water then enters the pump bay and is admitted to the pump suction near the bottom of the cell, as indicated in Fig. III-3. During the periods of reduced condensing water flow mentioned above, bypassed water is returned to the pump bay through an opening in the cell wall just upstream of the pump suction, also shown in Fig. III-3. The water from each 140,000-gpm pump is discharged at about 18 psig and at a velocity of about 8 fps through an 84-in.-diam pipe leading to a water box on one of the three turbine exhaust steam condensers. The water boxes are divided, with each pump supplying one-half of the required condenser flow. With this arrangement, if one pump on each condenser is not running or if a cooling system is otherwise inoperative, the electrical output of the turbine generator is reduced, but shutdown of the Plant is not necessary.

On leaving the intake water box, the water passes through 1-in.-OD No. 18 BWG admiralty-metal straight condensing tubes 50 ft long at a velocity of about 6 fps (at full flow) and exits after a single pass into the discharge water box. At this point the water will be at less than atmospheric pressure (by a few psi) and will have experienced a temperature rise of about 17 F° under full flow conditions and 25 F° under reduced flow conditions. The water then flows downward and exits beneath the surface of the water in the discharge canal.

The discharge canal system for the three Units is indicated schematically in Fig. III-2. The canal for Unit No. 3 is 18 ft wide and the water depth is about 17 ft at mean low water (ER, IP-3, Appendix FF, p. III-10). The water from Unit No. 3 then joins the water discharged from the other Units in a 40-ft-wide discharge canal. The water in this canal has a velocity of about 5 fps at full-flow conditions and about 3 fps at reduced-flow conditions (ER, IP-3, Appendix FF, p. IV-26). The actual velocity, however, depends on the exact location in the canal and the elevation of water in the river.

The residence time for nonscreenable biota from the time it enters the intake structure to the time it leaves the discharge canal, with all three Units operating, is about 8 min under full condenser flow conditions and about 13 min under reduced-flow conditions. Residence times for other modes of operation are indicated in Table III-3. (See Table 1, p. 7 in ER, IP-3, Appendix AA, for further information on this subject.) The estimated residence times were calculated by the applicant on the basis of a river water level of 1.5 ft above mean low water and a canal water level 1.5 ft above that in the river. (Adjustment for other reasonable conditions should not change the estimates by more than about ±10%.) The estimates are weighted averages and assume that there is no recirculation through either the de-icing pumps or the main pump bypasses.

The total inventory of water in the Units Nos. 1, 2, and 3 cooling systems is about 2 million cubic feet, as shown in Table III-4.

Table III-3. Average residence times of water in Indian Point cooling water systems from intake to outfall[a]

Units in operation	Residence time (min)	
	Full flow	Reduced flow
1	34	52
2	15	25
3	11	18
1 + 2	12	19
1 + 3	11	18
2 + 3	9	15
1 + 2 + 3	8	13

[a]Based on applicant's data (ER, IP-3, App. FF, p. IV-25), river water level 1.5 ft above mean low water, and height differential of 1.5 ft across discharge ports.

Table III-4. Inventory of water in condenser cooling systems[a] (ft^3)

	Unit No. 1	Unit No. 2	Unit No. 3	Units Nos. 1 + 2 + 3
Intake forebay	5.9×10^4	1.1×10^5	1.1×10^5	0.279×10^6
Forebay to outfall into discharge canal	2.7×10^4	8.1×10^3	8.1×10^3	0.043×10^6
Discharge canal				1.7×10^6
Total				2.0×10^6

[a]Taken from data supplied by applicant (ER, IP-3, App. FF, p III-8).

3. Discharge Structure

Units Nos. 1, 2, and 3 use a common discharge structure located about 1,100 ft downstream of the Unit No. 1 intake and about 500 ft downstream of the Unit No. 3 intake. The discharge structure is about 270 ft long and consists of 12 underwater openings, 4 ft high x 15 ft long, located on 21-ft centers, as indicated in Fig. III-4. Ten of the ports are provided with hand-operated gates that can be raised or lowered to regulate the water velocity leaving the opening. Two of the ports do not have adjustable gates and can be used only in the fully open or fully closed position. The centerline submergence of the ports with the gates in the fully open position is 12 ft below the elevation of the standard sea level datum of the river. The level of the water in the discharge canal upstream of the ports will be higher than that in the river by the head necessary to obtain the required velocity leaving the ports. The water level in the canal will rise and fall with the tidal fluctuation of the river level with little time lag.

The applicant states that the gates will be adjusted to provide a discharge water velocity of 10 fps under any combination of Units in operation and for different river conditions (ER, IP-3, p. 9-8). (The applicant will be required to maintain this velocity by the Environmental Technical Specifications, which will be a part of the license for Unit No. 3.) The head, h, will vary as $(V/C_v)^2/2g$, where the head is expressed in ft, the velocity, V, is in fps, C_v is the velocity coefficient of discharge, and g is 32.2 ft/sec^2. With C_v equal to 0.95, a head of about 1.7 ft would be required to maintain a 10-fps velocity. The applicant will be required in the Environmental Technical Specifications to determine the relationship between discharge velocity, open port area, and canal head above the river level by actual measurement. Current measurements will be needed initially to assure the measurement of the discharge velocity. As discussed in more detail in Sect. 2 of Appendix A of this Statement, if the water velocity leaving the ports falls below some value, which depends upon the river ambient temperature, the temperature at the surface of the river may exceed the 90°F allowable maximum temperature specified in the New York State water quality criteria. The staff notes the inconvenience of adjusting each gate individually by means of a hand crank located on a catwalk above the discharge ports, but the Environmental Technical Specifications will require the applicant to adjust the gates to obtain the desired water velocity with changing Plant operating modes within a specified time period. By December 1974 the gates will be motorized for lowering and raising.

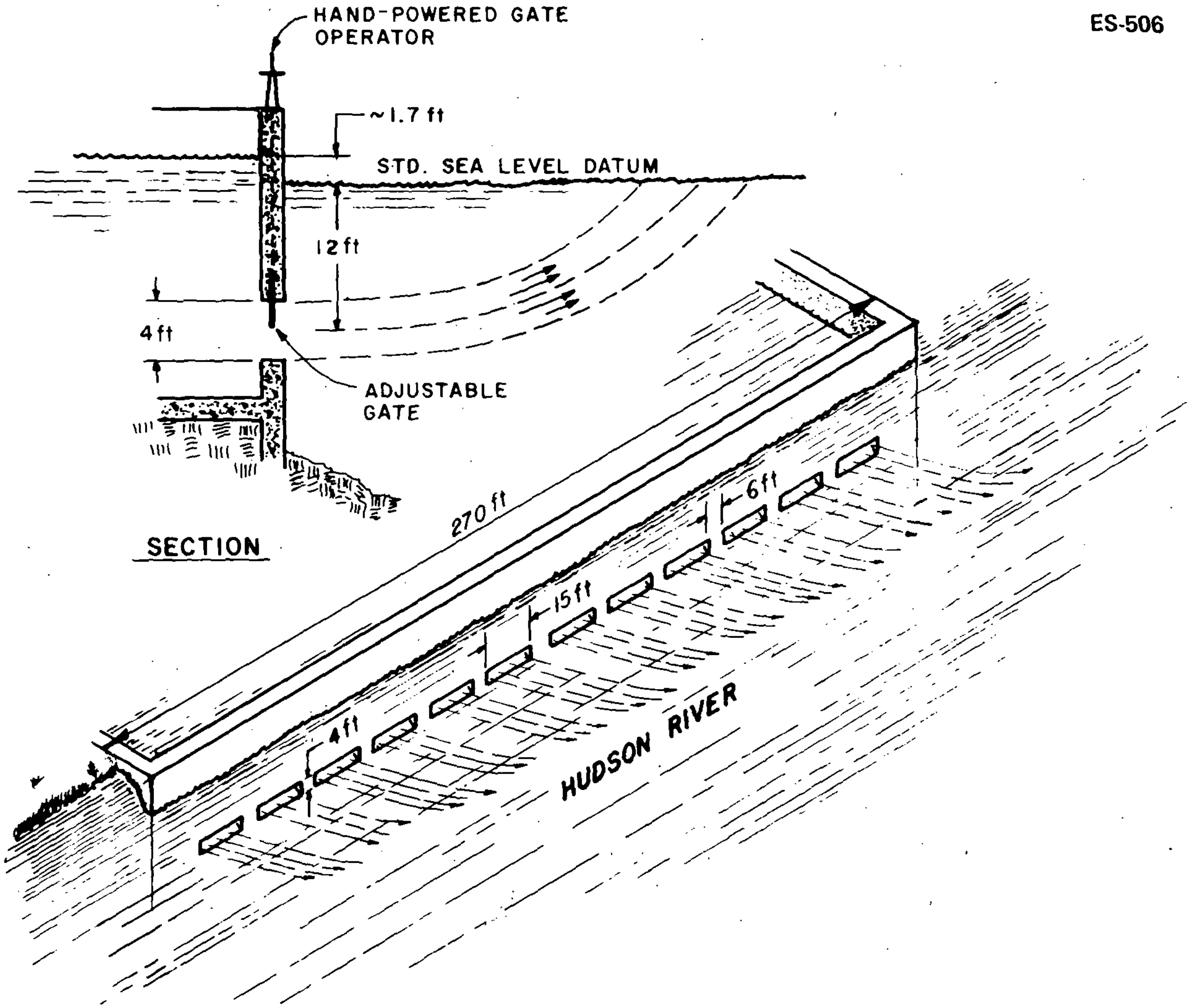

Fig. III-4. Diagrammatic representation of discharge structure.

The velocity of the heated water leaving the ports will cause river water to be entrained into the jet. As the momentum of the discharge is dissipated, the plume of warm water will rise toward the surface. As it nears the surface, it will begin to spread laterally and be further diluted and dispersed. The centerline of a plume may travel a horizontal distance of about 100 ft before reaching the surface, and the temperature of the water at this point may be about 6 F° above the background river water temperature at the Indian Point site, but the excess temperature is strongly dependent upon exit velocities and temperatures, interferences between the individual jets of the plume, and local ambient velocities.

After the warm water reaches the upper layers of the river, it will be dispersed across the stream, moved alternately upstream and downstream by tidal action, diluted by the freshwater flow, mixed with cooler water from lower depths and with warmed water from the discharge of other power stations on the river, and cooled by transfer of heat to the atmosphere. The hydrology of the Hudson River and the mechanisms for distribution of the discharged water and for dissipation of the heat are very complex and depend upon many variables for which more definitive data are needed. For further discussion of the thermal plume dispersion, see Sect. V.C and Appendix A.

REFERENCES FOR CHAPTER III

1. Consolidated Edison Company of New York, Inc., *Indian Point Nuclear Generating Unit No. 2, Final Facility Description and Safety Analysis Report*, October 1968.

2. Consolidated Edison Company of New York, Inc., *Indian Point Nuclear Generating Unit No. 3, Final Facility Description and Safety Analysis Report*, December 1970.

IV. ENVIRONMENTAL IMPACT OF SITE PREPARATION AND PLANT CONSTRUCTION

A. SUMMARY OF CONSTRUCTION STATUS

Construction at the Indian Point site has been almost continuous since 1956, when construction began on Unit No. 1. Construction of Unit No. 1 was completed in 1962. Construction of Unit No. 2 began in 1965 and was completed in April 1973, after which this plant achieved criticality on May 22, 1973. Construction of Unit No. 3 began in 1969, is currently about 92% complete, and is scheduled for completion in 1975. Unit No. 3 is estimated to be ready for fuel loading by the early part of 1975 and for power operation by the last half of 1975. The applicant has received all the necessary Federal, State, and local permits and licenses for the necessary construction work as described in Chapter I.

B. IMPACTS ON LAND USE

1. Onsite Construction

The site was formerly the Indian Point amusement park, which was abandoned when the use of the park decreased. The applicant purchased the abandoned site in the mid-1950's for use as a site for a power plant. The site was zoned for heavy industrial use.

About two-thirds of the 239-acre site has been affected by construction-related activities for all three Units. Upon completion of construction, about 35 acres, or 15%, of the 239-acre site will be utilized by permanent buildings and facilities.

During construction of Unit No. 3, few impacts of any significance on land use resulted, because no changes were needed for rebuilding or relocating highways, railroad lines, or gas lines. Most access lines and roads were built during the construction of Units Nos. 1 and 2. A permanent access road through the site starts at the corner of Bleakley Avenue and Broadway, a few blocks away from the New York-Albany Post Road (NYS Highway 9). Heavy equipment was shipped into the site via this access road from existing highways, expressways, and railroads or up the Hudson River by barge. Much of the construction work and impacts have been limited to the confines of the site itself.

Erosion in areas disturbed by construction will be reduced through continuous efforts to landscape and carry out vegetative measures on the site as construction work is being completed. The major effect of construction of Unit No. 3 is to delay the restoration of the areas of the site disturbed during construction of the other Units.

Because approximately one-third of the site has not been disturbed during construction, habitat remains for those forms of wildlife capable of adapting to the noise and human activity associated with a large construction project. The site topography and size and the existence of a wide band of vegetation at the site boundaries have aided in reducing noise problems common to any area during heavy construction work. Dust has also been kept to a minimum through asphalting roads and parking areas.

No local historic, archeological, and cultural resources were affected by the construction of Unit No. 3. Visual effects because of construction equipment will be reduced with completion of the construction work. As construction becomes completed, orderly restoration of the site will begin to accelerate. The applicant has developed a master plan to remove and clean up construction debris; to restore and enhance the attractiveness of the site through landscaping and planting after all construction work is completed; and to encourage the public to learn about the peaceful uses of atomic energy through a new visitors' center and to enjoy the picnic facilities and nature trails of an 80-acre natural area with the small Lake Iroquois in the northern part of the site. The development on site of the 80-acre natural preserve and the reduction of human construction activity allowing for increased areas of open lands will enhance the possibility of return of wildlife native to the area. A new reactor training facility is also being built on the site. The applicant's plans for restoration of the site following the completion of construction of Unit No. 3 (ER, IP-3, Sect. 7) have been evaluated by the staff as being acceptable, and the applicant is to be complimented for the plans to enhance the appearance of the site after construction is completed.

In addition, about 14 acres bordering on Lent's Cove have been transferred to the Village of Buchanan for development as a public marina. The major recreational activities in the area surrounding the site include fishing, boating, and the use of various parks in the general vicinity.

Discussion of the possible environmental and economic costs of excavation, construction, and layout of alternative cooling systems with the schedule and design considerations of such systems is presented in Section XI.C and Appendix G.

2. Transmission Line Construction

The Indian Point site was selected because of the proximity to the applicant's major load center of New York City so that transmission losses would be kept to a minimum. According to Figs. 48

and 49 of Sect. 22 of the applicant's ER, IP-3, the total power output of 2,103 MWe from the three Units will be transmitted from the turbine building across Broadway to the Buchanan substation, 2,100 feet away. Four site-located transmission structures (double-circuit towers designed to carry 345-kV output for Unit No. 3 and 138-k input for Unit No. 3 for light and power facilities, or the 138-kV output from Unit No. 1) will be utilized. Figure III-3 on p. III-5 of the FES for Unit No. 2 shows the type of steel transmission poles used by the applicant. Similar towers will carry the 345-kV output from Unit No. 2 to the Buchanan substation. Some of the power at this substation is interconnected with Lovett, Bowline Point, and Ramapo transmission lines across the river on the west side of the Hudson or else with Millwood or Sprain Brook substations south of the Buchanan substation. The applicant reports that new transmission lines are strung on existing towers or on new towers along old rights-of-way. The lines from Buchanan to Millwood substation, a distance of approximately 9.5 miles, were placed on existing structures on existing rights-of-way so that the added power from the Indian Point Units did not result in any major construction of new transmission corridors (ER, IP-2, p. S2-6). Although, according to the applicant, power from the Indian Point Plant cannot be separately identified beyond the Buchanan substation and only that from the Plants to this substation should be considered, the applicant at a New York State Public Service Commission public hearing in May 1973 reported that upgrading of transmission facilities is needed for transmission reliability and capability to handle the output of the Indian Point Plants and other power purchased in the north.[1,2] The applicant is rebuilding old lines and upgrading lines from 138 kV to 345 kV between Millwood, Sprain Brook, and other substations. Extra-high-voltage transmission lines are under construction to permit delivery of power generated from the Roseton, Bowline Point, and Indian Point Units when completed and from Quebec Hydro-Electric Commission for power purchase in 1977-1991.[3]

Development plans of the transmission structures for the Indian Point-Buchanan site were submitted to the Hudson River Valley Commission (HRVC) for review, comment, and approval, and the HRVC, with the Village of Buchanan, gave its approval of the alignment, structure type, and design and installation procedures (ER, IP-3, p. 20-1). New transmission lines are subject to regulation by the New York Public Service Commission pursuant to Article VII of the New York Public Service Law. Line design and construction are reported to conform to the guidelines for protection of aesthetic and other environmental values set forth in the report of the Working Committee on Utilities of the President's Council on Recreation and Natural Beauty, dated December 27, 1968, and the Federal Power Commission's Order No. 414, dated November 27, 1970.[4]

The transmission facilities for the Plants are designed and constructed in accordance with the environmental criteria and conditions discussed in the booklet on such systems[5] by the Department of the Interior and the Department of Agriculture.

For further details of the applicant's transmission facilities and interconnections with those of other utilities in the New York Power Pool and thence to the Pennsylvania-New Jersey-Maryland (PJM) system, see Chap. X in this Statement, Sect. 22 in Suppl. 1 and Suppl. 7 to the Environmental Report. In Sect. V.A.5, the environmental impacts for maintenance of transmission facilities are discussed.

C. IMPACTS ON WATER USE

During the construction and operation of Units Nos. 1 and 2, the intake-discharge structure was modified a number of times for purposes of reducing impingement of fish at the fixed and traveling screens of the intake and of meeting New York State thermal criteria (ER, IP-3, Appendix BB, Fig. 2, p. 7). Air bubblers were required by the State to be installed at the intakes in front of the fixed screens for Units Nos. 1 and 2. None are at the Unit No. 3 intakes. After tests of the air curtains at Units Nos. 1 and 2 intake structures have been evaluated, the applicant will consider their use at the Unit No. 3 intakes, in accordance with the agreement made between the staff and New York State Department of Environmental Conservation (ER, Suppl. 5, IP-3, pp. 2-6). The intake system was also modified to operate at reduced flow (84,000 gpm per pump) by allowing for 40% of the outlet water from the discharge side of the main pumps to be recirculated to the forebays in front of the pump. This is the expected manner of operation when the temperature of the river water becomes 40°F or lower. Above this temperature, about 2 million gpm of river water will be withdrawn and used to carry away the waste heat from the three Units.

Over the years changes have taken place in the design of the discharge canal. These include a conversion from a surface discharge along the eastern banks of the river to a submerged discharge structure 12 ft below the standard reference level. This structure has ten ports with adjustable gates so as to discharge a total of over 2 million gpm of cooling water from all three Units. A pressure head of at least 1.7 ft in the discharge canal is needed to obtain the desired discharge velocity of 10 fps. This velocity is required to obtain the proper mixing of the heated plume with the cooler river water in order to assure compliance with the New York State thermal criteria. The staff feels that these regulations are adequate to protect the biological and nonbiological aspects of the river at the Indian Point site. Thus, the applicant's utilization of the Hudson River should not interfere with other industrial or community uses of this resource except as related to the thermal load. Because no municipal drinking water is taken near the vicinity of Indian Point, any construction at the site will have no influence on water supplies.

Most of the impact of construction activities involving the intake and discharge system of once-through cooling has already occurred. Further changes in the once-through cooling system, in the event that construction of an alternative cooling system is required, may be necessary in the future. However, any modifications that would cause dredging or silting effects would be temporary until the changes were completed. Any construction changes of the once-through cooling system should result in a minimum impact on navigation or recreational aspects of the river, because the construction work would occur primarily along the shoreline. See Appendix G for further discussion on the effects of construction of the alternate cooling system.

D. EFFECTS OF RELEASE OF DISCHARGES DURING CONSTRUCTION

As discussed in Chap. IV in the FES for Unit No. 2, there will possibly be nonroutine chemical discharges to flush out equipment prior to startup. As shown in Table IV-1 of the FES for Unit No. 2, chemicals will be discharged on an intermittent basis and diluted sufficiently so that they should not affect other present industrial uses of the river water. All discharges will be required to comply with applicable Federal and State regulations, and the applicant will be required to obtain a Section 401 water quality certificate and a Section 402 National Pollutant Discharge Elimination System permit under the Federal Water Pollution Control Act Amendments of 1972.

The subject of chemical discharges and their impact on biota is discussed in Chap. V of this Statement as well as being detailed in the FES for Unit No. 2. The applicant shall be required to control all discharges, whether planned or unplanned, so as to meet applicable standards. Environmental Technical Specifications, required as part of the license, will limit discharges to be within applicable regulations.

E. SOCIAL AND ECONOMIC EFFECTS

As construction is being completed, the average manpower of 1,000 people used for Units Nos. 2 and 3 will decrease to about 400 workers who will come primarily from the local surrounding areas.

Thus, any congestion and noise from increased traffic in and out of the site and impacts on local communities as to housing, schools, and hospitals from the larger work force used during construction will be temporary. The temporary adverse effects were countered by the immediate benefits from the increased employment and stimulation of the local economy by the payroll income of the large construction force. Within a year almost all of the construction at the site, except for any changes in the once-through cooling system, will be finished. A minimal work force to operate and maintain the facilities of each Unit will be required.

REFERENCES FOR CHAPTER IV

1. *Peekskill Evening Star*, "Few Sparks Light Hearing on New Con Edison Lines," May 23, 1973, p. 35.

2. "1973 Report of Member Electric Corporations of the New York Power Pool and the Empire State Electric Energy Research Corporation Pursuant to Article VIII, Section 149-B of the Public Service Law," vol. 1, Exhibit 13, p. 5 of 17.

3. Letter dated August 16, 1974, from W. J. Cahill, Jr., Consolidated Edison Company of New York, Inc., to A. Giambusso, U.S. Atomic Energy Commission.

4. Letter dated December 27, 1971, from T. A. Phillips, Federal Power Commission, to R. S. Boyd, U.S. Atomic Energy Commission.

5. U.S. Department of Interior and Department of Agriculture, "Environmental Criteria for Electric Transmission Systems," February 10, 1970.

V. ENVIRONMENTAL IMPACTS OF STATION OPERATION

In this chapter, the effects on the environment of operation of the once-through cooling system of Indian Point Unit No. 3 in combination with that of Units Nos. 1 and 2 are described and assessed. A wide range of factors was considered in the environmental review. The impacts of up to 100% power operation of each Unit from mechanical shock, entrainment, impingement, and thermal, chemical, and radioactive releases on man and his environment are assessed in this chapter. The summary of the impacts of Unit No. 3 in conjunction with the other two Units at Indian Point as well as other power plants on the Hudson River is presented in Chapter VII.

The appendices of this Statement include much of the detailed supporting evidence for the information presented in this chapter. Additional details can also be found in the Final Environmental Statement for Indian Point Unit No. 2 as well as testimony presented in the hearing for Unit No. 2.

A. LAND USE

Since three Units occupy the site, identification of a land use impact uniquely associated with Unit No. 3 is difficult. Inasmuch as the 239-acre area is zoned for industrial purposes, its use as a reactor site should not cause significant alterations from use patterns that would have prevailed for other industrial applications. The buildings and other physical facilities utilizing once-through cooling occupy 35 acres of the site.

1. Aesthetics

The major impact on land use in regard to operation of the Indian Point Unit No. 3 occurred during Plant construction and construction of the transmission lines for Unit No. 1 and facilities for Units Nos. 1 and 2. The major aesthetic impacts on the land resulting from operation of Unit No. 3 are the use of uncultivated, abandoned land on which construction of man-made facilities such as buildings, parking lots, transmission lines, and electrical switchyards result in breaking the river profile with the three reactor containment vessels symmetrically placed on the site along the riverbank. The vessels and buildings have been architecturally designed to present a pleasant, attractive appearance, particularly when the site is viewed from the river. The applicant has developed a master plan to enhance the appearance of the site through landscaping and planting, developing an 80-acre woodland recreational facility, including a freshwater lake, and building a new visitors' center to encourage educational aspects of the facility for public information on peaceful uses of atomic energy. The layout of the buildings, park, and lake area is shown in the applicant's Environmental Report (ER, IP-3, Sect. 7). Following completion of construction of Unit No. 3 and subsequent cleaning up, restoration, and landscaping, the attractiveness of the site should improve. However, in view of the staff recommendation to require closed-cycle cooling systems at Unit No. 2 and at Unit No. 3 (see Chapter XI), the aesthetic appearance of the site would be significantly altered, depending on the system selected as the preferred one.

Considering the fact that the original site was an abandoned amusement park, development of the site for purposes such as construction of nuclear power plants might be considered to be more beneficial than construction of some other facility which could destroy the entire site. Furthermore, because the site is zoned for industrial use, the land is well used for a beneficial purpose of providing needed power to the metropolitan New York area.

The remainder of the site will be developed for multiple public use. About 14 acres of the site adjacent to Lent's Cove were transferred by the applicant to the Village of Buchanan to be developed into a marina. This will increase the beneficial impact on recreation, including boating, fishing, and other water-associated recreational activities. The applicant has been in contact with the Westchester County Department of Planning[1] to assure that any uses of the land area for the site will be consistent with the county's long-range plans for development of the area.

2. <u>Access</u>

The perimeter of the Indian Point site is posted, and the immediate area of the Plant facilities is fenced under restricted access control. The visitors' center and the recreational facilities, including the lake and nature trails, will be available to the public.

3. <u>Noise</u>

Nuclear power plants are relatively quiet facilities when compared with other industrial plants of similar physical size. The degree to which sound levels associated with operation of the Indian Point Plant might be considered objectionable must be evaluated in terms of ambient levels. The applicant has conducted limited investigations regarding ambient sound levels (ER, IP-3, Sect. 22, pp. 4.2-1 to 4.2-6).

At sampling points having particular importance to an assessment of noise likely to affect area residents (i.e., in the vicinity of the Broadway property lines), daytime sound levels, attributable largely to traffic, exceeded 60 dB(A) more than 50% of the time (ER, IP-3, Sect. 22, p. 4.2-7).

The applicant has not reported any lengthy and detailed measurements of ambient noise, including daily, weekly, and seasonal variations in sound levels. However, for purposes of examining the effects of noise emitted by the Indian Point Plant during intervals of low traffic movement, Franken and Page[2] have reported that ambient sound levels on the order of 35 and 40 dB(A) are typical for a "quiet" suburb during nighttime and daytime periods, respectively.

Sound level measurements in the vicinity of operating power plants of a size equivalent to the Indian Point Plants are not generally available. Data reported for a complex of three 175-MWe coal-fired units[3] show continuous sound levels on the order of 60 dB(A) at a distance of 250 ft from the plant. Extrapolation of this data to approximate net electrical output of the Indian Point Plants suggests a continuous sound level of 67 dB(A) (which corresponds to a factor of four). Based on a conservative sound reduction factor of 4 dB for each doubling of distance away from the Plant, at 2,250 ft (approximate distance to the Broadway boundary), 51 dB(A) of added noise would be expected.

A cautious interpretation of these results suggests that plant-induced sound levels will not constitute a source of serious annoyance to nearby residents. Considering that the combination of vegetative cover and irregular terrain surrounding the Plant structures will serve to lessen Plant noise, the staff considers it unlikely that sound levels attributable to normal operations will exceed 45 dB(A) at the Broadway property line. These levels are considered "acceptable" for sites seeking HUD funding for residential housing and are therefore not considered as having a serious impact upon area residents.

The foregoing treatment considers continuous operational sounds and does not evaluate sporadic Plant noise. The latter are expected to occur infrequently and are, to some extent, controllable. During daytime hours, when traffic noise along Broadway may exceed 60 dB(A) [ER, IP-3, Sect. 22, p. 4.2-7], spurious sounds emanating from the Plant are likely to be imperceptible as a separate entity. During nighttime hours, however, noise in excess of ambient background levels is likely to become annoying to area residents. The staff recognizes this potential for annoyance and therefore requires that the applicant implement appropriate plans for reducing sporadic noise (i.e., from an outdoor loudspeaker system) and for confining activities likely to produce excessive noise to the normal work week. After construction of Unit No. 3 has been completed, the staff recommends that a sound survey be carried out by the applicant to obtain ambient noise levels from once-through cooling operation.

4. Historical Landmarks

The closest historic landmarks are the Stony Point Battlefield (about 2 miles south of the site) and the Palisades Interstate Park (west side of the Hudson River) (see Sect. II.D). The Director of the New York State Historic Trust, speaking on behalf of the State Liaison Officer for Historic Preservation, states that the Trust "regrets the already unsatisfactory visual impact of Indian Point construction on the historic environment" of these two landmarks and further hopes there will be "no additional damaging effects on those surroundings."[4] After construction has been completed and the site extensively landscaped and developed into a park, the visual impact of the site with no additional physical facilities should be improved. The Commission's condition of operation of an alternate closed-cycle cooling system required of the applicant will, however, impose a further visual impact on the environs that must be taken into account in consideration of this alternative.

In compliance with Section 106 of the National Historical Preservation Act of 1966 and pursuant to Executive Order 11 593 of May 31, 1971,[5] the operation of the Indian Point Plants should have minimal effect on any National Register property such as the Van Cortlandt Manor on Highway 9 in Croton-on-Hudson. In fact, the site with its woodland area and visitors' center should attract visitors also to the Van Cortlandt Manor and Tarrytown places of interest. Thus the Indian Point project, through its cultural advantages, should add considerably to preserving the historical importance of the Hudson River Valley. The applicant's taxes from the Indian Point project should help to support maintenance and upkeep of the local area. In fact, in 1972 the applicant paid approximately $748,000 in taxes to the Village of Buchanan or almost 90% of the real estate levy resulting in a low tax rate of $17 per $1000 assessed value.[6] Obviously, the historical places will also utilize the electrical power from the Indian Point Plants.

5. Transmission Facilities

As discussed in Sect. IV.B.2, with the use of existing rights-of-way to carry the power output of 2,100 MWe from the Indian Point Plant to the Buchanan substation and then to the applicant's grid system, the impacts of transmission facilities for the Indian Point

Plants are limited. The first connection of the 138-kV or 345-kV lines from the bus bar of the Indian Point Plants to the Buchanan substation crosses only the site except for the crossing of Broadway. In the staff's opinion, there will be no incremental adverse environmental impact from these transmission lines beyond that which existed before construction of Unit No. 3 began. Any adverse impacts of the 138-kV or 345-kV lines from the Buchanan substation to the Millwood substation west and south to the Sprain Brook substation or other interconnections have already resulted, because their transmission facilities have existed over several decades. The applicant has attempted to improve the aesthetic effects of the facilities by improving the line design and tower structures to conform with Federal and State guidelines.

As presently required by the New York State Public Service Commission, the applicant has applied for Certificates of Environmental Compatibility for different sections of the transmission lines; some have been approved and some are pending. The applicant has developed policies[7] for right-of-way design, construction, and maintenance standards. The applicant has had consulting landscape architects to advise the utility on clearing and maintenance and has developed cleaning-up procedures to keep the impacts of rights-of-way to the minimum.

At the 345-kV level, fair-weather audible noise is nearly undetectable, except directly beneath the conductors or in the vicinity of transmission structures that may exhibit resonance. In damp weather and light rain, audible emissions increase but are not discernible beyond right-of-way boundaries. During periods of heavy rainfall, heightened ambient noise levels would mask any possible increase in audible noise attributable to 345-kV lines.

B. AIR USE

1. Climate

The atmosphere will ultimately absorb most of the waste heat from operation of Units Nos. 1, 2, and 3. These Plants use water from the Hudson River for once-through cooling as the intermediary during the dispersion of the thermal discharge in the circulating cooling water, primarily on the surface of the river. Because of the prevailing winds that blow up and down the river valley and the high probability of inversion, the dispersion of the thermal discharges on the surface may cause some fogging for short periods of time, depending on the meteorological conditions. Based on many years of observation at power stations,[8] no serious atmospheric effects are expected from heat dissipation by the once-through cooling systems. No substantive weather modification is expected with the once-through cooling system during heat dissipation into the atmosphere by the heated river water.[9] Wispy steam fog over the thermal plume may occur, depending on the plume size. Church[10] has indicated that steam fog forms when the vapor pressure difference between air and surface water is about 5 millibars with water temperatures between 32 and 41°F. The air layer next to the water surface will be heated and the moisture added; mixing of the air with the unmodified air just above the plume can lead to vapor saturation and condensation. Further vertical mixing tends to evaporate the steam fog. However, any observed steam fog is not expected to be thick nor to rise but a short distance off the river surface. Observation of steam fog over thermal discharges indicates that the visible plume will be thin and wispy and that the fog will rarely penetrate more than 10 to 50 ft inland before disappearing. The density of the fog is not expected to interfere with shipping or other modes of transportation on the river. Some of the water droplets will be removed by vegetation and other surfaces as they move across the shoreline, causing a local increase in humidity and dew.

2. Air Quality

Combustion products will be released to the atmosphere through the superheater stack at Unit No. 1 as a result of operation of the superheater[11] and three service boilers at Unit No. 1 and two package boilers each at Units Nos. 2 and 3. The boilers are operated intermittently to produce auxiliary service steam for startup and service heating. They will use No. 6 fuel oil with a sulfur content of 0.3%, subject to recent problems of availability. Fuel oil formerly in use contained 1% sulfur; however, the New York City code on air pollution control[12] required a reduction of sulfur content in No. 6 (bunker) fuel oil from a nominal 1% to 0.3% by October 1, 1971. The use of oil with a 0.3% sulfur content will be in compliance with a New York State air quality regulation which became effective on September 30, 1973.[13]

The expected amount of emissions from the package boilers using oil of 0.3% sulfur content at Unit No. 2 or Unit No. 3 will be 15,000 lb of particulates, 375,000 lb of SO_2, and 342,000 lb of NO_x annually; their effluents are discharged through the stack at Unit No. 1. Using this information, the applicant calculated the ground level concentrations of these pollutants at a distance 0.6 miles (1 km) downwind from the stack to be 3.3×10^{-3} ppm for SO_2, 4.2×10^{-3} ppm for NO_x, and 0.35 μg/m^3 for particulates. These are calculated on the basis of 3-min concentrations or instantaneous releases at an actual stack height of 280 ft instead of the effective height, which is at 390 ft above the water level.

The national primary ambient air quality standards (annual arithmetic mean) to be achieved by 1975 for the three pollutants are 0.03 ppm SO_2, 0.05 ppm for NO_x, and 75 $\mu g/m^3$ for particulates. The annual average values are usually a small fraction of the instantaneous values (ER, IP-3, Section 22, p. 3.2-2). The average values of ground-level concentrations of pollutants from the package boilers from all three Units at a distance of 1 km downwind from the stack under Class A stability conditions and with a speed of 2 m/sec have been estimated to be 1.1 $\mu g/m^3$ of nitrogen oxides. The environmental concentrations of pollutants from the boilers of all three Units will be about 33% for SO_2, 26% for NO_x, and 1.4% for particulates of the Federal Air Quality Standards that have to be achieved by 1975.

In addition, the State has adopted air quality regulations in which the maximum hourly value of 0.5 ppm for SO_2 and the maximum 24-hour standard of 55 mg/m^3 of particulates have been established. Thus the emissions from the package boilers from Unit No. 3 will be in compliance with State and Federal regulations.

The operation of Indian Point Unit No. 3 would not greatly increase the level of nonradioactive air pollutants in the area. It would, however, allow the applicant to reduce operation or shut down the number of old fossil-fueled plants and thereby decrease the pollution load of the air, primarily in New York City, where the plants are located.

In regard to the superheater at Unit No. 1, the annual average emissions from Unit No. 1, based on power demand, total 39 tons/year of particulates, 786 tons/year of SO_2, and 858 tons/year of NO_x. Emissions result primarily from the superheater with a small contribution from the auxiliary service steam package boilers. The computed rates conservatively equal 0.26 $\mu g/m^3$ of particulates, 5.2 $\mu g/m^3$ SO_2, and 5.6 $\mu g/m^3$ of NO_x at 0.6 km downwind from the stack. These concentrations represent less than 7% of the National Primary Ambient Air Quality Standards (40 CFR 50) of the Clean Air Act.[14] They also represent less than 7% of the New York Ambient Air Quality Standards (6 NYCRR Part 257) for each of the pollutants. Thus the emissions from the superheater and package boilers at Unit No. 1 will comply with Federal and State regulations. However, these regulations pertain to new stationary sources. Both of these regulations are quoted for the purpose of providing a basis for comparison with emissions of particulate matter, sulfur dioxide, and nitrogen oxides from all fossil-fuel sources at the Indian Point site. Sincy Unit No. 1 has been in operation for 10 years, no significant impact on the local vegetation seems to have occurred.

Ozone is recognized as a major component of the photochemical air pollution-oxidant complex. The toxicity of ozone to vegetation is well documented, with susceptible species showing symptoms of damage from exposures as low as 30 ppb O_3.[15,16] One source of ozone production is believed to be associated with the coronal discharges of high-voltage transmission lines. Few data exist concerning ozone production from transmission lines.[17] A recent study[147] showed that ozone concentration in the vicinity of 765-kV lines was not detectable with instruments sensitive to 2 ppb. Preliminary studies conducted indicate that levels directly beneath two 500-kV transmission lines may approach 200 ppb. Any possible deleterious effects on plants directly beneath the lines and those adjacent to the corridors, which could be affected by chronic exposure to ozone drift, have not been identified and are expected to be minimal.

C. WATER

1. Thermal Discharges

Operation of the three Units at the Indian Point Plant can result in a thermal discharge to the Hudson River of about 15.76 x 10^9 Btu/hr. (Unit No. 3 alone contributes about 7.5 x 10^9 Btu/hr.) About 2 million gallons of river water per minute are raised in temperature by 15.3 F° in passing through the Plants. The thermal effects on the river are particularly significant when heat from other power plants on the Hudson River is taken into account. See Appendix A for additional details on effects of the thermal discharges from Indian Point as well as other power plants on the river.

The applicant will be required to meet the effluent limitations of the Federal Water Pollution Control Act Amendments of 1972,[18] as well as any limitations imposed upon the applicant by the State of New York pursuant to a certification under Section 401 of the FWPCA. A Section 401 certificate has not yet been issued for Unit No. 3, and therefore the precise State limitations to be incorporated therein are not known.* However, the following analysis, based upon the existing New York State thermal criteria, is provided to assess the potential impact which State limitations might have upon the operation of the Indian Point Plants. This analysis is further utilized in the cost-benefit balance (see Chap. XI, Section I). To demonstrate whether the Indian Point Plants will comply with these criteria, the applicant has carried out studies using both hydraulic and mathematical models. Mathematical studies of thermal discharges conducted by the staff have been partially directed toward predicting compliance or noncompliance with the New York State criteria, as presented below. The waters of the Hudson River at Indian River Point are classified by the State as "SB" (for bathing and other usages except shell fishing for market purposes). The applicable section of the New York State Compilation of Codes, Rules, and Regulations is:[19,20]

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*Once a section 401 certificate is issued by the State, this would be determinative as to compliance with the limitations imposed under the FWPCA.

"(i) The water temperature at the surface of an estuary shall not be raised to more than 90°F at any point.

(ii) At least 50 percent of the cross sectional area and/or volume of the flow of the estuary including a minimum of one-third of the surface as measured from water edge to water edge at any stage of tide, shall not be raised to more than 4 Fahrenheit degrees over the temperature that existed before the addition of heat of artificial origin or a maximum of 83°F whichever is less.

(iii) From July through September, if the water temperature at the surface of an estuary before the addition of heat of artificial origin is more than 83°F an increase in temperature not to exceed 1.5 Fahrenheit degrees at any point of the estuarine passageway as delineated above, may be permitted.

(iv) At least 50 percent of the cross sectional area and/or volume of the flow of the estuary including a minimum of one-third of the surface as measured from water edge to water edge at any stage of tide, shall not be lowered more than 4 Fahrenheit degrees from the temperature that existed immediately prior to such lowering."

[6 NYCRR 704.2(b)(5)]

On November 10, 1971, the Environmental Protection Agency recommended thermal criteria[21,22] which are similar, but with the difference that no more than a distance of 1,000 ft on the surface in any direction shall be raised more than 4 F° over the temperature that existed before the addition of heat of artificial origin or a maximum of 83°F, whichever is less. Because of the studies that have been made on the estuarine portion of the Hudson River, the need for limiting the temperature rise during July through September to 1.5 F° is removed, and the conditions specified for October through June will be permitted year-round.

As seen from the discussion above, the New York State thermal criteria are based to a great extent on an excess temperature "over the temperature that existed before the addition of heat of artificial origin." This "ambient" temperature, however, is difficult either to determine, or to monitor, both because of its large variation in space and time and because of the fact that once "heat of artificial origin" is added, there is no way to know what the temperature at that location was before the heat addition.

Another important factor involving the river ambient temperature is the limitation that at least one-third of the river width or half of the river cross-sectional area should not be raised to more than 4 F° above ambient or to a maximum of 83°F, whichever is less. The applicant assumes that the maximum river ambient temperature is 79°F. In this case, the limitation of 4 F° excess temperature or maximum of 83°F are identical. However, as shown in Sect. II.E.1, there is strong evidence that the maximum river temperature, particularly during the month of August, can be above 82°F. Even when considering weekly average temperatures and taking into account that some of the measurements may have somehow been affected by artificial heating, the staff concludes that maximum river ambient temperature can be about 80 to 81°F. In this case, the 83°F maximum temperature limitation in the New York State thermal criteria will be the controlling limitation, and the excess temperature allowed will then be 3 or 2 F° rather than 4 F°. Neither the applicant nor the staff has analyzed how far the 2 and 3 F° excess temperature isotherms extend, but the staff sees the 83°F limitation and the 80 to 81°F ambient temperature condition as further evidence to support its conclusion that the State thermal criteria are likely to be violated for a major part of the time (see Section V.C.1.c).

The thermal effects on the river can be characterized as to the behavior of the warm water discharge in: (a) the near field, which includes the submerged plume and the area within about 150 ft of the discharge ports where the plume surfaces; (b) the intermediate field (plane of discharge), which consists of the width and depth of the river in the immediate vicinity of Indian Point; and (c) the far field, which includes the reach of the river for about 40 miles both upstream and downstream of the Plant.

The near field analysis is usually performed on the basis of excess temperature above background temperature. The background temperature itself, which is not to be confused with ambient temperature, must be determined from far field studies.

a. Applicant's Analysis

The applicant performed both physical and mathematical modeling on the effects of multiplant operation. Only the Indian Point, Bowline, and Lovett plants were included because the applicant judged that the Danskammer and Roseton plants, located over 20 miles upstream, would have little effect at Indian Point (ER, IP-3, Appendix DD).

The hydraulic (physical) modeling was conducted in a distorted model with a 1/400 scale in horizontal direction and 1/80 in the vertical direction, using an equivalent freshwater flow of 20,800 cfs. This model is similar to that used to analyze the thermal discharges as given in the applicant's Indian Point Unit No. 2 Environmental Report, but it has been extended from an equivalent length of about 3.4 miles to about 15.7 miles (ER, IP-3, Appendix DD). The staff believes that this greatly improves the usefulness of the model, although still noting that (1) the saline zone of the estuary cannot be simulated, (2) correct representation of heat interactions with the atmosphere is difficult, and (3) the model apparently continues to lose heat from its ends by withdrawing heated water and returning fresh water in the process of simulating tidal actions. In general, the hydraulic model showed that, with three plants operating, the 4 F° isotherm occupied less than one-half of the cross-sectional area, but that in most cases the 4 F° surface isotherm would extend all the way across the river (ER, IP-3, Appendix DD, p. 3) and therefore not meet the New York State thermal criteria. Furthermore, in some cases even the 5 F° surface isotherm extends all the way across the river, whereas the 4 F° surface isotherm completely covers more than 2 miles of the river length (see Fig. V-1). These studies also showed that, in the case considered by the applicant to be most representative, the average surface temperature rises about 4.5 F° (see Fig. V-2). The Thermal Stratification Factor (TSF), which is defined as the ratio between average surface excess temperature and average cross-sectional excess temperature, was in the range of 1.4 to 1.8 in the hydraulic models. This gives an average cross-sectional temperature rise of about 3.0 F°.

Behavior of the buoyant jet in the near field was also investigated by the applicant in a nondistorted hydraulic model. The near surface temperature rise observed in this model was between 9 and 11 F° above intake temperature. Since steady currents were used, "this maximum temperature rise does not reflect residual temperature build-up nor plant recirculation" (ER, IP-3, Appendix DD, pp. 1-2). Such temperature build-up and heat recirculation will tend, of course, to increase the maximum surface temperature rise and must be taken into account when total assessment is made.

The mathematical heat dissipation models presented by the applicant (ER, IP-3, Appendices DD and EE) are essentially the same as those used to analyze the thermal discharges for Indian Point Unit No. 2, and the staff has already commented on them (FES, IP-2, pp. III-24 to III-36) and has raised some issues that have not yet been resolved.[23] The staff concurs with the applicant's statement (ER, IP-3, Appendix DD, p. 3) that "lack of significant heat quantities existing in Hudson River discharges and lack of comprehensive river hydrodynamic measurements make the selection of certain system parameters difficult." The staff further believes that in this situation parametric studies and sensitivity analyses should be performed to place the calculated results in a realistic perspective.

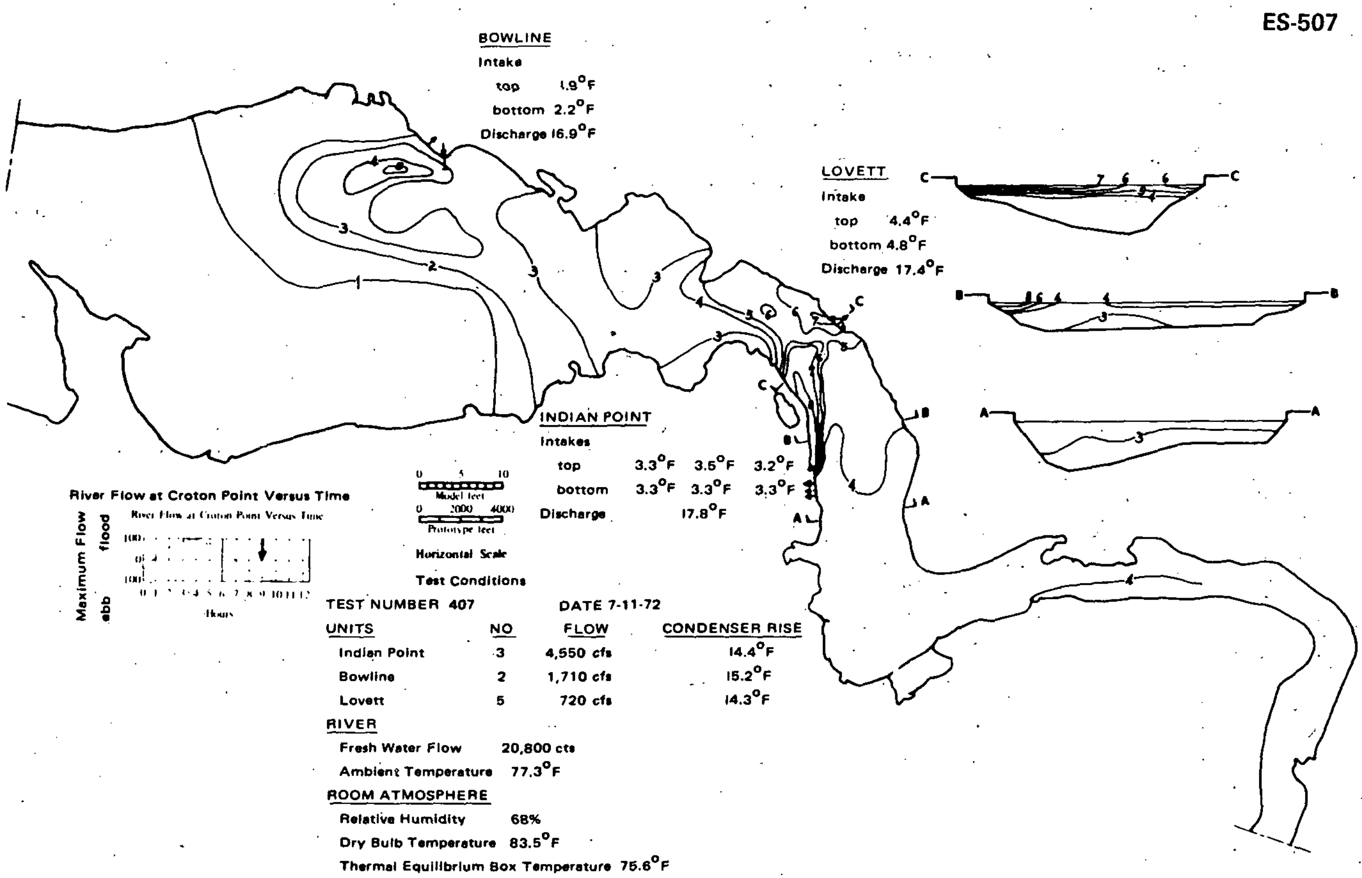

Fig. V-1. Temperature rise at surface above river ambient.
Source: ER, IP-3, App. DD(2), Fig. 22.

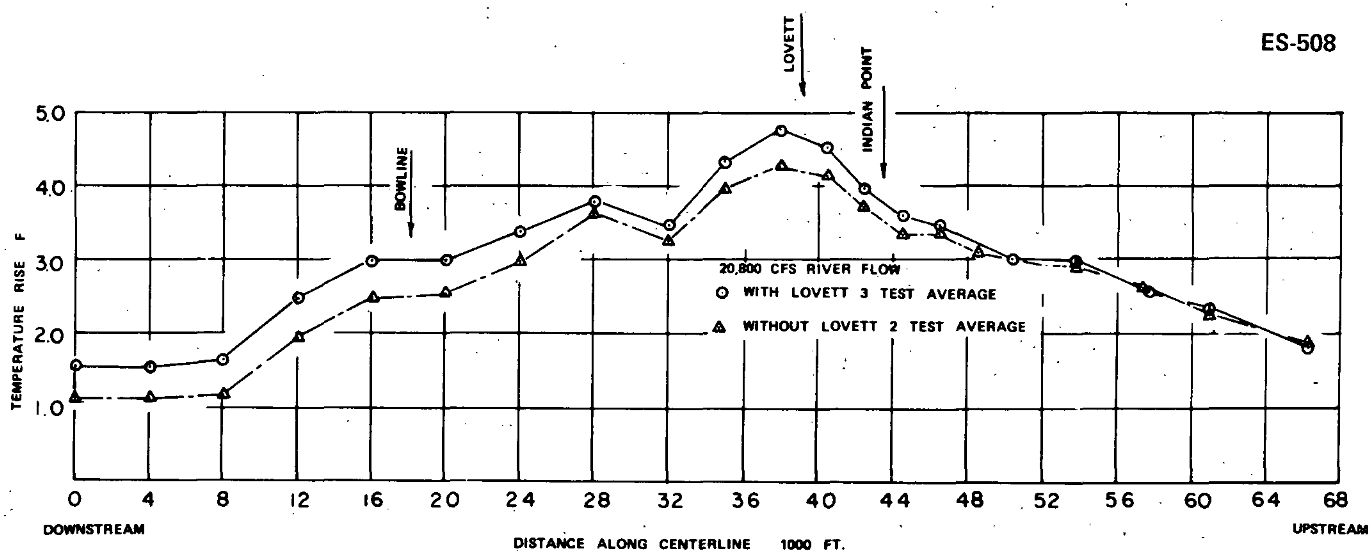

Fig. V-2. Comparison of time-spatial average surface temperature rise with and without Lovett. Source: ER, IP-3, App. DD(2), Fig. 68.

Physical parameters, such as density induced, tidal average flows in the upper and lower layers, TSF, dispersion coefficients, and even heat exchange coefficients, are not yet adequately quantified.

In its mathematical studies, the applicant assumed two cases, each of which was analyzed by a different model (ER, IP-3, Appendix DD, Table 6): (1) a freshwater flow of 20,800 cfs, a heat transfer coefficient to the atmosphere of 90 Btu/day·ft^2·F°), a dispersion coefficient of 6 sq miles/day, and a TSF of 1.5, and analyzed with both a steady-state, one-layer convective dispersion model divided into four river segments and a steady-state, one-segment, constant-parameter model; and (2) a freshwater flow of 4,000 cfs, a heat transfer coefficient to the atmosphere of 140 Btu/(day·ft^2·F°), and a TSF of 2.0, and analyzed with a steady-state two-layer convective model. Case (1) above deals with a condition in which the salt intrusion does not extend up to Indian Point. Under these conditions, a density-induced circulation probably does not exist, and this segment of the river should probably be treated as a freshwater, one-layer, tidal water body. Nevertheless, the applicant used a value of 6 sq miles/day for the longitudinal dispersion coefficient. The staff has previously questioned the method used by the applicant to derive this value,[23] which is possibly an order of magnitude greater than should be used under these conditions.[24] The staff estimates that the effect of reducing the dispersion coefficient from 6 sq miles/day to 1 sq mile/day is an increase of about 20% in the predicted average cross-sectional temperature rise above ambient downstream of the Lovett plant [based on a freshwater flow of 20,800 cfs, a heat transfer coefficient of 135 Btu/(day·ft^2·F°), and with Indian Point Units Nos. 1, 2, and 3, Lovett, and Bowline Plants in operation]. The applicant's studies also assumed a temperature rise of 14.8 F° through the Indian Point Plant, whereas the staff used a temperature rise of 15.3 F° in its own multiplant analysis. The staff comments regarding these and other differences in input parameters used have been previously stated (FES, IP-2, pp. III-30 to III-36).

A summary of the applicant's conclusions from its mathematical and physical studies is given in Table V-1. In brief, the applicant's mathematical studies indicate that the State criteria would be met in any of the situations studied, excluding the case in which the combined effects of the Indian Point, Lovett, and Bowline Stations are considered using the applicant's four-segment model. In this instance, the 4 F° surface isotherm would cover about 80 to 90% of the width and would not meet the State criteria. As indicated before, the physical studies show much more severe violations of these criteria. The applicant has also conducted extensive near-field studies, both physical and mathematical, and concluded that the present outfall design can attain an initial

Table V-1. Applicant's summary of temperature effects at Indian Point plane of discharge for study cases

Temperature effect	Case 1[a]				Case 2[b]		New York State thermal criteria
	Four-segment model		Constant parameter model, critical tidal phase	Physical Model	Two-layer system model		
	Tidal average	Critical tidal phase			Tidal average	Critical tidal phase	
Percent of cross-sectional area bounded by 4 F°	29	40	40	27	19	26	50
Portion of surface width bounded by 4 F°	1/2	2/3	2/3	3/3	1/3	4/10	2/3
Maximum surface temperature rise, F°	8–9	9–10	9–10	9–11	8–9	9–10	90°F max.
Percent of surface width bounded by 4 F° at Lovett (mile point 42)	81	90	43	100	38	63	67

[a]Case 1: Freshwater flow = 20,800 cfs, heat transfer coefficient = 90 Btu/ft² · day · °F.
[b]Case 2: Freshwater flow = 4,000 cfs, heat transfer coefficient = 140 Btu/ft² · day · °F.
Source: ER, IP-3, p. 9–13 and App. DD(1), Table 6.

dilution ratio of 2 to 1 in the near field, and that the near surface excess temperature can be about 8 to 9 F°, which includes also 1 F° rise for recirculation.

The maximum surface temperature during critical summer conditions, assuming an ambient temperature of 79°F, will be then about 87 to 89°F and will not contravene the 90°F maximum surface temperature criteria. However, the elevation of the river temperature due to the multiple discharges may allow only marginal compliance with the 90°F maximum surface temperature criteria in the near field at the Indian Point discharge.

The staff has reservations as to both assumptions, that the maximum river ambient temperature is 79°F and that the temperature rise associated with recirculation from the far field back to the near field is not more than 1 F°. These reservations are further discussed in later sections.

For additional discussion of the applicant's thermal models, see Sect. 9 of Suppl. 3 to the Environmental Report as well as Appendix DD and EE of that supplement.

b. Staff's Analysis

(1) Estimates of Temperature Distribution

The thermal impact of Indian Point Unit No. 3 on the Hudson River has been assessed by the staff on the basis that Units Nos. 1, 2, and 3 are operating simultaneously, with Units Nos. 1 and 2 at rated capacity and Unit No. 3 at maximum calculated capacity* (see Table III-1). The portion of the river relatively close to the warmed-water discharge ports (the near and intermediate fields) has been studied on the basis of considering only the heat discharged into the river from the Indian Point Plants; the far-field studies have also included the effects of thermal discharges from other major thermal power plants on the Hudson River.

Cessation of once-through cooling for Unit No. 2 is required by 1979, and the staff's conclusion is that cessation of once-through cooling for Unit No. 3 should be required by September 15, 1980, subject to the conditions of the stipulation reached among the parties, (see Chapter XI and Appendix G, Section 4.c). To reflect these

*The difference between using rated capacity for all three Units, as in the applicant's studies, is about 4% more heat rejection to the river. Because of the uncertainties in various parameters for which the staff has used ranges of values, this 4% difference does not affect the staff's conclusions.

conditions, the staff's thermal analyses include the following modes of operation for the Indian Point Plants (see Table V-2):

Base Design	Units Nos. 1, 2, and 3 operating with once-through cooling.
Alternative A	Units Nos. 1 and 3 operating with once-through cooling and No. 2 with a natural-draft cooling tower.
Alternative B	Unit No. 1 operating with once-through cooling and Units Nos. 2 and 3 with natural-draft cooling towers.
Alternative C	Unit No. 1 operating with once-through cooling and Units Nos. 2 and 3 with mechanical-draft cooling towers.

The thermal effects for these configurations are discussed in this Section and in Appendix A. As far as the thermal performance of the systems is concerned, Alternative C may be considered essentially the same as Alternative B. The overall environmental effects of these alternatives are discussed in Chapter XI.

The arrangement of the Indian Point turbine-condenser once-through cooling water systems is indicated schematically in Fig. III-2. Table V-2 gives the heat rejected to the river by the service water and condensing water systems for the three Units, the water flow rates in these systems, and the temperature rise from intake to discharge. A reduced-circulation case is also considered, in which the turbine-generator output remains essentially unchanged but the water flow rate through the condensers is reduced, by means of pump bypasses, to 60% of rated flow. In this case, the overall station net temperature rise is about 24.7 F° rather than the 15.3 F° at 100% of rated condenser flow.

The Hudson River characteristics have been previously described (FES, IP-2, pp. II-9 to II-23), but the data are limited, and such variables as the density-induced tidal-average upstream flow in the upper and lower layers, thermal stratification factor (TSF), and dispersion coefficients are not adequately quantified (FES, IP-2, pp. III-19 to III-25). The river conditions that would probably cause the greatest difficulty in meeting the New York State water quality criteria are those associated with low freshwater flows that tend to exist in the summer and fall, and with low coefficients of heat exchange from the surface to the atmosphere that occur in the fall and winter months.

Table V-2. Heat dissipation rates, cooling water flow rates, and total temperature rises for base design and alternative cooling systems, Indian Point Plant[a]

	Base design	Base design at reduced circulation	Alternative A	Alternative B
Heat dissipation method				
Unit No. 1	Once-through	Once-through	Once-through	Once-through
2	Once-through	Once-through	Cooling tower	Cooling tower
3	Once-through	Once-through	Once-through	Cooling tower
Heat dissipated to river, 10^6 Btu/hr				
Service water[b]				
Unit No. 1	150	150	150	150
2	100	100	100	100
3	140	140	140	140
Condensing water				
Unit No. 1	1,765	1,765	1,765	1,765
2	6,250	6,250		
3	7,350	7,350	7,350	
Blowdown[c]				
Unit No. 1				
2			87	87
3				103
Total	15,755	15,755	9,592	2,345
Heat dissipated to atmosphere, 10^6 Btu/hr				
Unit No. 1				
2			7,381	7,381
3				8,734
Total			7,381	16,115
Circulation of condensing water, percentage of full flow rate				
Unit No. 1	100	60	100	100
2	100	60	70[d]	70[d]
3	100	60	100	83[d]
Cooling system flow rates, 10^3 gpm				
Service water				
Unit No. 1	38	38	38	38
2	30	30	30	30
3	30	30	30	30
Condensing water				
Unit No. 1	280	168	280	280
2	840	504	590[d]	590[d]
3	840	504	840	698[d]
Blowdown				
Unit No. 1				
2			12	12
3				14
Evaporation and drift				
Unit No. 1				
2			14	14
3				17
Total intake from river	2,058	1,274	1,244	435
Total discharge to river (intake minus evaporation and drift)	2,058	1,274	1,230	404
Difference between river-water intake temp and discharge temp to river, F°	15.3	24.7	15.6	11.6

[a]Based on net generating capacities of 265 MWe (rated capacity) for Unit No. 1, 873 MWe (rated capacity) for Unit No. 2, and 1,033 MWe (maximum calculated capacity) for Unit No. 3.
[b]All service water cooling is by once-through river water flow.
[c]Tower blowdown heat dissipation is based on 95.5°F blowdown temperature and 81°F ambient river temperature.
[d]Recirculated through cooling towers.

When making an assessment of the thermal impact of the Indian Point Units on the Hudson River, the effect on the aquatic environment will be more completely described if the studies consider not only the heat released at Indian Point but also the heat released from all other power plants on the river that could have an effect. The locations of the principal power plants on the Hudson are shown in Fig. V-3, pertinent data for those considered important in the staff's analysis are given in Table V-3.

The staff's far field studies used the staff's transient one-dimensional mathematical model as presented in Section 1 of Appendix A to predict cross-sectional average temperatures in a longitudinal section of the river encompassing all the major thermal power stations located on the Hudson. The results of one of the studies, which assumes late summer conditions of a river freshwater flow rate of 4,000 cfs and a heat transfer coefficient to the atmosphere of 130 Btu/day$\cdot$ft$^2\cdot$°F, are shown in Fig. V-4. This figure indicates that the maximum estimated average cross-sectional temperature is more than 5 F° above ambient. Using more severe conditions of 4,000 cfs and 90 Btu/day$\cdot$ft$^2\cdot$°F (as apparently occurred in October and November of 1964, see Figs. II-5 and II-14), one gets a maximum cross-sectional temperature of more than 6 F° above ambient. Additional cases of the multi-plant effects on the Hudson River temperature distribution are given in Appendix A.

The staff's near field studies using the Hirst round jet model[25] and Koh and Fan slot jet model[26] indicate that the submerged discharge of warm water from the ports at slack tide will extend about 110 ft horizontally before reaching the surface; it will have a near-surface excess temperature of about 6 F° above background temperature for a jet velocity of 10 fps (see Tables V-4 and V-5). A schematic representation of the vertical profile of the discharged water plume for this set of conditions is shown in Fig. V-5. If the jet velocity is decreased or the intake and receiving water temperatures are increased due to recirculation effects or by the influence of other power stations on the river, there will be a corresponding increase in the surface temperature. The staff estimates that the surface temperature will be close to 90°F, for either intake and receiving water temperatures of 83°F and a jet velocity of 8 fps, or intake and receiving water temperatures of 81°F with a jet velocity of 5 fps (see App. A). For the following reasons, the staff has reservations concerning whether the 90°F surface temperature requirements of the State will be met at all times. (1) The far field studies for severe conditions provide estimated background excess temperatures at Indian Point as high as 3 F°. (2) Evidence shows that ambient river temperatures in the summer may reach 81 to 82°F (see Section II.E.1).

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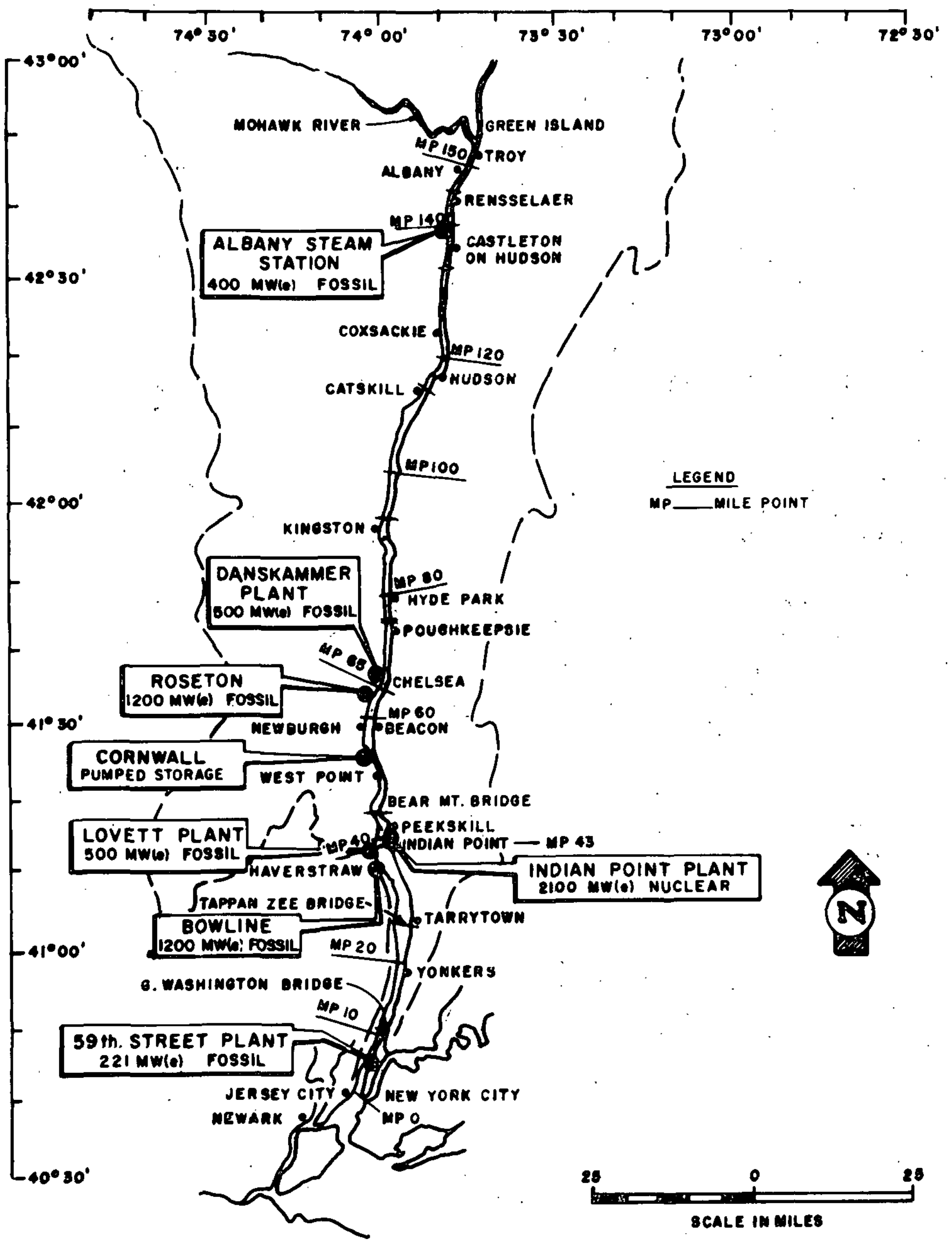

Fig. V-3. The Hudson River showing major existing and planned power generating plants. (Adapted from Quirk, Lawler and Matusky Engineers, "Hudson River Water Quality and Waste Assimilative Capacity Study," December 1970.)

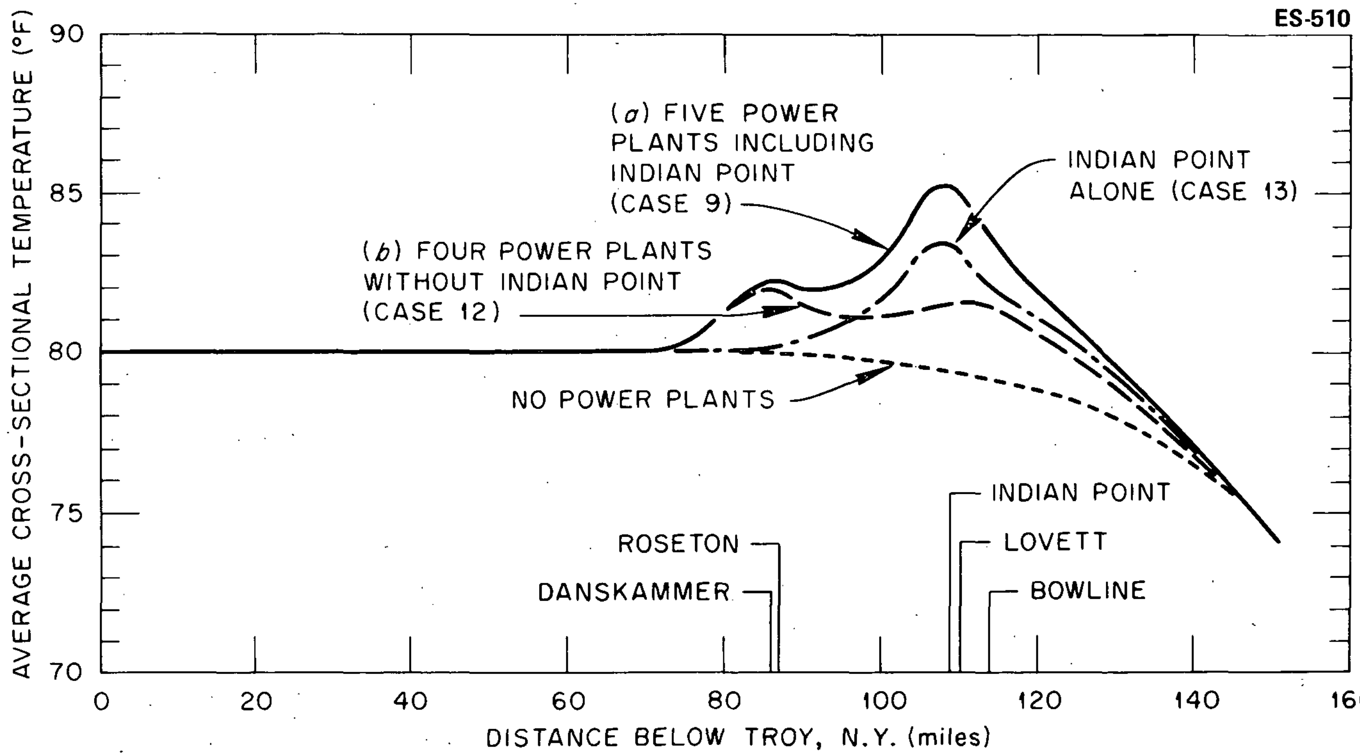

Fig. V-4. Calculated temperature distributions in the Hudson River with operation of (a) five power plants, (b) four plants without Indian Point, and (c) Indian Point alone. The Indian Point Station is at base design conditions, and freshwater flow in the river is 4,000 cfs with heat transfer to the atmosphere of 5.42 Btu/(hr$\cdot$ft$^2\cdot$F°), or 130 Btu/(day$\cdot$ft$^2\cdot$F°). Case numbers refer to Table A-6.

Table V-3. Thermal discharge data for principal thermal power plants on the Hudson River in the vicinity of Indian Point

	Danskammer	Roseton	Indian Point	Lovett	Bowline
Number of units	4	2	3	5	2
Plant location, mile point[a]	66.0	65.4	43.0	42.0	37.5
Net capacity, MWe[b]	508	1,200	2,171	503	1,240
Thermal discharge, 10^6 Btu/hr[b,c]	2,250	5,000	15,755	2,375	5,208
Cooling water circulation rate, cfs[c]	686	1,448	4,585	720	1,711
Water temperature rise through plant, F°[c]	14.6	15.3	15.3	14.6	13.5

[a]Miles above the Battery.

[b]Based on maximum calculated capacity for Indian Point Unit No. 3; based on rated capacity for all other units and plants.

[c]Assumes operation of all units.

Table V-4. Thermal plume analysis for Hirst round-jet model[a]

	Base case	Case 1	Case 2	Case 3	Case 4	Case 5
			Input parameters			
Jet salinity, ppt	7	7	7	7	0.15	7
River velocity, fps	0	0.4	0	0	0	0
Vertical salinity gradient, ppt/ft	0	0	0.015	0	0	0
Vertical temperature gradient, F°/ft	0	0	0.05	0	0	0
Exit jet velocity, fps	10	10	10	4	10	10
Equivalent port diameter, ft	8.7	8.7	8.7	8.7	8.7	7.5
			Calculated near-surface conditions			
Excess temperature at centerline of plume, F°	5.9	4.0	5.8	11.1	6.0	5.3
Distance along centerline of plume, ft	117.8	113.9	117.8	58.1	117.8	114.4

[a]Based on exit jet temperature 15.3 °F above river background temperature and port centerline submergence of 12 ft.

Note: These cases were calculated using a river background temperature of 79°F; other river background temperatures within the range of interest would have a negligible effect on the calculated plume excess temperatures.

Table V-5. Thermal plume analysis for Koh and Fan slot jet model[a]

	Base case	Case 1[b]	Case 2	Case 3	Case 4	Case 5	Case 6[c]	Case 7[d]
				Input parameters				
Port equivalent diameter, ft	3.82	4.25	3.82	3.82	3.82	3.82	4.18	2.39
Port equivalent spacing, ft	5.25	10.5	5.25	5.25	5.25	5.25	10.5	10.5
Jet exit velocity, fps	10	10	4	10	10	10	10	10
Jet exit temperature above river background temperature, F°	15.3	24.7	15.3	14.6	15.3	15.3	15.6	11.6
River surface salinity, ppt	7	7	7	7	7	0	7	7
Vertical river temperature gradient, F°/ft	0	0	0	0.05	0	0	0	0
Vertical river salinity gradient, ppt/ft	0	0	0	0.015	0	0	0	0
Number of 4-ft × 15-ft ports in use	10	5	10	10	10	10	5	5
Entrainment coefficient, round jet	0.057	0.057	0.057	0.057	0.03	0.057	0.057	0.057
Entrainment coefficient, slot jet	0.082	0.082	0.082	0.082	0.057	0.082	0.082	0.082
				Calculated near-surface conditions				
Centerline temperature, excess above river background temperature, F°	4.6	6.7	5.9	3.7	5.1	4.6	3.8	1.7
Horizontal distance of plume travel, ft	105.7	91.6	62.7	115.0	115.0	105.6	107.1	103.6
Volume of water above background temperature, 10^3 ft^3								
within 2°F isotherm	90.6	80.9	46.7	99.3	101.9	90.6	76.6	43.9
within 4°F isotherm	66.6	61.6	35.3	70.6	76.0	66.6	52.0	17.6
within 6°F isotherm	46.1	48.8	25.9	49.9	53.2	46.1	36.0	2.3

[a]For port centerline submergence of 12 ft.
[b]For 60% cooling water flow conditions.
[c]Represents Alternative A (see Table V-2).
[d]Represents Alternative B (see Table V-2).
Note: River background temperatures of either 79 or 81°F were used; background temperatures within the range of interest have negligible effect on the calculated plume excess temperatures.

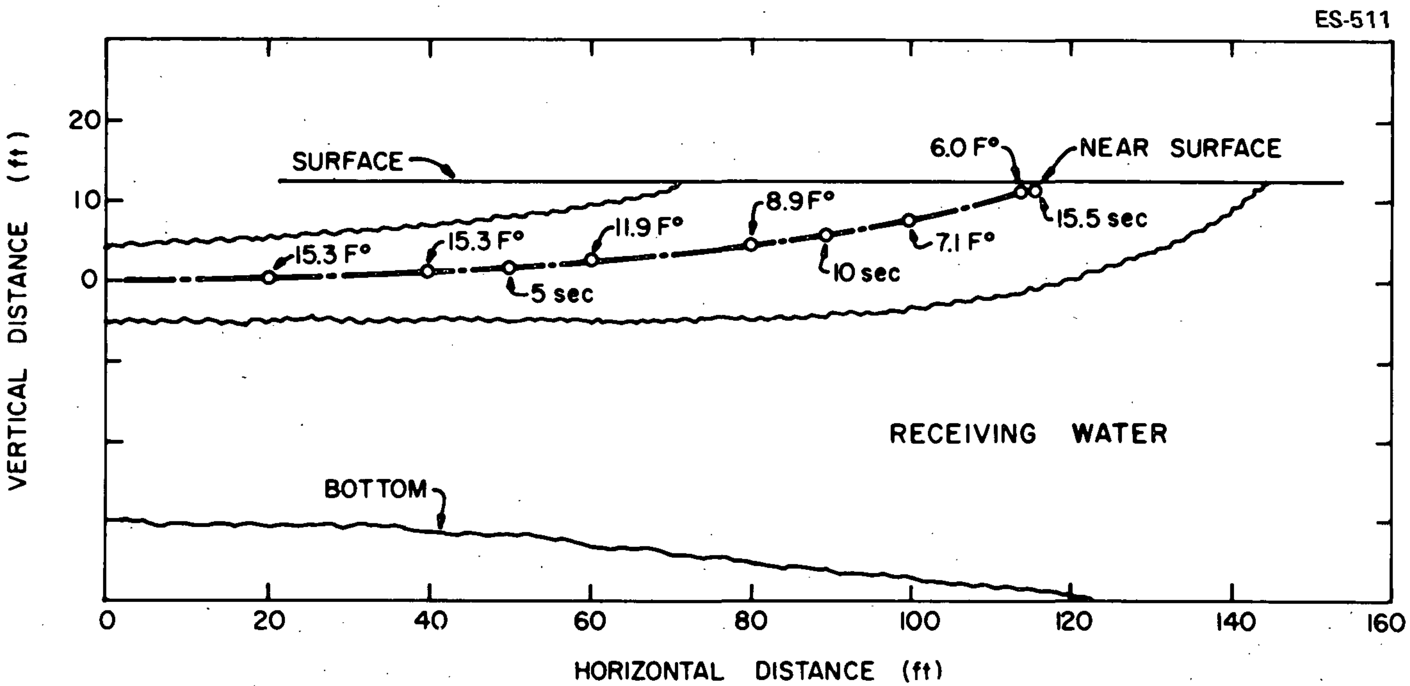

Fig. V-5. Schematic representation of vertical profile of Indian Point Plant water discharge plume using Hirst round-jet model for base-case conditions (see Table A-2). Temperatures and travel times apply to centerline of plume: temperatures are F° above receiving water temperatures; travel times are seconds after leaving discharge port.

Because of these reservations, the applicant will be required through the Environmental Technical Specifications to establish the surface temperature during the summertime to determine compliance with applicable criteria at all times. See Appendix A for further discussion of the near field models used.

The staff's intermediate field studies examined the thermal effects within a vertical plane extending across the width of the river at Indian Point. Because input values such as the dispersion coefficient, TSF, and heat loss coefficient to the atmosphere are subject to uncertainty due to the lack of field data, the staff carried out a parametric study over the following ranges of expected values:

Parameter	Range
River freshwater flow	4,000 and 7,000 cfs
Longitudinal dispersion coefficient	4 to 12 sq miles/day
Thermal stratification factor	1.0 to 3.5
Intake recirculation factor*	0.0 to 0.15
Submerged jet dilution factor	1.75 to 3.5
Surface heat exchange coefficient	90 to 130 Btu/day·ft^2·F°)

To facilitate the calculations, the staff used a computer program based on the applicant's mathematical model (ER, IP-3, Sect. 9), but with some modifications, as explained in Appendix A. (See ER, IP-3, Suppl. 3, Sect. 9.) The results are shown in Table V-6.

Evaluating the range of realistic values for each parameter is a very difficult task. To reduce the number of possibilities, it is reasonable to assume a constant submerged jet dilution factor of 2.0, a constant intake recirculation of 0.1, heat exchange coefficient to the atmosphere of 130 Btu/day·ft^2·°F, and a constant minimum freshwater flow of 4,000 cfs. The longitudinal dispersion coefficient and the TSF both have a larger range of uncertainty. In the staff's opinion, field experiments are clearly needed to establish the correct values for these parameters; values of 6.0 to 7.0 sq miles/day for the longitudinal dispersion coefficient and 1.5 to 2.0 for the TSF could be chosen. The above set of conditions are covered by cases 8 and 9 in Table V-6. Even when no recirculation of discharged water back to the intake is assumed, the surface width included within the 4 F° isotherm on a tidal maximum basis would exceed two-thirds of the width allowed by the State criteria for essentially all the combinations of parameters

*Defined as the ratio between intake excess temperature and condenser temperature rise minus one.

Table V-6. Parametric study of the intermediate-field temperature distribution in the Hudson River due to the Indian Point Plant thermal discharge

Case number	Input parameters: Dispersion coefficient (sq miles/day)	Input parameters: Thermal stratification factor	Input parameters: Recirculation factor	Input parameters: Submerged jet dilution	Temperature rise (F°): Cross section Av	Temperature rise (F°): Cross section Max	Temperature rise (F°): Surface Av	Temperature rise (F°): Surface Max	Fraction of total cross section and total width within 4 F° isotherm: Tidal average Cross section	Tidal average Width	Tidal maximum Cross section	Tidal maximum Width
Surface heat loss 130 Btu/(day·ft²·F°); freshwater flow 4,000 cfs												
1	4.0	1.0	0	1.75	7.2	15.3	7.2	8.7	0.76	1.0	1.0	1.0
2	4.0	1.0	0	2.0	7.2	15.3	7.2	7.7	0.76	1.0	1.0	1.0
3	4.0	1.0	0.15	2.0	8.2	17.6	8.2	8.8	0.84	1.0	1.0	1.0
4	4.0	1.25	0	1.75	6.5	15.3	8.2	8.7	0.66	1.0	0.89	1.0
5	4.0	1.25	0.15	1.75	7.5	17.6	9.4	10.1	0.73	1.0	0.98	1.0
6	8.0	1.0	0	1.75	5.3	15.3	5.3	8.7	0.50	0.74	0.67	1.0
7	8.0	1.0	0	2.5	5.3	15.3	5.3	6.1	0.50	1.0	0.67	1.0
8	8.0	1.0	0.15	2.5	6.1	17.6	6.1	7.0	0.55	1.0	0.74	1.0
9	8.0	1.25	0	1.75	4.8	15.3	6.0	8.7	0.44	0.99	0.59	1.0
10	8.0	2.5	0.15	1.75	4.0	17.6	9.9	10.1	0.34	1.0	0.46	1.0
11	12.0	1.0	0	1.75	4.4	15.3	4.4	8.7	0.40	0.53	0.54	0.71
12	12.0	1.0	0.15	1.75	5.1	17.6	5.1	10.1	0.44	0.62	0.59	0.83
13	12.0	3.0	0	1.75	2.6	15.3	7.8	8.7	0.23	1.0	0.31	1.0
14	12.0	3.0	0.15	1.75	3.0	17.6	8.9	10.1	0.25	1.0	0.34	1.0
Surface heat loss 130 Btu/(day·ft²·F°); freshwater flow 7,000 cfs												
15	4.0	1.0	0	1.75	6.2	15.3	6.2	8.7	0.61	1.0	0.82	1.0
16	4.0	1.5	0	1.75	5.4	15.3	8.1	8.7	0.51	1.0	0.69	1.0
17	4.0	1.5	0.15	1.75	6.2	17.6	9.3	10.1	0.56	1.0	0.76	1.0
18	8.0	1.0	0	1.75	4.9	15.3	4.9	8.7	0.45	0.63	0.61	0.85
19	8.0	1.0	0.15	1.75	5.6	17.6	5.6	10.1	0.50	0.73	0.67	0.99
20	8.0	1.0	0.15	2.50	5.6	17.6	5.6	7.0	0.50	1.0	0.67	1.0
21	8.0	2.5	0	1.75	3.3	15.3	8.3	8.7	0.29	1.0	0.40	1.0
22	12.0	1.0	0	1.75	4.1	15.3	4.1	8.7	0.37	0.48	0.50	0.65
23	12.0	1.0	0.15	1.75	4.8	17.6	4.8	10.1	0.41	0.56	0.56	0.76
24	12.0	3.5	0	1.75	2.4	15.3	8.3	8.7	0.21	1.0	0.28	1.0

Table V-6 (continued)

Case number	Input parameters				Temperature rise (F°)				Fraction of total cross section and total width within 4 F° isotherm			
	Dispersion coefficient (sq miles/day)	Thermal stratification factor	Recirculation factor	Submerged jet dilution	Cross-section		Surface		Tidal average		Tidal maximum	
					Av	Max	Av	Max	Cross section	Width	Cross section	Width
					Surface heat loss 90 Btu/(day·ft^2·F°); freshwater flow 4,000 cfs							
25	4.0	1.0	0	1.75	8.3	15.3	8.3	8.7	0.98	1.0	1.0	1.0
26	4.0	1.0	0.13	1.75	9.4	17.2	9.4	9.8	1.0	1.0	1.0	1.0
27	8.0	1.0	0	1.75	6.2	15.3	6.2	8.7	0.62	1.0	0.83	1.0
28	8.0	1.0	0.15	1.75	7.2	17.6	7.2	10.1	0.68	1.0	0.92	1.0
29	8.0	1.5	0	1.75	5.2	15.3	7.8	8.7	0.49	1.0	0.66	1.0
30	8.0	1.5	0.15	1.75	6.0	17.6	9.0	10.1	0.54	1.0	0.43	1.0
31	12.0	1.0	0	1.75	5.2	15.3	5.2	8.7	0.49	0.72	0.66	0.97
32	12.0	1.0	0	2.50	5.2	15.3	5.2	6.1	0.49	1.0	0.66	1.0
33	12.0	1.0	0.15	1.75	6.0	17.6	6.0	10.1	0.54	0.84	0.73	1.0
34	12.0	2.0	0	1.75	3.8	15.3	7.5	8.7	0.34	1.0	0.45	1.0
35	12.0	2.0	0.15	1.75	4.3	17.6	8.7	10.1	0.37	1.0	0.50	1.0
					Surface heat loss 90 Btu/(day·ft^2·F°); freshwater flow 7,000 cfs							
36	4.0	1.0	0	1.75	6.9	15.3	6.9	8.7	0.71	1.0	0.96	1.0
37	4.0	1.0	0.15	1.75	7.9	17.6	7.9	10.1	0.78	1.0	1.0	1.0
38	4.0	1.0	0.15	2.0	7.9	17.6	7.9	8.8	0.78	1.0	1.0	1.0
39	8.0	1.0	0	1.75	5.6	15.3	5.6	8.7	0.53	0.83	0.71	1.0
40	8.0	1.0	0.15	1.75	6.4	17.6	6.4	10.1	0.58	0.97	0.79	1.0
41	8.0	2.0	0	1.75	4.3	15.3	8.5	8.7	0.39	1.0	0.52	1.0
42	8.0	2.0	0.15	1.75	4.9	17.6	9.8	10.1	0.43	1.0	0.58	1.0
43	12.0	1.0	0	1.75	4.8	15.3	4.8	8.7	0.44	0.61	0.60	0.83
44	12.0	1.0	0	2.50	4.8	15.3	4.8	6.1	0.44	0.87	0.60	1.0
45	12.0	1.0	0.15	1.75	5.5	17.6	5.5	10.1	0.49	0.71	0.66	0.96
46	12.0	2.75	0	1.75	3.1	15.3	8.6	8.7	0.28	1.0	0.37	1.0
47	12.0	2.75	0.15	1.75	3.6	17.6	9.9	10.1	0.30	1.0	0.41	1.0

considered. Some combinations of parameters give estimated 4 F° isotherms on a tidal maximum basis covering more than one-half the cross-sectional area of the river.

Because of recent claims by the applicant that new information is showing heat exchange coefficients to be larger by a factor of 1.5 than those previously used by the applicant, the staff has used the same parametric study for a heat exchange value of 200 Btu/ $ft^2 \cdot day \cdot {}^\circ F$. Even with this most favorable heat exchange coefficient and for the 4,000-cfs flow (which according to Fig. II-7 may be expected to occur once every second year for a full week's duration), the 4 F° surface excess temperature isotherm will exceed two-thirds of the width of the river in almost all cases; only for the most favorable combinations of parametric values will the 4 F° isotherm extend less than two-thirds of the river width.

(2) Field Data and Research Program

Predictions based on mathematical models are greatly influenced by the values of the input parameters used. The applicant has recognized this limitation and agrees with the staff that "scarcity of field data makes the modeling difficult" and that "lack of significant heat quantities in existing Hudson River discharges and in comprehensive hydrodynamic measurements made the selection of certain system parameters extremely difficult" (ER, IP-3, pp. 9-13). The staff recommended in the Final Environmental Statement of Indian Point Unit No. 2 in September 1972 that field data should be taken as soon as possible to reinforce the mathematical predictions (FES, IP-2, pp. III-43, 49).

The applicant has stated that it "is in the process of formulating an elaborate thermal plume study program for Indian Point 2. The program consists of temperature measurements at both near field and far field, hydrological and meteorological data measurements, and comparisons of field data with model predictions" (ER, IP-3, p. 9-13). The staff is indeed anxious to see such a program implemented and hopes to have its results as soon as possible. To date, however, the staff has received only two documents[27,28] related to this program. The first document[27] explains the survey program and demonstrates the capability of the subcontractor (Dames and Moore) to perform such a survey as well as the workability of the instrumentation involved. The program seems to be well planned and includes most of the parameters involved in thermal modeling. There are, however, a number of deficiencies that need to be corrected:

- The planned program does not mention the fact that it takes weeks and sometimes months for the river to reach quasi-steady-state equilibrium. Therefore care must be taken to have the power plant at near-full load operation for as long a period as possible (at least two weeks) before the survey starts. The survey period itself should include data for at least three complete successive tidal cycles.

- The dispersion coefficient should be evaluated based on dye studies and not on salinity distribution, since the ocean salt intrusion phenomena is not the same as dispersion of discharged material toward the ocean. The dye study therefore should be extended to include dispersion in the far field in addition to recirculation in the near field. Dye studies are very helpful in the determination of dispersion coefficients; however, the dye concentrations cannot be looked upon as simulating the excess temperature above ambient. Dye lacks both bouyancy and heat exchange with the atmosphere compared to heated water which experiences both effects.

- The program refers to two intensive surveys which are planned for the spring and fall of 1974. First, neither of these two surveys were reported to the staff as of the date this Statement was being prepared. Second, the late summer (mid-August to mid-September) is definitely the most interesting period for thermal monitoring and should be included in that program. Specifically, the program in this time period has the advantage of being able to monitor not only the extent of the 4 F° excess temperature isotherm but also the extent of the 83°F temperature isotherm that, as explained before, can be of controlling importance with respect to New York State thermal criteria.

The second document[28] is the first report (May 1974) of the routine monthly thermal monitoring program conducted by the applicant in accordance with the Section 401 water quality certification requirements for Units Nos. 1 and 2. It should not be confused with the intensive thermal surveys that were mentioned in the first document by Dames and Moore.[27] The monitoring can be considered a reasonably good effort to "see what happened" on May 31, 1974, and reflects somewhat on whatever predictions have been made by now. It can not be used in any way for model corrections, model verifications, or model comparisons because this was not a complete survey.

The report states that, for the low water slack period, "the surface width of the 65.0°F isotherm (which is of greater extent than the 65.9° or 65.7°F isotherm) can be estimated from far field patterns (Fig. 24.1) as approximately 2,300 feet or about 46 percent." This statement must be qualified by the following differences between the May 31, 1974, conditions and those used by both the applicant and the staff in their evaluation of compliance with New York State criteria.

- Combined operating power level of both units was 1,074 MWe compared to 1,138 MWe, and total heat discharged into the river was 173 billion Btu/day (calculated) compared with 200 billion Btu/day considered by both the applicant and the staff.

- The survey was taken for a period of 1-1/4 tidal cycles only and was started only one day after raising the power level of Unit No. 2 from 400 MWe to 800 MWe (rated capacity is 873 MWe). As mentioned above, it takes a few weeks for the river to fully react and approach quasi-steady-state equilibrium.

- The history of the power plant level is reported in Fig. 3 of ref. 28 for only the day of operation and the day before. One must consider the actual power level during at least one month before the survey started.

- Many atmospheric and river ambient parameters were not monitored, and their effects on what happened during the monitoring period are therefore not known.

- May is not considered a critical month for thermal discharges.

- River freshwater flow was greater than 12,000 cfs as compared to 4,000 cfs considered by both the applicant and the staff to represent the summer low flow rate. Heat exchange coefficient to the atmosphere in May may or may not be higher than in August, depending on the actual conditions that prevailed on May 31, 1974. The total width of the river is considered to be 5,000 ft as compared to 4,000 ft previously used by the applicant and by the staff.

This last point can raise considerable confusion since a 2,300-ft extent gives 46% if based on 5,000-ft river width (as used here) and 57% when based on 4,000-ft river width. All the values reported before by the applicant and the staff were based on a 4,000-ft river width.

In spite of the more favorable conditions existing during the monitoring period, the extent of the 3.1 F° excess temperature isotherm (used to represent the 4 F° isotherm) is reported as 46% based on 5,000-ft river width (or 57% based on 4,000-ft river width). This can be compared to 31% reported by the applicant for "maximum severe conditions" possible [ER, IP-3, App. EE(1), Table 7]. The thermal stratification factor which can be calculated from this monitoring survey is about 1.5 to 2.0, which is in the range the staff has chosen as most reasonable in the FES for Indian Point Unit No. 2 and is being used in this Statement as well.

The research program proposed by the applicant[27] seems to be very comprehensive and will be very useful in determining more realistically the input parameters of the mathematical models currently being used for the thermal assessment. It may also be useful for modifying and calibrating these models so that more confidence will be gained in their prediction. However, the staff does not believe that predictions using these models will be accurate enough to eliminate the need for monitoring as a tool for determining actual violations of thermal criteria. Only a long period (probably a number of years) of trial and error experience, under many diversified hydraulic and meteorological conditions can determine the extent of such capability.

(3) Probability and Frequency of Occurrence

In the ASLAB decision on the Indian Point Unit No. 2 case,[29] the comment was made that "conditions which would threaten the 4°F limit are rare and, if they occur, the applicant must conform to New York State standards and actions such as slight reductions in plant power output may be necessary." Looking at the thermal criteria from such a point of view requires a new type of assessment. The question is not merely whether the operation of the power plant might violate the criteria but also how often this may occur and, in each case, to what level the applicant will have to reduce the power output and for what length of time in order to conform with those criteria. The staff's opinion is that such a point of view opens infinite possible situations, and the state of knowledge of predicting thermal effects does not allow such a complete determination of what will happen. Nevertheless, the staff has made an attempt to respond to part of this question using the best engineering judgments possible. Therefore, a reduction of 50% was assumed for benefit-cost calculations in Chapter XI. This assessment should not be considered a prediction but rather a rough estimate of the probability and frequency of occurrence for conditions that may cause violation of the New York State thermal criteria.

To begin with, the parameters involved in such an assessment are many and very complex. The ones that explicitly appear in the model used to predict the 4 F° excess isotherms are:

Q = River freshwater flow
K = Heat exchange coefficient with the atmosphere (which involves a large number of other river and meteorological parameters)
E = River dispersion coefficient
TSF = River thermal stratification factor
R = Percentage of heat recirculating back into the intake structure
D = Jet dilution factor in the near field.

All these parameters are interrelated; they depend on the seasons and vary from year to year. The uncertainty in each one can be very large. There are two parameters, however, that are most strongly dependent on weather conditions, these are the river freshwater flow (Q), which is normally measured, and the atmospheric heat exchange coefficient (K), which is normally calculated from the proper meteorological conditions. The staff has used freshwater flow data supplied by the U.S. Department of the Interior for 26 years between 1947 and 1972 (see Section II.E.1) and 10-year weather tapes furnished by the U.S. Weather Bureau Station at Newburgh (about 18 miles from Indian Point site) to produce statistical information on the frequency of occurrence for the months of May through October, as shown in Fig. V-6. The heat exchange coefficient is not measured directly but is calculated from the meteorological data supplied in the weather tapes.

The staff has used the recently published method for predicting heat exchange coefficients in artificially heated water bodies by Ryan and Harleman,[30] which is known to predict much higher values of the heat exchange coefficient than predicted by the more established methods of Edinger and Geyer[31] or Brady et al.[32] The staff used the Ryan and Harleman method because it is more sophisticated and it gives values in closer agreement with those used by the applicant. Based on its far field studies, the staff assumed 3 F° excess surface temperature and added this to all the river ambient

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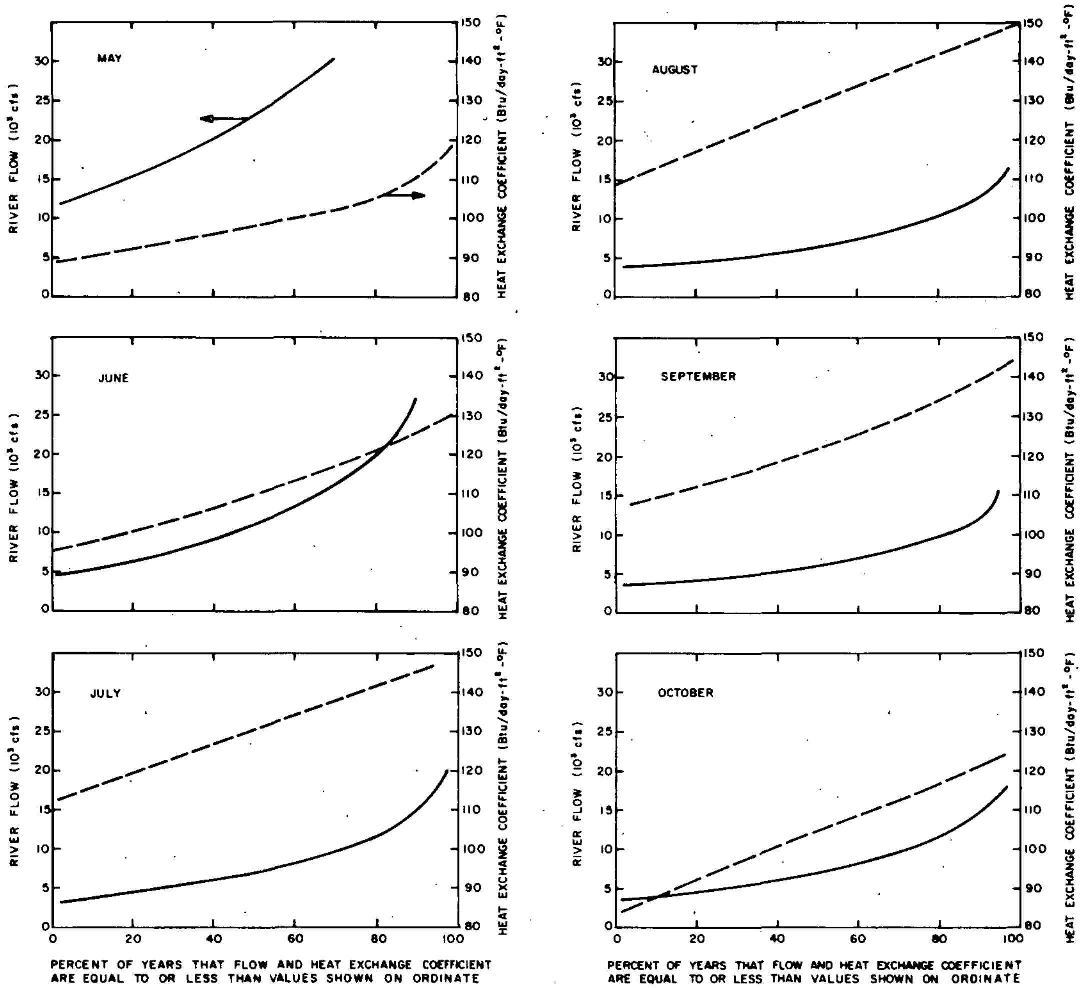

Fig. V-6. Frequency of occurrence of freshwater flow rates and surface heat exchange coefficients for the Hudson River, May–October based on monthly average values.

temperatures used in the calculations. The results of the staff's calculations are shown in Fig. V-7, which also shows average monthly values as reported in the ER, IP-3, App. EE. There is a fairly good agreement between the two sets of values even though the method of calculation and the data used are not the same. The maximum monthly average heat exchange coefficient calculated by the staff was 165 Btu/ft^2·day·°F for August 1958, using the Ryan and Harleman method[30] which is also recommended by the applicant.[33] The closest Weather Bureau data to Indian Point is that taken at Newburgh, New York, located about 18 miles from Indian Point. The applicant has already stated that weather data differences between Newburgh and Indian Point are not significant (ER, IP-3, App. I, p. B-12).

The rest of the parameters (i.e. dispersion coefficient, TSF, jet dilution ratio, and intake heat recirculation) are subject to a range of uncertainty. The staff has used its best engineering judgment to choose the most probable set of values for these parameters. The values chosen are:

Dispersion coefficient of 8 ft^2/day,
Thermal stratification factor of 1.75,
Intake heat recirculation of 0.0%
Near field jet dilution ratio of 1.75.

The chances of violating the 4 F° criteria decrease when using higher values for the dispersion coefficient, lower values for TSF, lower values for heat recirculation, and lower values for jet dilution ratio. Although the staff believes a recirculation value of 10% is correct, to eliminate the arguments with the applicant on the proper way to consider recirculation, the staff has set it to zero in all cases. In some cases, when it was difficult to make a clear judgment, more optimistic values were used; i.e., dispersion coefficient of 12, TSF of 1.5, and jet dilution ratio of 1.5.

Based on the above conditions and the frequency information for freshwater flow and heat exchange coefficient presented in Fig. V-6, the staff made its best estimate of the frequency of occurrence of violation of the 4 F° excess surface temperature criteria during the six months of interest.

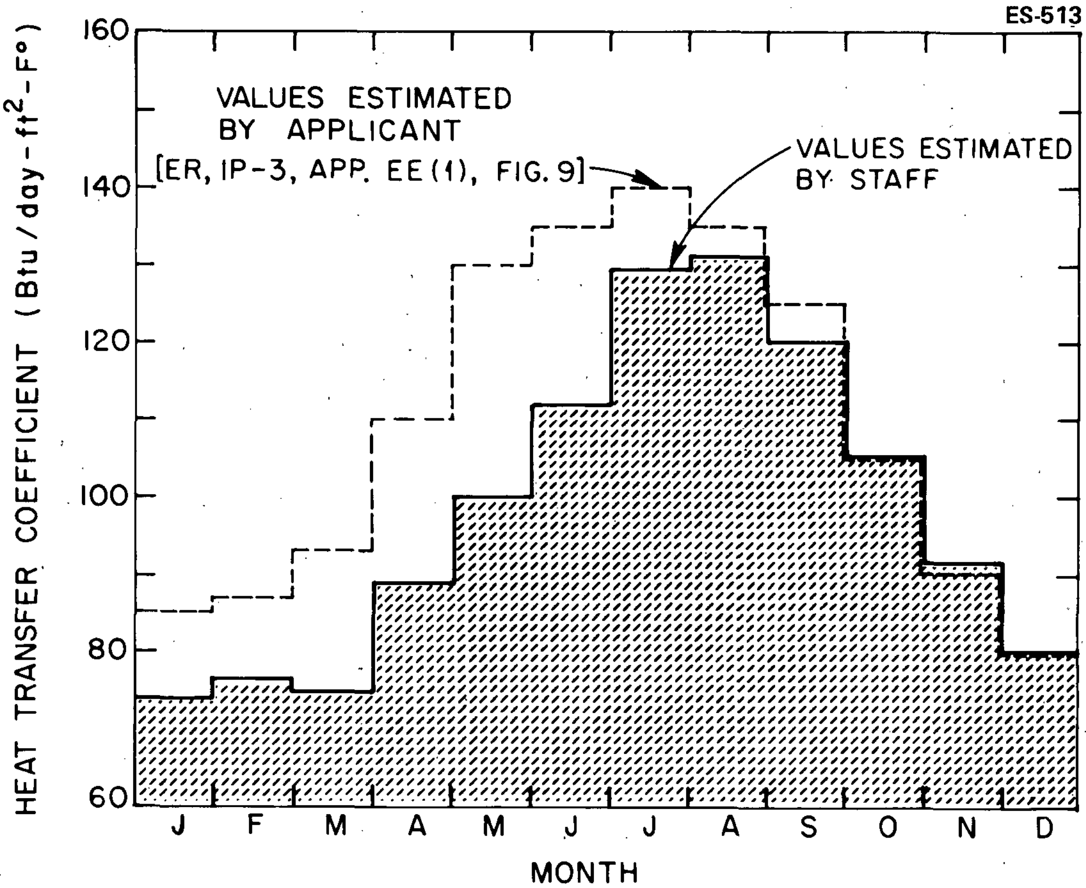

Fig. V-7. Hudson River water surface heat transfer coefficients calculated by staff. Estimates are based on Stewart Air Force Base (Newburgh, N.Y.) meteorological data (1958-68), on USGS water temperature data (1959-69) supplied by applicant (ER IP-3 Supp. 11, p. 9-1) to which 3°F was added (see text), and on equations of Ryan and Harleman (see text).

Month of the year	Percentage of years in which there will be a possible violation during the month indicated
May	45%
June	80%
July	90%
August	>95%
September	>95%
October	>95%

In addition, the staff has evaluated the frequency of violation on a yearly basis by using Fig. II-7 for monthly (30 consecutive days) drought flow occurrence and a year-round constant value of 165 Btu/day$\cdot$ft$^2\cdot$°F (the highest the staff has calculated) for the heat exchange coefficient and found a frequency of violation greater than 90% of the time. The meaning of this figure is that at least 9 years out of every 10, there will be conditions, persistent for 30 consecutive days, that will cause violation of New York State thermal criteria. Using the same flow data (Fig. II-7) but the most optimistic values for all other parameters (i.e. dispersion coefficient of 12 miles/day, TSF of 1.5, zero heat recirculation, jet dilution ratio of 1.5, and a year-round heat exchange coefficient of 200 Btu/day$\cdot$ft$^2\cdot$°F), the staff gets a frequency of violation about 60% of the time or approximately one month every second year. This value is indeed a substantial percentage of the time and was arrived at under very optimistic assumptions. The staff has used a frequency of occurrence of 30 days every second year in its analysis of the cost of cooling towers (Sect. XI.I.1).

Note that the above estimate assumes that maximum river ambient temperature is not greater than 79°F and therefore the 4 F° excess temperature criteria is the controlling limitation. As shown in Sect. II.E.1, there is strong evidence that the maximum river temperature can even be above 81°F. In this case, only 2 F° excess temperature will be allowed within one-third of the river width or half of the river cross section. Under such conditions, violation of the New York State thermal criteria is almost a certainty. There are not much data that will allow the staff to estimate the frequency of occurrence for maximum river temperature above 79°F. Based on the evidence supplied in Sect. II.E.1, however, this seems likely to occur quite often during the month of August and maybe the first part of September, but will rarely occur in other months of the year.

In the staff's opinion, in spite of all the uncertainties involved in the above estimate, there is no escape from concluding that operation of the Indian Point Plants at full load is expected to violate the 4 F° excess surface temperature for a major percentage of the time, and this is particularly applicable in the summer when the freshwater flow is the lowest. However, the applicant will be required to monitor the thermal discharges to assure compliance at all times with applicable laws and the Environmental Technical Specifications.

c. Summary and Conclusions

Both the applicant and the staff have performed very extensive studies to assess the effects of the thermal discharges from the Indian Point Power Plant on the Hudson River temperature distributions. The studies include both physical and mathematical modeling for both the near and the far field. A great deal of the effort was directed toward determining compliance with the New York State criteria. The nature of the New York State thermal criteria and the complex hydrology of the Hudson Estuary calls for a time-dependent, three-dimensional transport model, combined with very comprehensive field data. Neither the model nor the field data required for making a reliable prediction of those effects are available at the present time. Therefore, the assessment of both the applicant and the staff should be looked upon not as an exact analysis but as an overall estimate.

There exist some differences between the models used by the applicant and those used by the staff, a discussion of which is given both in this Environmental Statement as well as in the one prepared for Indian Point Unit No. 2. However, the staff concludes that those differences are not important when compared to the larger range of deviations that exist in the assumptions made and the input values used for the various physical parameters. The staff and the applicant are in complete agreement that "lack of significant heat quantities in existing Hudson River discharges and of comprehensive hydrodynamic measurements made the selection of certain system parameters extremely difficult" and that "scarcity of field data available makes the modeling difficult" (ER, IP-3, Suppl. 3, p. 9-13).

The staff therefore believes that comprehensive field surveys, which are indeed proposed by the applicant, are the most important step which can and should be taken at the present time. Such programs should be implemented without delay since they can be very time consuming. One should take advantage of having Unit No. 2 already in operation so that as much data as possible can be taken before Unit No. 3 is ready for operation.

Based on the thermal assessment to date, the following are the major conclusions from both the applicant and the staff studies concerning all three Units with once-through cooling.

Applicant's mathematical studies and field data information:

1. The maximum river ambient temperature is 79°F, and therefore the 4 F° excess temperature criteria is identical to the 83°F maximum temperature isotherm criteria.

2. The significance of the density-induced circulation on the thermal plume is established, and at least 20,800-cfs dilution flow exists at the vicinity of Indian Point (ER, IP-3, p. 9-9).

3. "In all cases, the criterion for cross-sectional area subjected to the temperature rises in excess of 4 F° should not be exceeded at any section if present design of the Indian Point outfall structure is used." [ER, IP-3, App. DD(1), p. 24].

4. "The surface width subjected to the temperatures rises in excess of 4 F° at the Indian Point plane of discharge, using the present outfall design, may be marginal to, but not contravene, the NYSDEC criterion. This conclusion is made for conditions of maximum severity." [ER, IP-3, App. DD(1), p. 23].

5. "The conservative estimate for surface width bounded by the 4 F° isotherm at Lovett (MP 42) may exceed the criterion under conditions of maximum severity, whereas the liberal estimate indicates compliance with the criterion." [ER, IP-3, App. DD(1), p. 24].

6. "The maximum surface temperature rise at Indian Point was determined to be 8 to 9 F° for tidal average conditions and 9 to 10 F° for critical tidal phase. Based on a maximum ambient temperature of 79°F in summer, the maximum surface temperature would be 89°F, which would not exceed the NYSDEC criterion of 90°F for maximum surface temperature." [ER, IP-3, App. DD(1), p. 22].

Applicant's physical hydraulic study (based on 20,800 cfs freshwater flow):

1. "With the present discharge configuration the 4 F° isotherm extends across the river at some location at all times with Lovett operating and approximately 90 percent of the time without Lovett operating" [ER, IP-3, App. DD(2), p. 3]. Furthermore, in some cases, even the 5 F° excess surface isotherm may extend all the way across the river (Fig. V-1).

2. "The 4°F isotherm occupies less than 50 percent of the cross-sectional area at all times" [ER, IP-3, App. DD(2), p. 3].

3. The average surface temperature near Lovett may rise by about 5 F° when Indian Point, Lovett, and Bowline power plants are simultaneously in full operation (Fig. V-2).

4. "The maximum surface temperature rise observed in the 1/50 model was between 9 and 11 F° above the intake temperature. Since steady currents were used, this maximum temperature rise does not reflect residual temperature build-up nor plant recirculation" [ER, IP-3, App. DD(2), p. 1].

5. The thermal stratification factor, defined as the ratio between the surface average temperature rise and the cross-section average temperature rise, was found in the model to be in the range of 1.44 to 1.77 [ER, IP-3, App. DD(2), Table 3].

Staff Analysis and Review Studies:

1. The maximum river ambient temperature in the months of August or September may be 80 to 81°F, and therefore, in some cases, the 83°F maximum temperature isotherm criterion is more restricting than the 4 F° excess temperature criterion and must be taken into account.

2. The density-induced circulation phenomenon exists in the vicinity of Indian Point and should be taken into account (as indeed it is by the use of unusually large values for dispersion coefficients in the one dimension convection-dispersion model), but the Net Nontidal Two Layers System Model used by the applicant is not an acceptable model for that purpose. The magnitude of the various flows involved are not yet established nor is the degree of vertical mixing involved.

3. Over two-thirds of the surface width of the river in the vicinity of Indian Point will likely experience, under severe operating conditions, a temperature rise of 4 F°,

and for certain conditions, even on a tidal average basis, the 4 F° isotherm temperature can reach across the entire surface width of the river in the vicinity of Indian Point.

4. In many cases of severe operating conditions, over one-half of the cross-sectional area of the river may experience a temperature rise of 4 F°.

5. The far field studies indicate that the cross-sectional average temperature rise in the vicinity of Indian Point can be from 3.5 F° when only the Indian Point Plants are in operation up to 6.3 F° when all the other major plants on the Hudson River are considered. The interaction between the various power plants is significant and should be taken into account when a total assessment is desired.

6. The near field jet maximum surface temperature is expected to be about 6 to 7 F° above the receiving water temperature into which the heated jet is discharged. A temperature buildup in the receiving water can affect the final surface temperature of the jet by both re-entrainment into the plume and recirculation through the intake. Considering that such temperature buildup from the far field can be more than 3 F°, that the ambient temperature itself may be about 80 to 81°F, and that the applicant currently has difficulties in maintaining the 10-fps discharge velocity, the staff concludes that compliance with the 90°F maximum surface temperature is possible but is very marginal. The chance of violating this criterion, however, increases when the effects of all the other four power plants are considered.

7. The staff has estimated the frequency of possible violations of the New York State thermal criteria for a full month's duration and found that, during the months of May through October, it can be 45%, 80%, and 90% of the time for May, June, and July, respectively, and over 95% for August, September, and October. On a total year-round basis, this frequency can be as high as 90% of the time or 9 out of every 10 years for a full month's duration. Using a most optimistic set of assumptions, this frequency becomes about 60% of the time, or roughly, 30 consecutive days one out of every two years.

8. Considering all the above conclusions, including those stated by the applicant, one must conclude that the Indian Point Plant, if operating with a once-through cooling system, will release thermal effluents having major effects

on the Hudson River temperature distribution and will violate the New York State thermal criteria as discussed above, particularly during the late summer when the freshwater flow is the lowest.

2. Chemical Discharges and Sanitary Wastes

a. Chemical Discharges

During the testing and operation of Unit No. 3, various liquid, gaseous, and solid wastes will be produced from leakage from the primary coolant system, steam generator blowdown, regeneration of demineralizers, flash evaporator blowdown, and cleaning of the condenser tubes. The different water treatment procedures carried out by the applicant are governed by the rate of water use of several systems rather than by operation at different power levels. Thus the chemical additions and discharges are the same for both partial and full-power operation with one exception; namely, chlorine used to maintain condenser cleanliness. Furthermore, while the waste products of testing are generally of short-term concern, the operational wastes will be present throughout the operating life of each Unit.

The applicant will be required to comply with all applicable New York State and Federal regulations pertaining to water and air quality standards in its disposal of these wastes. The New York State Department of Environmental Conservation established the Hudson River as "Class SB" (6 NYCRR 701.4)[19] based on waste uses (ER, IP-3, p. 10-7). However, these criteria are general in nature, and the applicant has proposed limits on the chemical discharges (Table V-7) that it believes will satisfy these criteria (ER, IP-3, p. 10-6). The State and EPA are in the process of establishing revised State water quality standards that will be in compliance with the requirements of FWPCAA of 1972.

The chemical discharges will be limited through the Environmental Technical Specifications and will be monitored to assure that the releases will not result in any significant adverse impacts and that they will be in compliance with Federal and State regulations.

During the operation of the Indian Point Units, certain chemicals must be used to maintain the desired water quality required in the primary and secondary water systems. Some of the chemicals will be contained in closed-loop systems and will eventually be disposed of as solid waste, while other chemicals will be discharged with liquid effluents into the Hudson River through the discharge canal.

The applicant uses the Hudson River as a source for once-through condenser cooling water for all three Units. The flow in the discharge canal, with all three Units in operation, will be 2,058,000 gpm. A water flow of about 100,000 gpm will be available for dilution of chemical wastes during outages; at such times, maximum chemical concentrations will be present in the discharge. A summary of the sustained chemical discharges is given in Table V-7. Note that the concentration levels are shown for the extreme case; that is, when only Plant service water is available for dilution. Additional dilution of wastes would occur when the full cooling water flow of 4,585 cfs is available. In Table V-8 are given the maximum intermittent chemical discharges to be expected from Unit No. 3 during testing or operation. Also shown are estimates of increases in concentrations to be expected in the river for a freshwater flow of 4,000 cfs.

(1) <u>Releases from Primary System</u>

The standard chemicals utilized in the primary systems include lithium hydroxide to control pH and oxygen levels and boric acid to control the neutron flux. These chemicals will be added to the primary coolant to obtain the desired water chemistry. The Chemical and Volume Control System (CVCS) is designed to maintain the chemistry and purity of the primary coolant, the desired boric acid concentration, and the volume of water in the primary system. See Sect. V.E for a description of the radioactive waste treatment system. Normally, leakage from the primary system would be processed through the CVCS or the waste disposal system. Based on the assumption of an evaporator breakdown in the waste disposal system, the maximum concentration that could be expected under the conditions of evaporator breakdown* occurring in Unit No. 3 would be about 2.2 ppm lithium with a maximum waste disposal flow rate of 25 gpm, yielding a possible sustained release of 0.66 (2.0)** lb/day of lithium hydroxide for 2 hr/day.

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*Chemical releases during evaporator breakdown are on an intermittent basis. Such releases should not be construed as occurring on any routine basis during normal operation.

**The releases are expressed for Unit No. 3 only, and the numbers inside the parentheses are the releases for all three Units whenever applicable; otherwise, the number represents releases from Units Nos. 2 or 3.

Table V-7. Maximum sustained discharges of chemicals to the Hudson River from the Indian Point Plant (Units Nos. 1, 2, and 3)

	Amount released (lb/day)			Total concentration in discharge canal (ppm)[a]	Increase in concentration in Hudson River (ppm)[b]	Applicant's proposed limits for discharge canal (ppm)[c]
	Unit No. 1	Unit No. 2	Unit No. 3			
Sodium phosphate (as PO_4)	15	38	38	0.076	0.004	1.5
Hydrazine	24[d]	1	1	0.022	0.001	0.1
Cyclohexylamine	2.5	2.4	2.4	0.006	0.0003	0.1
Lithium hydroxide (as Li)[e]	0.66[f]	0.66[f]	0.66[f]	0.020	0.001	0.01
Boric acid (as B)[e]	600	600	600	1.5	0.083	9
Potassium chromate (as Cr)[e]		30	30	0.050	0.003	0.05
Sodium hydroxide	156	12[g]	12[g]	0.37	0.020	10
Sulfuric acid	450[h]			9.0	0.50	10
Soda ash (as Na_2CO_3)	1,000[i]			1.7	0.094	5
Detergent	3[f]			0.030	0.002	1
Copper				0.002[j]	0.0001	
Zinc				0.001[j]	0.00006	
Residual chlorine				0.5[j]	0.028[k]	0.5
Chlorine reaction products				0.5[j]	0.028[k]	

[a]Based on 100,000 gpm flow in discharge canal. Concentrations are those calculated to occur during the period of release.

[b]Based on 4,000 cfs (1.8×10^6 gpm) freshwater flow in Hudson River.

[c]ER, IP-3, p. 10–8.

[d]Released once a year.

[e]Released only in case of evaporator breakdown at Units Nos. 2 and 3.

[f]Released for 2 hr/day.

[g]Released for 2 hr/day every four to seven days during evaporator breakdown.

[h]Released for 1 hr/day.

[i]Released for 12 hr/day two to four times a year.

[j]See text.

[k]Assumes no chlorine demand in the river.

Table V-8. Maximum intermittent chemical discharges to the Hudson River from Unit No. 3

Chemical	Concentration in discharge canal (ppm)[a]	Increase in concentration in Hudson River (ppm)[b]
Sodium phosphate (as PO_4)	0.5	0.03
Hydrazine	0.2	0.01
Lithium hydroxide (as Li)	0.03	0.002
Boric acid (as B)	2.1	0.12
Potassium chromate (as Cr)	0.05[c]	0.003
Sodium hydroxide	0.125	0.007
Cyclohexylamine	0.01	0.0006

[a]Based on 100,000 gpm flow in discharge canal.

[b]Based on 4,000 cfs (1.8×10^6 gpm) freshwater flow in Hudson River.

[c]Applicant states that discharge will be controlled such that this concentration will not be exceeded. The New York State Department of Environmental Conservation is requiring the collection of all chromium discharges in a tank where additional treatment will be carried out prior to discharge into the discharge canal. All acids or bases will be collected in neutralization tanks and neutralized prior to discharge to the river.

Boron in the form of boric acid is used for reactivity control in the primary coolant and may be present in the effluent. A breakdown of the boric acid evaporators would possibly necessitate a maximum sustained release of 600 (1800) lb of boric acid per day at a maximum discharge rate of 25 gpm. The expected concentration of boric acid as boron would be less than 10 ppm.

(2) Releases from Secondary and Auxiliary Systems

Releases from the secondary and auxiliary systems include sodium phosphate, which is used to control the steam generator acidity and to treat the house service boilers. In Unit No. 3 the phosphate concentration level (expressed as phosphate) of no more than 80 ppm at any one time or no more than 10 ppm on a sustained basis will be obtained at a maximum discharge rate of 40 gpm so that the concentration at the point of discharge into the river is 1.5 ppm. At the maximum expected discharge rate of 40 gpm, the expected sustained release (expressed as PO_4) is 38 lb/day from Unit No. 2 or No. 3 and 15 lb/day from Unit No. 1. Once the intertie of the steam generator blowdown from Unit No. 3 to Unit No. 1 is in operation, the radioactive content of the blowdown will be treated by means of the Unit No. 1 blowdown flash tank demineralizers of the Secondary Boiler Blowdown Purification System at Unit No. 1. See Sect. V.E for further details. The chemicals present in the blowdown would then be partially removed by the filters and demineralizers.

Hydrazine, which is needed to control oxygen in the steam generators, will be kept at a concentration of 2.0 ppm during normal operation. The expected discharge rate is 40 gpm, and the expected sustained release is 1 (2) lb/day during normal operation. However, a discharge of 100 ppm of hydrazine may occur once per year at the end of the refueling outage. Hydrazine is also discharged once a year from Indian Point Unit No. 1 during refueling at a flow rate of 40 gpm. The maximum possible release rate would be 24 lb/day at a maximum concentration of 50 ppm.

Cyclohexylamine, used to adjust the pH of feedwater and generator steam, will not exceed a concentration in the steam generator blowdown of 5 ppm, which is released on a sustained basis at an expected discharge rate of 40 gpm. The service boilers in Indian Point Unit No. 1 release blowdown continuously at a maximum rate of 40 gpm, containing a maximum concentration of 5 ppm cyclohexylamine. The expected sustained release of the amine is 2.4 (4.8) lb/day from Indian Point Units Nos. 2 and 3 and 2.5 lb/day from Unit No. 1. The proposed maximum concentration of amine discharged from all Units will be 0.1 ppm at the discharge point into the river.

Potassium chromate is used as a corrosion inhibitor in the closed cooling water system of Indian Point Unit No. 3. No discharge is planned, but some leakage at a maximum concentration of 100 ppm with a maximum discharge flow rate of 25 gpm could result in a concentration of 0.05 ppm (as the hexavalent chromium) at the discharge point to the river. A maximum sustained release of 30 (60) lb/day at Units Nos. 2 and 3 would occur. All chromium solutions will be treated prior to discharge.

Sodium hydroxide is also used during normal operation to regenerate the spent resins in the primary system demineralizers as the anionic form once every 4 to 7 days for 2 hr. Spent sodium hydroxide is drained to the waste disposal system where it is processed by the waste evaporator. It is also used to control the pH in the evaporator. The waste distillate can be reused, but the concentrates would be ultimately discharged at the rate of 25 gpm into the discharge canal. If the evaporator breakdown occurs, the maximum concentration discharged would be 500 ppm at the rate of 12 (24) lb/day. This applies to Unit No. 2 or 3. At Unit No. 1 for one hour per day, 120 lb of a 4% sodium hydroxide solution is used for one regeneration of the water treatment mixed-bed ion exchangers and discharged. Another 30 lb/day of sodium hydroxide is used to treat the service boilers at Unit No. 1, and 6 lb/day is discharged from the waste evaporator. The latter two are continuously blown down. Thus, in the most extreme case, a total of 180 lb/day of sodium hydroxide can be released to the discharge canal from all three Units.

Sulfuric acid is used to control the pH of river water, which is distilled in flash evaporators, and the distillate is used for makeup water for various Plant systems. The concentrates from the flash tank blowdown released to the discharge canal have a pH between 7.0 and 8.5. The applicant indicates that about 131,250 lb/hr (about 10,000 gal/hr) of water will be distilled, and the distillate for makeup will be 87,500 lb/hr, and the blowdown 43,700 lb/hr. The concentration factor is 3. Approximately 20 lb/hr of concentrated sulfuric acid is used. Therefore, the use of sulfuric acid (as SO_4^{2-}) will be 480 (960) lb/day. Construction of a neutralization facility has been completed during the summer of 1974 such that all acidic and basic solutions will be collected in a neutralization tank and neutralized; the neutralized salt solution is then discharged to the circulating water. No bulk amounts of acids or bases shall be instantaneously discharged without prior neutralization.

At Unit No. 1, sulfuric acid is used in the water treatment cation and mixed-bed ion exchanger regenerations. These regenerations occur for one hour per day. The releases of sulfuric acid as a salt at a concentration level of 3% is discharged at the rate of 450 lb/day. Thus a total of 1,410 lb/day of spent sulfuric acid as a salt solution in the form of sulfate ions can be discharged from the Plant. The proposed maximum concentration at the point of discharge into the river is 10 ppm.

Soda ash is used four times per year to wash flue-gas passages in the superheater of Indian Point Unit No. 1. A 2% solution is used for 12 hr, and the spent soda ash solution is discharged continuously as a salt solution during this period at a rate of 17 gpm. The proposed maximum concentration of soda ash at the discharge point is 5 ppm. The spent sodium carbonate will be neutralized prior to discharge.

The laundry that serves all facilities will use 3 lb of detergent daily. This detergent, Colgate Low Foam, consists of 26.5% sodium phosphate, 28% sodium sulfate, 10% sodium carbonate, 6% silicates, 15.5% benzene sulfates, 10% nonionics, and 4% water. Several biodegradable detergents such as the Sears detergent will also be used. The laundry water may be discharged at a rate of 25 gpm or processed through the waste disposal system.

All degreasing and cleaning solutions used prior to startup, as well as all oil and grease leakage from various nonnuclear components occurring during normal operations, will be collected, drummed, and picked up by an outside contractor for disposal offsite.

Chemicals and hazardous materials, such as ammonia, hydrazine, or organic solvents, will be stored and handled according to common industrial safety practices. Nonradioactive and radioactive materials in the laboratories will be handled with the normal precautions and safety practices required to protect operating personnel and workers from any health hazards.

Other waste, such as trash, shop, and construction debris, non-radioactive HEPA filters, and septic tank sludges, will be disposed offsite by a commercial service. Large materials from the water intake trash racks and the materials and dead fish that are flushed off the intake traveling screens and collected in a wire basket are disposed of as solid refuse by a commercial service.

According to the applicant, monitoring programs — primarily the radiological measurements — have been carried out at the Indian Point site since 1958. Chemical monitoring has been primarily conducted, in conjunction with the ecological studies, by New York University. The applicant used an automated environmental monitoring system (AES) to continuously monitor temperatures, dissolved oxygen (DO), and pH at the intake structure and temperature, DO, pH, salinity, and cupric ion at the outfall. However, the AES has not been found reliable and has since been discarded.

Details of monitoring the chemicals released from the Plant will be spelled out in the Environmental Technical Specifications. These include accuracy, sensitivity, and frequency of measurements of the effluent limits to assure that releases will not result in adverse impacts on the water quality of the river and the aquatic biota. Samples taken at different locations and depths will also be presented. Methods of analysis will be standard procedures used on waste waters.

All discharges, planned and unplanned, will be monitored prior to entry to the Hudson River. Intermittent discharges of chemicals will be staggered from each Unit to avoid simultaneous batch discharges from all Units and to allow the circulating water from all Units to dilute the chemicals from one Unit as much as possible.

(3) Circulating Water System

The source of chemical discharges from each Unit of greatest importance from a biological point of view will be due to the shock treatment of the condensers with sodium hypochlorite. The applicant states that 15% sodium hypochlorite solution will be added to the three condensers of Unit No. 3 at a rate of 5 gpm ($\sim$430 lb/hr) for approximately one hour three times a week (ER, IP-3, p. 10-5). Chlorination treatment will be staggered so that the three condensers at Unit No. 2 will alternate with those at Unit No. 3 every other day, and the one condenser at Unit No. 1 will be chlorinated on the same day as for example Unit No. 3. The staff recommends that chlorination shall not exceed a total of 9 hr/week, and the amount used shall be about 1,290 lb of available chlorine in sodium hypochlorite for Unit No. 2 every other day and 1,720 lbs on alternate days for Units Nos. 1 and 3. The condensers for each Unit are split so that one-half of each condenser will be treated at a time to give a concentration of about 1 ppm total residual chlorine. The residual chlorine undergoes an immediate 1:1 dilution after leaving the condenser so that the maximum concentration of the total residual chlorine possible is about 0.5 ppm. Due to such factors as the chlorine demand of the untreated water and the effect of light, the chlorine concentration at the outfall may be considerably less than 0.5 ppm. The applicant has presented a dilution schedule (ER, IP-3, App. AA, p. 9) for each Unit, using the cooling water of the other Units to aid in further dilution. The applicant is presently determining, through a series of tests on the Unit No. 2 condensers, the minimum concentration of residual chlorine that can be discharged. In addition, no chlorination is scheduled when the temperature of the river water is below 45°F; thus, no chlorine treatment is needed for about six months of the year. The applicant is attempting to minimize the total amount and concentration of residual chlorine discharged to the river to reduce the biological impacts. The applicant is required by the Environmental Technical Specifications to monitor the discharges at different depths in the discharge canal during chlorination treatment and to measure the concentration with a precision of ±0.05 ppm and an accuracy of ±0.1 ppm. Amperometric method of analysis is the recommended technique to use.

The circulating water system will also discharge corrosion products resulting from the interaction of the coolant with the condenser tubing. The applicant estimates that, under the worst conditions of intake water salinity, the corrosion rate of the condenser metal (Type B Admiralty metal) will approach ∿0.5 mil/year (ER, IP-3, App. FF, pp. III-14 to III-15). At these extreme conditions, the staff estimates the copper concentration in the effluent streams could be ∿2 ppb and the zinc concentration ∿1 ppb.

b. Sanitary Wastes

Sanitary wastes from Unit No. 3 will be treated in the same manner as those from Units Nos. 1 and 2. There are three sewage treatment facilities at the site, a main sewage plant and two auxiliary systems that service the Gate House and Observation Building. The main sewage plant treats all the sanitary waste, including that of the nuclear portion, of the site. The facility contains comminutors, septic tanks, and sand filter beds. The applicant states that no discharge of any type from these facilities is to be dumped into the receiving waters. A detailed description of the facilities has been presented (ER, IP-3, App. Z), and the system has been approved by the governing New York State authorities.

3. Water Use, Consumption, and Groundwater Effects

The once-through cooling system involves the use of 2,058,000 gpm (4,585 cfs), or 2.5% of the Hudson River tidal water of 80,000,000 gpm (178,000 cfs) passing the Indian Point site. However, the tidal flow has been estimated to be at least 9 million gpm in a section 500 to 600 ft wide immediately in front of the facility (ER, IP-3, App. Z, p. 26). Thus about 23% of this tidal water flow of 9,000,000 gpm is used by the once-through cooling system. In regards to the net mean downstream flow due to freshwater run-off, the Plant uses over 115% (4,585 cfs out of 4,000 cfs) at low flow. The heated water released from the discharge structure will lose about 60% of its heat to the atmosphere through evaporation.

Otherwise, the once-through cooling system involves only a negligible consumption of water within the Indian Point facilities, (ER, IP-3, Sect. 8.2) because there is no intentional evaporation of water within the Plants. A maximum of 175 gpm from the Hudson River will be consumed in providing makeup water for different facilities (ER, IP-3, App. FF, p. III-23). The Plant will consume 450,000 gpd from the local water supply system for normal Plant usages and sanitation (ER, IP-3, App. FF, p. III-26). The water usage or consumption should have no effect on the Hudson River to prevent use by other industries near or south of the Indian Point facilities, particularly since the salty water is not suitable for many industrial uses and for drinking purposes. Only the Standard Brands yeast factory just north of the site and the Lovett Station across the river use water from the Hudson. The discharges of chemical effluents will be sufficiently dilute so as not to interfere with other commercial or industrial uses of the Hudson River. As one can see in Tables V-7 and V-8, the amount of chemicals added to the system for operational purposes and discharged is insignificant compared to the natural salt concentration already present in the estuary. The discharges also should have no effect on increased turbidity of the river water, which is already quite turbid. All discharges will be monitored and controlled in accordance with the Environmental Technical Specifications to assure water quality protection. Accidental releases to groundwater at the Plant site will end up in the Hudson River and should not affect nearby wells because of the higher elevation of these wells. Only one municipal water supply within a 5-mile radius of the site utilizes groundwater. Because of the topography of the landscape, all releases along with the groundwater will flow to the river rather than to other land areas. Furthermore, no lowering or raising of groundwater levels is expected due to Plant operation, because no well water on the site is available and no excess water from the facilities is expected to flood any local areas. All water would drain into the Hudson.

No Indian Point discharges are expected to interfere with the use of the Hudson River for the drinking purposes of municipalities north of Indian Point. The closest municipal water supply intakes are the Castle Point Veterans Hospital and the Chelsea Pumping Station for the City of New York, both of which are located approximately 20 miles upstream from Indian Point. Similarly, no releases of radioactive materials to the Hudson River should reach these water supplies. See Sect. V.E for further details. Essentially, there will be no sewage discharged from the septic systems of the site into the river waters (ER, IP-3, App. Z, p. 20). The effect of operation of all three Units on these water supplies should be negligible.

Because the Hudson is used for commercial navigation, particularly shipping, the effect of the Indian Point Plants and their discharges should be minimal with all the equipment on the shoreline. The barge that brings oil up to Indian Point Unit No. 1, however, has had leaking problems and has been removed to prevent obstruction to traffic. The applicant should use due caution to control and prevent oil spills on the water.

4. Recreation

The intake and discharge structures along the bank of the Hudson River are so constructed as to represent a minimal impediment to recreational uses of the river. The velocity of water entering the intake structure (about 2 fps) should have a minimal effect on boating activities. The surface velocity from the submerged discharge is estimated by the staff to be about 5 fps and could interfere with boating activity in the immediate area. Although recreational use of the river in the immediate area is expected to be limited, warning signs would help reduce any adverse impact. As described above, the 80-acre woodland area with its nature trails, gardens, small lake, etc. will add to the recreational assets of the site. This also includes the future development of the 14-acre tract used as a marina. Boating, fishing, and other water sports will attract people to the area. The thermal plume may extend the growing season for fish attracted to heated water and these encourage fishermen to fish in such areas. However, if damage to the fish becomes excessive because of impingement, the boating activities will decrease, and thus the impact of the Indian Point Plants will indirectly have a greater adverse effect on the Hudson River. The heated water will keep ice from forming on the river, thus keeping the river open to continuous boat traffic on the river.

D. BIOLOGICAL IMPACT

1. Terrestrial Biota

The net long-term effect of plant operation on local fauna will be displacement of all species except those (e.g., songbirds, squirrels, rabbits) capable of adapting to altered vegetation types and to increased human activities, noise, and other mechanical disturbances. The development of the proposed nature area, marina, and picnic facilities will exert some influence upon the terrestrial ecosystem due to the increased presence of man. Considering the industrialized nature of the local area, however, one could expect those species present during construction to persist and, upon halting of construction activities, small mammal and bird populations to expand to fill available habitats.

2. Aquatic Biota

In this Section, in Section XI.C.3.c(4)(b), and in App. B, the staff has used the phrase "in the vicinity of Indian Point" to refer to a far-field region such as Region I in the Texas Instruments' Hudson River Ecological Study, which extends from upper Haverstraw Bay to Bear Mountain Bridge.

a. Impingement

A major problem encountered during the operation of Indian Point Unit No. 1 has been fish mortality during all times of the year, resulting from impingement on the screens used to filter out debris that could damage the circulating water system. The history of fish impingement at Unit No. 1 and modifications in Plant design and operational procedures implemented to reduce fish impingement have been summarized by the applicant[34] (ER, IP-3, App. BB) and the staff[35] (FES, IP-2, pp. V-26 to V-32).

In March 1963, fish were entering the open intake forebays of Unit No. 1 and subsequently were killed and collected on the traveling screens (3/8-in. square wire mesh). Striped bass, tomcod, and white perch made up the majority of fish killed. Apparently, these kills included both juvenile and adult fish, including large striped bass. Efforts to reduce kills using air bubble screens, pneumatic sound sources, and smaller mesh mechanical barriers in front of the forebays were not effective in solving the problem. Subsequent efforts, including alterations of the physical structures surrounding the intakes and alterations of the intensity of the light, were effective to a limited extent. In 1967 the applicant removed sheet piling and added fixed screens to the Unit No. 1 intake structure, a step which helped to eliminate the trapping effect, particularly of larger fish. The intake openings were enlarged to reduce the intake velocity.

In June 1965, a correlation between additions of sodium hypochlorite and kills of large fish was noted. The point of addition of the sodium hypochlorite was moved behind the traveling screens. Following this change, large fish were no longer collected on the screens. Apparently, the sodium hypochlorite was either killing the larger fish directly or, more likely, reducing the fishes' ability to avoid the intakes.

The actual effectiveness of the fish protection efforts from 1963 to 1966 as described above cannot be ascertained, because adequate data were not collected during this period. The only effort that produced desirable results was the change in procedure associated with adding sodium hypochlorite to the circulating water.

One modification in the design and operational procedures of Unit No. 1 that apparently has reduced the impingement problem is the installation of fixed fine screens in front of the traveling screens (see Figs. III-2 and III-3). During the spring and summer of 1967, fine mesh (3/8-in. square wire mesh) screens were designed to eliminate the possibility of large fish entering the forebays. This modification was the result of testing during January and March 1967, which showed a significant reduction in fish counted on the traveling screen of one forebay, fitted with a fixed screen at its mouth. According to the applicant, this modification appeared effective until the winter of 1969, although fish count data to support this contention do not exist. One problem with the fine screens, however, is that clogging increases the intake velocity which in turn increases impingement (ER, IP-3, App. BB, p. 10).

Substantial fish kills at Unit No. 1 were observed during January 1970 and were thought to be the result of openings under the fixed screens. This conclusion is supported by the fact that a significant reduction of the number of fish counted on the traveling screens occurred after the openings were eliminated. Collections of fish on the traveling screens when the fixed screens were in place did not adequately represent the extent of the fish kill, especially during periods when dead fish were netted from in front of the fixed screens and consequently could not have had a chance to be included in the counts of fish on the traveling screens. In essence, the impingement problem was simply shifted from the traveling screens to the fixed fine mesh screens. However, the applicant claimed that this process did reduce the average size of the fish that were captured (ER, IP-3, App. BB, p. 32). Nonetheless, the data offered in support of this conclusion (ER, IP-3, App. BB, Table 8) indicate that (a) the average length and weight of the striped bass collected are greater for the screened bay than for the unscreened bays and (b) the average length of white perch collected is less for the screened bay than for the unscreened bays; but the difference is not statistically significant at the 5% level.

A summary of the fish kills for the period of August 1962 to June 1970 has been presented in a Commission document[35] which concluded that operation of Unit No. 1 resulted in 1.5 million, and perhaps as many as 5 million, fish killed. However, the report stated that for the 1962-1970 period there were insufficient data to establish the significance of the numbers of fish killed with respect to the effect on the total fish populations and the overall ecology. Details of the fish kill counting and operating procedures for the June 1965-March 1972 period were also reported in the stipulation[36] of October 30, 1972, between the applicant and the intervenor. Review of the previous records of fish count collected over the years reveals inconsistencies and incoherence in times of counting and methods of counting. Methods and timing of counting changed without explanation. The resulting stipulation was that the number for monthly fish kills from 1965-1970 could be reasonably increased by 25% for missed sampling during each day and another 25% for under sampling, because the counts were made very irregularly, and essentially no counts were made from March 1967 through December 1969. Counts were again made during January through March 1970 and then intermittently until December 1970. Prior to this date, counting was done only for specific purposes outside the normal operating routine of Unit No. 1. Since December 1970, the applicant has been keeping detailed records as to the daily number, size, and species of all fish collected on the intake screens. Some information is available in the stipulations[36] on fish kills. The NYS Department of Conservation also has such data submitted on a monthly basis from the applicant. The applicant has reported information in Appendices S and BB of the Environmental Report for Unit No. 3 and in recent semiannual operating reports sent to the Commission.[104,105]

The precise cause of the impingement problem is not completely understood. All the fish kills at Indian Point Unit No. 1 appear to have been associated with the condenser cooling water system. Fish appear to be caught against the screens by the force of the river water drawn into the intakes. Once caught against the screens, they are unable to escape and eventually succumb to exhaustion, although the precise cause of death is unknown. A number of possible factors contributing to the problem have been examined. The wharf and related sheet piling structures located over the intakes may contribute by appearing to provide refuge for fish. Another factor may be related to the existence in wintertime of warmer river water in the vicinity of the Unit No. 1 caused by its discharge of heated river water. The outfall structure has been modified over the years to the present submerged discharge ports so as to reduce recirculation effects of thermal plume to the intakes and to assure compliance with the New York State thermal criteria.

There is a definite seasonal variation in the magnitude of the kill, the highest mortalities occurring in the winter months and the lowest mortalities in the summer. Apparently, this is due to reduced swimming ability of many fishes at the low (32°F) winter temperatures.

The most important factor contributing to impingement is the capturing capacity of the large volume of water withdrawn from the river. As pointed out by Clark and Brownell:[37]

> "Screen kill rate is often claimed to be a function of the velocity of flow of the cooling water into the intake structure, the higher rate of flow causing greater entrapment of entrained fish. This is probably true to a certain extent, but volume also plays an important role. In [Fig. V-8] the velocity curve [solid curve] is incorrectly drawn to fit 1965 data without regard for 1966 data. When this is refitted to include 1966 data [dashed line in Fig. V-8] the line more correctly indicates the experimental results. Certainly, one would expect entrainment to vary with volume of flow--more water through the screens, more fish killed--regardless of velocity. By plotting a straight line to the combined 1965 and 1966 data (dotted line of [Fig. V-8]) one finds a direct linear relation of screen kills to velocity and therefore to volume pumped. For example, the volume pumped at 1.0 fps would be five times that pumped at 0.2 fps and the kill also would be five times greater--about 30 instead of six fish per screen wash. Therefore, one might be convinced from these data that velocity is only a corollary to volume pumped and that volume is a primary factor in controlling screen kill of estuarine fishes. More conclusive evidence is lacking."

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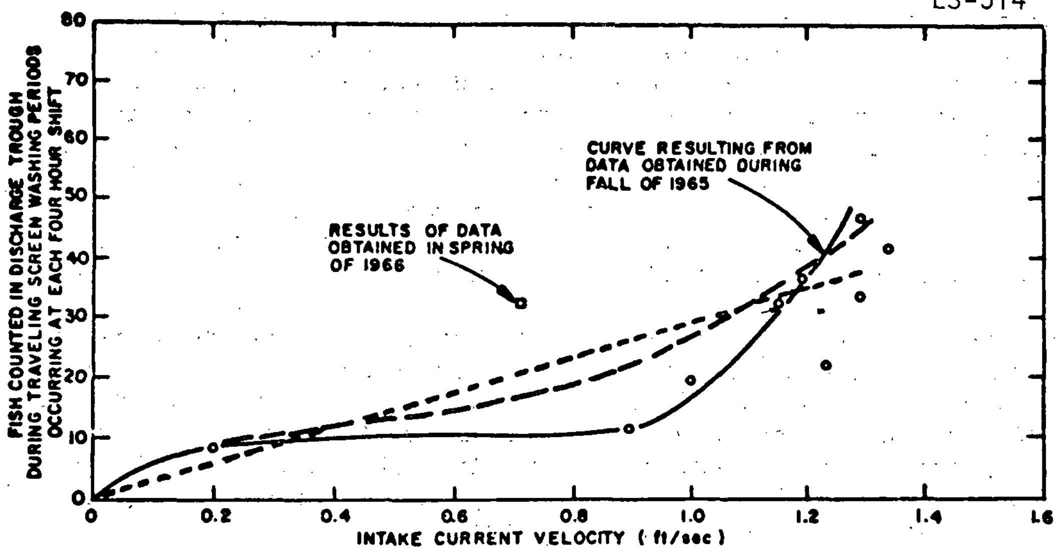

Fig. V-8. Relationship between number of fish counted in the fish collection basket during traveling screen washing periods at Indian Point Unit No. 1 and intake current velocity. The solid line is a curvilinear fit only to the 1965 data; the dashed line is a curvilinear fit to the 1965 and 1966 data; and the dotted line is a straight line fit to the 1965 and 1966 data. All curves are fitted by eye.

On October 19, 1971, the applicant presented testimony in support of its motion for testing Indian Point Unit No. 2 up to 50% of rated power and estimated the quantities of fish to be collected daily at the intake structure of Unit No. 2. These predictions depended on the abundance of fish in the area of the intake, the volume of water being withdrawn, and the intake velocities approaching the screens. The intake velocity would depend on (1) whether the de-icing loops were operating and (2) whether the recirculation loops were operating. Based on these different conditions of operation and the time of year, the applicant predicted higher fish kills during the winter months. The fish kills would consist primarily of white perch (80%); during the winter, more than 90% of the catch was predicted to be white perch. The white perch is found in fresh, brackish, and coastal salt water. The young and adults frequent shoal areas, except in winter, when they congregate in the deeper parts of bays and rivers, where they remain sluggish until spring. This may be a factor in the high percentage of perch killed in the winter months. Many factors, including the daily movements of fish in the vicinity of the intake, influence the actual collection of fish each day.

Because of the extensive fish kill of about 175,000 white perch, striped bass, and other fish that occurred in February 1972[38] during testing of two circulating water pumps at Unit No. 2, the New York State Department of Environmental Conservation required, among other things, that during the time when the ambient water temperature is 40°F or lower, the applicant should recirculate 40% of the flow of its pumps at Units Nos. 1 and 2. During the 1974-1975 winter when Unit No. 2 is in operation, the applicant will gain experience to determine the effectiveness of reducing impingement through reduced flow. By cutting the flow for each pump from 140,000 gpm to 84,000 gpm, the intake velocity will be reduced from 1.3 fps to 0.8 fps through the 3/8-in.-mesh fine screens at Unit No. 2 (FES, IP-2, App. A-III). Although no fixed fine screens are at the six intakes for Unit No. 3, the same 3/8-in.-mesh screen is used for the traveling screens, which will be washed automatically when the head differential exceeds 1 ft. Thus, the intake velocities will be 2.0 fps unless operation of reduced flow during the wintertime occurs for Unit No. 3. At reduced flow, the intake velocity through the outer traveling screens at Unit No. 3 becomes 1.2 fps.

The effectiveness of the recently installed air curtains at Units Nos. 1 and 2 in decreasing fish kills is in the process of being evaluated; air curtains are being designed for Unit No. 3. The New York State Department of Environmental Conservation[38] required that the intakes at Indian Point Units Nos. 1 and 2 be operated with air curtains as well as with reduced flow when ambient river temperature is below 40°F (ER, IP-3, App. BB). The applicant[39] has undertaken impingement studies to evaluate the effectiveness of the air bubbler system and other fish protection methods in accordance with the Environmental Technical Specifications and as part of the requirements of the 401 water quality certification for Unit No. 2. The data collected in substantiation of air bubblers are suspect because the air current creates a positive outflow away from the screen. Fish that have already been damaged or killed by impingement are thus moved out into the river rather than onto the traveling screens to be counted. The HRPC[40] has expressed its concern to the applicant regarding the highly questionable validity of data on impingement collected at the intake screens. The HRPC withdrew its endorsement of the impingement studies until the studies have been redesigned to account for the effects of the outward flow away from the screens. This flow causes fish already killed or damaged by impingement to move out into the river rather than be caught on the traveling screens.

In addition to studies on the effectiveness of the air bubbler and reduced flow in reducing impingement, the applicant is also undertaking a flume study to investigate fish guidance and avoidance devices, which, if installed at the intakes, could reduce fish impingement (ER, IP-3 Suppl. 9, p. 13-8). Because of the persistent fish kill problems, the applicant reports daily counts to the State and submits a monthly report which includes up to 66 species of fish counted. Such information is required by the Environmental Technical Specifications.

Based on the study of the past record and on the projected increase in the volume of water withdrawn, a number of estimates for future projections at the Units Nos. 1 and 2 intakes were made at the ASLB hearings. The applicant estimated the annual fish kills would amount to less than one million fish killed, the staff estimated between 2 and 5 million, and the intervenors estimated up to almost 6.5 million. Although the actual numbers may vary, it is the order of magnitude (i.e., 10^6) which is of concern to the staff. If fish kills remain high, even with reduced flows and operation of air bubble curtains, the applicant is required by the New York State Department of Environmental Conservation to consider an alternate common intake structure. (See Sects. I.B and XI.E for further discussion of this subject.)

The applicant has used the screen collection data from January 1971 to December 1972 for Unit No. 1 to estimate fish kills (shown below) due to impingement at Units Nos. 1, 2, and 3 (ER, IP-3, App. BB). The great majority of these fish would be young-of-the-year, 2 to 4 in. long; based on previous data, the average length of impinged striped bass would be 3.3 in.

	Numbers of fish per year	Weight per year (lb)
Unit No. 1	372,863	4,089
Unit No. 2	1,118,589	12,263
Unit No. 3	1,118,589	12,263
Total	2,610,041	28,615

The composition of the fish that will be impinged is expected to be 70.7% white perch, 3.1% striped bass, 8.3% tomcod, 12.8% herrings, 2.2% bay anchovy, and 2.9% other species.

By pairing for each month the 1971 and 1972 average daily impingement values at Indian Point Unit No. 1, the staff calculated, based on an unbiased estimate of the standard deviation for a sample size of 2,[44] that the average coefficient of variation associated with the above number and weight values is 75%. This coefficient of variation is an index of the precision of the applicant's estimates but not of the accuracy. Thus, the total annual estimates plus or minus one standard deviation are $(2.6 \pm 2.0) \times 10^6$ fish/year and $(29 \pm 21) \times 10^3$ lb/year for Units Nos. 1, 2, and 3. The corresponding values for Units Nos. 1 and 2 alone are $(1.5 \pm 1.1) \times 10^6$ fish/year and $(16 \pm 12) \times 10^3$ lb/year.

The applicant's projection is based on the assumption that all three Units operate every day of the year with operation at reduced cooling water flow during October through March; on the untested assumption that impingement at Unit No. 2 or 3 will be threefold greater than that at Unit No. 1 as a result of the greater intake flow (870,000 gpm vs 318,000 gpm); and on the use of a 25% correction factor for an unquantified collection error.

The collection error is due to several causes.[34] The fixed screens are raised and cleaned one at a time. The wash water hits the screen from behind above the water level, spraying some fish away from the screen. Most of these fish fall back into the water but do not escape the influence of the intake flow. These fish may not be collected until subsequent cleanings of the recessed traveling screens and may be collected from an intake bay other than the one where they were originally impinged. The spray from the cleaning process also deposits some fish on the steel supporting structure of the screens, and these fish are not collected. Fish may also be lost if they become impaled on the traveling screen, and if they are not removed by the cleaning spray, they are carried over the screen and are dislodged into the pump flow and not collected. The above losses are unquantified. In collecting fish washed from the traveling screens, a screen basket is placed in the sluice which carries the screen wash water. When debris (leaves, seaweed, plastic bags, and other garbage) is heavy, the sampling screen becomes clogged, and a clean basket is put in the sluice and the existing one removed. In the exchange of screens, fish are lost down the sluice. In November 1971 a screen basket was placed in the sluice downstream of the regular sampling point to collect fish lost in the collection process. This screen was relieved of the debris load by the upper screens and therefore collected very efficiently. In an attempt to compensate for the losses in the collecting process, a factor of a single 25% increase for the more recent data was agreed to, with Mr. Clark[41] representing the Hudson River Fishermen's Association, and has been applied to the data. This factor includes the losses occurring in the sluice and all other unquantified losses described above. The factor has been applied to the data on an annual basis. Only since December 1970 has the applicant made a real attempt to collect and count fish on a daily basis.

As pointed out by the applicant,[34] three important considerations are not factored into its method of projection. First, there are the unpredictable occurrences of short-term, large fish collections such as occurred in March 1970 at Unit No. 1 (120,000 fish in 2 days) and in February 1972 at Unit No. 2 (175,000 fish in 5 days with two of six pumps at full flow for one day and one pump at full flow for another four days).[36] Each such occurrence could increase the annual totals substantially. Second, the method relies on the untested assumption that increases in impingement will be proportional to increases in total cumulative flow. Third, the method does not take into account the fact that intake velocities at Units Nos. 2 and 3 will be about 20% higher than the velocity at Unit No. 1 (FES, IP-2, App. III-1).

Because of the above considerations and because the method is not based on the biological and physical factors that underlie the impingement problem,[34] the staff does not place great confidence in the extrapolated estimates of the absolute magnitude of numbers or weight of fish that will be impinged.

The significance of impingement should be the easiest to evaluate of the power plant impacts on aquatic biota. The number of fish impinged can be counted relatively easily, and the size of young-of-the-year populations can be estimated on a yearly basis using tag-recapture data. This evaluation should be made for the Indian Point Plant in combination with other power plants on the river. Unfortunately, the staff has been unable to obtain copies of the impingement data that are being collected at the Danskammer, Roseton, Lovett, and Bowline plants.

In the absence of these data, the staff has made the assumptions that the catch per unit effort and the species composition of fish impinged at the four other power plants are the same as that at Indian Point. Thus, the number of fish impinged at these other plants can be estimated to a first approximation by the relationship

$$N = F(N_1/F_1)$$

where N is the combined annual "catch" at the other plants, F is the combined annual "effort" at the other plants, N_1 is the annual catch at Indian Point Units Nos. 1, 2, and 3, and F_1 is the annual effort at Indian Point Units Nos. 1, 2, and 3. The annual catch at Indian Point is taken to be 2,610,041 fish per year and 28,615 pounds of fish per year, as estimated by the applicant (ER, IP-3, App. B, p. 65). The annual effort at Indian Point is taken to be the total volume of water withdrawn during the year, assuming that all three units operate every day of the year at 100% condensing-water flow (4585 cfs) from April through September and at 60% condensing-water flow (2838 cfs) from October through March (see Table V-2). Thus,

$$F_1 = \left[\left(\frac{4585\ \text{ft}^3}{\text{sec}} \cdot \frac{183\ \text{days}}{\text{year}}\right) + \left(\frac{2838\ \text{ft}^3}{\text{sec}} \cdot \frac{182\ \text{days}}{\text{year}}\right)\right]\left(\frac{86{,}400\ \text{sec}}{\text{day}}\right)$$

$$= 1.171 \times 10^{11}\ \text{ft}^3/\text{year}\ .$$

The combined annual effort at the other plants is taken to be the total volume of water withdrawn during the year, assuming once-through cooling at full flow every day of the year for each unit at each plant (see Table V-3). Thus

$$F = \left(\frac{686\ \text{ft}^3}{\text{sec}} + \frac{1448\ \text{ft}^3}{\text{sec}} + \frac{720\ \text{ft}^3}{\text{sec}} + \frac{1711\ \text{ft}^3}{\text{sec}}\right)$$

$$\left(\frac{86{,}400\ \text{sec}}{\text{day}} \cdot \frac{365\ \text{days}}{\text{year}}\right) = 1.440 \times 10^{11}\ \text{ft}^3/\text{year}\ .$$

Finally, substituting the values given and calculated above into Eq. (1), the combined annual impingement impact at Danskammer, Roseton, Lovett, and Bowline is estimated to be 3.2×10^6 fish per year and 3.5×10^4 pounds of fish per year.

Use of this relationship assumes not only that the number of fish impinged is directly proportional to intake flow, but also that

(a) the population densities in the river for each of the fish species are approximately the same from Danskammer to Bowline and (b) the differences in the intake structures and operating procedures at the other plants, as compared with Indian Point, do not significantly modify the dependence of impingement on intake flow. The annual estimated impingement loss for Indian Point Units Nos. 1, 2, and 3 with once-through cooling plus the other four plants is 5.8×10^6 fish/year. The number of white perch and striped bass impinged may be estimated by multiplying this value by 0.7 and 0.03, respectively.

A 1973 field-tagging study[42] by a consultant for the applicant indicates that the September-October population estimates to be used for planning purposes should be 23 million white perch for the entire Hudson River. This population estimate includes all age groups and not just young-of-the-year, but the young-of-the-year account for the majority of the white perch impinged. This population estimate is tentative, it may vary by an order of magnitude from year to year, and it is based on 1973 data (whereas the impingement estimates are based on 1971-1972 data); nevertheless, the staff feels that impingement may have a significant impact on the white perch population. For example, the projected total impingement loss at all plants with once-through cooling at the three Indian Point Units is 4.1 million white perch per year. If the assumptions are made that these are all young-of-the-year and that 80% of the total white perch population of 23 million are young-of-the-year, then 20% to 25% of these young-of-the year white perch will be impinged.

The applicant's suggestion that the plant may be acting as a scavenger in impinging only the less fit members of fish populations is partially supported by the data indicating that impinged adult white perch showed a statistically significant higher incidence of parasitic isopods on the gills than "normal" river adult white perch during September and October 1972.[34] However, the frequency of parasitism is so low (6% or less) and the difference between the two groups is so slight (5.4%) that it seems unlikely that the intake functions as a selective predator on weaker individuals in the population to an ecologically meaningful extent.

The staff has two reservations concerning the applicant's inference that the plant functions as a selective predator on weaker individuals in the population, based on the length-to-weight relationships for white perch and for striped bass captured by conventional techniques in the Indian Point region as compared with those impinged at the Indian Point intake screens for October 1972 (ER, IP-3, App. BB). First, the great majority of the white perch and striped bass impinged measured less than 160 mm in length. For both species, length-weight curves for river fish and impinged fish do not differ appreciably at lengths less than 160 mm. Second, for lengths greater than 160 mm for white perch and greater than 240 mm for striped bass, the distribution of data points suggests that the impinged fish are from a different "population" than the river fish. More explicitly, relatively thin fish were rare in the river population, suggesting that the lower condition factor (i.e., ratio of weight to length) of the impinged fish may be a result of weight loss incurred during sustained swimming in the hours prior to actual impingement. Samples of fish netted immediately in front of the intake, in addition to samples of river fish and impinged fish, are needed before suggesting that the intake may function as a selective predator on weaker individuals in the population.

As a further consideration, the applicant established the Fish Advisory Board (ER, IP-3, App. BB, pp. 11-12) in 1970 to recommend to the applicant fish protection procedures involving modification of plant design and operation. This Board recognized the importance of low intake velocity, self-cleaning capability for the traveling screens, elimination of sanctuary areas near intakes, and effective fish transfer facilities; they recommended the above mentioned changes as well as consideration of horizontal traveling screens, the feasibility of a common intake structure, and a population dynamics study to determine the ecological significance of impingement mortality at Indian Point. The traveling screens for Unit No. 3, which have the same 3/8-in. mesh as the traveling screens and fixed screens at the other units, are located at the entrances of the six intake forebays, flush with the river. Thus, the fish cannot enter the bay behind the screens and fish in front of the screens can swim laterally to avoid impingement. These traveling screens will be washed automatically while in place when the head differential exceeds one foot, unlike the fixed screens at Units Nos. 1 and 2 which must be manually removed for cleaning. Although the staff agrees with the applicant that the design improvements in the Unit No. 3 intake should result in less impingement than at Unit No. 2, until actual experience is gained with Units Nos. 2 and 3 in operation, evaluation of the relative effectiveness of the two intake systems in reducing impingement is difficult.

As a requirement for the Environmental Technical Specifications, however, the occurrences of the screen washings, and the number, size, and type of fish collected on all intakes will be recorded and the information reported on a monthly basis to the Atomic Energy Commission. The applicant[39] has also undertaken an impingement study to evaluate the effectiveness of the air bubbler system in compliance with the Environmental Technical Specifications and as part of the requirements of the 401 water quality certification.

The staff has recently received a draft of the Indian Point Impingement Study by Texas Instruments for the period June 15, 1972, through December 31, 1973,[145] which is summarized by Texas Instruments as follows:

> "The impingement of fish on the intake screens at the Indian Point Power Plants has occurred since Unit 1 began operation in October 1962 (Consolidated Edison, 1970). On June 15, 1972 Texas Instruments Incorporated was awarded a contract to study fish impingement at Indian Point as part of an ecological study of the Hudson River. This report summarizes the results of the impingement study during the period June 15, 1972 through December 31, 1973.
>
> The specific objectives of the study were:
>
> - Gather and analyze data on seasonal occurrence numbers, species and size composition of fish collected on the Indian Point Unit 1, 2 and 3 intakes; assess annual variations in impingement; and calculate impingement rates
> - Recover marked fish to assist in the mark/recapture program designed to ultimately estimate intake exploitation rate on key fish species
> - Monitor selected plant operational variables
> - Gather physical/chemical data in the vicinity of the plant
> - Determine the relationships between impingement rates of key species and a) selected river physical/chemical and b) plant operational variables
> - Determine if the velocity of water approaching an intake screen affects the rate of fish impingement
> - Evaluate the effectiveness of air curtains in reducing fish impingement
> - Compare the relative effectiveness of Indian Point Unit 2 and 3 intake designs in reducing impingement rates
> - Compare the survivorship of impinged fish collected at the Indian Point Unit 2 and 3 intakes

- Evaluate alternative fish protective devices for use with once-through cooling at Indian Point

- Evaluate a fish pump for use in a fish collection and by-pass system

"A total of 230,480 impinged fish were collected from the Indian Point Unit 1 and Unit 2 intake screens between May 20, 1972 and December 31, 1973. On Unit 1 intakes, Atlantic tomcod were collected in the greatest numbers (42.5%) with white perch second (33.2%). The reverse situation occurred on Unit 2 intakes where white perch were collected in the greatest numbers (54.1%) with tomcod second (27.6%). Striped bass comprised 1.8% of the Unit 1 collections and 1.3% of the Unit 2 collections.*

"Impingement rates in 1972 for all species were higher at Unit 1 than at Unit 2 but in 1973 impingement rates were higher at Unit 2 than at Unit 1.

"In 1973, impingement collections from Units 1 and 2 intake screens yielded 42 recoveries of marked white perch and striped bass. Of the 13,912 white perch (>100 mm in total length) that were fin-clipped and released during 1973, 36 were recovered on the intakes (0.3% recovery). Two fin-clipped striped bass were recovered on the intakes, which represents 0.01% of the 15,734 releases. Only four of 16,988 white perch tagged during 1973 were thusly collected. None of the 602 striped bass tag releases were recovered on the intakes. Recaptures contributed to the overall mark/recapture program to estimate population size of white perch and striped bass.

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*Although the applicant reports that a total of 230,480 impinged fish were collected at Units Nos. 1 and 2 intake screens during the period of May 20, 1972, to December 1973, it should be pointed out that from December 31, 1972, to February 1974, Unit No. 1 was shutdown for maintenance and repairs and Unit 2 went critical on May 22, 1973. During the summer 1973, the applicant was conducting a series of tests under a 50% testing license and it was not until August 9, 1973, that the applicant received a 50% steady-state operating license for Unit No. 2 in which only three circulating water pumps or reduced flow of six circulating water pumps were in operation. After Unit No. 2 received a full-power operating license on September 28, 1973, Unit No. 2 was shutdown in mid-November for the rest of 1973 because of maintenance and repair work on the steam generators. Therefore, the staff does not place much confidence in the number of 230,480 impinged fish as representative when Units Nos. 1 and 2 will be in operation during a period of one year.

"The relationship of impingement to environmental parameters is confounded by interactions among physical/chemical variables and plant operational variables as well as the biology of the fishes. Impingement peaks seem to be associated with the intrusion of the salt front into the Indian Point area. The distribution and consequent relative abundance of the fishes may be influenced by the position of the salt front. Furthermore, osmoregulatory stress may increase the vulnerability of the fish to impingement.

"At equal flow rates, impingement was higher at a calculated approach velocity of 1.5 ft/sec (0.46 m/sec) than at 1.0 ft/sec (0.30 m/sec). There was no difference between impingement rates at 1.0 ft/sec (0.30 m/sec and 0.5 ft/sec (0.15 m/sec).

"The Unit 1 air curtain was not an effective fish deterrent during the summer either when the fixed screens were raised or lowered. The air curtain was especially ineffective at night. Fish collections were lower at Unit 2 when the air curtain had been operated for at least 10 hours. The lower collections may have been due to either the air curtain repelling fish from the intakes or washing impinged fish off the screens into the river. The ineffectiveness of the air curtains may have been due to high turbidities in the Hudson. The air curtains may also have been placed where approach velocities to the air curtain exceed the swimming ability of commonly impinged fish.

"Many studies have been conducted on the effectiveness of behavior influencing devices. For example, Sharma (1973) lists 64 references on electricity alone. No behavioral device yet tested appears to be generally applicable in reducing impingement. A modified traveling screen is a potential mechanical device for reducing impingement mortality. Survival of impinged fish was greater for fish collected from a continuously operated traveling screen (Unit 3) than a fixed screen (Unit 2). The inclined plane screen would probably be the most logical choice for fish protection and mechanical reliability. Survival of fish might be increased if the inclined plane screen were completely submerged so that fish could be removed from the screen without being taken out of the water. Results of fish pump tests suggest that fish could be pumped from the collection area to an escape area."

Based on the above review, analysis, and recent Texas Instruments Impingement Report, the staff's best judgment is that impingement at Indian Point Units Nos. 1, 2, and 3 operating with once-through cooling, together with impingement at the other power plants, is of concern for white perch, tomcod, herring, and striped bass. The number of striped bass collected at the intakes is considerably less than the number of white perch, tomcod, or herring collected. Population estimates of striped bass and white perch tagged as young-of-the-year in the fall and recaptured the same fall indicate that the striped bass and white perch populations between river miles 12 to 62 are approximately the same size.[94] Thus, the white perch seem to be much more susceptible to impingement than the striped bass and, therefore, impingement damage to the white perch is a considerable concern. The impingement of striped bass, although relatively much lower, is still of concern because it is an additional stress to a large estimated entrainment impact [Section V.D.2.d(3)(c)(iii)].

[See Section V.D.2.d(3)(c)(vi) for a discussion of the short-term and long-term effects on fish species other than the striped bass. See Section XI.I.1 for a description of the generating costs of the proposed facility, including an estimate of the cost of the fish impinged.] Clearly, the applicant has made progress in characterizing the dependence of impingement on intake velocity, intake flow, water temperature, salinity, and distribution of fish. However, in the staff's opinion, with the exception of reducing intake flow, the applicant has not proposed or evaluated a methodology that is expected to appreciably reduce the number of fish impinged below the applicant's projections.

b. Entrainment

The importance of entrainment is related to the fraction of the river population of each species withdrawn by the once-through cooling system, the level of mortality incurred, the effectiveness of compensatory mechanisms, the turnover time of the entrained species, and their niche in the aquatic ecosystem.

The withdrawal of water through the once-through cooling system of Indian Point Unit No. 3 in conjunction with Units Nos. 1 and 2 not only results in impingement mortality of screenable biota but also results in entrainment mortality of nonscreenable organisms due to mechanical abrasion, pressure changes, and thermal and chemical shock. The power plant acts like a large predator. Predation, as such, is related to the rate at which the organisms are "consumed" and their subsequent probability of mortality. For passive organisms and nearly passive organisms, consumption rates are related to the rate of water used. The percentage of river water withdrawn by the three Units depends on the tidal flow and the freshwater runoff flow (Sect. V.C.3).

The once-through cooling system involves the use of 2,058,000 gpm (4,585 cfs), or 2.5% of the Hudson River tidal water flow of 80,000,000 gpm (178,000 cfs) passing the Indian Point site.

Organisms which are susceptible to entrainment effects are bacteria, planktonic algae, many invertebrate species, and fish eggs and larvae. See App. B of this Statement for further discussion on this subject.

The applicant's position (ER, IP-3, App. AA, pp. 41-42) is that:

> "Entrainment through Indian Point Unit 3, whether operating singly or in conjunction with Units 1 and 2, will result in limited mortalities of certain species as a function of their tolerances to abrupt pressure changes, mechanical abrasion, temperature and chlorine. Research indicates that only larval fish show any appreciable degree of mortality as a result of the combined effects of pressure and mechanical abrasion encountered during entrainment. This effect would then be significant only during the spawning periods and one to two months following. Temperatures in the detrimental range would occur during only three months of the year and even then would affect only a small percentage of the faunal assemblage at Indian Point. Chlorine is added to a maximum of 1.78% of the water entrained and during four months of the year no chlorination whatsoever occurs.
>
> "Little or no mortality due to entrainment could be expected during four months of the year when temperatures are low, no chlorination occurs and most of the pressure-abrasion sensitive fish larvae are absent from the ecosystem. Temperatures in excess of the tolerance limits will result in limited mortalities of some species entrained during three of the remaining eight months while only the effects of chlorination, pressure and mechanical abrasion should occur during the other five months.
>
> "Based upon tidal flow, only 2.5% of the water passing Indian Point is entrained. This fact, with the distributional patterns, both vertical and horizontal, of the holoplankton and meroplankton of the region indicates that percentages of a total population which might be entrained will be quite low. The total effect of entrainment at Indian Point Unit 3 then becomes the product of low percentages of total populations entrained and limited mortalities to certain species during portions of the year. From this, it seems reasonable to conclude that no irreversible damage to the Hudson River ecosystem will result from the operation of Indian Point Unit 3 either

alone or in conjunction with Units 1 and 2 before environmental studies are completed in 1977. Any significant increase in mortality of young of the year striped bass, such as that suggested by the AEC to be plant induced would be readily detected by Con Edison's Ecological Study. Both short term and long term alternate mitigating measures are available to prevent irreversible damage."

The staff has evaluated the entrainment impact by considering (1) phytoplankton and zooplankton and (2) fish eggs, larvae, and juveniles, with particular emphasis on striped bass.

(1) Phytoplankton and Zooplankton

In this section the staff discusses: (a) those parts of the NYU Progress Report for 1971 and 1972[45] on entrainment mortality of bacteria, phytoplankton, and zooplankton; (b) those parts of the NYU Progress Report for 1973[46] on entrainment mortality of phytoplankton and zooplankton; and (c) the staff's best judgment as to the significance of entrainment of phytoplankton and zooplankton at Indian Point.

(a) New York University Progress Report for 1971 and 1972

Information from one of the applicant's consultants on the probability of mortality upon entrainment for bacteria, phytoplankton, and zooplankton for 1971 and 1972[45] is summarized below by NYU. This information is organized first by trophic level and then by type of stress within each trophic level. To date, only thermal and chlorine stresses have been evaluated.

BACTERIA

"The results of laboratory thermal tolerance studies indicate that significant differences (decrease) in bacterial abundance occur only at temperatures higher than those projected for normal plant operations.

"Chlorination caused a significant decrease in ATP* concentrations in water samples obtained from condensers being chlorinated. However, recovery to intake levels of ATP concentration occurred by the time the water reached the D-1 station. Results based on data obtained when the plant was at operational ΔT, and with normal chlorination schedules, indicate that even should a

*ATP is adenosine triphosphate.

significant effect occur due to passage through the condensers, recovery to intake levels of abundance and ATP activity would occur before the water left the discharge canal via the submerged diffusers. The overall effect of normal plant operation on river populations would be negligible."

PHYTOPLANKTON

"The results of entrainment studies indicate that no visually determined damage or change in growth rates occurs to the microflora in passing through the plant.

"Physiological testing (^{14}C primary productivity) was done to determine the effects of elevated temperatures and/or chlorination on the microflora. At various times of the year the same resultant temperature may have had a stimulatory, negligible, or depressant effect on ^{14}C uptake within the condenser samples. At times when there was only a minor reduction in ^{14}C uptake in the condenser samples, recovery to intake levels usually occurred within the discharge canal.

"Microscopic analysis of samples collected from various sampling points in the Hudson River estuary did not yield any significant differences in abundance, nor was there any evidence that the Indian Point facility was altering the species composition within the phytoplankton.

"No stratification was detected at any of the stations investigated nor were any significant day-night differences observed for abundance or species composition."

MICROZOOPLANKTON

"River and entrainment studies indicate that microzooplankton numbers and species composition vary with the season, i.e., with changes in ambient river temperature. Studies of abundances in the intake and discharge ports at Indian Point indicate possible stratification of microzooplankton in the plant vicinity, since there were significantly different abundances at different depths.

"Entrainment studies indicate that the plant may be affecting abundances of microzooplankton in the cooling water. However, river studies do not indicate any differences in abundances at the sampling stations near the plant, including the discharge plume compared to control stations.

"The species lists and abundances from river and intake-discharge samples are similar. This indicates that microzooplankton are quite subject to entrainment. However, intake-discharge entrainment studies of microzooplankton indicate that these organisms survive pump entrainment by Indian Point Unit 1. Laboratory studies indicate that, during summer maximum ambient water temperatures, some of the more sensitive organisms (i.e., calanoid copepods) may experience some mortality at ΔT of 15°F (8.3°C). This prediction could not be tested since the ΔT at Indian Point never reached 15°F."

MACROZOOPLANKTON

Susceptibility to Entrainment

"*Gammarus* sp. is observed year-round at Indian Point. Its subjectivity to entrainment shows diel periodicity, however, with considerably higher abundances occurring at night.

"*Neomysis americana* occurs in the Indian Point area primarily during the summer, when salinity is present in the river at Indian Point. Continued occurrence during the fall would depend on the salinity distribution in the Hudson River estuary.

"*Monoculodes edwardsi* was found at Indian Point throughout the 1972 sampling period except during June and early July. *N. americana* and *M. edwardsi* also display pronounced increases in abundance at night."

Effects of Stresses Encountered During Entrainment

"Figure 6-26 summarizes the laboratory thermal tolerance results on *Gammarus* sp., *N. americana* and *M. edwardsi*. A 15.0°F (8.3°C) ΔT during summer ambient temperatures would be expected to result in 50% or greater mortality of entrained *N. americana*. The other species would not be expected to suffer mortalities resulting from thermal stresses during entrainment.

"All macrozooplankton organisms entrained during periods of chlorination could be expected to experience some lethal effects. During the summer (76.8 to 78.8°F ambient, 12.7 to 15°C ΔT) *Gammarus* sp. sampled at station D-1 displayed about a 25% increase in both dead and stunned classifications over pre-chlorination levels.

Since the mean short-term mortality of stunned organisms was 68%, overall initial mortality due to chlorination may be 40% of entrained organisms. Nighttime chlorination at Indian Point was performed specifically for the purposes of this study, since daytime abundances of zooplankton were too low to provide statistically meaningful data on entrainment effects. The absolute numbers of zooplankton deaths by daytime chlorination, which is the normal practice, are less than for the experimental nighttime chlorination reported here.

"No laboratory bioassays have been conducted on the effects of pressure, turbulence, and mechanical stresses that may be encountered by entrained organisms. However, the relatively high survival of organisms in discharge samples indicates that these stresses are not contributing significantly to entrainment mortalities. In situations of measurable discharge-canal mortality, the lethal effects can be attributed to specific stresses such as temperature or chlorine."

(b) New York University Progress Report for 1973

Information on the probability of mortality upon entrainment for phytoplankton and zooplankton for 1973[46] is summarized below by NYU. In this case the information is organized by stress and then by trophic level within each stress.

TEMPERATURE STRESS

"Acclimation temperature, exposure time, ΔT, and life-history stage all affected the temperature tolerance of the entrainable organisms studied.

"Assuming transit times of entrained organisms are comparable to calculated times for water passage through the plant, the organisms will be exposed for as long as 33.32 minutes at a ΔT of 12.6°F, and as little as 5.91 minutes at a ΔT of 16.3°F during full-flow operation.

"Under reduced-flow conditions, exposure times and ΔT's will range from 55.54 minutes and 21.0°F to 9.84 minutes and 27.1°F. Reduced-flow operations are projected to occur between November and March of each year. Ambient water temperatures during this time of year are generally less than 50°F.

PHYTOPLANKTON

"Measurements of ambient Hudson River phytoplankton ^{14}C uptake rates, chlorophyll *a* content, and light were taken in the Indian Point vicinity from August to December, 1973. Phytoplankton communities were incubated in the river (*in situ*) during each study period. Statistical analyses of the ^{14}C uptake data indicate that there were no significant differences ($\alpha = 0.05$) over the sample period.

"Laboratory thermal tolerance and intake-discharge canal studies of the phytoplankton community in the Indian Point vicinity were continued in 1973. Representative phytoplankton assemblages were collected from the river, intake canal, or discharge canal in the presence and absence of a plant ΔT and incubated in the laboratory or in the river (*in situ*) during each study period. ^{14}C uptake rates were measured on a seasonal schedule to provide physiological information on the thermal tolerance of the algal communities present during each calendar period. Beginning in July 1973, chlorophyll *a* measurements were taken to provide corollary information on the potential for photosynthetic activity within the algal community. Communities were also examined for delayed effects upon ^{14}C uptake and chlorophyll *a* content at 4 and 24 hours after thermal exposure. During July and August, 1973 when the Indian Point facility was inoperable, some limited studies were done at the Lovett generating plant.

"Phytoplankton collected at spring, summer, and fall ambient temperatures (52 to 80°F or 10.9 to 26.5°C) showed decreased productivity following exposure to temperatures of 100°F (38.0°C) for 60 minutes. Summer communities exposed to a combination of a lower overall temperature and exposure time of 87°F (30.5°C) for <1 minute showed decreased productivity, while a higher overall temperature and longer exposure time (i.e., 91°F (32°C) for 60 minutes) stimulated productivity. These responses may indicate a potential for acclimation or accommodation on the part of the algal community.

"Winter phytoplankton communities collected at an ambient temperature of 38°F (3.5°C) exhibited a lower temperature tolerance resulting in decreased ^{14}C uptake at final temperatures of up to 95°F (35°C) for

60 minutes. Winter communities at the same ambient temperature, i.e., 38°F (3.5°C), were also studied for delayed effects of temperature elevation relative to ^{14}C uptake and chlorophyll *a* content. Decreased productivity and a trend towards decreased chlorophyll *a* content were noted at 4 and 24 hours following temperature elevations to 95 and 120°F (35 and 49°C).

"Based on laboratory bioassays done in 1973, and given projected rated-capacity operating conditions at Indian Point, we would expect no significant reduction in the photosynthetic rate of entrained phytoplankton due to temperature exposure. Our results indicate that under anticipated operating conditions, the ΔT's produced by the Indian Point plant will have a stimulating effect on phytoplankton productivity at summer ambient temperatures. At no time during the season studied--roughly May through December--would the overall temperature produced by the Indian Point plant reach levels where they might have an inhibitory effect on phytoplankton productivity. It should be noted, however, that the laboratory apparatus was not capable of producing an instantaneous temperature increase such as would be experienced by an organism passing through the plant condensers. Thus, a definitive evaluation of potential damage to entrained phytoplankton must await tests at the site under actual operating conditions.

"Tests performed at the Indian Point plant on two dates when a ΔT was being produced indicated no significant change in photosynthetic activity of entrained phytoplankton. Also, no significant reduction in photosynthetic activity of phytoplankton was observed in tests performed at the nearby Lovett plant, where ΔT's are similar to those anticipated at Indian Point.

MICROZOOPLANKTON

"During the 1973 sampling season, the dipteran *Chaoborus* sp. and the cladoceran *Leptodora* sp. were the only microzooplankters present in sufficient numbers for experimentation. Laboratory studies on these two species [indicate] little mortality until temperatures are within a few degrees of the overall temperatures producing high mortality. Within that range, the amount of mortality varies considerably, but most surviving organisms are in stunned condition. The sensitivity of *Leptodora* sp.

appears similar to that of four other microzooplankters studied in the laboratory in 1972.

"In limited studies performed at the Lovett plant, which produces a ΔT similar to that expected at Indian Point under rated-capacity operating conditions, there was no significant difference in the mortality of cladocerans and copepods collected at the intakes and at the discharge canal. The mortality of *E. affinis* at Lovett was lower than had been expected for such temperature conditions, based on laboratory experiments in 1972 simulating Indian Point exposure, but this may be because of the shorter transit time at Lovett.

MACROZOOPLANKTON

"During 1972, short-term temperature tolerance data on *N. americana* obtained during an ambient temperature range of 75.6 to 78.3°F. In November 1973, comparable tests were done on *N. americana* obtained at a 56.8°F ambient. A comparison of 5-minute and 30-minute TL_{50} and TL_{95} values at each ambient temperature revealed a direct relationship between ambient temperature and thermal tolerance. Although the absolute tolerances (TL_{50} and TL_{95}) are lower at 56.8°F (13.8°C), *N. americana* are capable of tolerating considerably higher ΔT's during the cooler ambient temperature.

"Groups of *Gammarus* sp. exposed to a 15°F ΔT over an ambient of 77.9°F for periods of 5, 30, and 60 minutes had rates of survival ranging from 88 to 92%, while controls had 90% after 10 days. In exposures to a 15°F ΔT over an ambient of 81.9°F and exposure times of 0, 5, 60, and 180 minutes the 180 minute group had significantly higher mortality than the other three groups.

"Thus, *Gammarus* can tolerate 15.0°F exposures at summer ambient temperatures for periods up to 1 hour. But significant mortalities occur when exposure time is increased to 180 minutes. At cooler ambient temperatures (53.1°F, 11.7°C) *Gammarus* can survive ΔT's of up to 30°F (16.7°C) for as long as 180 minutes without any apparent increase in latent mortality. When ambient river temperatures are below 50°F (10.0°C) *Gammarus* could live for extended periods in the discharge canal.

"The importance of latent mortality observations is exemplified by the 180-minute exposure to a 15.0°F ΔT at an ambient of 81.9°F (27.7°C). Although there was only a 4% initial mortality, there was pronounced mortality during the first 5 days following temperature exposure.

"It is apparent that once an acutely lethal time-temperature exposure combination is reached, increased latent mortalities of *Gammarus* sp. can be expected within 5 days. (This generalization is also supported by the increased latent mortalities observed in *Gammarus* sp. collected at the Lovett station during a lethal discharge temperature).

"Studies of *Gammarus* sp. acclimated to a sustained ΔT of 28.1°F (15.6°C) above ambient of 48.4°F (9.1°C) did not indicate any adverse effects when the temperature was immediately returned to ambient. Thus, it appears that this type of cold shock is not an important consideration in the entrainment of *Gammarus* sp.

"Laboratory studies were also done to note the effects of temperature change on the reproductive and feeding mechanisms of *Gammarus* sp. The exposure of *Gammarus* sp. to long- and short-term ΔT simulation did not produce adverse effects on reproduction; long-term exposure to simulation of maximum operating ΔT's (28.1°F) above ambient temperatures of 50°F (10°C) stimulated reproduction. Short-term exposure of *Gammarus* sp. to simulated ΔT's produced a decrease in feeding activity at food densities conductive to both high and low feeding rates.

"Intake and discharge canal studies of latent mortality of *Gammarus* sp. at the Orange and Rockland Utilities Lovett plant with discharge temperatures of 95 to 98.4°F (35 to 36.9°C) revealed significant reductions (contingency table analysis) in latent survival in all cases. No differences in survival were noted between discharge canal samples returned immediately to ambient temperature and those maintained at discharge temperature for 30 minutes.

OTHER STRESSES

"During the 1973 entrainment sampling program, operating conditions were highly variable. Chlorination was scheduled but apparently did not take place because of a malfunction. A ΔT was present on only three sampling dates and then for only a portion of the sampling period. Thus, when the samples exposed to ΔT and possible chlorination are excluded, the data collected reflect the effects of those stresses other than thermal or chemical--i.e., pressure, velocity shear and mechanical damage, acting individually or in combination."

(c) Staff's Best Judgment as to the Significance of Entrainment of Phytoplankton and Zooplankton at Indian Point

After reviewing the above NYU reports in detail and other related information, the staff's best judgment is that entrainment of phytoplankton and microzooplankton is not expected to have any measurable effect on the aquatic ecosystem in the vicinity of Indian Point. Except for *Neomysis*, the staff's opinion is the same for the macrozooplankton such as *Gammarus* and *Monoculodes*.

The data for *Neomysis* indicate that the importance of this mysid crustacean in aquatic community dynamics near Indian Point will vary from year to year depending upon the salinity distribution. During years when the salt front is in the vicinity of Indian Point for much of June through October, the importance of *Neomysis* may be comparable to that of *Gammarus*. The present data concerning the frequency and location of reproduction by *Neomysis* in relation to the corresponding longitudinal salinity profile are not adequate to dismiss the possibility that reproductive activity is relatively high at the salt front. Thus, because entrainment mortality of *Neomysis* is quite high,[45,46] *Neomysis* tend to be concentrated at the salt front and its reproductive activity may be relatively high at the salt front.[45,46] When young-of-the-year striped bass or white perch and *Neomysis* occur together, *Neomysis* is an important component of the striped bass and white perch diet;[63] therefore, the staff concludes that when the salt front is in the vicinity of Indian Point for much of June through October, entrainment of *Neomysis* at Indian Point, Lovett, and Bowline may well have an adverse effect on the growth and survival of striped bass and white perch young-of-the-year. (See the staff's response to Con Edison's comments 144 and 149, Section XII.L for more detail concerning *Neomysis*.)

The importance of *Neomysis* in the diets of other fish species (e.g., tomcod and clupeids) in the vicinity of Indian Point has not been investigated.

(2) Fish Eggs, Larvae, and Juveniles

Because of the location of the Indian Point Plant in the low-salinity zone of the Hudson estuary, operation of Indian Point Units Nos. 1, 2, and 3 with the present once-through cooling system may adversely influence the fish populations that use the area for spawning and for initial periods of growth and development. See Section V.D.2.d(3)(c)(i) for discussion of spawning characteristics of striped bass. Recruitment rates and standing crops of several species may be lowered in response to the increased mortality caused by entrainment of nonscreenable eggs and larvae and by impingement of screenable young-of-the-year.

Those species most likely to be affected are the tomcod, bay anchovy, blueback herring, alewife, white perch, and striped bass [see Sect. V.D.2.d(3)(c)(vi)]. Direct effects on the freshwater species, such as the two sturgeon species that commonly occur in the vicinity of Indian Point, however, are not expected to be severe.

In this section the staff has considered: (a) summary of NYU ichthyoplankton entrainment studies for 1971 and 1972; (b) summary of NYU ichthyoplankton entrainment studies for 1973; (c) summary of ORNL 1974 studies on survival of larval striped bass exposed to fluid-induced and thermal stresses in a simulated condenser tube; (d) estimate of the probability of short-term mortality upon entrainment (f_c) for striped bass; and (e) other f factors. Much of the information in this section relates specifically to estimating input parameters used in both the staff's and applicant's striped bass population models.

(a) Summary of New York University Ichthyoplankton Entrainment Studies for 1971 and 1972

Information on the probability of mortality upon entrainment for ichthyoplankton for 1971 and 1972[45] is summarized by NYU as follows:

Laboratory Tolerance Studies

"Results of laboratory tolerance experiments indicate that early stages of tomcod larvae, striped bass eggs, and striped bass larvae may experience mortality due to time-temperature exposure during entrainment through the Indian Point plant, especially when only one unit is operating at rated capacity. The older stages of tomcod larvae and striped bass eggs and larvae appear capable of tolerating the time-temperature exposures projected to occur during entrainment through the Indian Point facility cooling systems.

"Tolerance of the fish eggs and larvae to abrupt temperature elevations is different for the various developmental stages tested. The temperature tolerance for a particular developmental stage is an inverse function of exposure time.

"Preliminary analyses of chlorine-tolerance data indicate that striped bass eggs are quite tolerant of short exposures to chlorine, possible because of the protective membranes of the egg. On the other hand, most striped bass larvae were killed by chlorine even at quite low concentrations. More complete information on chlorine tolerance will also become available as the data is analyzed.

"Striped bass eggs appear relatively tolerant to chlorine exposure compared to the striped bass larvae."

Intake and Discharge-Canal Studies

"Sampling with plankton nets in the Indian Point Unit 1 intake bays and discharge canal during 1972 was done twice weekly (once during the day and once at night) from June 27 to August 24, after which the day sampling was discontinued and only night samples were collected until December 26. The sampling effort was designed to determine the effects of pumped entrainment on macrozooplankton, fish eggs, and larvae (ichthyoplankton). Effects were determined by comparison of the numbers and condition of specimens collected in samples from the Unit 1 intake bays and discharge canal. Planktonic egg and larval stages of six species, out of the more than 50 fish species that occur in the middle portion of the Hudson River estuary, accounted for almost all of the ichthyoplankton taken in entrainment samples. These were, in order of decreasing abundance, anchovy, alewife and blueback herring, striped bass, white perch, and tomcod. A very few larvae or small fish of about six additional species, the American eel, tessellated darter, spottail shiner, hogchoker, and one or more species of cyprinids were taken sporadically in entrainment samples.

"Most of the anchovy and clupeid larvae were dead in both intake bay and discharge-canal samples. Therefore it was not possible to determine effects of pumped entrainment on these species with available collecting techniques.

"Striped bass eggs were too sparse in the samples to permit analyses of pumped entrainment effects. Data on larvae of the striped bass and white perch (*Morone* spp.) were combined to achieve statistical sensitivity sufficient to detect effects of pumped entrainment.

"The remainder of the species observed in the plankton occurred sporadically, usually in extremely small numbers, and will not be discussed further here. The data for all ichthyoplankton collected in 1971 and 1972 are contained in a separate volume of appendix tables.

"The estimated effect of pumped entrainment through Indian Point Unit 1 operating without ΔT was to reduce the number of live, apparently healthy *Morone* spp. larvae by from 7 to 39%. The estimated effect of entrainment with ΔT up to 11°F was an almost identical reduction of from 5 to 37% in live, apparently healthy larvae. The effect of pumped entrainment on *Morone* ssp. larvae at full 15 to 16°F 8.3 to 8.9°C) ΔT for Units 2 and 3 respectively has not yet been determined. Population effects will be determined by ascertaining the proportion of the total river population that is entrained and the life stages at the time of entrainment.

"Entrainment studies will continue in 1973 to attempt to get entrainment survival data at rated-capacity 15°F ΔT operation and to improve the precision of the estimates of entrainment effects for larvae of striped bass and other fish species. These studies will continue to include assessment of the condition of the larvae immediately after collection, and live and stunned larvae will be held in the laboratory and examined for delayed effects.

"Concurrently, intensive sampling of the larvae will be done throughout a 24-hour-day once per week in the plant intake and the river to improve estimates on the relationship of spatial distribution of larvae in the river to the numbers of larvae entering the plant."

(b) Summary of New York University Ichthyoplankton Entrainment Studies for 1973

Information on the probability of mortality upon entrainment for ichthyoplankton from the NYU Progress Report for 1973[46] is summarized by the staff.

1. Laboratory bioassays for ichthyoplankton were not included in the 1973 study program.

2. Results from the study to compare abundances in the river, in the intakes, and in the discharge canal are not available at this time pending completion of data processing.

3. Results of the short-term viability study with respect to striped bass indicate that:

   a. During the 1973 entrainment sampling program, operating conditions at Unit No. 1 and Unit No. 2 were highly variable. A ΔT was present on only three sampling dates, and then only for a portion of the sampling cycle. The frequent changes in operating mode hindered the collection of samples as well as the analysis and interpretation of the entrainment data.

   b. The numbers of striped bass life stages caught in the Unit No. 1 intakes and in the discharge canal are given in Table V-9.

Table V-9. Numbers of striped bass life stages caught at Unit No. 1 intake and discharge canals during the 1973 striped bass entrainment season and their point of capture

	Intake	Discharge	Totals
Eggs	946	616	1562
Yolk-sac larvae	132	99	231
Larvae	849	3516	4365
Juveniles	153	785	938

Source: New York University, "Hudson River Ecosystem Studies, Progress Report for 1973," September 1974, p. 230.

   c. In all but one case tested there was no significant difference between the two intake bays at Unit No. 1.

   d. In similar tests of data from the discharge-canal stations, there were more statistically significant differences. Regardless of the final explanation of these differences, the importance of sampling at more than one discharge-canal station becomes obvious.

e. The calculated differences (and their 95% confidence intervals) between the mean percentages live, stunned, or dead at the intakes and the corresponding percentages at the discharge canal are given in Tables V-10 and V-11. These differences reflect mortality essentially due to pressure and mechanical effects alone, because a ΔT was present on only three sampling dates and there was no chlorination present.

f. Both the more extensive 1972 data for striped bass and white perch larvae combined and the June 26, 1973 data for striped bass larvae indicate no significant difference in short-term viability with and without a ΔT. However, in both cases, the ΔT was considerably less than 15°F, the appropriate ΔT expected with the Units at full power and full flow.

4. Results of the latent-effects viability study indicate that (Fig. V-10):

a. Survival curves for striped bass larvae collected in the intakes and in the discharge canal and initially classified as live did not differ significantly by the end of the 3-day holding period. The same result was found for striped bass juveniles initially classified as live and for striped bass larvae initially classified as stunned. No comparisons of stunned juveniles collected from the intakes and discharge canal were made because of the small sample size of juveniles collected from the intakes.

b. In all cases the majority of mortality occurred during the first 24 hours.

c. The overall latent survival of stunned larvae, whether collected in the intakes or in the discharge canal, was substantially less than the overall latent survival of those larvae initially classified as live.

5. Results of the study to determine whether the species compositions and abundances entering the Indian Point Units Nos. 1 and 2 are the same are not available at this time, pending completion of data processing.

6. A mark and recapture experiment was done to estimate the survival of striped bass eggs entrained at Indian Point in the absence of ΔT and to estimate the efficiency of

Table V-10. Means and 95% confidence intervals of percentages alive, stunned, and dead in striped bass entrainment samples, 1973

Life stage	Intake bay at Unit No. 1			Sampling stations in the discharge canal				
	I-1	I-2	Weighted average of I-1 and I-2	D-1	D-2	Discharge ports (DP)	Weighted average of D-1 and D-2	Weighted average of D-1, D-2, and DP
Live								
Eggs			60.4 ± 6.3				13.5 ± 5.3	
Yolk-sac larvae			26.3 ± 10.6	1.9 ± 3.8	24.2 ± 19.2		11.3 ± 8.7	
Post yolk-sac larvae			31.7 ± 6.3					13.7 ± 3.2
Juveniles	55.9 ± 17.7	88.9 ± 13.9	68.3 ± 12.9					21.4 ± 6.7
Stunned								
Yolk-sac larvae			23.5 ± 10.1				7.1 ± 7.4	
Post yolk-sac larvae			13.7 ± 4.5					8.3 ± 2.3
Juveniles			8.6 ± 8.2	19.2 ± 8.7	9.3 ± 6.9	36.4 ± 33.5	14.4 ± 5.5	16.6 ± 5.9
Dead								
Eggs			39.6 ± 6.3				86.5 ± 5.3	
Yolk-sac larvae			49.8 ± 11.9	93.2 ± 8.6	66.3 ± 21.6		81.8 ± 10.8	
Post yolk-sac larvae			54.6 ± 6.7					78.2 ± 3.8
Juveniles			23.1 ± 11.5	59.8 ± 11.8	68.1 ± 12.2	45.5 ± 34.7	63.8 ± 8.3	62.0 ± 8.1

Source: New York University, "Hudson River Ecosystem Studies, Progress Report for 1973," September, 1974, p. 232.

Table V-11. ***Morone saxatilis,*** **95% confidence intervals of the differences between the mean percentages of live, stunned, and dead at intake and discharge stations**

Life stage	Comparison[a]	Difference[a]	Confidence interval[b]
Live			
Eggs	I-1, I-2 vs D-1, D-2	46.9%	38.5 ≤ diff ≤ 55.3*
Yolk-sac	I-1, I-2 vs D-1	24.4%	13.3 ≤ diff ≤ 35.5*
larvae	I-1, I-2 vs D-2	2.1%	−18.9 ≤ diff ≤ 23.1
Larvae	I-1, I-2 vs D-1, D-2 +DP	18.1%	11.8 ≤ diff ≤ 24.4*
Juveniles	I-1 vs D-1, D-2, DP	6.3%	−4.0 ≤ diff ≤ 16.6
	I-2 vs D-1, D-2, DP	67.5%	50.1 ≤ diff ≤ 84.9*
Stunned			
Yolk-sac larvae	I-1, I-2 vs D-1, D-2	16.4%	3.5 ≤ diff ≤ 29.3*
Larvae	I-1, I-2 vs D-1, D-2, DP	5.4%	0.8 ≤ diff ≤ 10.0*
Juveniles	I-1, I-2 vs D-1	10.6%	−1.1 ≤ diff ≤ 22.3
	I-1, I-2 vs D-2	0.7%	−9.8 ≤ diff ≤ 11.2
	I-1, I-2 vs DP	27.8%	0.1 ≤ diff ≤ 55.5*
Dead			
Eggs	Reciprocal of difference for mean percent alive		
Yolk-sac	I-1, I-2 vs D-1	43.4%	28.4 ≤ diff ≤ 58.0*
larvae	I-1, I-2 vs D-2	16.5%	−7.1 ≤ diff ≤ 40.1
Larvae	I-1, I-2 vs D-1, D-2, DP	23.6%	16.5 ≤ diff ≤ 30.7*
Juveniles	I-1, I-2 vs D-1	36.7%	20.5 ≤ diff ≤ 52.9*
	I-1, I-2 vs D-2	45.0%	28.8 ≤ diff ≤ 61.2*
	I-1, I-2 vs DP	22.4%	−5.6 ≤ diff ≤ 50.4

[a]From Table V-10 (previous table).
[b]Differences significant at the 5% level are indicated by an asterisk.
Source: New York University, "Hudson River Ecosystem Studies, Progress Report for 1973," September, 1974, p. 235.

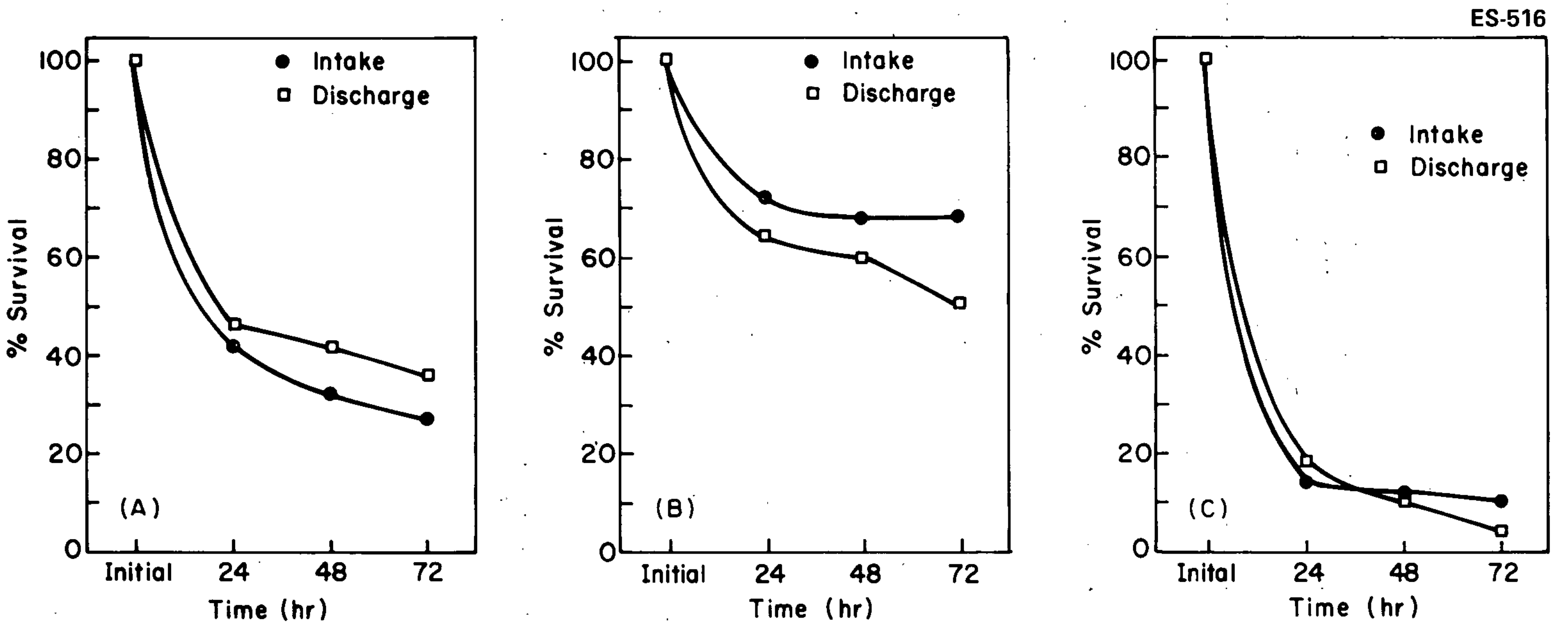

Fig. V-10. Percent survival of striped bass at intake and discharge of Unit No. 1; (A) post yolk-sac larvae initially classified as alive, (B) juveniles initially classified as alive, (C) post yolk-sac larvae initially classified as stunned. (Source: New York University, "Hudson River Ecosystem Studies, Progress Report for 1973," September 1974, pp. 249, 250, and 252.)

the nets used in the entrainment-effects studies to capture striped bass eggs. The results of the initial experiments on striped bass eggs mark and recapture techniques demonstrated collection efficiencies considerably below expectation (i.e., 17% and 26.8% of the expected number of eggs), and indicate the need for developing methodology that can provide a quantitative estimate under controlled conditions of the validity and impact of the observed egg losses.

(c) Summary of Oak Ridge National Laboratory 1974 Studies on Survival of Larval Striped Bass Exposed to Fluid-Induced and Thermal Stresses in a Simulated Condenser Tube

Additional information on the probability of mortality upon entrainment for striped bass larvae is available from the recent studies of Coutant and Kedl,[47] which are summarized below.

Passage of approximately two-week-old larval striped bass, *Morone saxatilis*, through a laboratory mock-up of a power plant condenser tube resulted in only a slightly greater percent mortality (<5%) than that for the control group, when only mechanical stresses were exerted. These studies did not involve passage of larvae through a pump, so the effect of this mechanical stress has not been evaluated to date in this research. Mortalities were comparable to thermal bioassay results when temperature was an added stress. The experiments were conducted such that turbulent shear, pressure change, and temperature rise could be examined in varying proportions. There does not appear to be synergism between thermal and mechanical stresses acting simultaneously; there were indications that mechanical stress may have slightly enhanced thermal resistance, although this result needs further critical examination. While these results suggest minimal mortalities with no ΔT, they should not be taken uncritically as indicative of overall effects of entrainment. Experiments reported here were designed to test one component of the cooling water system to which entrained organisms are exposed, namely the condenser tube. Other components, principally the pump, which were not studied could also be the locus of mechanical damage. These should also be examined. The pump now appears to be the most logical site for damages that have been identified at operating power plants.

Other factors may combine to make entrainment damages more severe than these experiments indicate. Tidal movements in an estuary may cause multiple exposures of larvae to condenser passage. The larvae in these experiments were subjected to only one pass. Presence of silt or other organisms in the water may also influence such factors as abrasion. The water supply was free of such material.

Age of fish as a factor in mortality remains to be resolved. The supply of striped bass larvae was insufficient to allow testing of the large numbers required at more than one general age, about two weeks.

Coutant and Kedl's[47] conclusion that pressure changes and other mechanical effects may be more important in causing entrainment mortality than temperature is supported by Marcy's findings. Marcy reports:[48]

> "Most of the young fish of nine species that were entrained in the condenser cooling-water system of the Connecticut Yankee nuclear power plant were dead by the time they reached the lower end of the plant's 1.83-km (1.14 mile) long discharge canal. Sampling during June and July, when 95% of the nonscreenable fish were abundant near the plant's intake, showed that approximately 80% of the mortality in the canal was caused by mechanical damage [which occurs upon passage through the condensers and thus is independent of the length of the discharge canal] and 20% was attributed to heat shock and prolonged exposure to temperatures elevated above 28°C.
>
> "Estimates of fish mortality due to mechanical damage during passage through the condenser cooling-water system ranged between 72 and 87%, averaging approximately 80% (Table 4). Mortality percentages were consistent (71-72%) on all dates except the June 27-28 night sample when the percentage reached 87%, probably as a result of a greater proportion of larger fish (20-40 mm total length) in the sample as compared to the majority of less than 15 mm in the other samples. Increased mechanical injury with increased size during condenser passage has been reported by Markowski (1962), Oglesby and Allee (1969), and Marcy (1971). The species, their life stages and their sizes influence the percentage of mechanical damage. The high percentage of mechanical damage noted in the present study may have been largely influenced by the fact that 97.5% of the fish entrained were in the more critical post yolk-sac stages, and that the more fragile clupeids made up 97.6% of the total fish entrained."

(d) Estimate of the Probability of Short-Term Mortality upon Entrainment for Striped Bass

Based on the above information from the NYU studies on entrainment mortality of striped bass ichthyoplankton, the staff has developed the following equation for estimating the probability of short-term survival upon passage through the condenser cooling system. This equation then is used to provide estimates for each of the entrainable life stages.

Define:

P_I probability of an organism being alive in the intake.

P_D probability of an organism alive in the intake being alive in the discharge canal after passage through the plant.

P_S probability of an organism alive in the intake or discharge canal being classified "alive" in the pyrex sorting dish after collection from the intake or discharge canal.

Then the probability of any organism being classified as live in the intake sample, P_{IS}, is

$$P_{IS} = P_I \cdot P_S \quad ,$$

and the probability of being classified as live in the discharge-canal sample, P_{DS}, is

$$P_{DS} = P_I \cdot P_D \cdot P_S = P_{IS} \cdot P_D \quad ,$$

assuming P_S is the same for intake and discharge-canal samples.

Thus, the probability of an organism alive in the intake being alive in the discharge canal after passage through the plant, P_D, is (from the preceding two expressions):

$$P_D = P_{DS}/P_{IS} \quad ,$$

and the probability of short-term mortality upon passage through the plant, f_c, is

$$f_c = 1 - P_D = 1 - \frac{P_{DS}}{P_{IS}} = \frac{P_{IS} - P_{DS}}{P_{IS}} \quad .$$

P_{IS} and P_{DS} are estimated by calculating the fraction or percentage of organisms classified as live from counts of the total number of organisms classified as live, stunned, and dead in intake and discharge-canal samples, respectively. This procedure tends to underestimate f_c because those organisms classified as stunned are assumed dead (except for eggs) and because P_S is assumed to be the same at both the intake and the discharge, when in fact net damage is likely to be more extensive per unit of sampling time at the discharge due to the higher water velocities that generally occur in the discharge.

Values for the mean percentage of nonscreenable life-stages of striped bass classified as live in the intake samples and in discharge-canal samples are given in Table V-10 taken from the NYU Progress Report for 1973[46] [see Sect. V.D.2.b(2)(b)]. Using these values and the above equation for the probability of short-term mortality after passage through the plant, estimates of f_c have been calculated for each life stage (Table V-12): 0.78 for eggs, 0.57 for yolk-sac larvae, 0.57 for larvae, and 0.69 for entrainable juveniles. Estimates of 95% confidence intervals for these f_c values are not available at present. These values reflect mortality due to pressure changes and other mechanical effects alone, because during the 1973 sampling periods there was no chlorination and for the most part no ΔT. During periods of chlorination the f_c values would be higher for all life stages. With a ΔT, the f_c values would be approximately the same or higher depending on the ambient temperature.[45,47,49] For example, during operation of the Units at high power levels, the temperatures in the discharge canal at Indian Point will exceed 90°F beginning about the second week in July. As the exposure temperature increases from approximately 85°F to approximately 95°F, the staff expects that f_c will approach 1.0 for all life stages of striped bass.[45,46] A final caveat is that these f_c values are estimates of short-term mortality and do not include consideration of possible differential delayed mortality and increased susceptibility to predation of organisms classified as "live." The probability of short-term survival is $(1.0 - f_c)$. The staff's best judgment, based primarily on the information in NYU's Progress Report for 1973,[46] is that the probability of long-term survival, PSE, may be 10% lower than the probability of short-term survival (i.e., PSE = $[1 - f_c] - 0.1[1 - f_c]$) (Table V-12).

Sufficient data are not presently available to the staff to do a comparable analysis for other species such as white perch, tomcod, alewife, blueback herring, and anchovy.

Table V-12. Estimation of the probability of short-term mortality upon entrainment for the nonscreenable life stages of striped bass based on 1973 data at Indian Point with no chlorination and, for the most part, with no ΔT

Life stage	Unit No. 1 intakes 1 and 2[a]		Discharge canal[a]			f_c[b]	PSE[c]
				Mean percent live at stations			
	Number	Mean percent live	Number	D-1 and D-2	D-1, D-2, and DP		
Eggs	946	60.4	616	13.5		0.78	0.20
Yolk-sac larvae	132	26.3	99	11.3		0.57	0.39
Larvae	849	31.7	3,516		13.7	0.57	0.39
Juveniles	153	68.3	785		21.4	0.69	0.28

[a]Numbers of organisms are from Table V-9, and mean percent live values are from Table V-10.

[b]$f_c = \frac{\text{(mean \% live in intake)} - \text{(mean \% live in discharge canal)}}{\text{(mean \% live in intake)}}$.

[c]PSE = $0.9(1 - f_c)$.

(e) Local Spatial Distribution of Striped Bass Eggs, Larvae, and Juveniles

The situation with respect to f factors relating to the local spatial distribution of striped bass eggs, larvae, and juveniles, at the time of the Indian Point Unit No. 2 Hearings, was summarized by the Atomic Safety and Licensing Board[50] as follows:

"Although there were differences between the Staff and Applicant with regard to the basic models, the really major difference was concerned with the values chosen by the Applicant for the "f" factors, which could be used in either model, and for the effect of compensation. Factor f_1 accounts for a non-uniform distribution of entrainable stages across the river cross section and relates the concentration of organisms in the vicinity of the plant to the average concentration in the river cross section at Indian Point. Factor f_2 is a measure of the susceptibility of organisms to the intake flow expressed as the ratio of the concentration in the intake flow to the concentration in the vicinity of the plant. Factor f_3 accounts for a delay in replacement of organisms removed from the river by the plant. The final factor f_c is the fraction of the organisms that are killed in passing through the plant. Applicant has estimated values for the f factors from the few field measurements that are available. The product of the chosen values is about 0.4 for eggs and larvae and 0.1 for entrainable juveniles. Use of these factors results in a substantial reduction in the calculated plant impact that HRFA and the Staff argued was not justified by the data. The Board agrees that it is desirable to provide for such effects in a model, that f_c is likely to be less than 1, and that the Applicant has some justification for its best estimate of the combined f factors. Because of the large uncertainties in the data, however, the Board considers the calculations with the combined f factors equal to 1 to be appropriately conservative."

In summary, the controversy over f factors is indicative that all parties realize that (1) the estimated values for these factors have a marked effect on the model predictions of plant impact on the striped bass population and (2) the true values for these factors will have a marked effect on the actual plant impact on the striped bass population. Also, it is obvious that at least f_1, f_2, and f_c, unlike compensation, are relatively amenable to estimation from actual data if the proper sampling program is designed and executed.

One of the primary objectives of the applicant's research program for 1973 was to estimate separately for striped bass eggs, yolk-sac larvae, larvae, and juveniles a composite or 24-hour ratio of concentration of organisms in the intakes of the Indian Point Units to the average concentration of organisms in a cross section of the river at Indian Point. (Throughout this Final Statement, the staff denotes this ratio by f_I and refers to a cross section of the river at Indian Point or any other power plant as a transect. The staff's definition of f_I is equivalent to the quotient of the composite "f" over f_c as defined by the applicant, which in turn is approximately equivalent to the product of the applicant's f_1 and f_2. A discussion of the applicant's f_1 and f_2 is given in Appendix B, Section B.3.h.) The staff has not received these data or an analysis of these data.

Similar, although less comprehensive, sampling programs were designed and executed in 1973 by Quirk, Lawler, and Matusky at the Bowline, Lovett, Danskammer, and Roseton plants. In response to the staff's request, the raw data and the final estimates of a composite "f" factor (= $f_c \cdot f_I$) for each of the four plants for each life stage — striped bass eggs, yolk-sac larvae, post yolk-sac larvae, and juveniles (Table V-13) — were provided. The staff considers these data on the other plants to be crucial in arriving at a sound and accurate assessment of the potential impact of

Indian Point on the Hudson River striped bass population. [see Sect. V.D.2.d(3)(c)(iii)]

Table V-13. Summary of Quirk, Lawler, and Matusky's composite f factors (1973) with $f_c = 1.0$

Plant	Egg stage[a]	Yolk-sac larval stage	Post yolk-sac larval stage	Juvenile stage
Bowline	0.2	0.1	0.1	0.6
Lovett	0.2	0.2	0.1	0.2
Roseton	0.2	0.1	0.5	0.3
Danskammer	0.2	0.2	0.5	0.3

[a]Based on river average observation of striped bass egg behavior surveyed by Texas Instruments in 1973. Since the duration time of the egg stage is approximately 1 to 3 days, the exposure of eggs to entrainment is much smaller than the exposure during the larval stage. Consequently, the f factors for the egg stage are not critical.

Source: Letter from E. R. Fidell (Le Boeuf, Lamb, Leiby, and MacRae) to J. F. Scinto (USAEC), dated August 27, 1974.

The staff has independently analyzed the Quirk, Lawler, and Matusky data. Tables V-14, V-15, and V-16 summarize, by sampling data and life stage for the Bowline, Lovett, and Roseton-Danskammer transects, the number of transect samples, the number of these samples containing one or more striped bass, and the number of these samples containing 10 or more striped bass. Two points deserve mention.

1. No data on striped bass eggs are available for Bowline, Lovett, Roseton, or Danskammer. The egg estimates in Table V-13 are apparently based on Lawler's October 1974 testimony on the effect of entrainment and impingement at Cornwall on the Hudson River striped bass population.[111]

2. The staff contends that a reliable estimate of f_I depends on there being a relatively high number (e.g., ≥ 10) of striped bass ichthyoplankton in the majority of the transect samples during a 24-hr study.

   While the data set is of value with respect to indicating the weeks when striped bass ichthyoplankton were present at each of the plants during 1973, the frequent occurrence of zeros in columns B and C of Tables V-14, V-15, and V-16 indicate that most of the sampling effort at each of the

Table V-14. Tabulation of number of transect samples(A), number of transect samples containing one or more striped bass ichthyoplankters(B), and number of transect samples containing ten or more striped bass ichthyoplankters(C) for each sampling date at Bowline[a, b]

Date	A	B_1	B_2	B_3	C_1	C_2	C_3
4/10/73	9(6)	0	0	0	0	0	0
5/1/73	4(2)	0	0	0	0	0	0
5/9/73	10(8)	0	0	0	0	0	0
5/23–24/73	76(60)	52(44)	8(7)	0	10(10)	0	0
6/6–7/73	83(43)	33(28)	5(5)	0	6(6)	0	0
6/13–14/73	84(55)	54(38)	49(33)	0	36(24)	32(21)	0
6/20–21/73	74(37)	32(18)	40(20)	4	10(8)	19(10)	0
6/27–28/73	80(46)	41(33)	55(39)	22(15)	14(14)	42(32)	7(4)
7/4–5/73	86(48)	1(1)	26(18)	14(6)	0	4(3)	2(1)
7/10–11/73	91(47)	0	12(9)	8(3)	0	0	0
7/17–18/73	104(56)	0	6(5)	8(2)	0	0	1(0)
7/24–25/73	88(52)	0	0	2(1)	0	0	0
7/31–8/1/73	99(51)	0	0	1(1)	0	0	0
8/7–8/73	113(59)	0	0	0	0	0	0
8/14–15/73	65(34)	0	0	0	0	0	0
8/22–23/73	73(40)	0	0	0	0	0	0
8/30/73	24(14)	0	0	0	0	0	0

[a]The subscripts on the columns headed B and C mean 1 for yolk-sac larvae, 2 for post yolk-sac larvae, and 3 for juveniles.

[b]Values not in parentheses are the number of samples taken at the West, Channel, East, Bowline Pond, and Plume sites; values in parentheses are the number of samples taken at the West, Channel, and East sites.

Source: Letter from E. R. Fidell (LeBoeuf, Lamb, Leiby, and MacRae) to M. J. Oestmann (USAEC), dated August 15, 1974.

Table V-15. Tabulation of number of transect samples (A), number of transect samples containing one or more striped bass ichthyoplankters (B), and number of transect samples containing ten or more striped bass ichthyoplankters (C) for each sampling date at Lovett[a]

Date	A	B_1	B_2	B_3	C_1	C_2	C_3
4/9/73	20	0	0	0	0	0	0
5/8–9/73	58	5	0	0	0	0	0
5/22–23/73	62	43	10	0	21	0	0
6/5–6/73	75	69	1	0	30	0	0
6/19–20/73	59	48	48	0	30	34	0
7/3–4/73	66	12	46	21	0	5	0
7/18–19/73	111	1	0	0	0	0	0
8/1–2/73	116	0	2	1	0	0	0
8/21–22/73	99	0	0	0	0	0	0

[a]The subscripts on the columns headed B and C mean 1 for yolk-sac larvae, 2 for post yolk-sac larvae, and 3 for juveniles.

Source: Letter from E. R. Fidell (Le Boeuf, Lamb, Leiby, and MacRae) to M. J. Oestmann (USAEC), dated August 15, 1974.

three transects was wasted for the purposes of estimating f_I for striped bass ichthyoplankton. The juvenile data are particularly weak. In the staff's opinion, the sampling grid and time schedule for sampling were not adequate for estimating f_I. Because the concentration in the Upper West Quadrant at each of these plants is required to estimate both f_1 and f_2,[111] more extensive sampling in that quadrant would have been appropriate, particularly during the approximate four-week period when high concentrations were expected in the transect.

Table V-16. Tabulation of number of transect samples (A), number of transect samples containing one or more striped bass ichthyoplankters (B), and number of transect samples containing ten or more striped bass ichthyoplankters (C) for each sampling date at Roseton-Danskammer[a]

Date	A[b]	B	C
3/13/73	2(2)	0	0
3/21/73	4(4)	0	0
4/11/73	8(8)	0	0
5/3/73	2(2)	0	0
5/10–11/73	35(35)	5	0
5/22–23/73	86(78)	17	2
6/7–8/73	68(18)	18	14
6/19–20/73	71(35)	30	8
7/2–3/73	88(46)	12	3
7/17–18/73	86(63)	15	1
7/31–8/1/73	106(105)	9	0
8/14–15/73	69(67)	1	0
8/29–30/73	61(51)	0	0

[a]No distinction was made among yolk-sac larvae, post yolk-sac larvae, and juveniles.

[b]Values not in parentheses are the number of transect samples analyzed for total number of ichthyoplankters of all species combined; values in parentheses are the number of these transect samples further analyzed for number of striped bass ichthyoplankters.

Source: Letter from E. R. Fidell (Le Boeuf, Lamb, Leiby, and MacRae) to M. J. Oestmann (USAEC), dated August 15, 1974.

On the basis of the detailed information summarized in Tables V-14, V-15, and V-16, as well as corresponding data from samples collected at the intakes and discharges of these four plants, the staff estimated f_I for each transect and each life-stage for the two best (i.e., greatest number of samples with striped bass) sampling dates. The data for juveniles at Bowline and Lovett merited analysis on only one date. The estimates are summarized in Table V-17. The details of the staff's analysis are given in Appendix B. While these estimates do not agree exactly with the Quirk, Lawler, and Matusky estimates in Table V-13, they are commonly less than 0.5.

Thus, in summary, the Quirk, Lawler, and Matusky data, as analyzed by the staff using Method B (see Table V-17), suggest that f_I may be less than 0.5 for yolk-sac larvae and post yolk-sac larvae at the other four plants; the data suggest a higher value for juveniles. The staff, however, cannot accept these estimates as accurate representations of reality for the following reasons.

Table V-17. Summary of the staff's estimates of the ratio of intake concentration to transect concentration (f_I) for striped bass yolk-sac larvae (YSL), post yolk-sac larvae (PYSL) and juveniles (JUV) for Bowline, Lovett, Roseton, and Danskammer based on the 1973 QLM data analyzed using Method B[a]

Plant	Date	$f_{I,1}$[b]			$f_{I,2}$[c]		
		YSL	PYSL	JUV	YSL	PYSL	JUV
Bowline	6/13–14	0.90	1.07		0.02	0.04	
	6/27–28	0	0.07	0.74	0	0.07	0.88
Lovett	6/5–6	0.06			0.07		
	6/19–20	0.37	0.09		0.44	0.09	
	7/3–4		0.16	0		0.15	0
Danskammer	6/7–8	0.32			0.27		
	6/19–20		0.89			0.89	
Roseton	7/3–4		13.3			20.5	

[a]Method B (assigning uniform lateral weight as opposed to assigning double weight to midchannel values as in QLM's Method A) was selected by the staff because it is simpler and because QLM's answers using the two methods, except at Cornwall where the 1973 Texas Instruments data are relatively limited, do not differ substantially (i.e., less than 0.1) or systematically. (Testimony of Dr. John P. Lawler, Quirk, Lawler, and Matusky on Effect of Entrainment and Impingement at Cornwall on the Hudson River Striped Bass Population, Federal Power Commission, Project No. 2338, October 1974.)

[b]Average intake and transect concentrations calculated as the average of individual concentrations. See Appendix B for details.

[c]Average intake and transect concentrations calculated as the ratio of the total number collected to the total volume filtered. See Appendix B for details.

(1) No information, such as current measurements, thermal measurements, dye studies, or hydrological intake models, has been presented to support the applicant's assumption that the intakes at Bowline, Lovett, Roseton, and Danskammer withdraw 100% of their water from the Upper West Quadrant.

(2) The sampling methods in the transect and in the intakes differ substantially. No information comparing the relative efficiencies and possible sources of bias of the two methods has been presented.

With respect to the second reservation, the staff has defined the following variables:*

$\bar{x}_I$: the measured average intake concentration over a given period of time.

x_I: the true average intake concentration over the same period.

$\bar{x}_T$: the measured average transect concentration over the same period.

x_T: the true average transect concentration over the same period.

$\bar{x}_S$: the measured average segment concentration over the same period.

x_S: the true average segment concentration over the same period.

Let

$$K_I = \bar{x}_I/x_I; \quad K_T = \bar{x}_T/x_T; \quad K_S = \bar{x}_S/x_S \quad ,$$

---

*The term transect refers to a cross section of the river taken in front of a power plant, that has a longitudinal dimension of less than one mile. The term segment refers to a reach of the Hudson River specified in either the staff's or the applicant's striped bass model. In those segments containing a power plant, the segment encompasses the corresponding transect. The longitudinal dimension of a segment is two miles in the staff's model and ten miles in the applicant's model.

and let $\hat{f}_I = \bar{x}_I/\bar{x}_T$; $f_I = x_I/x_T$

$$\hat{f}_T = \bar{x}_T/\bar{x}_S;\ f_T = x_T/x_S \quad .$$

The caret over an f denotes an estimate as opposed to the true parameter.

Quirk, Lawler, and Matusky (QLM) is assuming that $\hat{f}_I \simeq f_I$ (i.e., that $K_I = K_T$). In fact, K_I, K_T, x_I, and x_T are unknown. Moreover, there is reason to believe that $K_I < K_T$, which would result in $\hat{f}_I < 1.0$, even if $x_I = x_T$ and $f_I = 1.0$. At the intakes QLM used a fixed 1/2-m Hensen net; the approximate intake velocities were 0.2 to 0.3 fps at Bowline, 0.8 fps at Lovett, 0.5 to 0.7 fps at Roseton, and 0.8 fps at Danskammer.

In the transects QLM towed a 1-m Hensen net at a velocity of 2.6 to 3.0 fps. The difference in efficiency at a series of velocities of a 1/2-m net containing a flow meter and fixed in a rack and a 1-m net without an internal flow meter and towed behind a boat clearly should have been evaluated, but apparently it was not. To assume equal efficiencies even at a common velocity is not technically sound for reasons discussed in Sect. V.D.2.e. To assume equal efficiencies at velocities of less than 1.0 fps (as at the intakes) and approximately 3.0 fps (as in the transect sampling) is even less technically sound. Although the staff is not aware of any data for striped bass ichthyoplankton relating estimated concentration to towing speed, size, or type of net, it is reasonable to define a new f-factor, f_V, as the ratio of the concentration obtained at the towing speed used in the transect or segment with a 1-m net to the concentration obtained at a towing speed that corresponds to the intake velocity with a 0.5-m net rigged as much as possible like the 0.5-m fixed nets at the intakes. In general, estimates of concentration of mobile ichthyoplankton increase with increasing tow speed or, more generally, with increasing velocity of the water being sampled relative to the sampling net.[51,52] Also, estimates of concentration increase with increasing size of the net, provided adequate velocity relative to the water can be maintained.[53] The point is that f_V may well be greater than 1.0 for post yolk-sac larvae and juveniles. For eggs and yolk-sac larvae, f_V could be less than 1.0 due to loss of organisms in the net at high velocities. Information necessary to estimate f_V is essential before estimates of f_I should be considered accurate.

As discussed in Appendix B, QLM has completely ignored the f factor relating transect concentrations to river segment concentrations (f_T). The transect concentrations generally are based on data from 5-min, longitudinal tows in the river opposite the plants at a speed of approximately 2.8 fps; thus, transect concentrations are representative of a volume having a longitudinal dimension of less than a quarter of a mile (2.8 fps for 5 min = 0.16 miles ≅ 300 yds). The QLM segment concentrations are representative of a volume having a longitudinal dimension of 10 miles in their model. From a conceptual and mathematical point of view, f_T must be included in the model formulation; QLM has implicitly assumed that $f_T = 1.0$.

The factor f_T is also worth considering from the point of view of sampling efficiencies, because data are available to estimate both transect and segment concentrations. The average weekly segment concentration ($\overline{x}_S$) for yolk-sac larvae, post yolk-sac larvae, and juveniles for each of the sampling dates used in the staff's estimation of f_I (Table V-17) are given in Table V-18 for the QLM river segments containing Bowline, Lovett, Roseton, and Danskammer. The 24-hr average transect concentrations ($\overline{x}_T$) and intake concentrations ($\overline{x}_I$) also are given in Table V-18 calculated by using both Methods 1 and 2 (i.e., average of the individual concentrations versus the ratio of the average number collected to the average volume sampled).*

The staff's opinion is that on the average $x_T \cong x_S$; that is, the true average transect concentration over a period of time will approximately equal the true average river segment concentration over the same period. Thus, when the corresponding measured concentrations quite consistently indicate that $\hat{x}_T > \hat{x}_S$, one can logically assume that $K_T > K_S$ due to differences in sampling efficiencies. The transect samples are collected using 1-m Hensen nets and a tow speed of 2.6 to 3.0 fps. The segment samples are collected using an epibenthic sled and Tucker trawl with tow speeds of approximately 2.6 fps for the sled and 4.9 fps with the trawl.[54] The 1973 QLM and Texas Instruments (TI) data strongly suggest that the QLM transect sampling was consistently more efficient than the TI segment sampling. Why this should be so is not apparent to the staff since the sampling equipment and tow speeds do not appear to differ inordinately, and most of the differences would tend to bias the TI data to the high side rather than the low side, at least for older stages. An alternative

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*The staff's Methods 1 and 2 for calculating concentration of organisms in a sample which are defined above, should not be confused with the applicant's Methods A and B for calculating f_I.[111]

Table V-18. Weekly segment concentration, 24-hr transect concentration, 24-hr intake concentration, and the staff's alternative estimate of the intake factor (all concentrations have units of number of organisms per 1000 cubic meters)

Values are given using Methods 1 and 2 (See Appendix B, Section B.3) for striped bass yolk-sac larvae (YSL), post yolk-sac larvae (PYSL), and juveniles (JUV) for Bowline, Lovett, Roseton, and Danskammer based on the 1973 QLM transect and intake data and the QLM reduction of the 1973 TI river-segment data.

Plant	Date	Method 1											
		$\bar{X}_S$[a]			$\bar{X}_{T,1}$[b]			$\bar{X}_{I,1}$[c]			$\hat{f}^*_{I,1}$[d]		
		YSL	PYSL	JUV	YSL	PYSL	JUV	YSL	PYSL	JUV	YSL	PYSL	JUV
Bowline	6/13–14	29.7	110.2		154.5	198.0		138.9	211.0		4.68	1.92	
	6/27–28	0	128.6	0	121.8	474.9	11.8	0	33.8	8.78	0	0.26	8.78
Lovett	6/5–6	7.7			105.3			6.25			0.81		
	6/19–20	0	26.4		146.8	418.6		54.8	36.3		54.8	1.38	
	7/3–4		13.7	5.2		29.2	3.73		4.63	0		0.34	0
Danskammer	6/7–8	113.3			598.9			193.2			0.77		
	6/19–20		29.6			35.6			31.9			1.08	
Roseton	7/2–3		30.1			7.20			96.0			3.19	

Plant	Date	Method 2											
		$\bar{X}_S$[a]			$X_{T,2}$[e]			$X_{I,2}$[f]			$\hat{f}^*_{I,2}$[g]		
		YSL	PYSL	JUV	YSL	PYSL	JUV	YSL	PYSL	JUV	YSL	PYSL	JUV
Bowline	6/13–14	29.7	110.2		148.8	184.4		2.53	6.93		0.09	0.07	
	6/27–28	0	128.6	0	107.6	426.5	10.9	0	28.3	9.09	0	0.22	9.63
Lovett	6/5–6	7.7			100.8			7.16			0.86		
	6/19–20	0	26.4		136.9	399.1		61.3	35.4		60.0	1.36	
	7/3–4		13.7	5.2		27.6	3.45		4.91	0		0.30	0
Danskammer	6/7–8	113.3			586.1			177.2			0.80		
	6/19–20		29.6			36.5			32.5			1.10	
Roseton	7/2–3		30.1			4.72			81.3			3.21	

[a]Weekly segment concentration as calculated from the number of organisms and volume data from QLM's reduction of the 1973 TI river data. Letter from Carl L. Newman, Vice President, Consolidated Edison Company of New York, Inc., to George W. Knighton, Chief, Environmental Projects Branch No. 1, Directorate of Licensing, U.S. Atomic Energy Commission, dated August 30, 1974.

[b]Twenty-four hour average transect concentration calculated using the individual concentrations.

[c]Twenty-four hour average intake concentration calculated using the individual concentrations.

[d]$\hat{f}^*_{I,1} = \hat{f}_v (\bar{X}_{I,1}/\bar{X}_S)$. The staff has used $\hat{f}_v$ = 1.0 for all stages, although there is reason to believe that f_v exceeds 1.0 for post yolk-sac larvae and juveniles.

[e]Twenty-four hour average transect concentration calculated using the average of the number of organisms in the samples and the average volume of water sampled.

[f]Twenty-four hour average intake concentration calculated using the average of the number of organisms in the samples and the average volume of water sampled.

[g]$\hat{f}^*_{I,2} = \hat{f}_v (\bar{X}_{I,2}/\bar{X}_S)$. The staff has used $\hat{f}_v$ = 1.0 for all stages, although there is reason to believe that f_v exceeds 1.0 for post yolk-sac larvae and juveniles.

explanation for the consistent and considerable differences between the QLM transect concentraitons and the TI segment concentrations would be systematic inconsistencies between QLM and TI in distinguishing between striped bass and white perch such that QLM identified more *Morone* sp. as striped bass.

Having established that K_T is consistently and considerably greater than K_S, it is of paramount concern to know if K_I is closer to K_T or K_S. If $K_I \cong K_T$, the $\hat{f}_I$ values in Table V-17 may be appropriate. If $K_I \cong K_S$, the staff's alternate $\hat{f}_I^*$ values in Table V-18 may be appropriate; the alternate intake f factors are commonly greater than 1.0.

In the face of the considerable uncertainty concerning f factors, the values of which have a dramatic effect on the model predictions of the impact of Indian Point operation on the striped bass population, the staff has done an extensive parametric study for f_I using the staff's new y-o-y striped bass model. Fig. V-11 is a graph of predicted percentage reduction in y-o-y striped bass versus f_I over the range for f_I of 0.0 to 2.0. A f_I value of 0.2 as compared to 1.0 decreases the predicted percentage reduction in number of y-o-y striped bass surviving the first 20 weeks of life due to the operation of Indian Point Units Nos. 1, 2, and 3 with once-through cooling from approximately 36% to 14%.

The staff's best judgment concerning the value of f_I is that the data and analyses currently available, including the staff's analysis as given in this section and in App. B, Sections B.3 and B.4.b(3)(b)(i), support an f_I value of less than 1.0 for yolk-sac larvae, post yolk-sac larvae, and juveniles at Bowline, Lovett, Roseton, and Danskammer. Furthermore, the staff believes that it is safe to extrapolate this judgment to include striped bass eggs and to include all four life stages at Indian Point. This extrapolation is based in part on the staff's results from the new young-of-the-year model.

To achieve reasonable verifications of the staff's model based on 1973 data, it was necessary to use relatively high values of the convective transport defect factor [see App. B, Section B.4.b(5)(b)] for the early life stages (eggs, yolk-sac larvae, and post yolk-sac larvae), indicating that significant vertical and/or lateral variations in the distribution of the age group populations do indeed exist in the estuary, with high concentrations occurring near the bottom or near the shores. These variations result in the retardation of the convective downstream motion of the populations by the net freshwater flow. Hence, from considerations of consistency in modeling as well as from indications in the

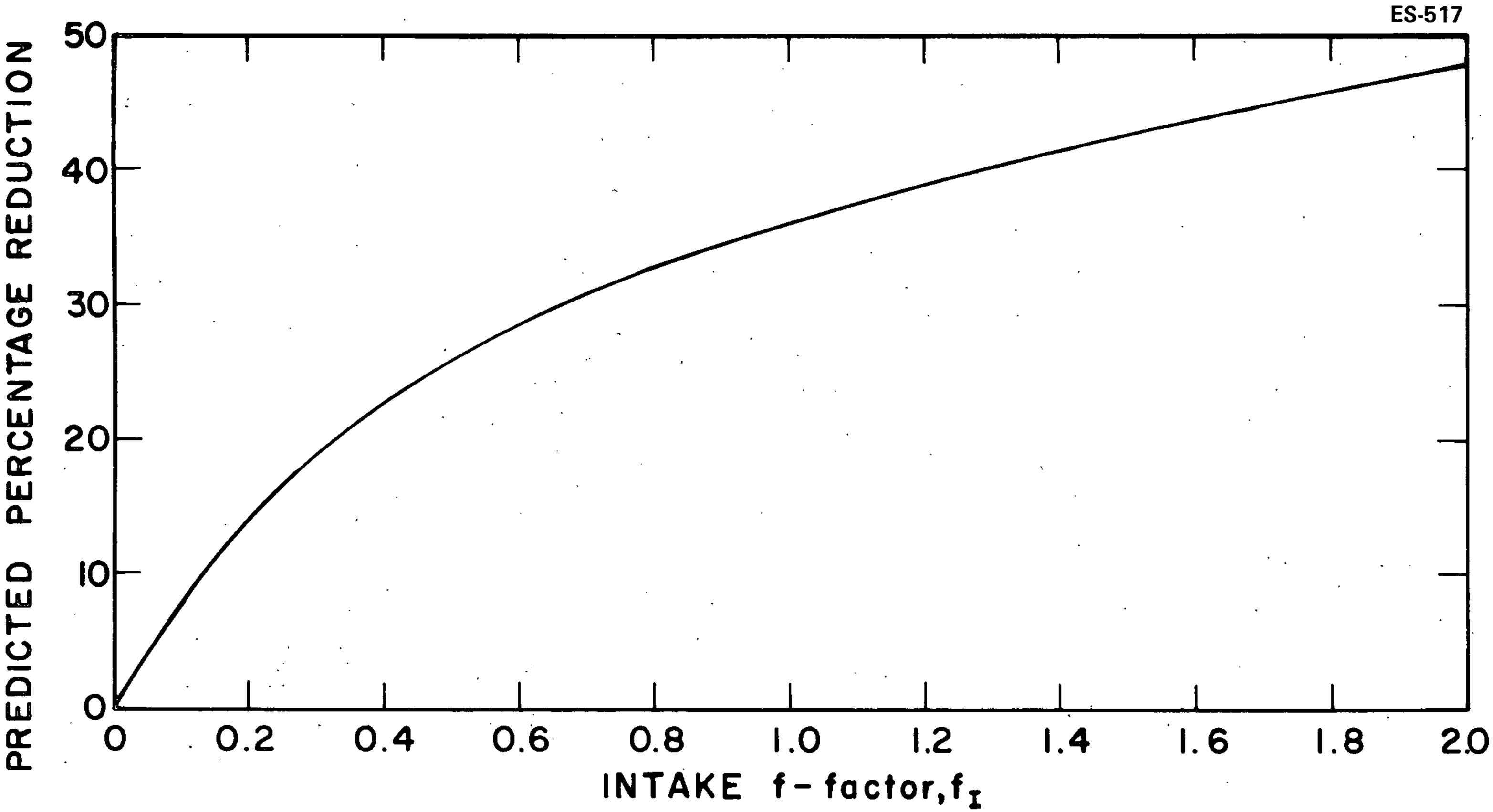

Fig. V-11. Predicted percentage reduction in number of y-o-y striped bass surviving the first 20 weeks of life due to the operation of Indian Point Units Nos. 1, 2, and 3 with once-through cooling as a function of the intake f-factor, f_I. The baseline used for calculation of percentage reduction values was conditions in 1973 (i.e., all units at Lovett and Danskammer and Unit No. 1 at Bowline).

1973 data, it is realistic to accept that the f_I values can indeed be, and likely are, less than unity. However, due caution must be exercised in the estimation of the values for the intake density ratio, and the above conclusion by no means implies that the extremely low values for the intake f factors suggested recently by the applicant (Table V-13) are realistic and acceptable for the assessment of the entrainment and impingement impact.

Because there is considerable uncertainty in the available data and because the value of f_I has a marked effect on forecasts of percent reduction by the staff's y-o-y model, the staff has done each run of the model using values of 0.5 and 1.0 for f_I. Results are presented in Sect. V.D.2.d(3)(c)(iii).

The staff's opinion is that the data are too limited and too variable to specify a single best estimate. Rather, the staff's best judgment is that for all life stages at all plants, f_I is probably less than 1.0 but not less than 0.5.

c. Effects of Discharges in the Hudson River

(1) Thermal Effects

Temperature is a particularly important factor governing the occurrence and behavior of organisms. It not only affects the distribution of a single species but may also modify the species composition of a community.

Planktonic forms are most susceptible to temperature fluctuations resulting from power plant operations, because they are dependent upon water currents for much of their movement. Larger, motile organisms are usually able to find and remain in areas near their preferred temperature unless trapped in shallow or enclosed areas or forced to migrate through thermally altered zones. Many organisms have restricted ranges of temperature within which they can reproduce successfully.[55] For these reasons, many species may exist in excessively heated areas only by continued recruitment from the outside. In such areas, fish may be absent during warm summer months and present in cold winter months. In some locations, populations of widely heat-tolerant species may replace less heat tolerant species.

A survey of the effects of temperature increases on biota (decomposers, producers, and consumers) has been presented by the staff in Appendix V-1, Sect. A of the Final Environmental Statement for Unit No. 2. In addition, the applicant has presented in Appendix CC of its Environmental Report a discussion of the previous studies of thermal effects on biota at Indian Point and other pertinent information. In summary, the applicant has concluded the following (ER, IP-3, App. CC, p. 48):

> "The temperature of water discharged into the Hudson River will never exceed 90°F with the exception of the small area surrounding the submerged ports. Previous studies indicate that damage to estuarine biota increases sharply at summer temperatures above 90°F but appears minimal below 90°F. The literature also suggests that most organisms of the Indian Point area can tolerate temperatures above those which will be discharged with all three Units at full capacity. The thermal discharge at Indian Point may cause small scale and local changes in the estuarine community. Some organisms at all trophic levels may be stressed causing shifts in species abundance and, possibly, species replacement within the local areas of maximal temperature additions. The present state of understanding of community interactions is inadequate for accurate predictions of the effects of the Indian Point thermal discharge because little research has been conducted on the indirect and long term effects of elevated temperatures on the estuarine ecosystem. Although above ambient thermal exposure may stress some planktonic organisms in the Indian Point area, any adverse effects will probably be limited to the immediate area of the discharge during summer. The discharge will be avoided by several species of estuarine fishes.
>
> "Con Edison is currently monitoring the aquatic biota at Indian Point for important changes in community structure. Sublethal effects of long term exposure and indirect effects of the warm water discharge are being investigated. This information will contribute to development of more biologically sound thermal standards and plant operating procedures. Biological research is designed to determine the thermal receiving capacity of the estuarine environment with minimal damage to the biotic community and maximum sustained use of the resource."

Thermal tolerance data on phytoplankton, zooplankton, fish eggs, larvae, and juveniles collected at Indian Point using populations, exposure temperatures, and exposure times (assumed) specific to Indian Point are summarized in Section V.D.2.b. During periods when ambient water temperatures are about 80°F (26.7°C), many of these organisms will be living near their upper limits and probably above their thermal optima. Additions of large quantities of heat to the Hudson at these times could conceivably result in changes in the biotic community such as in the distribution of a single species or in species composition. Such changes might not be readily apparent, especially if the changes involve planktonic microcrustaceans or algae, unless an adequate biological sampling program were designed and executed to test this hypothesis.

The results of the recent Texas Instruments Fish Behavior and Physiology Study, which emphasizes thermal effects, are summarized by TI as follows:

(a) First Annual Report, April 1973[63]

Discharge-Canal Studies

"Trap nets were found to be practical for sampling and characterizing the fish community residing in the discharge canal, and night fishing proved most effective.

"White catfish was the most common species (87 percent) in the summer, followed by white perch (7.5 percent), brown bullhead (3.6 percent), and eel (1.2 percent). No obvious differences in the growth rates of these white perch were found when compared to the river studies. The sample size was small. Size frequencies for the white catfish and white perch were established and temperatures at the times of capture noted.

"During early winter, white catfish predominated (98.1 percent). Size classes were again calculated and temperature associations recorded. A population estimate (Schumacher-Eschmeyer) made for the white catfish revealed that 71,500 (95-percnet confidence band of 48,000 to 141,000) were present in the discharge canal. On December 12, the plant was shut down and the temperature dropped from 15 to 3°C in 30 min. The next day, stressed white catfish were caught both in the canal and outside the canal in the ambient-temperature plume area; 32 white catfish and 10 tomcod were transported to the laboratory and held for several days at ambient conditions with no mortalities. After the plant shutdown, a crude population estimate was made based on proportionate C/f data; 3000 white catfish were estimated. The data indicated that the white-catfish population was definitely stressed, that the larger fish were affected more than the small ones, and that the population left the discharge canal (in a somewhat incapacitated condition) but apparently revived and survived the incident.

Thermal Plume

"A relatively small thermal plume existed during 1972. The maximum temperature recorded was 27.5°C on September 1.

"Attraction of several pelagic species to the plume did occur, but the data were highly variable with many zero observations. Blueback herring and bay anchovy seemed to exhibit the greatest attraction.

"No differences in bottom-trawl catches were found — and practically no differences in temperatures near the bottom between the plume and the control areas.

Thermal-Avoidance Experiments

"Two experiments with striped bass were conducted in 1972. Striped bass that acclimated at 15 and 16°C avoided temperatures >28°C. These avoidance temperatures represented ΔT values of 12 and 13°C. Of the miscellaneous behavioral observations made, one of the most important was lack of schooling by the tested fish; this has practical importance in our experimental design.

"White perch that acclimated at 12.5, 13.0, and 14.5°C avoided temperatures >30.3, 31.0, and 29.5°C, respectively, representing ΔT's of 18 and 15°C. White perch showed more of a tendency to school under the conditions extant in our experiments. White perch taken from the forebays and acclimated at 5.0, 4.0, 3.2, and 2.8°C showed avoidance reactions to temperatures >9.0, 12.5, 10.5, and 10.5°C, respectively.

"Tomcod that acclimated at 4.0, 2.1, 1.8, 1.6, 1.0, and 0.5°C avoided temperatures >13.8, 11.5, 15.4, 14.3, 13.0, and 12.0°C, respectively. The tomcod tended to move about in small groups.

Temperature-Tolerance Experiments

"There was an extensive review of water requirements for meaningful physiological experiments. The ideal design would be to use ambient river water, but the high turbidity is disadvantageous.

"Several filter systems were evaluated and a vacuum-type high-flow-rate system selected for the intensive studies of 1973. Several preliminary experiments were conducted and subsequent modifications made in the experimental chambers and equipment. Temperature differentials and mixing rates were established and are described.

"A 24-hr experiment conducted in October subjected 10 young-of-the-year striped bass to a shock of a 4°C rise; no mortalities or abnormal behavior resulted. After 24 hr of a 96-hr thermal-shock experiment on white perch acclimated at 3°C, none were dead in the control, 17 percent in the +10°C, and 58 percent in the +15°C;

these results indicate that shocks of 15°C above ambient are required to produce 50-percent mortalities."

(b) Second Semiannual Report, November 1973[42]

Discharge-Canal Investigations

"During the winter and spring of 1973, fish-trapping in the discharge canal continued yet resulted in small catches. No thermal discharge existed during the sampling periods, but the circulators were operating. Because a greater diversity (nine species) and much larger numbers of fish were caught during the fall when temperatures were elevated by thermal discharge, a positive attraction of fish to the heated effluent is confirmed.

Thermal-Plume Investigations

"Surface trawls in the plume produced small catches during 1972; gear avoidance was a distinct possibility. Consequently, floating gill nets will be tested during 1973 to determine their effectiveness in catching fish in the plume and control areas.

Thermal-Preference Investigations

"Thermal-preference investigations were initiated in the spring of 1973. Apparatus for establishing temperature gradients was constructed and, in initial experimentation, proved to be satisfactory for observing thermal preference. Preliminary results suggested that thermal selections by white perch were dependent on acclimation temperatures and independent of size. White perch that were acclimated to ambient temperatures of 17°C to 20°C selected temperatures of 27°C to 29°C.

Thermal-Avoidance Investigations

"Thermal-avoidance experiments were performed with six species. Linear regression demonstrated that white perch, tomcod, and spottail shiners had a significant relationship between avoidance and acclimation temperatures ($\alpha = 0.01$). The relationship between acclimation temperature and avoidance temperature for striped bass during spring was unclear. Striped bass acclimated to temperatures of 14.0°C to 21.2°C avoided temperatures ranging from 21.3 to 29.0°C; white perch acclimated to 6.5 to 15.0°C avoided 15.0 to 26.0°C; tomcod acclimated to 0.5 to 2.1°C avoided 9.9 to 17.6°C; spottail shiners acclimated to 3.0 to 6.3°C avoided 8.0 to 17.2°C; smelt acclimated to 6.0°C avoided 16°C; and alewife acclimated to 10.6 to 12.5°C avoided 16.0 to 18.0°C.

"Comparison of the upper avoidance temperatures of Hudson River fish and the theoretical maximum temperatures of the Indian Point plume (as determined by QLM) suggests that none of the investigated species will be behaviorally excluded from the thermal plume of Units 1, 2, and 3 during the spring of the year.

Thermal-Tolerance Investigations

"Upper thermal-tolerance determinations for white perch (acclimation temperatures of 8.0°C to 20.0°C) indicated upper lethal temperature limits of 22.8°C to 30.2°C. Thermal-tolerance limits are related to acclimation temperatures, and seasonal effects are suggested. The upper thermal-tolerance zone of white perch was 392°C^2, which is similar to that of other estuarine species but lower than most freshwater/warmwater teleosts. Speculation on the effects of a thermal discharge is premature at this time.

FISHERIES SAMPLING PROGRAM

"The 1973 fisheries sampling program has provided not only catch statistics for a number of species over a large area of the Hudson River* but fish for use in various laboratory studies related to environmental physiology and behavior and the biological characteristics of these fish species. Analysis-of-catch data provide information on spatial distribution and movements.

"Beach-seine catch/effort for white perch and striped bass increased in an upriver direction in April-May. Also for both species, axial bottom trawl catch/effort increased in an upriver direction from late April to early May but declined precipitously over the entire 30-mi (48-km) region covered from early May to early June. White perch catch/effort in trap nets increased substantially in the month of June. The combination of information from these three gears suggests an upriver and inshore movement of both white perch and striped bass in the spring and early summer. The time of this movement coincides well with the white perch spawning season."

(c) Second Annual Report, July 1974[94]

No additional results from this study are given in this report.

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*From Troy, N.Y., in the north to the George Washington Bridge in the south.

The staff's position is that the thermal discharge may increase river water temperatures to levels detrimental to aquatic biota in the vicinity of Indian Point. However, because the plume volume is an unbounded system and because of the lack of adequate biological data, the environmental effect cannot be quantified on an absolute scale (e.g., pounds per year) due to the discharges of water of above ambient temperatures at Indian Point. Nevertheless, the extent of adverse thermal effects (effects on survival, reproduction, and species composition, for example) would tend to be positively correlated with the volume of water within a specified isotherm and with the distance along the longitudinal axis of the Hudson River for which the predicted temperature exceeds specified ΔT's.

Relative to Units Nos. 1, 2, and 3 at full flow, the volume of water contained within the 4 F° isotherm, as estimated by the Koh and Fan slot-jet model[26] with an ambient river temperature of 81°F (Table V-5), is 0.9 for Units Nos. 1, 2, and 3 at reduced flow. The relative far-field thermal impact would be 1.0 for all isotherms, because the amount of heat added to the river, which is the only plant parameter considered in the staff's far-field, one-dimensional, thermal model, would be the same at both flows.

The time of spawning for striped bass is dependent in part on temperature. However, adequate data are not available for the Hudson River, striped bass population to indicate the manner in which the longitudinal distribution of spawning varies as a function of the longitudinal temperature distribution or the rate of temperature increase in the spring. Calhoun, Woodhull, and Johnson[56] hypothesized that during a wet cold spring the striped bass in the San Francisco Bay estuary migrate farther upstream and out of the delta to spawn, while in years when the water warms up rapidly, most of the bass spawn in the delta and the lower part of the rivers. This hypothesis has been found to agree reasonably well with observations of spawning in the Sacramento River but only partly with observed spawning behavior in the San Joaquin River.[57]

In expressing concern that the discharge of heated water by the Indian Point Units may result in a greater proportion of the annual production of fertilized eggs occurring in the vicinity of Indian Point, the staff has in mind not just the observable, near-field, thermal plume but also the far-field region affected by the thermal discharge from the Indian Point Plant and the Danskammer, Roseton, Lovett, and Bowline plants. One approximation of the geographical boundaries of this far-field region is given in the staff's far-field, multiplant thermal analysis. Assuming the

Indian Point Plant is at base design conditions, freshwater flow in the river is 4,000 cfs, and heat transfer to the atmosphere is 3.75 Btu/hr $\cdot$ ft^2 $\cdot$ F°, the calculated temperature distribution (average cross-sectional temperature) in the Hudson River with operation of five power plants (Case 1-a) exceeds the assumed ambient water temperature of 80°F by more than 4 F° between river miles 35 and 50 (App. A, Fig. A-2).

Estimates of the percentage of the total Hudson River striped bass egg production produced within the "vicinity of Indian Point" can be made for four different years.

Year	Percentage between river miles 35 and 50
1955	30
1966	23
1967	10
1973	23

The mean and range of the above estimates are 21.5% and 10 to 30%, respectively.

The percentage values given above, except for 1973, were calculated from figures of index of striped bass egg abundance versus river mile as the ratio: (Area under the curve between river miles 35 and 50)/(Total area under the curve). The 1955 curve (see Fig. A-V-14, FES, IP-2) was obtained by plotting the three-point moving average of the "Per cent of total" values in Table 1 in Rathjen and Miller.[58] The 1966 and 1967 curves (see Fig. A-V-14, FES, IP-2) were obtained by plotting percent mile values obtained from Table A-V-4 (1966) and Table A-V-6 (1967) of the IP-2 FES and by dividing the percent values by the length of the longitudinal axis of the given river segment. The 1966 and 1967 estimates of the percentage of the total Hudson River striped bass egg production produced between river miles 35 and 50 are corrected for differences in segment volumes. The 1973 value was calculated from the table of weekly standing crops of eggs (Quirk, Lawler, and Matusky's reduction of the 1973 Texas Instruments' ichthyoplankton date[103]) as the ratio: (total number of eggs for the season between river miles 35 and 50)/(total number of eggs for the season in the entire river). The numerator was calculated as the sum of the eggs in the river segment for river miles 40-50 plus one-half the eggs in the river segment for river miles 30-40.

From the point of view of striped bass or any other migrating fish species, the thermal discharge from the Indian Point Units is not likely to interfere with migration per se. However, the thermal discharges from the Indian Point, Danskammer, Roseton, Lovett, and Bowline plants may result in a downriver shift of the spawning distribution. The extent of this downriver shift will depend on the magnitude of the far-field temperature change and the relative importance of temperature in controlling extent of upriver migration and spawning.

If there were increased spawning of striped bass and subsequent hatching of fertilized eggs in the vicinity of Indian Point due to the thermal discharge from Indian Point, Danskammer, Roseton, Lovett, and Bowline, it still would not be possible with the present level of knowledge to predict a priori what effect this would have on the proportion of the total number of eggs spawned in the Hudson River that would survive through the first year of life. Variables that must be considered in assessing the possible effect include quality and quantity of food, number and type of predators, salinity, temperature, probability of entrainment, and probability of impingement. Each of these variables has a direct or indirect effect on the probability of survival of young-of-the-year. To determine how the probability of survival varies as a function of the thermal discharge from the Indian Point Plant, one must understand the dependence of upriver migration and spawning on temperature and the manner in which the variables given above, and thus probability of survival of young-of-the-year, vary longitudinally along the river. Such an analysis of a "wild" ecosystem[60] such as the Hudson River estuary, based on empirical data would be extremely difficult.

The subsequent influence on the size and age structure of the Hudson River, striped bass population would depend on the magnitude of the change in the probability of survival of the young-of-the-year.

One of the factors affecting the extent of impingement may be related to the existence in the wintertime of warmer river water in the vicinity of Indian Point Units Nos. 1, 2, and 3, particularly near the outfall, caused by the discharge of heated river water from the discharge canal. A related concern is cold shock following shutdown of a Unit in the winter. The applicant claims that, during the years of operation of Indian Point Unit No. 1, cold shock has not resulted in any discernible fish kill. The applicant recognizes that this has been a problem at other plants with other outfall designs, but it has not been a problem at Indian Point. Once all three Plants are operating, the potential for cold shock will be minimized because severe cold shock could only occur if all three Plants shut down simultaneously. Another point is that the high-velocity, submerged discharge assures rapid dilution so that the applicant does not anticipate that large areas of the river will be heated to a degree that could cause cold shock. The staff is in general agreement with this evaluation. Finally, the Technical Specifications limit the rate of temperature change for planned shutdowns, and the planned rate is 7 F°/hour in the discharge canal, which will result in a rate of change in the river of less than 1 F°/hour. An unplanned shutdown might stress the fish within the discharge canal, but these populations are not significant in size relative to populations in the river.

Fish may be attracted to heated discharges and resident there for several months.[62] Premature spawning can be speculated to have many repercussions, ranging from loss of progeny due to lack of proper food to species changes brought about by the dominant large warm-water fry.

Even though the staff's thermal analysis indicates that, for operation of the once-through cooling system, the 4 F° surface isotherm would extend across the river under certain conditions (Sect. V.C.1), sufficient information is not available to quantify the probability of altering the behavior and spawning distribution of anadromous species due to thermal discharges. However, thermal impacts on aquatic biota greater than those produced by Unit No. 2 alone are anticipated from operation of the once-through cooling system of Indian Point Units Nos. 1, 2, and 3.

(2) Dissolved Oxygen

Dissolved oxygen (DO) in the Hudson River is found to range from low summer values of 3 ppm to high winter values of 11 ppm,[62] although there has been considerable discussion concerning the accuracy of these data (FES, IP-2, p. II-19). Texas Instruments[63] reports that for 1972 the mean monthly DO levels in the Hudson River varied from 5.0 to 13.0 ppm. The NYS Department of Environmental Conservation maintains an automatic sampling station at Verplanck and has recorded in the summer months some values of DO less than 4.5 ppm. Values of less than 4.0 ppm were recorded at Lovett in 1970.[64]

According to the applicant, because warm water contains less oxygen in solution at saturation than cooler water, increasing intake water temperatures by 15 F° (or by 26 F° during wintertime operation) can theoretically result in some loss of oxygen. However, studies have indicated that the oxygen content of cooling water changes very little in its passage through electrical generating stations.[65] Most unheated water is not saturated. In addition, the turbulent flow of most effluent outfalls allows unsaturated water to be recharged by atmospheric gases, while supersaturated water has a tendency to lose dissolved gases. The net result is a relatively stable oxygen concentration across the condensers. Where oxygen concentrations change, they are relatively small when compared with those occurring in most natural waters through photosynthesis, respiration, and the oxidation of organic effluents (ER, IP-3, p. 12-26).

The source of reduction in DO that is of greater staff concern, however, is the effect of the thermal discharge in the vicinity of Indian Point, where biota can be exposed to higher temperatures at reduced DO. Because the thermal discharges from the Indian Point Plants and from the Danskammer, Roseton, Lovett, and Bowline plants will increase the water temperature in the vicinity of Indian Point, which will, in turn, increase the metabolic oxygen demand of aquatic organisms, DO concentrations may occasionally be lower in the vicinity of Indian Point than if there were no thermal discharge from the Plant. At certain times of the year, when dissolved oxygen levels are low as a result of natural occurrences, such further reductions resulting from Plant operations could be harmful to certain components of the aquatic community. The applicant's modeling of DO levels in the vicinity of Indian Point has included physical-chemical factors but not biotic factors, such as increased metabolic oxygen demand of aquatic organisms and increased photosynthesis of phytoplankton at elevated temperatures.

The staff concludes that during extreme conditions of low freshwater flow, high river temperatures, and high densities of plankton, the discharged thermal waste from Units Nos. 1, 2, and 3 with once-through cooling together with discharges from Lovett and Bowline may reduce the dissolved-oxygen concentration in the plume and in the vicinity of Indian Point to levels detrimental to aquatic life.[66] Mortality, reduced growth rates of larval and juvenile fish, and reduced production of phytoplankton and zooplankton may result.

(3) Chemical Discharges

Many of the chemicals shown in Table V-7 will be discharged into the Hudson River during operation of Indian Point Unit No. 3 as well as the other two Units. Some of the chemicals that will be released during operation can be toxic to aquatic organisms. The toxicity of the chemicals has been discussed by the staff in Appendix V-1 of the Final Environmental Statement for Unit No. 2

and by the applicant (ER, IP-3, Sect. 12, and App. Z and AA). The Commission also published a tabulation[67] of various chemicals used in power plants in regard to their toxicity to aquatic life. The magnitude of the response of biota to toxic chemicals depends on the concentration and type of chemical, the duration of exposure, and variations in species sensitivity. In Fig. V-1 and Table V-4 of the FES for Unit No. 2, the staff summarized chlorine toxicity data taken from the literature indicating toxic effects to several organisms at exposure times below 10 min and concentrations below 1.0 ppm. The staff also presented additional information[68] on the toxic effects of chlorine at Indian Point. In the staff's best judgment, potential problems exist primarily for releases associated with chlorination to clean the condenser tubes.

The applicant has identified the impacts of major concern associated with chlorine discharges as follows (ER, IP-3, App. Z, p. 58):

> "In order to prevent reduced heat transfer and flow caused by this slime, chlorine is introduced into the cooling water on some periodic schedule. Although chlorination has previously been considered a panacea for all problems, recently environmental research has disclosed the possible adverse effects which chlorine may have on aquatic organisms. Among these are:
>
> a. Direct impacts
>
> - Suppression of algal photosynthesis and respiration
> - Damage to zooplankton
> - Damage to fish, both juvenile and adult
>
> b. Indirect impacts
>
> - Effects of chloroamines
> - Effects of chloro-organics
>
> The potential effects of chlorination are based on two factors: concentration and time of exposure. By limiting either or both of these factors, the adverse effects associated with chlorine can be reduced or eliminated. It should be noted that there are several forms of chlorine of interest:
>
> - hypochlorous acid (HOCl)
> - hypochlorite ion
> - chloramines NH_xCl_{3-x} and
> - organic chlorine compounds."

The applicant discusses the chlorination schedule used at Unit No. 1 (ER, IP-3, App. AA) and also the dilution that can be experienced during the alternate days of chlorination in which the cooling water from the other Units aids in diluting the residual chlorine prior to release to the Hudson River. The minimum dilution ratio is 1:1 for a single condenser (Unit No. 1) when chlorination is initiated with 1.0 ppm chlorine entering one-half of the condenser and only water entering the other half, resulting in a concentration of about 0.5 ppm residual chlorine if the other pumps are not operating. The maximum dilution ratio is about 1:12 when chlorination of the one condenser at Unit No. 1 is carried out and all the pumps at all units are in operation to aid in the dilution.

The applicant does not plan to chlorinate for about four months when the temperature of the water is less than 45°F. At temperatures above 45°F, chlorination treatment will be staggered so that chlorination of the three condensers at Unit No. 2 and those at Unit No. 3 will occur every other day and the one condenser at Unit No. 1 will be chlorinated on the same day as those at Unit No. 3. The total amount of chlorine used for the three condensers at Unit No. 2 and the three condensers at Unit No. 3 will be a total of six times greater than that used during the chlorination of the one condenser in Unit No. 1. The combined output of chlorine will be 9 hr/week for a total of 7 times more chlorine products released to the river than for Unit No. 1 alone.

During chlorination, mortalities of organisms that pass through the condensers being chlorinated are expected to approach 100% for most species.

Although the New York State Department of Environmental Conservation and the Environmental Protection Agency[148] have established 0.5 ppm as the maximum concentration for chlorine discharges, there is evidence[67] to indicate that total residual chlorine concentrations as low as 0.1 ppm may have adverse effects.[139] Because of the sensitivity of different species at different life stages to chlorine concentrations below 0.5 ppm, the staff is concerned that the organisms in the thermal plume will be exposed to concentration levels of residual chlorine, chloramines, and chlorinated organics, which could result in deleterious effects.

The length of time that organisms will be exposed to toxic levels of residual chlorine is presently unknown. During past operations of Unit No. 1, the applicant has determined that the 1 ppm chlorine demand in the Hudson River water causes the free chlorine concentration to be reduced to less than 0.1 ppm before discharge. Unfortunately, the magnitude of chloramine and chlorinated organics production and subsequent rate of decay of biologically active forms are unknown. However, data from Unit No. 1 operating alone should not be extrapolated to Unit No. 2 or No. 3, because chlorinated water is retained during Unit No. 1 operation for approximately 40 min, as compared to 10 min with Unit No. 2 in operation.

The applicant has carried out bioassays on toxicity of chlorine to various species that are summarized above in Sect. V.D.2.b. The applicant also has developed a model for predicting residual chlorine concentrations in the river, which has been calibrated using field data.

The probability of causing serious impacts to the aquatic community would be lessened by chlorination schedules that coincide with peak tidal flows during daylight hours. This procedure would reduce the exposure of the planktonic crustaceans and larval fish that tend to concentrate near the bottom during daylight hours, because most of the toxic chlorine compounds will be in the thermal plume, which will be spread out on the surface as long as the thermal stratification factor is greater than 1.0 (see Appendix A). However, even with these precautions, there is a higher potential for detrimental consequences of chlorine releases from Indian Point Units Nos. 1, 2, and 3 than has previously been experienced with chlorinating only Unit No. 1.[50] Because neither the concentration nor the duration of exposure can be established with certainty, the level of impact which may be caused by releases of discharged chlorine from Unit No. 3 alone or in conjunction with Units Nos. 1 and 2 cannot be estimated with any certainty.

Other chemical discharges of importance from a biological point of view include boron, chromium, and trace metals. However, these discharges are intermittent in most cases and will be rapidly diluted by river water. The concentrations will probably be below the tolerance level (TLm) of most organisms. The applicant reports that the actual release concentrations under normal operating conditions will be below the 1/10 TLm values. Thermal effects will have little effect on the toxicity of metals to fish in the river (ER, IP-3, App. Z).

Acids and bases will be neutralized prior to release to the river. The added sulfate ions should result in minimal impacts on the saline estuary.

Chromium discharges will be collected and treated prior to any release in the river. The concentration of the chromium releases will be limited to 0.05 ppm, which is also set as the Federal drinking water standard. Discussion of the toxicity of chromium can be found on pp. A-XI-8 to A-XI-12 in the FES, IP-2.

Overall, the chemical releases will be limited to protect the aquatic biota through the Environmental Technical Specifications, and in compliance with the Environmental Protection Agency's effluent guidelines and standards[69] through the applicant's 402 NPDES discharge permit for each Plant.[148]

(4) Radiological Effects

No guidelines have been established for radiation exposures to species other than man. There is general agreement, however, that the limits established for man may also be considered in relation to other species. Terrestrial organisms surrounding the Indian Point site will receive approximately the same radiation doses as those calculated for man in Sect. V.E.2. Aquatic organisms are exposed to both internal and external radiation.[70,71] Exposure pathways for organisms other than man are shown in Fig. V-12. 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.[72]

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

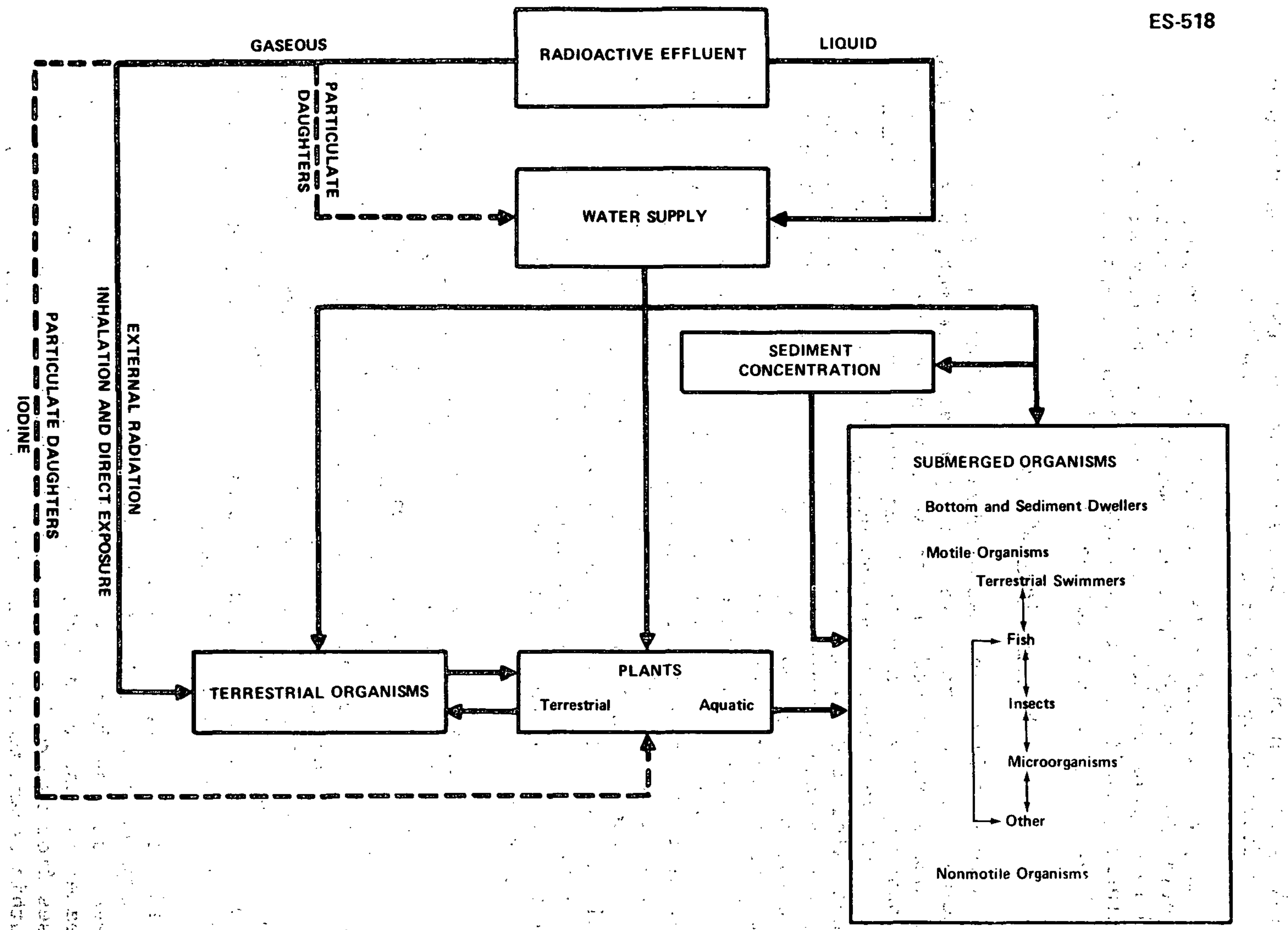

Fig. V-12. Generalized exposure pathways for organisms other than man.

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.[73] 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.[73]

The total estimated internal and immersion radiation doses to aquatic plants, invertebrates, and fin fish in the Indian Point effluent canal are given in Table V-19 for the initial and modified radioactive waste treatment processes as described in Sect. V-E. Essentially all of the dose, in all three biotic groups, is from internal radiation, particularly from the radionuclides of cesium and iodine. The estimate of water immersion dose from beta-gamma and gamma radiation only to all biota are also shown in Table V-19. Because the assumptions used to estimate doses to aquatic organisms tend to maximize the dose, and because the doses are still less than 0.1 rad/day, there should be no discernible effects to these organisms as a result of the low-level releases.[73,74] Bioaccumulation factors, internal doses, water-immersion doses for the individual radionuclides, and the method of calculation and assumptions are given in App. C.

Table V-19. Total estimated internal and immersion radiation doses to aquatic organisms in the Indian Point effluent canal for the initial and modified radioactive waste treatment processes

Radioactive waste treatment process	Immersion dose to all aquatic biota (rads/year)		Total internal dose (rads/year)		
	Beta-gamma	Gamma	Plants	Invertebrates	Finfish
Initial	0.0035	0.0025	15	8.3	0.70
Modified	0.0022	0.0013	15	7.1	0.64

The conclusions that populations of aquatic organisms residing near the outfall of the discharge structure of the Indian Point Plant will not be adversely affected by radionuclides in the discharged effluent is based on the following considerations: (1) the expected releases of radionuclides will be a small fraction of releases that have occurred in the past at major nuclear facilities without detectable adverse effects; (2) the estimated dose rates will be several orders of magnitude less than those expected to cause radiation damage. Environmental radiological monitoring will be conducted by the applicant to evaluate the accumulation of radionuclides in biota. See Section V.E.2.e for further details of the applicant's monitoring program.

d. Short-Term and Long-Term Effects

In Sect. 12 of the applicant's Environmental Report, along with appendices and other documents supplied by the applicant, the applicant discusses the biological effects of operation of Indian Point Unit No. 3 alone and in conjunction with operation of Units Nos. 1 and 2. A position is established with regard to probable minimal impacts and adverse impacts of operation primarily of the once-through cooling system for the three Units and an alternate cooling system. The applicant's position for Indian Point Unit No. 2 is summarized below as presented in its "Findings of Fact and Conclusions of Law," dated May 17, 1973:[75]

> "Operation of the facility with its presently designed once-through cooling system shall be permitted until September 1, 1981. Unless otherwise authorized by an amendment to the operating license following review of the results of licensee's ecological study program, operation shall be permitted after September 1, 1981, only if a closed-cycle cooling system shall have been installed by that date."

A similar position was taken by the applicant for Indian Point Unit No. 3, except the date was changed to September 1, 1983. The staff has reviewed these documents and has presented its assessment of the biological impacts of impingement, entrainment, thermal discharges, changes in dissolved oxygen concentration, chlorine discharges, and radioactive discharges in some of the previous sections of V.D and in Appendices B and C in this Statement for Unit No. 3 and in rebuttal testimony at the ASLB hearings in the proceeding for Indian Point Unit No. 2.

Below are presented additional details of the impacts on aquatic biota, both short-term and long-term, and the significance of these impacts in relation to the Hudson River Estuary and the fisheries supported by fish populations using this estuary as a spawning and nursery ground.

The staff agrees with the applicant that the Hudson River in the vicinity of Indian Point supports large populations of resident and migratory organisms. Of the 56 species of fish reported from the lower Hudson watershed in 1936, 48 were collected near Indian Point in 1971 and 52 species were collected in 1972. The principal commercial species are American shad and striped bass but sturgeon, herrings, carp, catfish, eel, white perch and yellow perch are also harvested. Striped bass is the principal sport species and American shad, herrings, largemouth bass, white catfish, chain pickerel, yellow and white perch, pumpkin seed, eel, and sturgeon are also caught. Special consideration has been afforded the striped bass because of the availability of extensive data compared with those for other species of fish and because of its importance to the sport and commercial fisheries (ER, IP-3, p. 12-3).

Furthermore, the Atlantic sturgeon, *Acipenser oxyrhynchus*, is officially classified as a rare species; and the shortnose sturgeon, *A. brevirostrum*, is an endangered species. The American shad resource has been depleted over the years, at least in part, by commercial fishing. Commercial harvest has varied from 2 million pounds (1945) to 36,000 pounds (1965). State fishing regulations now are set to protect this species. Small numbers of these have been collected on the intake screens at Unit No. 1.

Due, at least in part, to pollution control programs, the quality of the water in the Hudson River has improved in recent years, as evidenced by the reappearance of several benthic and fish species, including blue crabs.[63]

(1) Decomposers

The staff believes that no important changes will occur in bacterial populations as a result of operations of Unit No. 3 along with Units Nos. 1 and 2. This conclusion is supported by the thermal tolerance studies conducted for the applicant, which showed no important effects within the range of temperature that will result from Plant operation.[76]

(2) Producers

The staff's evaluation indicates that changes in species composition could occur in the phytoplankton community in the vicinity of Indian Point as a result of operation of all three Units with once-through cooling. However, the staff cannot at this time quantitatively assess the magnitude of the possible changes or the probability of their occurrence.

Phytoplankters, in addition to detritus and bacteria, are the basic food source of many zooplankters, which themselves are food for larger organisms. Seasonal shifts in species composition, diversity, and abundance occur normally and have been related to temperature, light intensity, salinity, and available nutrient supply. Phytoplankton populations at Indian Point are similar to those of other river stations.[77] Although some rooted aquatic plants exist in the Hudson River near Indian Point, they are limited to very shallow waters by the high turbidity. Few studies have been conducted on the diversity, distribution, and abundance of higher aquatic plant communities along the shores near Indian Point.

Information related to the operation of Indian Point[78] and other power plants indicates that the primary productivity of entrained phytoplankton may be reduced or eliminated. Species so affected would be effectively removed from the reproductive population but for a time could contribute to other trophic levels. During periods of low flow, the equilibrium concentration of organisms so removed from the population can be a large proportion of the total population at Indian Point. Two possible consequences from this source of damage to the producer populations could occur: a decrease in production and a change in species composition, especially during periods of chlorination. The applicant believes that no significant changes in abundance or composition of phytoplankton or zooplankton will result from Plant operations (ER, IP-3, p. 12-6).

Reduced production would reduce the food input to other trophic levels. Microscopic analyses and primary productivity analyses from laboratory tolerance studies and intake and discharge-canal studies suggest that a complete reproductive kill will not occur except perhaps during periods of chlorination.[78] When ambient river temperatures are below optimum for algal growth, productivity would be significantly increased in the larger thermal plume. This effect would be amplified, because the increase in temperature would be greater in the upper layer, which is the photosynthetically active zone.

Inherent to the question of availability of different algal groups as food for invertebrates is the succession of these algae with increasing temperature. Diatoms are represented by the largest number of species with relatively low temperature tolerances, namely, to temperatures below 86°F. Reports of field studies of the biota associated with discharge canals of power plants, where the water temperature is still essentially as high as it was when it left the condensers, have noted dominance of the periphyton community by heat-tolerant blue-green algae when water temperatures exceed about 86°F. The lethal temperature of the algae varies with the species.[79] For most of the algal species studied to date, the lethal temperature is in the range of 91.5°F to 113°F, with the majority being near 111°F. Diatoms that require cooler temperature (stenotherms) are generally most sensitive to temperature change and can withstand only an 18 F° temperature change. Diatoms suited to warmer temperatures can tolerate temperature changes of from 27 F° to 36 F°. At Indian Point, the diatom *Melosira* is dominant throughout most of the year, although its dominance declines during the summer period of high temperatures and salinity. Many other species are also consistently present.[80] However, there is a seasonal change in composition characterized by diatom dominance much of the year, with green and blue-green algae becoming more abundant in late summer and early fall. (See FES, IP-2, App. V-1 for further details.)

Thus, a much greater increase in productivity could result from thermal discharges than would occur if either photosynthesis or elevated temperatures were randomly distributed in the volume of water. When ambient temperatures are at their highest levels, however, considerable inhibition of production may occur in the plume, which again would be more significant than if photosynthesis were evenly distributed in the water column. The net result could be a greater variation in algal populations than now occurs; greater production in winter and spring would be followed by a reduction in the summer and fall, which would reduce the input of food (algae) to the rest of the community during late summer as a result of both "reproductive death" and inhibition in the plume. Recent data from laboratory, temperature-tolerance studies indicate, however, that inhibition of primary production will not occur at maximum plume temperatures (Ref. 78, Table 4A-8).

Another type of change in the algal populations that might occur during the summer and early fall would be significant increases in the populations of blue-green algae and concurrent reductions in diatoms and/or green algae. The far-field warming of water in the vicinity of Indian Point would favor algae with higher thermal optima and tolerance. New York University studies[78] have not detected any shifts in algal-species composition with Unit No. 1 alone in operation. However, Table 2, p. 15 of Ref. 81, indicates a higher percentage of blue-green algae at Indian Point in the east channel than in mid-river or the west channel during September and October of 1970.

The staff's conclusion concerning changes in species composition is based on differential responses of the various species to the thermal discharges. When ambient temperatures are below optima for all species, most would respond to increased temperatures with increased production. However, when ambient temperatures are above the optima for some species and below optima for others, an increase in temperature would increase production in some species while it decreased production in others. With this situation, the resultant production of the mixture would be less responsive to temperature changes than before and could show either slight increases or decreases in productivity. The effect that this would have on populations would be to inhibit production in those near or above their thermal optima and enhance production in those below their thermal optima. The staff believes that changes may occur in the algal populations during summer conditions.

The applicant wrote that "the productivity of natural populations of phytoplankton of the York River was affected by increases in water temperature. Productivity was evaluated using ^{14}C uptake as a measure of the rate of photosynthesis (Warinner and Brehmer, 1966).[82] During the winter, when ambient river temperatures are naturally low, increases in water temperature (up to 25 F°) enhanced primary production. At ambient temperatures above 58°F, increasing the temperature more than 10 F° significantly depressed primary production. Results indicate that the greater the temperature rise, the greater the depression of production. During summer (ambient river temp. 68–81°F) an increase of 6 F° was sufficient to depress production. In general the range of tolerance to temperature narrows as ambient river temperatures increase, and only a small temperature rise results in great reduction in production at ambient river temperatures over 77°F. These results are in contrast with those of Lauer (1972b),[83] who showed no decrease in productivity of phytoplankton at Indian Point at predicted plume temperatures" (ER, IP-3, App. CC, p. 23).

Present data[80,84] indicate that the fluctuations predicted in the preceding discussion may already be occurring as the result of natural cycles, which perhaps are augmented by the operation of Indian Point Unit No. 1 and the Lovett Plant. Complete interpretation of these data is not possible because the effects of temperature and salinity cannot be separated and because some of the algae, namely, the blue-greens, may have originated elsewhere. However, if these fluctuations are temperature dependent, the additional operation of Indian Point Unit No. 2 and Unit No. 3 may magnify the changes. The applicant's phytoplankton sampling program should be able to detect these fluctuations if they occur.

(3) Consumers

(a) Benthic Fauna

The direct effects will be the result of the interaction of four factors: entrainment of larvae, thermal discharges, residual chlorine releases, and intake scouring. The operation of the Indian Point complex will have a detrimental effect on the resident benthic organisms over a small portion of the estuary. The velocity of the intake water is expected to cause scouring over about one acre of the bottom adjacent to these structures, which may eliminate these areas as suitable habitats for some benthic species. Many of these organisms have planktonic larvae that would be subjected to entrainment. Although sufficient data are not available to quantify the magnitude of this aspect of the problem, some mortality of entrained larvae can be expected. Some scouring during discharge will possibly occur, but its effect is expected to be minimal because of the rising trajectory of the plume.

High mortality of entrained plankton could have two effects on the benthic biota. There would be an incremental reduction of larvae, which could affect recruitment rates, and, at the same time, there would be an increase in food availability as damaged or killed plankton settle to the bottom. Consequently, a high mortality rate of entrained organisms could direct more production through the benthic community and thereby slightly increase the overall density of benthic fauna. The combined effects of entrainment mortality of larvae and increased productivity in the benthic community, if of sufficient magnitude, would have the capability of causing changes in the species composition of the attached benthos.

From the above evidence, some changes can be expected to occur in the species composition and density of the benthic community, but these changes will probably not be important.

(b) Zooplankton

Discharges of residual chlorine, entrainment, and exposure to the thermal plume may affect the zooplankton community. If high entrainment mortality is encountered, selection for heat-tolerant microcrustaceans with short population turnover rates will result. However, the situation will be complicated by the residual chlorine releases, which will be at concentrations greater than those known to reduce reproductive capability in *Daphnia*. Thus, there could be a significant shift in age distributions and a reduction in the concentrations of some species of microcrustaceans during late summer as a result of operation of Indian Point Units.

The staff believes that, as was the case with phytoplankton, changes in microzooplankton can occur; however, neither the probability of occurrence nor the importance of the projected changes can be established, and no conclusions concerning the detrimental or beneficial effects of such changes are deduced.

The New York University laboratory study[83] for the applicant shows that microinvertebrate zooplankton can tolerate the cooling system and plume temperatures expected throughout the year, except during summer when cooling temperatures may exceed (by 1 to 2 F°) the tolerance of the more sensitive species. The applicant also found that mortality caused by chlorination was moderate because the generation times of most species studied are relatively short. However, the staff notes that no population-dynamics analyses were performed by the applicant on the species involved.

Larger epibenthic crustacean components (amphipods and mysids) of the zooplankton will be similarly affected. Most of these species undergo diurnal vertical migrations in that they leave the river bottom and move up into the water column at night and move back to their substrate during the day. Thus, their susceptibility to the intake will be increased at night. The possible consequences to the populations of these species are related to the fractions of the populations being affected and the length of the generation time. Although some data are available on the spatial and temporal distribution of these species at Indian Point, they offer little predictive utility as related to the populations as a whole, because the data include only the densities of the free-swimming organisms and do not provide adequate estimates of the total population, which is composed of both free-swimming individuals and those dwelling on the substrate. The species most likely to be adversely affected is the opossum shrimp, *Neomysis americana*, since it has a relatively long generation time and is temperature sensitive [see Section V.D.2.b(1)].

Similar arguments apply to *Gammarus fasciatus* and other species with long generation times. However, the data supplied by the applicant[81] indicate that *Gammarus* populations are less likely to be affected than are populations of *Neomysis* because of higher thermal tolerances. In addition, in contrast to *Neomysis* where each female reproduces only once each year, *Gammarus* produces two or more generations per year per female and there are generally gravid females present during spring, summer, and fall in the vicinity of Indian Point. Although only qualitative statements have been made regarding whether any substantial impacts on zooplankton populations will occur, no quantitative information is available from the applicant as to the effects of damage to the overall zooplankton populations in the Hudson River.

The staff's best judgment is that for microzooplankton the combined effects of entrainment mortality and exposure to thermal and chlorine stresses in the river are not expected to have any measurable effects on the aquatic ecosystem including fish populations in the vicinity of Indian Point. For the macrozooplantkon populations, such as *Neomysis*, *Gammarus*, and *Monoclodes*, there may be short-term reductions in population levels and productivity, which are not expected to have any significant long-term (i.e., beyond approximately two months) effects on these macrozooplankton populations. However, depending on the timing, these short-term reductions in population levels and productivity may have an adverse effect on the survival and growth of young-of-the-year fish, striped bass and white perch in particular, since macrozooplankton form a major component of their diet.[63]

(c) Fish

Because of the location of the Plant in the low salinity zone of the Hudson estuary, operation of Indian Point Units Nos. 1, 2, and 3 with the present once-through cooling system will adversely influence the fish populations that use the area for spawning and initial periods of growth and development. Recruitment rates and standing crops of several fish species will be lowered in response to the increased mortality caused by entrainment of nonscreenable eggs and larvae and by impingement of screenable young-of-the-year.

Those species most likely to be affected are the tomcod, bay anchovy, blueback herring, alewife, white perch, and striped bass. Direct effects on freshwater species that commonly occur in the vicinity of Indian Point are not expected to be severe.

In this section the staff discusses the following topics: (i) distribution of striped bass eggs, larvae, and juveniles in the Hudson River; (ii) compensation in the Hudson River striped bass population; (iii) forecasts of percentage reduction in the number of young-of-the-year striped bass due to power plant operation; (iv) forecasts of the subsequent impact on the Hudson River striped bass population; (v) zone and degree of influence of the Hudson River striped bass population; and (vi) consideration of other fish species.

(i) Distribution of striped bass eggs, larvae, and juveniles in the Hudson River

Because the striped bass is economically important for both sport and commercial fisheries, the staff has analyzed in greatest detail the probable impact of Plant operations on the population of this species that is maintained by recruitment from nursery areas in the Hudson River.

Each spring, adult striped bass migrate upstream and enter the freshwater portion of the river where spawning occurs as temperatures increase from about 50 to 70°F (see Table B-2). However, the great majority of the annual egg production occurs during the period of time when temperature increases from about 58 to 62°F. Thus, the longitudinal distribution of the egg production in the estuary is partly controlled by temperature. Because of this relationship between temperature and spawning location, the discharge of heated water by the three Indian Point Units and other plants may result in a greater proportion of the annual production of fertilized eggs occurring in the vicinity of the Plant, although the extent of this effect would vary from year to year, depending on the salinity of the water at Indian Point and the character of spawning migrations. See Section V.D.2.c(1) for additional information relating to the relationship between temperature, spawning, and the possible effects of thermal discharges.

The eggs and larvae drift with the currents in a net downstream direction and concentrate in a region of low salinity, generally in the vicinity of the Plant. The juvenile bass grow slowly at first. Although they become increasingly less susceptible to passive transport over the first 6 to 8 weeks, during this period, they are subject to entrainment by the intakes of the once-through cooling system. At the end of their planktonic stage, the young bass begin to move into shoal areas with a water depth of ≤20 ft. The importance of such shoals is apparent from the high concentrations of young bass in the shallow trawl stations sampled by Raytheon Company, which were also found by the trawl and beach seining done by Texas Instruments, Inc. for the applicant. These areas serve as the major nursery grounds, where the juvenile bass grow rapidly. The major such nursery area in the Hudson River occurs below Indian Point in Haverstraw Bay and the Tappan Zee. In 1968, trawl sampling of shoals for the length of the river showed that 70 to 90% of the surviving portion of the total annual production of young bass had migrated past Indian Point by late July or early August.

The applicant's suggestion that the downstream migration is composed of older fish that are not susceptible to entrainment is not supported by the available data. The peak abundance of young-of-the-year striped bass below Indian Point generally occurs in late July and early August. Furthermore, the peak abundance in the smaller upstream nursery areas does not precede the peak downstream; instead, the two coincide. In addition, the disappearance of larvae from plankton nets and surface trawls coincides with their appearance in shoals and the shallow areas that can be sampled with seines (App. B, Fig. B-10).

(ii) Compensation in the Hudson River striped bass population

One of the most important differences between the applicant's, intervenors', and staff's approaches in estimating the effects of entrainment and impingement on the striped bass population is concerned with the relative importance of natural density-dependent mechanisms (that might act to compensate for losses from operation of the once-through cooling system of the Indian Point Plants) versus density-independent mechanisms.

In this subsection, the staff discusses (1) the applicant's formulation of compensation in its striped bass model, (2) the staff's evaluation of the applicant's formulation, (3) the staff's formulation of compensation in its striped bass life-cycle model, (4) the staff's analysis of two possible density-dependent mechanisms that might operate within the 0-age class, (5) the biological bases for the staff's formulation of compensation in its striped bass young-of-the-year model, and (6) the summary.

Population regulatory mechanisms may, in general, be classified as density-independent or density-dependent and may act on various life stages of the populations involved. For a specified life stage, if mortality is controlled by density-independent factors, the population mortality rate (or the probability of an individual's dying) is independent of the population density of such organisms in the area under consideration. On the other hand, if mortality is controlled in a density-dependent manner, the mortality rate is correlated with, and is a function of, the population density. Traditionally, the term "density-dependent," when applied to population-regulation mechanisms, implies a positive relationship between density and mortality rates (high density implying increased mortality rates), with the result that a negative feedback exists which tends to stabilize population size. The concept of density-dependent mortality can, on the other hand, be extended to situations where an inverse relationship exists between population size and mortality rates. In such a situation, *survival* probability is increased with larger population size, and *mortality* rates are decreased. This inverse density-dependent mechanism would apply, for example, to the situation where mortality rates were predominantly a result of predation if a limited number of predators were involved and if they were satiated part of the time. Viewed in this manner, density-independent regulation can be considered a boundary condition that lies at the transition between inverse density-dependent relationships and (direct) density-dependent relationships. Inverse density-dependent regulatory mechanisms apply positive feedback and imply the existence of at least potential density-dependent regulation of some other life stage of the population, as well as the likelihood of population fluctuations.

The applicant's formulation of compensation in its striped bass model

The applicant describes and justifies its mathematical formulation for density-dependent mortality of early life stages, which is used in its striped bass model calculations to estimate percent reduction due to power plant operation, as follows:[155]

"Quantitative accounting for compensation in biological systems is simply a recognition that, as in other physical systems, first order kinetics cannot be employed to describe survival kinetics over the whole range of population. This recognition requires that rather than using the simple first order decay function exclusively to describe natural survival behavior, a more complex expression must be employed.

"This expression should reduce to the first order function over the range of populations where such is appropriate, but should also recognize the tendency of the system to compensate itself when driven substantially beyond this range in either the direction of increased populations or in the direction of decreased populations. This is the concept of homeostasis or 'biofeedback', that is, that a living system tends to be self-stabilizing.

"The first order decay expression is written:

$$\text{Rate of mortality, fish/unit volume/day} = K_E N$$

in which:

N = number of fish per unit volume of water

K_E = unit first order decay rate, a constant having the units of days^{-1}.

"This expression was used in the early modeling to describe the natural mortality behavior in any life stage. The numerical value of K_E is obtained when the duration of the stage in days and the percent survival for that stage are known.

"The kinetic expression employed in the transport model was developed by employing the first order form, in which a general rate coefficient K, rather than the constant K_E, is introduced and is allowed to vary with fish concentration.

"For any stage, K is varied with the prevailing concentration so that the rate of mortality in that stage increases with increasing concentration (due to crowding, less food per unit number of fish, more food [fish] for predators, etc.) and decreases with decreasing concentration for the converse reasons. Thus, the concept of homeostasis is preserved in the model.

"The functional form chosen for variation of K is:

$$K = K_E + (K_E - K_o)\left(\frac{N - N_s}{N_s}\right)^3 \quad \ldots\ldots\ldots\ldots(1)$$

in which:

K = generalized unit mortality rate, day^{-1}

K_E = conventional first order or "equilibrium" rate, day^{-1}

K_o = minimum unit mortality rate consistent with system biology, day^{-1}

N_s = "saturation" or equilibrium population level, fish per unit volume

N = actual fish concentration at any point in time (week and year) and space (river location)

"This kinetic model has been developed after extensive review of population dynamics literature [18 through 23]. Many of the concepts described herein are presented in these earlier references in a largely qualitative fashion; they have been quantified here.

"Figure V-12a which is a graphical representation of the behavior of Equation 1 for a given set of rate constants (K_E, K_o, N_s) shows how the generalized rate coefficient, K, varies with population density. Explanation of the behavior of Equation 1 and Figure V-12a follows.

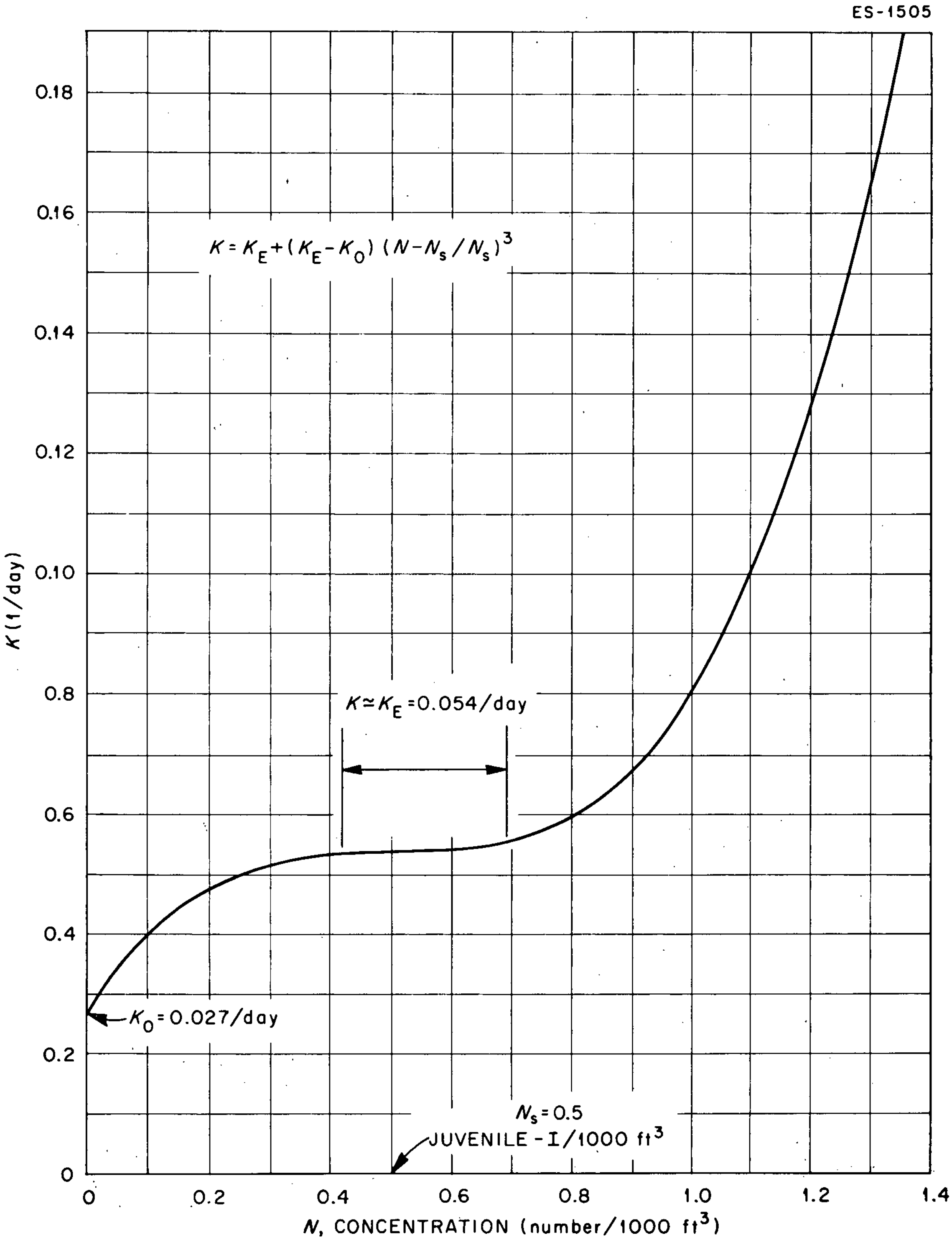

Fig. V-12a. Exponential mortality coefficient vs concentration (Juvenile I) (modified from Fig. 9 of ref. 139).

"Consideration of Equation 1 shows that when the actual population, N, is equal to the "saturation" population, the K rate reduces to the constant K_E, signifying normal first order behavior.

"What we are saying is that, on a long-term basis, exclusive of the plant's effect, we are considering the estuary juvenile striped bass population to have reached some "saturation" or "equilibrium" level. This does not imply that the estuary can never support more life — it simply says that for the existing set of background conditions, i.e., conditions both natural and man-made that exist prior to the operation of the plant, the river is "in balance" or is supporting that level of life which it is capable of supporting, considering all the external factors, both good and bad, that presently exist.

"These include, for example, the possibility that railroad construction before the turn of the century on both sides of the river may have cut off some natural nursery areas, that the Sacandaga and Indian Lake Reservoirs in the Adirondack Mountains near the headwaters of the Hudson are probably posing a different freshwater regime than once existed, etc.

"Whether we are close or far from the theoretical ultimate saturation that might be reached under the best of conditions is beside the point. We are only interested in saying that before a specific new influence enters the river, the river is probably not in a state in which significant departure from a balanced population exists.

"The mathematics chosen represent this notion quite well. The plateau shown in Figure V-12a, extending over a concentration range of .42/TCF cubic feet to .68/TCF cubic feet of juvenile I's, and in an approximate sense over an even broader range, corresponds to the saturation level. The decay rate is constant at .0536 day^{-1}, the chosen value of K_E. Note that this corresponds to 20% survival over 30 days of life of any juvenile I complement. The kinetics over this relatively broad range are essentially first order, the system is in relative balance or at relative equilibrium, and there is little active compensation. The important point is that this numerically apparent non-compensatory behavior is occurring over a relatively broad range centered about "existing" conditions in the river.

"This notion is shown again in Figure V-12b where survival rate versus concentration is plotted. The daily survival rate at which relative equilibrium is attained for this stage is .948. Note that the carrying capacity concentration satisfying this plateau

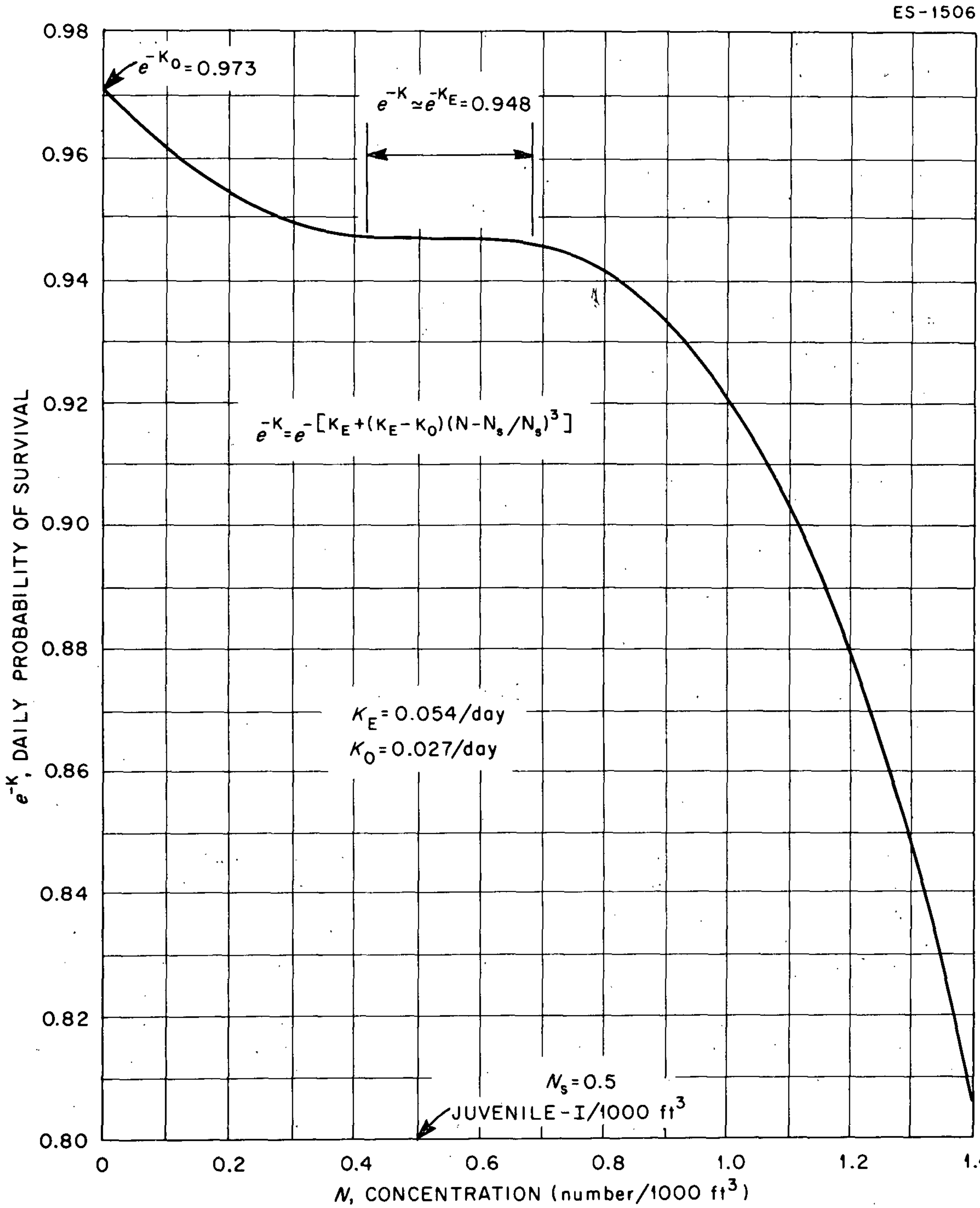

Fig. V-12b. Probability of survival vs concentration (Juvenile I) (modified from Fig. 10 of ref. 139).

is in the range .42 to .68 per one thousand cubic feet for given values. On either side of this plateau, we observe either an increase or decrease in survival of existing concentration. Survival increases to compensate for lower concentration and decreases to compensate for higher concentration.

"Now, Equation 1 also indicates that as the fish concentration drops off, because of induced population-draining effects, the rate of mortality, K, continues to decrease until a minimum rate of mortality, K_o, is reached. K approaches K_o as the population decreases toward zero. Thus, K_o may be interpreted as the minimum rate of mortality that will exist in the system when population influences on mortality (competition for food, availability to predators, etc.) are eliminated.

"In this sense, K_o has the same system interpretation as does K_E and N_s, i.e., it is representative of the "now" condition in the estuary, taking into account all positive and negative, natural and man-made influences on the system.

"Equation 1, therefore, shows that, as concentrations are reduced by plant effects, the mortality rate due to other effects will decrease, thereby compensating partially for the smaller numbers by allowing a larger fraction of the fish that remain to advance to the next stage. This will only partially offset the effects of the plant, since each early stage is subjected to either entrainment or impingement by the plant.

"Note that in the presence of a factor which will tend to increase population, such as a year in which "everything is right," the mortality rate, K, will exceed K_E and the tendency to increase the population will be controlled. Thus, compensation can be seen to be the mechanism which keeps a fluctuating population under control. The fate of a fluctuating, non-compensating feed back system is discussed in detail in the early testimony.

"In summary, then, Equation 1 was chosen to represent background or existing survival kinetics in the model because it operates in a normal first order fashion about existing concentrations and will permit partial compensation if significant departures from existing levels occur upon introduction of new influences."

The staff's evaluation of the applicant's formulation

The staff feels that the applicant's mathematical formulation, as described above, is not biologically sound. As implemented in the applicant's striped bass model, the assumption is made that without the new power plants (Indian Point Units Nos. 2 and 3, Bowline, Roseton, and possibly Cornwall), "the system is in relative balance or at relative equilibrium, and there is little active compensation." The staff's concern is that for early life stages of striped bass that are either initially largely passive (yolk-sac larvae and post yolk-sac larvae) or that tend to school (juveniles), it is difficult to visualize sources of mortality that (1) are ineffective at low densities, (2) become increasingly more effective as densities increase, then reach a broad plateau over a range of intermediate densities (0.42 to 0.48 in Figs. V-12a and V-12b), and (3) above an upper critical density again become increasingly effective as densities become very high. The staff accepts the plateau and the right half of the curves in Figs. V-12a and V-12b. In fact, the compensation functions used by the staff have the same basic property as those used by the applicant, namely, they have a plateau and then above a critical density they have a monotonic decreasing curve. More explicitly, Figs. B-25 to B-28 in App. B for the staff's young-of-the-year model are analogous to the right half of the applicant's curve in Fig. V-12b and in the staff's life-cycle model. Figure B-41 is analogous to the right half of the applicant's curve in Fig. V-12a, and Figs. B-42 and B-43 are analogous to the right half of the applicant's curve in Fig. V-12b. However, the staff feels that there is not a sound basis for the left half of the curves in Figs. V-12a and V-12b concerning fish populations such as striped bass. Much of the theory of compensation in animal populations is based on experience with terrestrial and higher vertebrate populations. In these populations there seem to be sound biological bases for hypothesizing the left half of the curves in Figs. V-12a and V-12b, which show a decreasing mortality coefficient and an increasing probability of survival all the way to zero density. The biological bases for this type of curve involve refugia, territoriality, food preferences of predators on target species (i.e., striped bass), and other behavioral phenomena that tend to be more highly developed in terrestrial and higher vertebrate species than in nonterritorial fish species such as the striped bass. Since for each life stage in the applicant's model for which the compensation function is implemented the density in each river segment initially starts at zero and finally drops back down to zero, the left halves of the curves in Figs. V-12a and V-12b are certainly utilized. Based on results the applicant has presented to date, it is not clear which half of these two curves is the most important in offsetting the power plant impact.

In the staff's opinion, a mathematical formulation with a sounder biological basis is one that has a plateau extending from zero to some critical density, beyond which the mortality coefficient (or the probability of survival) increases (or decreases) with further increases in density.

Then, with respect to the applicant's formulation, the major issue (i.e., the extent to which the parties should rely on compensatory changes in mortality to offset the increased mortality due to the power plants) becomes a judgment as to how steep the right limbs of the curves in Figs. V-12a and V-12b should be and how the curve should be positioned with respect to N_s for each life stage.

<u>The staff's formulation of compensation in its striped bass life-cycle model</u>

In the staff's striped bass life-cycle model, the staff has assumed that fishing mortality is a density-dependent source of mortality that may act, with or without new fishing regulations, in a compensatory manner so as to partially offset the increased mortality due to the power plants on the Hudson River. The general bases for this assumption are that:

(a) Fishing mortality appears to be a more important source of mortality than natural causes for adult striped bass once they enter the fishery [see Section B.4.c(3) in App. B].

(b) The sport catch substantially exceeds the commercial landings of striped bass [see Section V.D.2.d(3)9c)(v)], and the staff believes the sport fishery is likely to show more dependence on the size of the striped bass population than the commercial fishery.

(c) Cropping due to fishing, like cropping by a power plant, is a source of mortality that could be regulated. Thus, if sport and commercial fishery did not combine to compensate for this effect, it would be possible to legislate and enforce such regulation.

The staff considers such imposed regulation to be highly undesirable, and the staff is aware that such regulation would require a degree of coordination and timing among states (in addition to New York State) that has not been evidenced in the past. However, apart from imposed fishing regulations, the staff feels that the striped bass fishery would respond by itself in a compensatory manner to partially offset the increased mortality due to the power plants.

The following assumptions might be made with respect to the dependence of fishing mortality on the size of the legally fishable striped bass population:

(a) Fishing mortality may be divided into two components, a density-independent component and a density-dependent component.

(b) The density-independent component, which by definition is not strongly influenced by the size of the fishable striped bass population, constitutes a background fishing mortality. This background fishing mortality arises from two sources:

(1) fishing effort not directed just at striped bass (i.e., primarily sport fishing effort directed at whatever species are available, be they shad, bluefish, weakfish, or striped bass);

(2) striped bass directed fishing effort that is not overly sensitive to the number of striped bass available (i.e., the hard-core and habitual striped bass fisherman). The temporal and spatial distribution of the striped bass migratory stocks are commonly known (e.g., October and November is generally the best time for striped bass fishing along the south shores of Long Island), and thus, other factors (such as weather) being equal, fishing effort will be high at that location and time over a broad range of sizes of the striped bass population.

(c) The density-dependent component of the total fishing mortality is a function of the size of the fishable population, primarily in terms of its weight rather than the number of fish and primarily in terms of the size of the fishable population for the current year. Conversations with sport fishermen on Long Island indicate that the response time to news of good striped bass fishing is a matter of hours to days. The following assumptions have been made with respect to this density-dependent component:

(1) For population sizes greater than some minimum (below which the fishing is not good enough to significantly influence the fishing effort directed at striped bass), the individual fish's probability of surviving fishing steadily decreases with increasing population size. This relationship exists because high levels of abundance of striped bass cause increasing fishing effort, which in turn increases fishing mortality.

(2) A minimum probability of surviving fishing is approached asymptotically and depends on the maximum effort that can be expended, which in turn depends on the number of fishermen and boats available.

In developing the above assumptions for how the fishery might respond to changes in the size of the striped bass population, the staff has been aware that a number of real-world phenomena have not been included. For example, Assumption (c)(1) relies on the further assumption that density (e.g., school size) changes directly with population size. The size of the striped bass population could conceivably increase or decrease, without the density in the heavily fished areas increasing or decreasing in direct proportion, if the region occupied by the population increased or decreased, for example, to include or exclude areas further offshore that were not heavily fished.

Also, the approach of treating the sport fishery (e.g., surf casting, party boats, private boats) and the commercial fishery (e.g., offshore trawlers, inshore trawlers, haul seines, gill nets, and pound nets) as a single fishery is an obvious oversimplification. There are distinct "subfisheries" that are subjected to different economic and social pressures, which thus may respond differently to changes in the size of the striped bass population. Still, the staff's opinion is that the integrated result of such subfisheries that operate on a striped bass population, which is that heterogeneously distributed spatially and temporally, can be adequately simulated by a single function of the type assumed by the staff, provided that a thorough sensitivity analysis of the parameters in the function is carried out [see App. B, Section B.4.c(7)].

Thus, in the staff's life-cycle model, recruitment to the fishery is dependent primarily on the reproductive activity of mature individuals, which in turn is dependent on the activities of the fishery and on the laws that regulate it. In such a situation, the result of destruction of a fraction of the young fish (which are below the size taken by the fishery) by an extrinsic mortality source is to reduce recruitment into the fishery several years later. The effect of such reduced recruitment on the regional population of striped bass in part depends on the activity of the fishery. In effect, the additional source of man-induced mortality (in this case, the Indian Point Power Plant together with the Danskammer, Roseton, Lovett, and Bowline power stations) acts as a competitor with the fishery. The staff has included a function that incorporates the above assumptions in its new striped bass life-cycle model [App. B, Section B.4.c(3)(c)].

The staff's analysis of two possible density-dependent mechanisms that might operate within the 0-age class

The staff envisions two possible natural density-dependent mechanisms, as opposed to a density-dependent fishery, that might operate within the 0-age class under certain conditions, which, in the staff's opinion, merit further attention in the applicant's research program but which do not provide an adequate basis for modeling compensation in the staff's striped bass young-of-the-year model. The two mechanisms are: (a) cannibalism on young-of-the-year (y-o-y) striped bass and (b) dependence of growth rate (and consequently, duration and intensity of exposure of y-o-y striped bass to predators) on availability of food.

(a) Cannibalism by Striped Bass The assumptions that might be made with respect to predation on y-o-y striped bass are:

(1) The cannibals having the major effect on the y-o-y are 1-year and 2-year-old striped bass. Cannibalism on y-o-y striped bass by older y-o-y striped bass undoubtedly does occur, but it is assumed to be of less importance than cannibalism by 1-year and 2-year-old striped bass.

(2) The number of y-o-y striped bass consumed by cannibals is proportional to the number and weight of the cannibals present in the nursery areas.

(3) There is a constant "background" mortality due to predation by other fish species (e.g., tomcod and white perch) which is assumed to be independent of the number of y-o-y striped bass.

(4) Above the number of predators (other than striped bass) corresponding to the background predation mortality, the probability of surviving steadily decreases with increasing number of cannibals.

(5) There is a minimum probability of surviving predation that is approached asymptotically and that arises because some prey (i.e., y-o-y striped bass) always escape predation.[87]

(b) Dependence of Growth Rate and Duration of Exposure to Predation on Availability of Food. The assumptions that might be made with respect to the number of y-o-y consumed by a predator, duration of exposure of the y-o-y to predation, growth rate of the y-o-y, and availability of food for the y-o-y are:

(1) The number of y-o-y striped bass consumed by a predator is directly proportional to the duration of exposure to the predators and is inversely proportional to the size of the y-o-y. The greater the duration of exposure, the greater the number of prey consumed per predator. The smaller the prey, the greater the number of prey required to satiate a predator and the less able the prey are to escape the predators.

(2) Duration of exposure of the y-o-y is inversely related, and average size of the y-o-y at a given time is directly related, to the growth rate of the y-o-y; larger y-o-y are more motile and can better avoid predators.

(3) Below some minimum number of y-o-y striped bass and competitors, food is not limiting and growth is a maximum for the given temperature and other environmental conditions (i.e., an *ad libidum* feeding regime).

(4) Above this minimum number of y-o-y striped bass, food becomes increasingly limiting and growth rate steadily decreases with increasing y-o-y.

(5) There is a maximum number of predators for any given year that can be satiated by large numbers of y-o-y striped bass and similar prey and that is approached asymptotically.

(6) This density-dependent mechanism would be inoperative primarily after the entrainment period when the y-o-y concentrate in the shoal and beach areas and when competition for available food could be high.

These two interrelated mechanisms could operate to prevent the number of y-o-y striped bass surviving to enter age class 1 from being either very large for successive years or very small for successive years. The effect of operation of the primary mechanism (i.e., cannibalism) can be illustrated by considering a hypothetical dominant year-class. If the freshwater flow and water temperature are favorable and the number of striped bass in age classes 1 and 2 is relatively small, a dominant year-class is possible. However, for the next two years in particular, the number of predators will be greater due to the presence of members of the dominant year-class. Thus, even if hydrological conditions by chance were favorable for a second or third year in a row, the probability of successive dominant year-classes is reduced. On the other hand, the absence of dominant year-classes during the previous two to three years means that the number of cannibals may not be particularly great. Thus, even if hydrological conditions are not favorable, the probability of large numbers of y-o-y striped bass surviving to enter age class 1 is increased.

Operation of this primary mechanism might be modified to some extent by density-dependent growth within age class 0. The effectiveness of the predators in reducing the number of y-o-y is assumed to increase with increasing duration of exposure of the prey and to decrease with increasing size of the prey. Duration of exposure and size of the prey, in turn, depend on the balance between availability of food (microzooplankton and then macrozooplankton) and number of y-o-y, as reflected in growth rate.

Analyses of stomach contents of striped bass and white perch by Texas Instruments[63] suggest that young-of-the-year striped bass are not a common food item for either species. To further investigate the significance of predation, and cannibalism in particular, in regulating the size of the y-o-y striped bass population, the staff recommends that the applicant expand its research program as follows.

From July through November in the shoal areas north of Cornwall and in Haverstraw Bay-Tappan Zee Bay, the applicant should

(a) estimate relative abundance and biomass of the various prey, in addition to y-o-y striped bass;

(b) identify predators, including 1- and 2-year-old striped bass;

(c) determine the composition of diet for each predator species;

(d) estimate relative abundance and biomass of the different predators; and,

(e) carry out an analysis to estimate the proportion of y-o-y striped bass killed by striped bass, by white perch, by tomcod, and by other predators.

Data are not presently available to determine the importance of the second mechanism; that is, dependence of growth rate (and, consequently, duration and intensity of exposure to predation) on availability of food. However, the research program could be modified to investigate the importance of this mechanism in several ways, such as:

(a) Study the relationship between food availability and density of y-o-y striped bass with respect to both growth and survival: (1) in relatively well controlled experiments in the laboratory; (2) in less well controlled experiments at striped bass rearing facilities in the South; and (3) in pens located in the shore zone in areas such as Haverstraw Bay.

(b) Collect data on a yearly basis to study the relationship between the density of y-o-y striped bass in the shoal and beach areas in the fall or the spring and the length distribution of these fish. A significant negative correlation would be indicative of density-dependent growth within age class 0. Clark[88] presented such data for y-o-y striped bass in the Chesapeake, for which the correlation coefficient is -0.22 ($N = 12$; $P > 0.10$), which suggests an absence of density-dependent growth within age class 0. The major shortcoming of this suggestion is that each year of research generates only one datum point for the correlation analysis.

<u>The biological bases for the staff's formulation of compensation in its striped bass young-of-the-year model</u>

The staff has proposed mathematical formulations for the two young-of-the-year natural compensation mechanisms discussed above, which are consistent with the two sets of assumptions.[89] However, given the limited amount of data available to parameterize these mechanistic functions, the staff has chosen not to implement them in the striped bass young-of-the-year or life-cycle model. Instead, the staff has chosen in its young-of-the-year model to represent the end result of natural compensation by means of a single empirical function, rather than modeling specific compensatory mechanisms. Cannibalism and dependence of growth rate on availability of food are only two possible density-dependent mechanisms that might operate within the 0-age class of striped bass. Other mechanisms for the 0-age class (e.g., an increased predation rate by bluefish at higher densities of young-of-the-year striped bass) are certainly possible but equally difficult to assess empirically. Also, natural compensatory mechanisms may be operative within older age classes. Compensation may be viewed as the integrated, macroscopic end result at the population level of a kaleidoscope of innumerable, microscopic encounters at the individual level. These events may be temporally and spatially distributed in a heterogeneous manner throughout the year and throughout the region the species inhabits.

The staff's judgment is that at the present level of understanding and ability to study marine fish populations and complicated estuarine ecosystems, the empirical assessment and ranking of specific compensatory mechanisms for a striped bass population is not possible. A comprehensive research program may provide indications of possible mechanisms, but such a program cannot be expected to provide quantitative estimates of the degree of compensation.

On the other hand, (1) the inability of a research program to demonstrate that natural compensation will occur and (2) the lack of empirical data at present to demonstrate that natural compensation has been important in regulating the Hudson River striped bass population in the recent past does not logically lead to the conclusion that natural compensation is not or will not be operative in the population.

This line of reasoning suggests modeling the end result of natural compensation by means of a single empirical function, rather than modeling specific compensatory mechanisms. Such an approach is discussed below.

The following assumptions are made:

(1) Natural compensatory mechanisms may be operative in age classes other than age class 0; they may involve interactions between older age classes and young-of-the-year; and they may involve a time lag of more than a year between a change in density of an age class or of a young-of-the-year life stage in one direction and between buffering of that change due to compensatory changes in survival, growth, or fecundity. However, the staff assumes that the net effect of all natural compensatory mechanisms can be adequately approximated by a density-dependent expression for the probability of natural survival of one or more life stages of young-of-the-year striped bass. This assumption is consistent with the

opinion of several fish population biologists who feel that for marine and estuarine fish populations, natural compensation most likely occurs during the first year of life, particularly during the first few months of the first year.[149-152]

(2) Below some critical number of young-of-the-year striped bass, or of individuals in a particular young-of-the-year life stage (e.g., yolk-sac larvae, post yolk-sac larvae, or juveniles), their probability of natural survival is independent of their density.

(3) Above this critical number, their probability of natural survival steadily decreases with increasing young-of-the-year.

The staff has used a mathematical formulation, which reflects the above assumptions, in its new young-of-the-year striped bass transport model [see App. B, Section B.4.b.(2)(b)(i)].

An alternative interpretation of the staff's formulation of compensation in its striped bass life-cycle model is based on the same line of reasoning used in this subsection. Without attempting to distinguish between the relative likelihood and importance of natural compensation and compensation by the fishery, one can argue in favor of a single empirical function that is assumed to adequately represent the integrated result of all density-dependent mechanisms. This function is then assumed to operate on the fishing mortality, since there is reason to expect that the striped bass sport-fishing effort, in particular (which is considerably greater than the commercial-fishing effort), is dependent on the size of the striped bass population.

Summary

From the staff's point of view, the concept of natural compensation, as opposed to compensation by the fishery, and the fact that natural compensation is occurring and will continue to occur to some degree, are not the issues in controversy. Rather, the primary issue, provided the applicant has not and will not be able to quantify the degree of natural compensation, is to what extent should the parties rely on compensatory decreases in natural mortality to offset the increased mortality due to the power plants. The staff's position is that to rely on natural compensation to any major extent is not environmentally sound. Thus, in reaching its conclusions in this Final Environmental Statement for Indian Point Unit No. 3, the staff has assumed that natural compensation of early life stages and older age classes is not likely to be of major importance in offsetting the increased mortality due to the power plants. However, the staff has included a compensation function in its young-of-the-year model to determine the effect of changes in the compensation parameters on the model results used to assess the potential impact of plant operation on the striped bass young-of-the-year population.

Given that (1) fishing mortality appears to be a more important source of mortality than natural causes for adult striped bass once they enter the fishery, (2) the sport catch substantially exceeds the commercial catch, and (3) the staff believes the sport fishing effort in particular is likely to be dependent on the size of the striped bass population, the staff has assumed that the combined fishery will respond in a compensatory manner, with or without new fishing regulations, to partially offset the increased mortality due to the power plants. On the basis of this assumption, the staff included a density-dependent, fishing-mortality function in its life-cycle model.

(iii) Percent reduction in number of y-o-y striped bass

The subject of entrainment effects on the Hudson River spawned striped bass population was one of the major issues in the hearing before the ASLB for Units Nos. 1 and 2. All parties have proposed models to estimate the magnitude of entrainment, and detailed discussion has been presented of each model in the Final Environmental Statement for Unit No. 2, the staff and applicant's testimony for the Unit No. 2 hearings, the applicant's Environmental Report and Supplements (App. AA) for Unit No. 3, and the intervenors' testimony for Unit No. 2. In this Final Environmental Statement for Unit No. 3, the staff has used a new population transport model for young-of-the-year striped bass (App. B, Section B.4.6), and a new life-cycle population model for the total Hudson River striped bass population (App. B, Section B.4.c).

Based on the information in Sect. V.D.2.b(2), V.D.2.d(3)(c)(i) and V.D.2.d(3)(c)(ii) and in Appendix B, Section B.2, the staff has developed a new young-of-the-year striped bass population transport model for forecasting percent reduction due to power plant operation in the number of y-o-y striped bass in the Hudson River that survive to mid-October. This simulation model is described in Appendix B, Section B.4, which includes comparisons of predicted longitudinal distributions with longitudinal distributions obtained from 1973 data.

This new model, which is conceptually similar to the entrainment models used by the staff during the Indian Point Unit No. 2

proceedings and in the DES for Indian Point Unit No. 3, is more soundly based with respect to hydrologic and transport theory, and it includes biological phenomena not included in the staff's previous models.

The model is a daily transient (tidal averaged), longitudinally one-dimensional (cross-sectionally averaged), discrete element model. In applications to the Hudson, the model considers 152 miles of the estuary, from the Troy Locks to the Battery, as consisting of 76 segments of 2-mile equal lengths. The high spatial resolution was selected to guarantee the necessary accuracy in specifying the locations of the intakes and discharges relative to the existing geometrical characteristics and the flow conditions in the river that can influence the distributions of the populations, and hence the local conditions of entrainment and impingment at the power plants.

The mathematical formulation of the model is based on the straightforward concept of conservation of numbers by balancing the time rates of change of the age group population numbers in each discrete element resulting from rates of longitudinal convection, transport and migration across the element enclosure surfaces, rates of transfer by growth to higher life stages and mortality in the element, and rates of reduction by entrainment and impingement at the existing power plants in the element.

Percent reduction values obtained from this model are given in Table V-20 for:

(1) two baselines from which to calculate percent reduction;
(2) two values of the input f-factor (f_I);
(3) eleven configurations for power plants on the Hudson River.

<u>Baselines for calculating percent reduction values</u>

The two baselines the staff has used to calculate percent reduction values address two somewhat different questions. Percent reduction values calculated with a baseline of no plants operating on the river (Case 1) are estimates of the entrainment and impingement impact through October 15 of each year* on the Hudson River spawned striped bass population relative to a hypothetical no-impact situation. With this baseline, the emphasis of the analysis is on the combined impact of all the power plants and how this combined

*Percent reduction values are calculated from the results of the young-of-the-year model on the basis of the number of juveniles surviving to October 15 of each year.

Table V-20. Young-of-the-year model results

Numbers for the various cases indicate percent reduction in the young-of-the-year from the base populations as indicated for each set of results

Case	Other plants[b]	Cornwall	Method of cooling[a]			Percent reduction[d]	
						Intake f-factor (f_I)	
			IP-1	IP-2	IP-3	0.5	1.0
						Without plants on the river as the baseline (Case 1)	
1[c]	–	–	–	–	–	15.86	15.86
2	1973	–	–	–	–	14	23
3	+	–	–	–	–	21	34
4	+	–	OT	OT	–	29	45
5	+	–	OT	OT	OT	34	50
6	+	–	OT	CC	OT	30	46
7	+	–	OT	CC	CC	23	37
8	+	+	OT	OT	OT	47	64
9	+	+	OT	CC	OT	44	61
10	+	+	OT	CC	CC	38	55
11	–	–	OT	OT	OT	21	32
12	–	+	–	–	–	24	33
						All other plants except Cornwall as the baseline (Case 3)	
3[c]	+	–	–	–	–	12.50	10.42
4	+	–	OT	OT	–	10	16
5	+	–	OT	OT	OT	17	24
6	+	–	OT	CC	OT	11	17
7	+	–	OT	CC	CC	3	5
8	+	+	OT	OT	OT	33	46
9	+	+	OT	CC	OT	28	40
10	+	+	OT	CC	CC	22	32

[a]OT means once-through cooling; CC means closed-cycle cooling. See Sect. XI.C for further discussion of closed-cycle cooling alternatives.

[b]Other plants include four units at Albany, four units at Danskammer, two units at Roseton, five units at Lovett, two units at Bowline, and seven units at 59th Street. In 1973 (case 2), the two units at Roseton and the second unit at Bowline were not operating. + indicates plants included in the calculation, and – indicates plants not included in the calculation.

[c]Values in this row are millions of young-of-the-year striped bass in the Hudson River on October 15 of each year.

[d]Convective transport defect factor (CTDF) = 0.8.

impact may be reduced with closed-cycle cooling instead of open-cycle cooling at Indian Point Units Nos. 2 and/or 3. The striped bass population (as well as the applicant's research effort to measure the population) experience the combined impact of all the power plants and will experience the reduction in the combined impact following a change from once-through cooling to closed-cycle cooling at Indian Point.

Percent reduction values calculated with the second baseline of all plants on the river in operation except Indian Point Units Nos. 1, 2, and 3 (and Cornwall) (Case 3) provide estimates of the incremental entrainment and impingement impact through October 15 of each year due to Indian Point Units Nos. 1, 2, and 3 (and Cornwall). With this baseline, the emphasis of the analysis is on the incremental impact of Indian Point (and Cornwall) and how this incremental impact may be reduced with closed-cycle cooling instead of open-cycle cooling at Indian Point Units Nos. 2 and/or 3. However, the striped bass population will not experience this isolated incremental impact of Indian Point (and Cornwall) apart from experiencing the combined impact of all the power plants. Likewise, neither will the population experience the reduction of this isolated incremental impact following a change from once-through cooling to closed-cycle cooling at Indian Point Units Nos. 2 and 3 apart from experiencing a reduction of the combined impact. As expected, the percent reduction values are greater when using Case 1 as the baseline (Table V-20). Also as expected, the estimated benefit of installing closed-cycle cooling systems at Indian Point Units Nos. 2 and/or 3 is greater when using Case 3 as the baseline (Table V-20).

The presentation of percent reduction values from the young-of-the-year model using both baselines emphasizes that the choice of a baseline has a marked effect on the apparent impact and the extent to which this impact may be reduced with closed-cycle cooling at Indian Point. Although this FES has been prepared in the course of the licensing procedure for a single power plant (Indian Point Unit No. 3), the impact of Unit No. 3, which is of primary concern to the staff (entrainment and impingement of fish, striped bass in particular), involves populations that are not restricted to the vicinity of Indian Point. Rather, these fish populations inhabit the entire Hudson River Estuary and beyond, and as such, they are subject to entrainment and impingement impacts from the entire complex of power plants on the Hudson River. In terms of intake flow, once-through cooling at Indian Poing Unit No. 3 (1,938 cfs) represents only about 20% of the total intake flow at Indian Point Units Nos. 1, 2, and 3, Bowline, Lovett, Roseton, and Danskammer (10,308 cfs).

For the above reasons, the staff's position is that the baseline of no plants operating on the river is the more appropriate baseline for assessing the entrainment and impingement impact of Indian Point Unit No. 3 and of the other plants on the Hudson River spawned striped bass population. Accordingly, analysis of the long-term impact on the adult population using the staff's life-cycle model [Section V.D.2.d(3)(c)(iv)] and analysis of the economic impact on the fisheries (Section XI.J.2.c) are based on percent reduction values from the staff's young-of-the-year model calculated with this baseline.

Convective transport defect factor and the intake f factor

The staff selected two values for the input parameters for the convective transport defect factor (CTDF) and the intake f factor (f_I). The convective transport defect factor is used to control the susceptibility of striped bass ichthyoplankton to downriver transport [see Appendix B, Section B.4.b(5)(b)]. The value of 0.8 resulted in a very close fit between the simulated distributions and the observed distributions. A second level for CTDF (0.4) was used in the final runs when it became obvious that forecasts of percent reduction were quite sensitive to the value of this parameter. However, when CTDF = 0.4, the striped bass ichthyoplankton are transported downriver faster than indicated by the Texas Instruments' 1973 river data.

As indicated in Sect. V.D.2.b(2)(e), the staff concludes that the data and analyses currently available (including the staff's) support an f_I value for all entrainable striped bass life stages at all plants of less than 1.0 but not less than 0.5. However, since there is considerable uncertainty in the available data and since the value of f_I has a marked effect on forecasts of percent reduction by the y-o-y model, the staff did each final run using values of 0.5 and 1.0 for f_I.

Forecasts of percent reduction with once-through cooling at Indian Point Unit No. 3

The staff's single best estimate for the CTDF is 0.8, whereas the staff's best estimate for the intake f factor is the range 0.5 to 1.0. Consequently, in summarizing the forecasts of percent reduction with once-through cooling at Indian Point Unit No. 3, the staff has not considered the results for CTDF = 0.4.

In the absence of Cornwall, the percent reduction values range from 34 to 50% with once-through cooling at both Units Nos. 2 and 3 (Case 5) and from 30 to 46% with a cooling tower on Unit No. 2

and once-through cooling at Unit No. 3 (Case 6) (Table V-20). With Cornwall, the percent reduction values range from 47 to 64% with once-through cooling at both Units Nos. 2 and 3 (Case 8) and from 44 to 61% with a cooling tower on Unit No. 2 and once-through cooling at Unit No. 3 (Case 9).

Compensation

The staff's discussion in this subsection of the implementation of compensation in its young-of-the-year model deals with preliminary results; the compensation results have not been considered in the preceding subsection on "Forecasts of percent reduction with once-through cooling at Indian Point Unit No. 3."

The staff's generalized compensation function for the young-of-the-year model is described in App. B, Section B.4.b(2)(b)(i). The same type of function was used for all life stages except eggs; no compensation function was used for eggs. Parameterization of the function in this subsection differs from the description given in App. B in that (refer to Fig. V-12c):

(1) Optimum survival percentage (OSP) values for life stages from yolk-sac larvae through Juvenile III were 58, 75, 93, 93, and 96 respectively. These values were calculated from the effective survival percentages (ESP) as follows: OSP = ESP + 0.3 (100-ESP). The effective survival percentages (ESP) used are 40, 64, 90, 90, and 95 for yolk-sac larvae through Juvenile III respectively.

(2) Values for observed maximum density (DMAX) of each life stage (except eggs) were chosen by using the maximum 5-element, 7-day average densities from a model run that did not include any power plants on the river and that used the effective survival percentage values in Table B-24 (i.e., without the compensatory function).

(3) The critical density (DCRT) for each life stage (except eggs) was chosen as 10% of DMAX.

(4) A population density at which the survival percentage was zero (DINT; not discussed in App. B) was chosen as 2.0 times DMAX. The compensatory part of the function was thus a straight line passing through two points, the (population density, survival percentage) coordinates of which were (DCRT, OSP) and (DINT, 0).

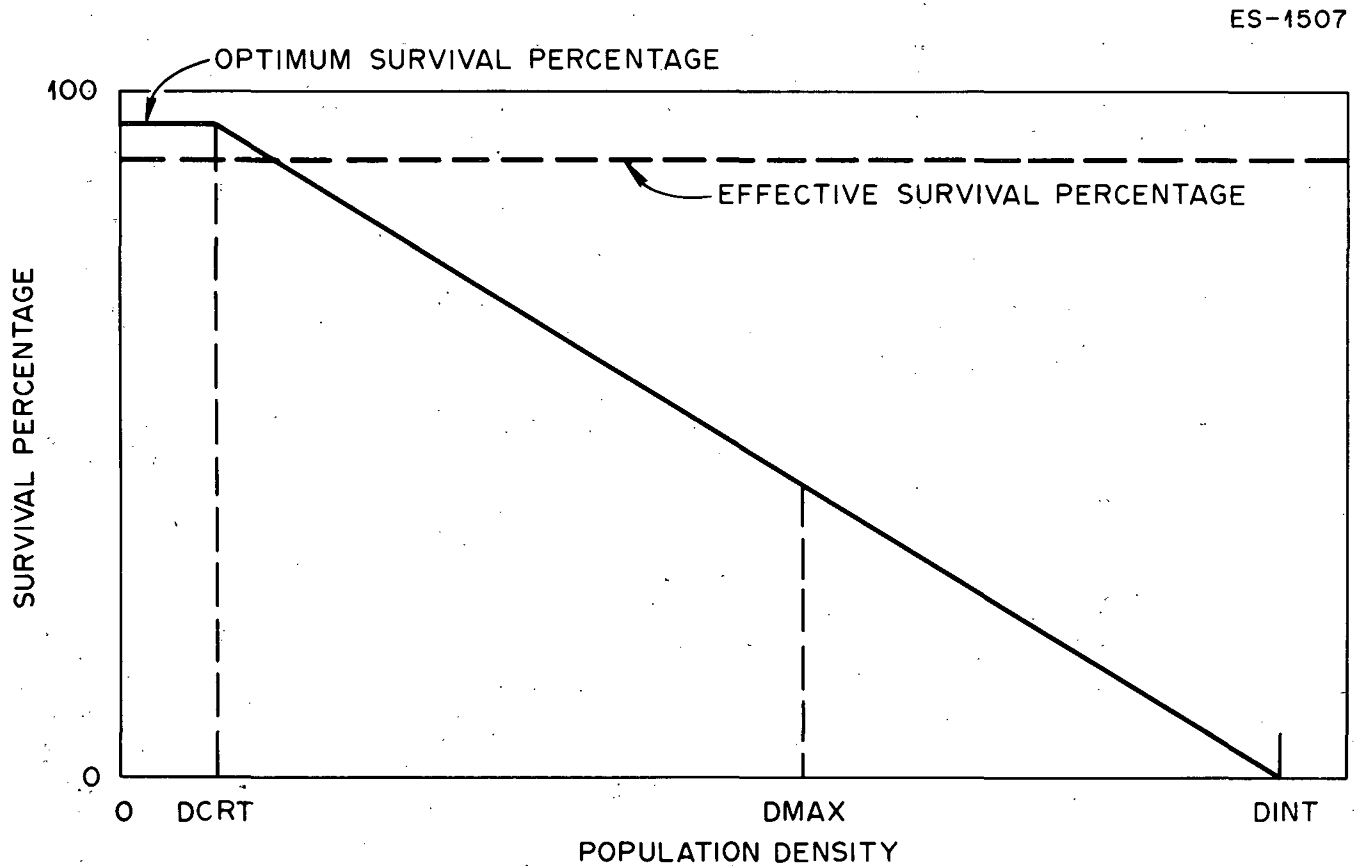

Fig. V-12c. Schematic representation of staff's strong compensatory function (solid line) and noncompensatory function (dashed horizontal line).

The parameters were chosen with the following two guidelines in mind: (a) to give a compensation curve of the type in Fig. V-12c for each life stage, which in the staff's judgment reflected strong compensation, and (b) to satisfy the constraint that the total number of juveniles left in the estuary on October 15 was approximately the same for the 1973 case (Case 2 in Table V-20) with and without compensation.

Model runs were done for Cases 1 and 5 (defined in Table V-20) both with and without compensation. In all four runs, f_I was 1.0 and CTDF was 0.8. The percent reduction for Case 5, using Case 1 as the baseline, is 50% without compensation and 43% with compensation.

Based on this result, the staff concludes that the implementation in its young-of-the-year model of a strong compensatory function for the survival percentage of all stages except eggs does not greatly reduce the predicted extent of power plant damage to the population as of October 15. Further runs with the model, which involve the implementation of existing additional compensatory functions[153] and the extension of runs throughout the entire year, are planned.

(iv) Forecasts of impact on Hudson River striped bass population

The staff has used a striped bass life-cycle model to evaluate the long-term impact of changes in y-o-y mortality on the striped bass population. The general question concerns the effect on a fish population when density-independent sources of mortality, particularly entrainment and impingement at power plants, are introduced that act on the y-o-y. The model and computer programs are described in Van Winkle et al. (1974);[89] the model is also described in Appendix B, Section B.4.

Briefly, the population model consists of a system of difference equations involving age-dependent fecundity and survival. The model deals only with females. The fecundity for each age class is assumed to be a function both of the fraction of females sexually mature and of the weight of females as they enter each age class. Natural mortality for age classes 1 to 15 and over is assumed to be independent of population size. Fishing mortality is assumed, in part, to vary with the total weight of fish available to the fishery in a density-dependent manner [see Section V.D.2.d(3)(c)(ii)].

Before presenting results, a caveat is in order to the effect that the staff wishes to de-emphasize and discourage efforts to play meaningless games with "soft" numbers by treating them as "hard" numbers. The emphasis in discussing the results of the life-cycle model is on trends, inequalities, and qualitative and semiquantitative properties of the forecasts. The staff offers no apology for not presenting a more quantitative assessment, which has a lower level of uncertainty, of the potential impact of Indian Point on the Hudson River striped bass population. Our efforts reflect the state of the science and the state-of-the-art of forecasting the effects of environmental impacts on a large fish population, inhabiting an open system, that is the subject of an intense sport and commercial fishery. The staff hastens to add that these comments are equally valid for the applicant's modeling efforts.

The staff emphasizes that its striped bass life-cycle model is a single-species population model, which appears to simulate the behavior of the population in a reasonable manner. However, in reality, the Hudson River spawned striped bass population is one component of a complicated fish community that inhabits an even more complicated estuarine and marine ecosystem. Thus, the dynamics of the striped bass population undoubtedly depend, to some extent, on interactions between striped bass and other biotic and abiotic components of the ecosystem. In addition, since striped bass are the subject of an intense sport and commercial fishery, and since fishing mortality is of importance in regulating the population, the dynamics of the Hudson River striped bass population also depend on social and economic factors that affect fishing effort. Neither the staff's nor the applicant's life-cycle model includes interactions between the striped bass and other biotic and abiotic components of the ecosystem or the social and economic factors that may influence fishing effort. The justification for the more limited approach adopted is that data on these interactions and social and economic factors are lacking, and even if they were available, an understanding of the cause-effect relationships necessary to include such phenomena in a model is not adequate. The hope is that by focusing on the population per se, where there are adequate data on fecundities and survivals, the staff's life-cycle model will be sufficiently realistic to a first approximation to serve as part of the basis for making a rational management decision concerning the unacceptability of once-through cooling at Indian Point Unit No. 3 (base design or Alternative A) and the timing of installation of closed-cycle cooling at Unit No. 3.

The staff's life-cycle model has certain properties which must be kept in mind when interpreting the results but which the staff feels are justified given the present state-of-the-art of forecasting the long-term effects of environmental impacts on a fish population such as the striped bass. A natural steady state has been assumed such that following the removal of a perturbation to the population, such as increased mortality to the young-of-the-year due to entrainment and impingement, the population always returns to its original size before the perturbation was applied. The staff is aware that in the present application of the model, this assumption of a natural steady state is not consistent with commercial landings and sport catches over the last 40 years or so.[93,154] The commercial landings and sport catches have both been increasing, and these increases are generally accepted as indicating a real increase in the size of the Atlantic coast striped bass stock.[93,154] The fisheries statistics are not adequate enough to conclude that the Hudson River spawned striped bass population _per se_ has been increasing over the past 40 years. Regardless of past trends, the staff's assumption in its life-cycle model and in its benefit-cost analysis (Section XI.J.c.2) of a natural steady state over the next 100 years is a simplification of what could happen in the future given no power plant impact. This simplification should be kept in mind when interpreting the results.

In this same vein, the staff's approach of making forecasts 80 and 100 years into the future merits comment. In any simulation model of this type, the degree of uncertainty in the results steadily increases with each year's projection into the future. Such a situation is an unavoidable consequence of making projections into the future. However, it does not relegate simulation modeling to the status of a meaningless exercise; rather, it requires that in making a rational management decision, the limitations of simulation modeling in forecasting 100 years into the future be appreciated.

A final property of the staff's life-cycle model that merits comment is that theoretically, the model population can never go to biological extinction. This property of the model exists because striped bass 15 years old and older are lumped into the "box" labeled age class 15 (see App. B, Fig. B-40). Losses out of this box due to natural mortality and fishing mortality are a constant fraction of the number remaining in the box once the population has decreased to the level where only density-independent fishing mortality is assumed to be operative (see App. B, Fig. B-41). The staff does not consider this property to be a limitation of the model in its present application, since even with extreme parameter combinations the size of the population does not drop below 10 to 20% of its size before the power plant impact, and since the duration of impact (30 to 40 years) does not exceed the likely maximum age of reproductively active female striped bass.

The primary output from the life-cycle model that the staff has relied on in assessing the impact of Indian Point on the striped bass population are curves of relative yield vs year (Fig. V-12d). Relative yield is defined as the ratio of the yield of striped bass to the fishery (in weight rather than numbers of fish) with a given level of power plant impact to the yield to the fishery with no power plant impact. The staff then has used two criteria to analyze the information in curves of the type given in Fig. V-12d. First, the increase in cumulative yield over the duration of the model run (80 or 100 years) for an alternative is expressed as a percent of the cumulative yield for the base design. In other words, the shaded area in Fig. V-12d is expressed as a percent of the area under the curve from year 0 through year 100 for the base design. Second, for the base design and each alternative, the number of years for which the relative yield is less than 0.50 is calculated. For example, referring to the hypothetical curves in Fig. V-12d, for the base design the relative yield is less than 0.50 for 29 years, while for the alternative the relative yield is never less than 0.50.

The staff considers the number of years the relative yield is less than 0.50 as an index of the risk of irreversible effects on the striped bass population. The longer the relative yield is reduced below 0.5, the less likely it is that the recovery curve forecast by the simulation model will be an accurate reflection of reality. The topic of irreversible effects is further discussed later in this subsection. The staff considers the increase in cumulative yield to be an approximate estimate of the benefit to the striped bass population of installing closed-cycle cooling systems at Indian Point. A similar methodology provides a basis for a detailed assessment of the economic impact of the Indian Point Plant on the striped bass fisheries (Section XI.J.2.c).

The staff has used the percent reduction values discussed in the preceding subsection as input to the life-cycle model by calculating the probability of surviving (or not being exposed to) entrainment or impingement through October 15 (= PPO) as

$$\text{PPO} = \frac{100 - \text{percent reduction}}{100}$$

Runs were done using the following conditions:

(1) Parameter Set 1, that is, the staff's best estimates for all input parameters other than PPO (see App. B, Table B-43), which is calculated from the percent reduction values from the y-o-y model.

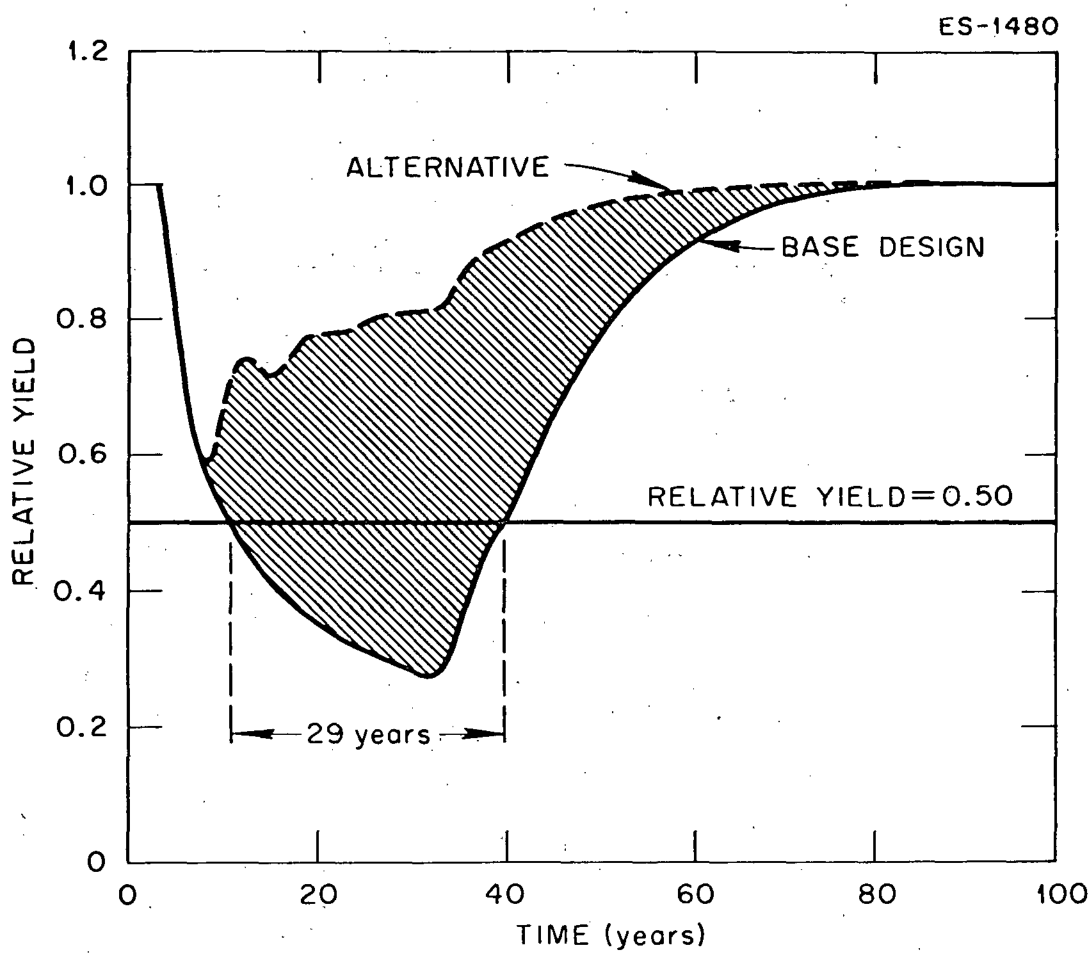

Fig. V-12d. Two hypothetical curves of relative yield vs years to illustrate the two criteria used by the staff to further analyze results from the life-cycle model.

(2) Twenty-four combinations of PPO values and durations are summarized in Table V-21:

(a) Three configurations at Indian Point: (i) the base design (i.e., once-through cooling at Unit No. 2 starting in 1974 and once-through cooling at Unit No. 3 starting in 1975); (ii) Alternative A (i.e., once-through cooling at Unit No. 2 starting in 1974 and then changing over to closed-cycle cooling starting in 1979, and once-through cooling at Unit No. 3 starting in 1975); and (iii) Alternatives B and C (i.e., Unit No. 2 as in Alternative A, and once-through cooling at Unit No. 3 starting in 1975 and then changing to mechanical-draft (Alternative B) or natural-draft (Alternative C) cooling towers starting in 1982). Decommissioning is assumed to occur in 2008 for Unit No. 2 and in 2010 for Unit No. 3. Indian Point Unit No. 1 and all units at Bowline, Lovett, Danskammer, and Roseton are assumed to operate at full power with once-through cooling from 1974 through 2010. In those cases with Cornwall, Cornwall is assumed to operate from 1982 through 2031.

Only results for the base design and Alternative A are considered in this section; Alternatives B and C are considered in Section XI.C.3.c(4)(b)(iv). Each value in the column headed "Number of years" in Table V-21 is the number of years the model is run using the PPO values in that row.

(b) Two values for the intake f factor (f_I; see Sect. V.D.2.b(2)(e)]. Each value of f_I in the y-o-y model determines a percent reduction value for a specified configuration of conditions at Indian Point.

(c) With and without Cornwall (Storm King) pumped storage plant.

As discussed in the previous section under the heading of "Baselines for calculating percent reduction values," the staff's position is that the baseline of no plants operating on the river is the appropriate baseline for assessing the entrainment and impingement impact of Indian Point Unit No. 3 and the other plants on the Hudson River spawned striped bass population. Accordingly, the analysis of the long-term impact on the striped bass population using the life-cycle model is based on percent reduction

Table V-21. Input parameters for the life-cycle model based on results from the young-of-the-year model[a]

Configuration at Indian Point[b]					$f_I = 0.5$[c]		$f_I = 1.0$[c]	
Alternative	IP-2	IP-3	Period	Number of years	% reduction	PPO[d]	% reduction	PPO
					Without Cornwall			
Base design	OT		1974–75	2	29	0.71	45	0.55
	OT	OT	1976–2008	33	34	0.66	50	0.50
		OT	2009–10	2	29	0.71	45	0.55
			2011–53	43	0	1.00	0	1.00
A	OT		1974–75	2	29	0.71	45	0.55
	OT	OT	1976–78	3	34	0.66	50	0.50
	CT	OT	1979–2008	30	30	0.70	46	0.54
		OT	2009–10	2	29	0.71	45	0.55
			2011–53	43	0	1.00	0	1.00
B	OT[e]		1974–75	2	29	0.71	45	0.55
	OT	OT	1976–78	3	34	0.66	50	0.50
	CT[f]	OT	1979–81	3	30	0.70	46	0.54
	CT	CT	1982–2008	27	23	0.77	37	0.63
		CT	2009–10	2	22*	0.78*	36*	0.64*
			2011–53	43	0	1.00	0	1.00
					With Cornwall (1982–2031)			
Base design	OT		1974–75	2	29	0.71	45	0.55
	OT	OT	1976–81	6	34	0.66	50	0.50
	OT	OT	1982–2008	27	47	0.53	64	0.36
		OT	2009–10	2	43*	0.57*	60*	0.40*
			2011–31	21	24	0.76	33	0.67
			2032–73	42	0	1.00	0	1.00
A	OT		1974–75	2	29	0.71	45	0.55
	OT	OT	1976–78	3	34	0.66	50	0.50
	CT	OT	1979–81	3	30	0.70	46	0.54
	CT	OT	1982–2008	27	44	0.56	61	0.39
		OT	2009–10	2	43*	0.57*	60*	0.40*
			2011–31	21	24	0.76	33	0.67
			2032–73	42	0	1.00	0	1.00
B	OT		1974–75	2	29	0.71	45	0.55
	OT	OT	1976–78	3	34	0.66	50	0.50
	CT	OT	1979–81	3	30	0.70	46	0.54
	CT	CT	1982–2008	27	38	0.62	55	0.45
		CT	2009–10	2	37*	0.63*	54*	0.46*
			2011–31	21	24	0.76	33	0.67
			2032–73	42	0	1.00	0	1.00

[a]Percent reduction values with an asterisk were estimated by assuming that the shutdown of Unit 2 with a cooling tower after the year 2008 would decrease the percent reduction 1%.

[b]All units at Bowline, Lovett, Danskammer, and Roseton are assumed to start operation in 1974 and to cease operation in 2010.

[c]Convective transport defect factor (CTDF) = 0.8.

[d]$PPO = \frac{100 - \%\ reduction}{100}$

[e]OT denotes once-through cooling.

[f]CT denotes cooling tower.

values from the staff's young-of-the-year model calculated with a baseline of no plants operating on the river. The reader is referred to the previous subsection for further discussion of the justification for and implications of this choice of a baseline.

The results of these 24 runs are summarized in Table V-22, and the relative yield versus year curves for the three alternatives at Indian Point without Cornwall for (CTDF, f_I) = (0.8, 1.0; 0.8, 0.5) are illustrated in Figs. V-13 and V-13a, respectively. As indicated in discussing Fig. 12c, the number of years the relative yield is less than 0.50 (Table V-22, Column B) is determined by counting the number of years the relative yield curves in figures such as Figs. V-13 and V-13a are below the horizontal line through 0.50 on the relative yield axis. The increase in cumulative yield at year 80 as a percent of the cumulative yield for the base design (once-through cooling at Indian Point Units Nos. 2 and 3) (Table V-22, Column C) is calculated by finding the area between the curves for Alternative B and the base design and Alternative A and the base design and expressing this area as a percentage of the area under the curve for the base design.

As mentioned in the preceding subsection, the staff's single best estimate for the convective transport defect factor (CTDF) is 0.8, whereas the staff's best estimate for the intake f factor is the range 0.5 to 1.0. Consequently, in summarizing the results from the life-cycle model with once-through cooling at Indian Point Unit No. 3, the staff has not considered the results for CTDF = 0.4. Without Cornwall, (a) the number of years the relative yield is less than 0.50 ranges from 15 to 36 years for the base design and from 0 to 33 years for Alternative A; and (b) the increase in cumulative yield at year 80 for Alternative A as a percent of the cumulative yield for the base design ranges from 4 to 5%. With Cornwall, (a) the number of years the relative yield is less than 0.50 ranges from 41 to 55 years for the base design and from 38 to 54 years for Alternative A; and (b) the increase in cumulative yield at year 80 for Alternative A as a percent of the cumulative yield for the base design ranges from 3 to 4%. Again, a detailed assessment of the economic benefit to the striped bass fisheries of Alternative A as compared to the base design is given in Section XI.J.2.c.

To interpret the results a little more clearly, it is instructive to consider one set of conditions rather than a range of values. Consider the results given in Table V-22 for f_I = 0.5. Excluding Cornwall, once-through cooling at all Units of Indian Point would mean that the relative fishery yield would be reduced below 0.5 of the "clean" river yield for 15 years.

Table V-22. Results of the sensitivity analysis using Parameter Set 1 (see Appendix B, Table B-43) for two values of the intake f-factor (f_I) for the base design, Alternative A, and Alternative B, without and with Cornwall, using the PPO values and durations given in Table V-21

f_I[c]	Alternative at Indian Point			Results[a,b]			
				Without Cornwall		With Cornwall	
	Alternative	IP-2	IP-3	A	B	A	B
0.5	Base design	OT[d]	OT	15	0	41	0
	A	CT[e]	OT	0	4	38	3
	B	CT	CT	0	9	28	7
1.0	Base design	OT	OT	36	0	55	0
	A	CT	OT	33	5	54	4
	B	CT	CT	28	14	53	10

[a]Number of years relative yield is less than 0.50 (Column A) and the increase in cumulative yield at year 80 as a percent of the cumulative yield for the base design (column B).
[b]Convective transport defect factor (CTDF) = 0.8.
[c]f_I = intake f factor.
[d]OT denotes once-through cooling.
[e]CT denotes cooling towers.

ES-519

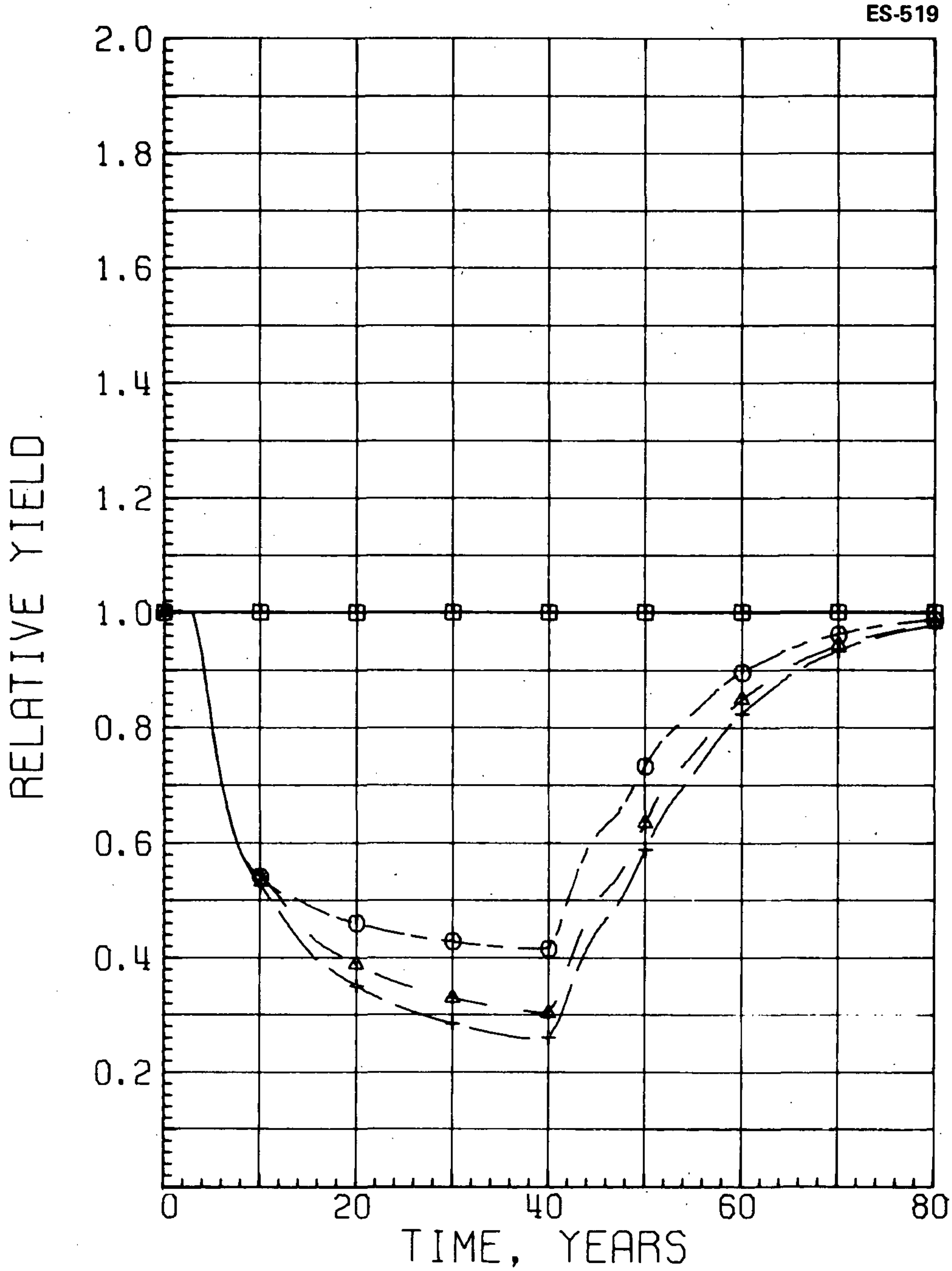

Fig. V-13. Relative yield vs time curves for various configurations at Indian Point without Cornwall but including Roseton, Danskammer, Lovett, and Bowline [i.e., base design (+) — once-through cooling at both Units Nos. 2 and 3; Alternative A (Δ) — a cooling tower at Unit No. 2 and once-through cooling at Unit No. 3; and Alternatives B and C (O) — cooling towers at both units]. Values calculated using f_I = 1.0 and CTDF = 0.8 in the young-of-the-year model.

ES-539

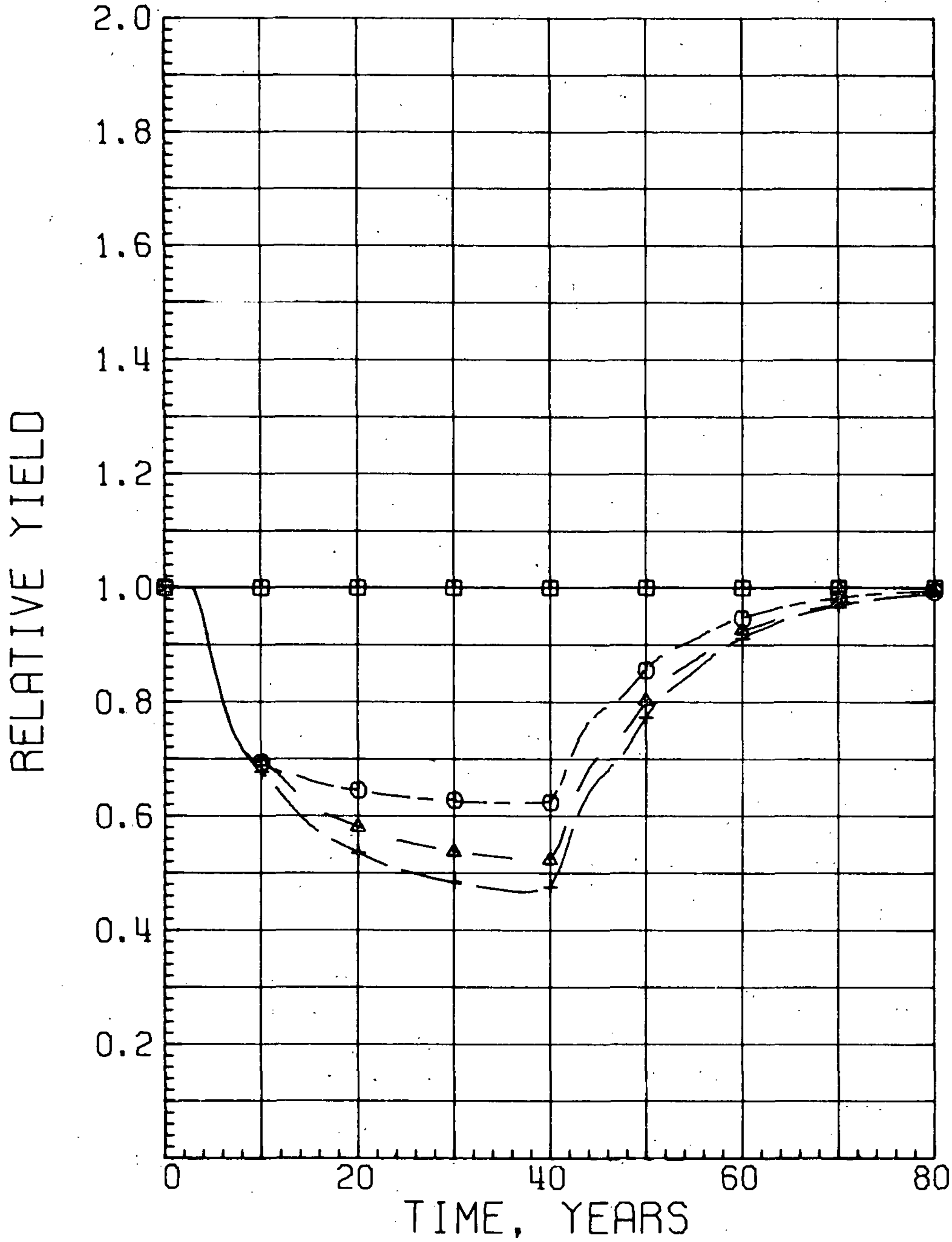

Fig. V-13a. Relative yield vs time curves for various configurations at Indian Point without Cornwall but including Roseton, Danskammer, Lovett, and Bowline [i.e., base design (+) — once-through cooling at both Units Nos. 2 and 3; Alternative A (Δ) — a cooling tower at Unit No. 2 and once-through cooling at Unit No. 3; and Alternative B (O) — cooling towers at both Units]. Values calculated using results of the young-of-the-year model with f_I = 0.5 and CTDF = 0.8.

Installation of a cooling tower at Unit No. 2 would reduce this to 0 years, and for cooling towers at both Units Nos. 2 and 3 the yield would never be depressed below 0.5. Similarly the cumulative yield to the fishery would be increased 4% by a cooling tower at Unit No. 2 and 9% by cooling towers at both Units.

Given the use in subsequent paragraphs of the phrase "irreversible damage" and the variety of terms that were used in the Indian Point Unit No. 2 ASLB Hearings to describe the possible damage to the Hudson River spawned striped bass population, the staff feels that further discussion of this phrase is required. The staff's opinion is that the terms irreparable, irreplaceable, irrecoverable, irrevocable, and irretrievable should be considered synonyms. Consider the case where an entrainment impact results in a decrease in the population and in the yield to the fishery, but that subsequently the magnitude of the entrainment impact is decreased and there is a corresponding increase in the population and yield to pre-stress levels. In this example, the population would be said to have recovered, although the loss in yield to the fishery during the interim period is irretrievable.

The term irreversible (or permanent) as applied to the effect of a stress like entrainment and impingement on a population such as the striped bass has the ecological connotations of (1) biological extinction (i.e., no striped bass of any age class in the Hudson River for all time), (2) fishery extinction (i.e., such a small striped bass population spawning in the Hudson River as to be insignificant in its contribution to the sport and commercial striped bass fishery for all time), or (3) permanent reduction (but above the fishery-extinction level) in population size that continues even after the stress is removed.

The staff considers biological extinction or fishery extinction due to entrainment and impingement mortality of striped bass eggs, larvae, and juveniles to be only a remote possibility even with once-through cooling at Indian Point Units Nos. 1, 2, and 3 for the lifetime of the plant. However, permanent reduction in population size is a distinct possibility. If one component of a biological community is selectively stressed so that that population is reduced to low levels for many years, the system of which it is part will tend to adjust, perhaps in such a way that even after the stress on this population is removed, the population is unable to return to its previous size. The history, present status, and prognosis for several fish populations in Lake Erie is an example of this possibility, as indicated by the following quotation:[140]

"The metalimnion and hypolimnion of the Central and Eastern basins were summer sanctuaries for many valued cold-water fishes — lake trout, lake herring, lake whitefish, and blue pike. During this century, catches of all these species have declined to commercial extinction (the first three species) or possible biological extinction (the blue pike).

"Although eutrophication of the Central Basin, together with intense fishing, has been implicated in the fluctuations and collapse of the dominant species in the hypolimnion, the analysis cannot end there. All these species also inhabited the Eastern Basin, which only now is approaching the degree of hypolimnetic anoxia that directly stresses mature fish. However, fishing and eutrophication were not responsible for the final collapse of the dominant fish populations. We suggest that the final collapse was caused by predation by smelt, cannibalistic interactions between year classes of blue pike, predation of blue pike on other species, and species desegregation (21) — all intensified by the effects of the fishery.

"The rainbow smelt invaded Lake Erie around 1931. Its numbers increased rapidly in the late 1940's, and it became extremely abundant by 1951. Smelt generally occupy pelagic areas of Lake Erie down to the metalimnion during the summer thermal stratification in the Central and Eastern basins (22). Young smelt feed on plankton and crustaceans, and yearling and older smelt feed to some extent on small fish. By 1950, the stocks of lake whitefish and lake trout were greatly reduced, and during the late 1950's the blue pike and sauger had almost disappeared and the stocks of walleye were decimated. When predatory pressure on the smelt from trout, blue pike, and sauger was relieved, it became the most abundant fish in the pelagic area of central and eastern Lake Erie. Consequently, the predatory stress exerted on the young of other species by ever-increasing numbers of smelt during the 1950's and 1960's was a significant factor in the severe reduction or extirpation of the young of the remnant stocks, of lake herring, sauger, blue pike, lake whitefish, and walleye (15).

"There is, of course, general agreement that species interact in Lake Erie, that environmental changes may favor a new species over an established one, and that great reductions in one species because of over-exploitation or other stresses can favor proliferation of less intensely stressed species. Yet, most fishery research on Lake Erie to date has dealt with single-species problems, or with a particular variety of species. This type of research will always be necessary. But we infer from the story of Lake Erie and similar lakes (5) that broader and more comparative studies of the structure and dynamics of ecosystems are necessary if we are to achieve the insight into the roles of cultural and natural stresses required for predicting the consequences of fishery and environmental management. We need to understand the mechanisms that control the flow of energy and material within ecosystems under growing or diminishing stresses.

"The current management objective in Lake Erie is not full restoration of historical fish communities. Such restoration is impossible for several reasons: (1) Viable spawning populations of certain valued fish cannot be easily re-established because lake tributaries are blocked by dams or silted in marshes have been destroyed by drainage, and many inshore lake spawning grounds have been covered with silt. (ii) Predation by rainbow smelt (now the most abundant pelagic species of fish) would probably inhibit restoration of lake whitefish and lake herring, or a percid like the blue pike if it were to be introduced. (iii) The existing large populations of freshwater drum (the most abundant nonpelagic species in western Lake Erie), carp, and goldfish might effectively resist the reintroduction of such species as northern pike, lake whitefish and lake herring."

To further discuss the possibility of irreversible damage to the Hudson River striped bass population due to the additional stress of entrainment and impingement mortality at the power plants on the Hudson River, it is necessary to distinguish between the following two classes of impact.

On the one hand, there are (1) impacts that eliminate spawning and nursery grounds (e.g., dredging or dams) or that in some way render the aquatic environment unsuitable as a habitat for reproduction or existence (e.g., toxic materials or anoxic conditions) and (2) impacts, such as intentional or accidental introduction of new species, that result in changes in the interactions among species within a fish community to the detriment of some of the original species. On the other hand, there are impacts, such as entrainment and impingement, that directly crop a certain fraction of the population (as does the fishery), but that do not directly alter the suitability of the habitat and, if the cropping is not too great, that do not greatly alter the interactions among species within the fish community.

The danger of irreversible damage is greater for the first class of impacts than for impacts involving increased cropping of a population. However, the possibility of permanent reduction (but above the fishery-extinction level) due to excess cropping is a risk which cannot be ignored.

Although the staff is concerned that the effects of thermal and chemical discharges from Indian Point and the other power plants could alter the suitability of the habitat, the staff's primary concern with respect to the striped bass population is the effect of cropping due to entrainment and impingement on top of the cropping by the fishery. The combined cropping by entrainment, impingement, and the fishery, if severe enough and extended over a sufficiently long period of time, could well result, both directly and through biological interactions, in substantial changes in the relative population levels of many species. The effect of such changes might be to change the time required for the striped bass population to recover following cessation of major cropping by entrainment and impingement. Alternatively, the combined cropping pressure could cause or facilitate a shift to a different and stable set of relative population levels in the fish community which would prevent eventual recovery of the striped bass population to the undisturbed level. Such a shift might or might not involve the establishment of "new" species. The present level of understanding of species interactions in complex ecosystems is not sophisticated enough to permit quantitative statements to be made about the likelihood of such "permanent" changes occurring as a result of 30 or 40 years of a specified level of cropping.

In summary, it must be pointed out that the present approach of treating each new plant on the Hudson River as a separate benefit-cost (or risk) exercise contains a bias against preserving the environment. This approach conceivably could result ultimately in the complete destruction of the Hudson River striped bass population. Nevertheless, for each new plant the benefits of cooling towers (or whatever measures were taken) would be calculated to be less than the costs (or risks) because the incremental (fractional) damage to the striped bass population would be less with each additional power plant. But, beyond some point, society is likely to conclude that further deterioration of the striped bass population is intolerable.

Furthermore, the possibility that the additional effect of once-through cooling at Indian Point Unit No. 3 (added to the effects of Indian Point Units Nos. 1 and 2 plus the other power plants on the river) will be the "straw that broke the camel's back" is a risk which cannot be lightly overlooked. The adult model indicates full recovery of the fishery after cessation of the operation of the plants on the river. However, the model may not be an accurate representation of the dynamics of the striped bass population with respect to large perturbations [see App. B, Section B.4.c(7)(c)]. It is possible that if the insult of the power plants exceeds some maximum value for long enough the Hudson River spawned bass population will not fully recover. Rather, it may seek some new lower equilibrium value.

It is the staff's position that the number of years the relative yield is forecast to be less than 50% of its original size before the power plant impact is an index of the risk of irreversible damage to the population. This risk and the extent of irreversible damage cannot be more rigorously quantified. Furthermore, there are no generic guidelines as to what risk and extent of irreversible damage is acceptable or unacceptable to society. Such decisions are a matter of judgment. It is the staff's judgment that for the base design and Alternative A (with or without Cornwall), the risk of irreversible damage to the Hudson River spawned striped bass population is of sufficient concern that the long-term operation of Indian Point Unit No. 3 with once-through cooling is unacceptable.

(v) <u>Zone and degree of influence of the Hudson River striped bass population</u>

Recapture locations of striped bass tagged in the Hudson River (north of Yonkers) during March through June provide an indication of the zone of influence of the Hudson River striped bass population (Table V-23 and Fig. V-14); the identification numbers in Table V-23 correspond to the numbers in Fig. V-14. Adult striped bass caught in the Hudson during this time (i.e., pre-spawning and spawning period) are probably of Hudson origin, assuming that East Coast striped bass have a strong "homing" instinct such as salmon, an assumption which has not been verified. Although additional conclusions could possibly be inferred if sex, age, and size data were available for each recapture, the pattern of recapture locations indicates that Hudson striped bass contribute to the fisheries in the Hudson River itself, Long Island Sound, the New York Bight, and New England (as far north as Boston, Mass.). The staff defines the New York Bight as the coastal zone from Barnegat Inlet, New Jersey, to Moriches Inlet on the south shore of Long Island.

Table V-23. Summary of reported recoveries of striped bass tagged in the Hudson River north of Yonkers, N.Y. during the prespawning and spawning period (March through June) for the years 1969–1974

Identification number	Release			Recovery		Time at large (days)	Reference[a]
	Date	Location	Length (mm)	Date	Location		
1	4/69	Westchester Co., N.Y.		6/69	Fairfield Co., Conn.	~60	1
2	4/68	Westchester Co., N.Y.		6/69	Fairfield Co., Conn.	~425	1
3	5/70	Westchester Co., N.Y.		6/70	Kings Co., N.Y. (Brooklyn)	~30	1
4	5/69	Westchester Co., N.Y.		6/69	Monmouth Co., N.J.	~30	1
5	5/70	Westchester Co., N.Y.		11/70	Richmond Co., N.Y. (Staten Island)	~180	1
6	5/70	Westchester Co., N.Y.		7/70	So. Soffolk Co., N.Y.	~60	1
7	5/70	Westchester Co., N.Y.		8/70	Plymouth, Mass.	~90	1
8	5/70	Westchester Co., N.Y.		7/70	Fairfield Co., Conn.	~60	1
9	5/71	Westchester Co., N.Y.		5/71	Weschester Co., N.Y. (Hudson River)	~15	1
10	4/71	Westchester Co., N.Y.		5/71	Northern Nassau Co., N.Y.	~30	1
11	5/71	Westchester Co., N.Y.		6/71	Fairfield Co., Conn.	~30	1
12	4/69	Westchester Co., N.Y.		6/69	Fairfield Co., Conn.	~60	1
13	4/69	Westchester Co., N.Y.		5/69	Kings Co., N.Y. (Brooklyn)	~30	1
14	4/29/72	Hudson River, N.Y.		7/4/72	Waterford, Conn.	66	2
15	5/10/72	Hudson River, N.Y.		7/6/72	Great South Bay, N.Y.	57	2
16	5/4/72	Croton River, N.Y.		7/19/72	Verranzano Straits, N.Y.	76	2
17	5/7/72	Croton, N.Y.		7/23/72	Hoffman Is., N.Y.	77	2
18	4/29/72	Croton, N.Y.		8/19/72	Rockaway, N.Y.	112	2
19	5/10/72	Croton, N.Y.		9/11/72	Jamaica Bay, N.Y.	124	2
20	5/1/71	Croton, N.Y.		10/18/72	Greenwich Cove, N.Y	535	2
21	5/24/73	Croton River, N.Y.		7/13/73	Romer Shoals, N.J.	50	3
22	3/9/73	Hudson River, RM 33	645	4/23/73	Hudson River, RM 34	45	4
23	3/9/73	Hudson River, RM 33	570	4/27/73	Hudson River, RM 39	49	4
24	3/9/73	Hudson River, RM 33	670	7/21/73	Long Island Sound, Mamaroneck, N.Y.	134	4
25	3/13/73	Hudson River, RM 32	610	5/1/73	Hudson River, RM 39	49	4
26	3/13/73	Hudson River, RM 32	650	6/20/73	Long Island Sound, Matinicock Pt., N.Y.	99	4
27	3/13/73	Hudson River, RM 32	650	7/27/73	Long Island Sound, Stamford, Conn.	136	4
28	3/14/73	Hudson River, RM 34	552	3/14/73	Hudson River, RM 34	<1	4
29	3/15/73	Hudson River, RM 33	870	7/5/73	Nantucket Sound, Nantucket, Mass.	112	4
30	3/26/73	Hudson River, RM 34	575	6/7/73	Great South Bay, Robert Moses Bridge, N.Y.	73	4
31	4/3/73	Hudson River, RM 33	492	4/13/73	Hudson River, RM 31	10	4
32	4/19/73	Hudson River, RM 60	903	10/12/73	Long Island Sound, Montauk Pt., N.Y.	174	4
33	4/20/73	Hudson River, RM 59	975	6/19/73	Buzzards Bay, New Bedford, Mass.	60	4
34	4/26/73	Hudson River, RM 59	745	9/17/73	Lower New York Bay, Rockaway Pt., N.Y.	145	4
35	4/20/73		1016	7/15/74	Boston Harbor, Mass.	451	5

[a] 1. J. Clark, personal communication, 1974.
2. *Underwater Naturalist*, 8(1): 34–40 (1974).
3. *Underwater Naturalist*, 8(3): 36–48 (1974).
4. Texas Instruments, Inc., "Hudson River Ecological Study in the Area of Indian Point, 1973 Annual Progress Report," July 1974.
5. P. Campbell, Texas Instruments, Inc., personal communication, 1974.

ES-520

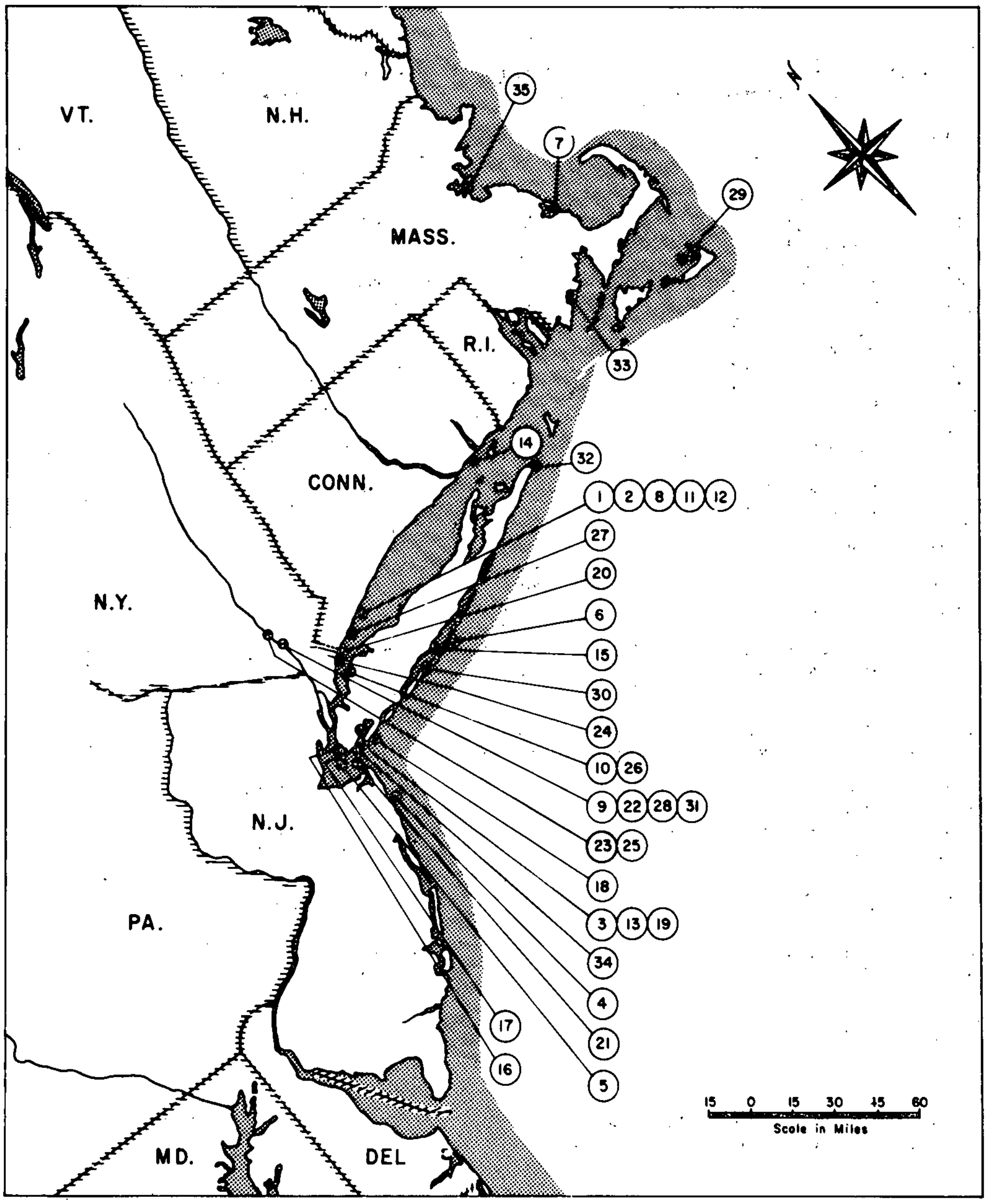

Fig. V-14. Zone of influence of the Hudson River striped bass population as determined by recapture location of striped bass tagged during March through June.

These recapture locations probably delineate the northern boundary of the zone of influence of the Hudson River striped bass population more accurately than they delineate the southern boundary. Ninety-seven percent of the fish recaptured (i.e., 34 out of 35 were recaptured during mid-March through October, which includes the period when the coastal migratory stock is known to be in the northern part of its range. Only one fish was recaptured from November through mid-March, which includes the period when the coastal migratory stock is known to be in the southern part of its range. Only one of the 35 striped bass recaptured was recaptured along the New Jersey coast or south, and that one was recaptured off Monmouth County, which is the northernmost coastal county in New Jersey. The above analysis has caused the staff to shift its emphasis in defining the zone of influence of the Hudson River striped bass population from the mid-Atlantic region (Appendix F, IP3, DES) to the northern part of the mid-Atlantic region and the New England region.

The staff wishes to emphasize that tag-recapture data of the quality and quantity currently available are only of value in generally indicating where along the Atlantic Coast the Hudson River striped bass population is contributing to the fishery. These data do not provide a basis for estimating the percentage contribution of the Hudson stock to the mid-Atlantic or New England fisheries or even to the striped bass fishery in Long Island Sound and the New York Bight, that is, to the Inner Zone, which is defined in the following paragraph.

The staff's position, which is in agreement with that of the applicant (ER, IP-3, App. HH) and the intervenors,[50] is that the Hudson River stock is the major source of striped bass caught in the Hudson River, the western half of Long Island Sound (both the north and south shores west of Bridgeport, Connecticut, and Port Jefferson, Long Island, New York), and the New York Bight (Barnegat Inlet to Moriches Inlet). The staff refers to this zone as the Inner Zone of influence of the Hudson River spawned striped bass population. By "majority" the staff means more than 50% of the sport and commercial landings, but less than 100% since adult striped bass tagged in the Chesapeake during the pre-spawning and spawning season have been recaptured in this region.[146] In estimating the economic impact of the Indian Point Plant on the striped bass fisheries (Section XI.J.2.c), the staff assumed a value of 90%.

Within the Inner Zone, where it is agreed that the Hudson River stock is the major source, there is a paucity of information documenting the size of the fishery in terms of number or pounds of fish, number of sport fishermen, effort, or monetary value. As Lawler[141] has indicated, the commercial striped bass landings in this region are not great on either a relative or an absolute scale. Quoting from Lawler:[141]

> "Table [V-24] lists the New York commercial catches of striped bass by area for the years 1961 through 1969 and Figure [V-15] indicates the location of these statistical areas. Table [V-25] gives the catches for New Jersey by county for the same years and Figure [V-16] shows the locations of the New Jersey counties.
>
> "From Table [V-24] it can be calculated that, on the average, 86%* of the commercial catch is landed in areas 5, 6, 7, and 8, the areas which comprise the eastern portion of Long Island. From Table [V-25] one can calculate that the three southern counties in New Jersey, i.e., Atlantic Ocean, Cape May, and Cumberland, account for 90% [sic; should be 68%] of the landings in that state."

The staff has reproduced, with minor modification, Tables V-24 and V-25 and Figs. V-15 and V-16 from Lawler's testimony. Lawler's analysis based on the information in Table V-24 is somewhat in error, because he failed to include Hudson River commercial landings in the New York commercial landings. Hudson River striped bass commercial catches for 1961-1969 have been added to Table V-24. An average of 4.5% (i.e., 100 x 469,000/9,749,720) of the New York commercial catch came from the Hudson, and 82% instead of 86% of the New York commercial catch was landed in areas 5, 6, 7, and 8, the areas which make up the eastern portion of Long Island.

The staff considers, however, that the commercial landings are a poor indicator of the size and value of the striped bass fishery in the Inner Zone because of the numerous legal restrictions on fishing. The New York State restrictions are paraphrased from Ginter[90] as follows:

> <u>Regulations on Time</u>. The use of haul seines is prohibited from midnight Thursday to 6:00 P.M. Sunday in waters in the Peconic bays and around Shelter Island.

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*"In my testimony, I mentioned the 86% as 'in the Ocean.' Actually a small percentage of this number comes from the enclosed bays in the southeastern and eastern end of Long Island. 80% comes from Ocean Areas 5 and 7 and 63.5% comes from area 7 along (see Table [V-24])."

Table V-24. New York State striped bass commercial catches 1961–1969 (lb)[a]

Landing area[b]	1961	1962	1963	1964	1965	1966	1967	1968	1969	Total 1961–1969	Av percent of total catch w/o Hudson River	Av percent of total catch with Hudson River
	Year											
1	1,700	17,400	26,200	3,000	4,475	3,750	9,195	22,480	25,840	114,040	1.2	1.2
2	32,200	5,100	4,600	16,300	19,775	10,700	39,720	19,500	0	147,895	1.6	1.5
3	86,300	48,100	76,000	34,300	58,050	41,997	96,962	132,107	64,557	638,373	6.9	6.5
4	800	0	3,300	0	3,650	150	3,150	0	0	11,050	0.1	0.1
5	221,100	94,050	136,900	95,800	29,000	57,450	228,525	315,655	361,830	1,540,310	16.6	15.8
6	0	0	0	0	0	1,200	13,700	28,500	14,890	58,290	0.6	0.6
7	417,600	389,700	351,200	772,500	540,125	765,859	1,045,890	798,445	812,946	5,894,265	63.5	60.5
8	79,300	49,700	34,800	43,600	35,300	62,289	31,979	91,647	62,112	490,727	5.3	5.0
9	0	3,200	0	0	12,560	59,313	104,606	81,316	113,950	374,945	4.0	3.8
10	0	0	2,800	0	0	200	0	0	0	3,000	0.03	0.03
11	0	1,200	0	0	0	3,200	1,650	125	1,650	7,825	0.08	0.08
12	0	0	0	0	0	0	0	0	0	0	0	0
Subtotal	839,000	608,450	635,800	965,500	702,935	1,006,108	1,575,377	1,489,775	1,457,775	9,280,720	99.9	
Hudson River[c]	71,000	48,000	47,000	29,000	37,000	44,000	55,000	61,000	77,000	469,000		4.8
Total	910,000	656,450	682,800	994,500	739,935	1,050,108	1,630,377	1,550,775	1,534,775	9,749,720		99.9

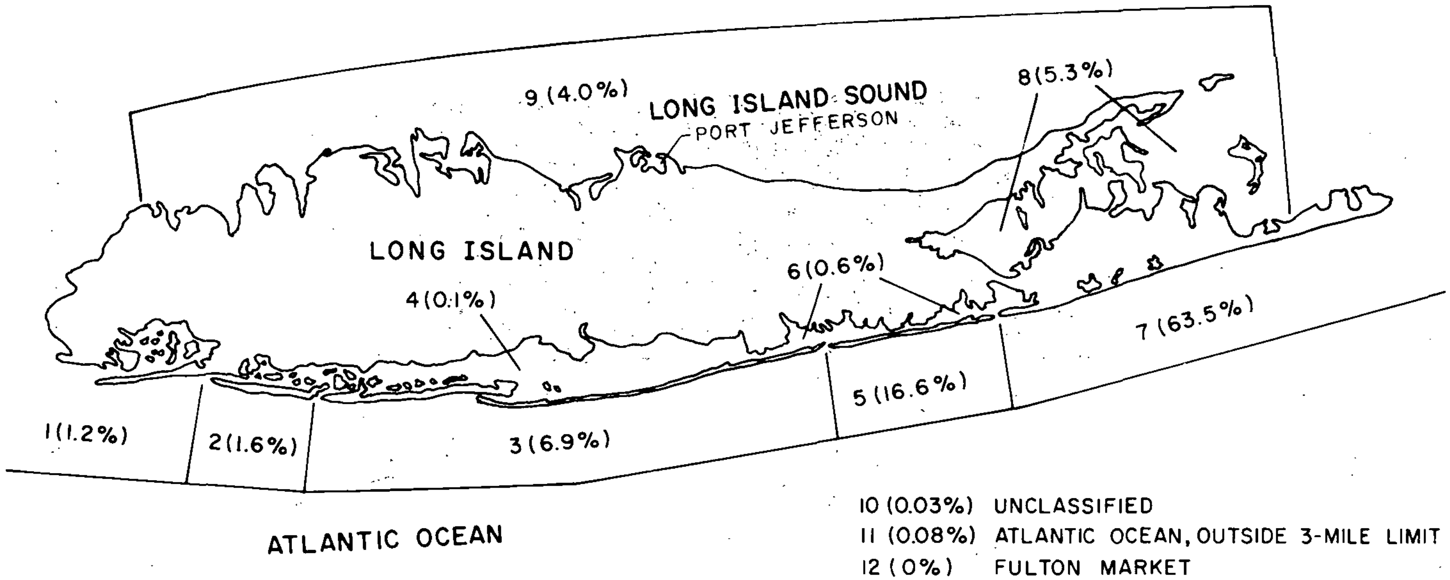
[a]The values presented in the original Table D-1 and used in the Lawler's analysis included striped bass commercial catches only in the Marine District of New York State.
[b]See Fig. V-14 for location of landing areas.
[c]The Hudson River catch values are from ER, IP-3, Appendix GG, Table 1, p. 2, Suppl. 10, November 1973.

Table V-25. New Jersey striped bass commercial catches 1961–1969 (lb)

County[a]	Year 1961	1962	1963	1964	1965	1966	1967	1968	1969	Total 1961–1969	Average percent of total catch
Monmouth	9,073	29,852	9,513	64,632	116,939	15,378	39,985	20,137	93,164	398,673	9.8
Ocean	56,428	34,271	190,504	302,124	267,620	15,173	9,039	4,074	16,567	895,800	22.0
Atlantic	109,353	200,428	453,127	566,450	350,886	134,492	93,059	37,448	50,257	1,995,500	48.9
Cape May	35,745	36,045	20,174	31,303	14,776	44,488	67,488	100,515	108,811	459,345	11.3
Cumberland	25,042	65,001	45,246	14,501	29,473	31,317	50,529	34,552	33,138	328,799	8.1
Total	235,641	365,597	718,564	979,010	779,694	240,848	260,100	196,726	301,937	4,078,117	100.1

[a]See Fig. V-15 for location of county.

ES-521



NO.	DESCRIPTION OF AREAS
1	OCEAN ; N. J. BOUNDARY TO EAST ROCKAWAY
2	OCEAN ; EAST ROCKAWAY INLET TO JONES INLET
3	OCEAN ; JONES INLET TO MORICHES INLET
4	GREAT SOUTH BAY
5	OCEAN ; MORICHES INLET TO SHINNECOCK INLET
6	MORICHES AND SHINNECOCK BAYS
7	OCEAN ; SHINNECOCK INLET TO MONTAUK INCLUDING BLOCK ISLAND SOUND
8	GARDINERS, PECONIC, AND ADJOINING BAYS
9	LONG ISLAND SOUND

Fig. V-15. Location of New York commercial catches of striped bass for the years 1961 through 1969.

ES-522

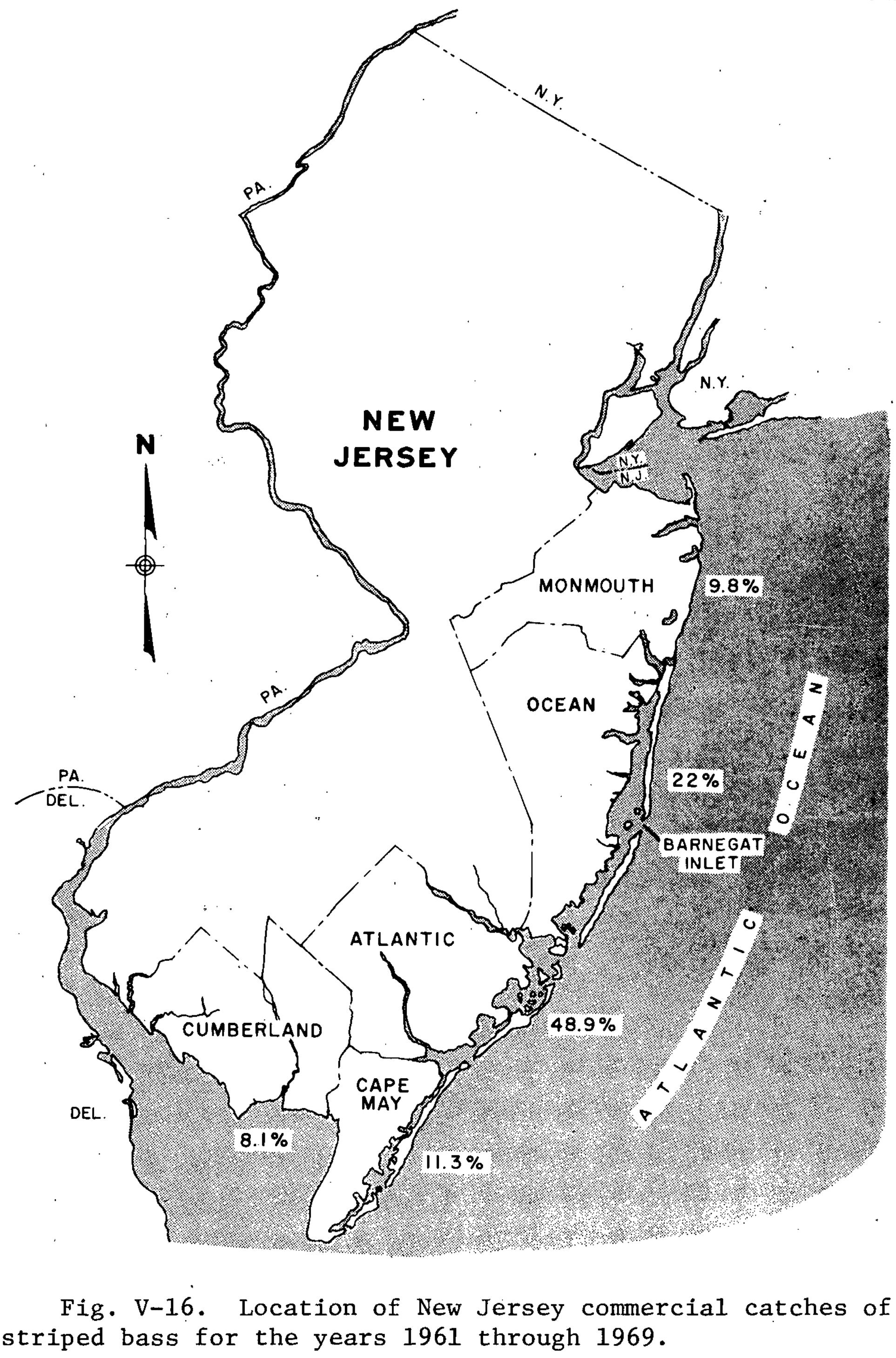


Fig. V-16. Location of New Jersey commercial catches of striped bass for the years 1961 through 1969.

Regulations on Season. The use of beam and otter trawls is prohibited: (1) from April 15 to October 1 in the waters of Suffolk County west of Gardiners Island, including the waters around Shelter Island, the Peconic bays, Flanders, Noyac and Gardiners bays--essentially, this includes all the marine waters between the north and south forks at the eastern end of Long Island; and (2) from April 1 to November 1 in the waters of Long Island Sound west of a line from Eaton's Neck Point to the New York-Connecticut boundary line on the mainland.

Regulations on Area. (1) In addition to limitations on the use of beam and otter trawls listed under regulations on Season, the use of beam and otter trawls is prohibited at all times in all marine waters in Queens, Kings and Richmond Counties; within one-half mile of the Atlantic Ocean coastline; in all tidal waters inshore of the coastline; in all south shore inlets; in Manhasset Bay, Hempstead Harbor and the Nissequoge River; in the Harlem River and between the Triboro Bridge and Kings Point; and (2) purse seines are prohibited for taking food fish from all areas of the marine district at all times.

Regulations on Fishing Gear. Most gear limitations regulate the operation of various types of nets: beam and otter trawls, seines, pound, trap and gill nets. Almost all of these gear restrictions pertain only to specified areas of the marine district. In addition to various area and season restrictions on beam and otter trawls discussed above, all kinds of nets are prohibited from the following areas: Jones Inlet, Fire Island Inlet, Moriches, Shinnecock and Mecox Inlets and in the ocean within 1/2 mile of the seaward shores of these inlets, Connetquoit River, Long Island Sound west of a line from Eaton's Neck Point northwest to the interstate boundary from April 1 to November 1, and within 1,000 feet of the beach between Jones Inlet and Oak Beach. In many other areas only special kinds of nets with specified size limits are permitted.

These regulations, together with the fact that commercial fishing for striped bass is unlawful in Connecticut, guarantee that the commercial striped bass landings are an inadequate indicator of the size and value of the total striped bass fishery in the Inner Zone. More explicitly, within this region of primary concern, the sport landings not only exceed the commercial landings, but they exceed (on a weight basis) the commercial landings by considerably more than along the Atlantic Coast in general, as indicated in the following two paragraphs.

The regions along the Atlantic coast for reporting landings data are different for the sport fishery and the commercial fishery. For the sport fishery there are three regions: North Atlantic, Middle Atlantic, and South Atlantic. The Hudson River, the western half of Long Island Sound, and the New York State part of the New York Bight are in the North Atlantic Region; the New Jersey part of the New York Bight is in the Middle Atlantic region. For the commercial fishery there are four regions: New England, Middle Atlantic, Chesapeake, and South Atlantic. The Hudson River, the New York Bight, and the New York part of the western half of Long Island Sound are in the Middle Atlantic region; the Connecticut part of the western half of Long Island Sound is in the New England Region.

The weight in 1970 of the striped bass commercial catch in the New England Region plus New York State (including the Hudson River) was 2,780,000 lb, while that along the entire Atlantic Coast was 11,136,000 lb.[91] The weight in 1970 of the striped bass sport catch in the North Atlantic (which includes New York State) was 45,844,000 lb, while that along the entire Atlantic coast was 83,783,000 lb.[92] Thus, in 1970 the weight of the sport catch exceeded that of the commercial catch by a factor of 7.5 along the entire Atlantic Coast but by the considerably larger factor of 16.5 for the North Atlantic Region. Additional information on the magnitude of the striped bass sport fishing effort and catch in the New York metropolitan region should be forthcoming soon in a NOAA report and in a benefit/cost analysis by Quirk, Lawler, and Matusky for the applicant.

The staff defines an Outer Zone of influence of the Hudson River spawned striped bass population as extending from Maine to Cape May County, New Jersey, inclusive, less the Inner Zone previously defined. The staff's present best judgment is that the percentage contribution of the Hudson River striped bass population to the Outer Zone cannot be accurately estimated on the basis of data presently available. Estimates of the contribution to the mid-Atlantic ranging from "no more than 10%" (IP3, ER, App. HH) to "a minimum of approximately 80% (IP3, DES, p. V-85 and App. F) have been presented.

All parties are in agreement that at present, with the Delaware River so heavily polluted, spawning of striped bass there is insignificant, although striped bass do use the Chesapeake and Delaware Canal and Elk River areas to spawn. Thus, the two primary sources for the mid-Atlantic and New England stock are the Hudson River and Chesapeake Bay. The proportion contributed by each source undoubtedly varies somewhat from year to year, from the sport fishery to the commercial fishery, and from place to place (i.e., Cape Cod to the southeast shore of Long Island to the southern coast of New Jersey). In light of the uncertainty concerning the percentage contribution of the Hudson stock to this Outer Zone, the staff has assumed values of 10% and 50% in estimating the economic impact of the Indian Point Plant on the striped bass fisheries (Section XI.J.2.c).

An additional complicating factor is that there has been a general upward trend for the past 30 to 40 years in commercial landings of striped bass along the Atlantic coast from Chesapeake Bay north.[93] This upward trend, in turn, must be due to increased productivity of striped bass in the Chesapeake and/or the Hudson — enough to more than offset the decreased productivity of the Delaware. As McHugh[93] points out:

> "It seems unlikely that the great increase in striped bass landings over a 35-year period has come about through an equivalent increase in fishing effort, for this species has been popular as a commercial and recreational species for a long time. It has been suggested (Mansueti, 1961) that the species has been able to take advantage of increased nutrient loads in its nursery areas in Chesapeake Bay and elsewhere and that the increased catch has been largely, if not completely, caused by a real increase in abundance. This is entirely hypothesis, and data probably do not exist with which to test it."

It is interesting to note that, to the extent the great increase in striped bass landings over the past 40-year period is due to increased nutrient loads, this increase may be reversed in proportion to the success of the anti-pollution efforts to reduce nutrient loads in the striped bass nursery areas.

One aspect of the applicant's research program is directed at estimating the contribution of the Hudson River striped bass population to the Mid-Atlantic and New England fisheries. In the staff's opinion the research program has the potential for narrowing the present range of uncertainty by the end of 1976, if not sooner. The applicant's approach will be to develop a character block for the Hudson stock and for the Chesapeake stock (and perhaps for substocks within the Chesapeake, i.e., Potomac, Elk River, James River, etc.). This character block will consist of three primary strata: (1) a character index combining the number of rays (bones) in the anal, dorsal, and pectoral fins of striped bass; (2) a critical analysis of the vertical relief profile on the surface of striped bass scales from the focus (origin) to the second annulus or growth ring; and (3) electrophoretic analysis of serum proteins.

Preliminary data are available only for the first stratum. These data indicate a modal number of 54 rays, with 58% of the fish in the range of 53 to 55 rays, for Hudson River striped bass and a modal number of 57 rays, with 72% of the fish in the range of 56 to 58 rays, for Chesapeake striped bass. In other words, there are two somewhat distinct but overlapping frequency distributions. The staff anticipates a similar situation with the other two strata. The final task will be to obtain data for all three strata from samples having unknown proportions of fish from the Hudson and Chesapeake and then to use discriminant analysis or equivalent techniques to obtain a point estimate and measure of variability of the proportion of fish of Hudson origin in the mixed sample.

The staff's position is that this aspect of the applicant's research program probably will narrow the present range of uncertainty by the end of 1976. However, the staff expects that there will be considerable overlap among the character blocks of the various stocks and that the degree of uncertainty will still be appreciable (e.g., ±20 to 30%).[142] Furthermore, the staff expects the proportion of fish of Hudson River origin in a mixed sample to vary from place to place for a given year (e.g., Cape Cod to Montauk Point to the southern New Jersey coast) and from year to year at a given place.

(vi) Other fish species

Two types of data, impingement and entrainment data, are particularly relevant for assessing which other fish species have the greatest potential for being adversely affected by operation of the Indian Point Plant with once-through cooling. Impingement data (ER, IP-3, App. BB) covering the period April 1970 through December 1972 indicate that, on the average, of the fish impinged at Indian Point 70.7% are white perch, 12.8% are clupeids (primarily alewife and blueback herring), and 8.3% are tomcod (as compared to 3.1% striped bass). The New York University entrainment data[45] indicate that anchovy, alewife, blueback herring, white perch, and tomcod (in addition to striped bass) accounted for most of the fish eggs and larvae entrained through the Indian Point Plant; no percentages nor ranking of these six species is given. Thus, based on impingement and entrainment data at Indian Point, the other five species that merit the greatest consideration are white perch, tomcod, alewife, blueback herring, and anchovy.

The three-month periods when entrainment and impingement are generally highest are given in Table V-26 for each of these five species plus striped bass. The pattern of impact over the year is such that during no month can the impact of plant operation be ignored, although June and July appear to be the worst for entrainment and December, January, and February appear to be the worst for impingement.

Table V-26. Three-month periods when entrainment and impingement tend to be highest for each of the six fish species of greatest concern

Species	Entrainment[a]	Impingement[b]
Striped bass	May–July	December–February
White perch	May–July	December–February
Tomcod	February–April	August–October
Alewife and blueback herring	June–August	September–November
Anchovy	July–September	August–October

[a]New York University, "Hudson River Ecosystem Studies, Progress Report for 1971 and 1972," September 1973.
[b]ER, IP-3, App. BB.

Two points of view are available for assessing the relative importance of the fish species in the Hudson River. From the fisheries point of view, the only two species of major importance are striped bass and shad. There is a limited commercial fishery in the Hudson for blueback herring and white perch; the mean annual catch during the period 1965–1970 was 4,150 lb of blueback herring and 1,650 lb of white perch.[94] The sport fishery for white perch in the Hudson is casual and not well defined but may be appreciable. The alewife that use the Hudson River as a spawning and nursery area contribute an unknown amount to the coastal alewife fishery.[95] There are no appreciable commercial or sport fisheries for the anchovy or tomcod that use the Hudson River as a spawning and nursery area.

From the fish-community and ecosystem point of view, the dominant species, as determined by seasonal and regional standing crops (in numbers and biomass per hectare), are the six species most commonly entrained and impinged (i.e., striped bass, white perch, tomcod, alewife, blueback herring, and anchovy).[94] On both a temporal and spatial basis, these species occupy different niches, which considered together constitute the basic functional structure of the complex fish community in the Hudson River Estuary (see Appendix F).

Texas Instruments'[94] extensive analysis of the apparent fluctuations in the populations of abundant species, common species, and infrequent species, indicates the following:

(a) The yearly densities of these species appear to be fluctuating approximately in unison (Figs. V-17 and V-18).

(b) Freshwater runoff appears to be a major factor in determining the success of the year class in this physically dominated estuarine ecosystem; however, Texas Instruments failed to include this covariable in their covariance analysis.

(c) After adjusting the 1969, 1970, and 1972 catch-per-effort (C/f) statistics to a common temperature and salinity, there were no significant differences among the beach-seine C/f statistics for white perch or striped bass for these three years.

(d) The bottom trawl C/f statistics for striped bass declined significantly from the 1969 level to the 1970 and 1972 levels, with 1972 being slightly less than 1970. The same statistic for the white perch population was lowest in 1970 and increased in 1972 but was still significantly lower than the 1969 level.

As pointed out by Texas Instruments,[94] problems associated with this analysis include differences among years in (1) the net used in the bottom trawl and towing speed, (2) distribution of sampling effort, (3) distribution of species, and (4) temperature, salinity, and freshwater flow regimes.

The staff's concern (FES, IP-2, pp. V-93 to V-95) that the Hudson River white perch population has already shown a substantial reduction, perhaps due to impingement at the various power plants (Indian Point Unit No. 1 in particular), is lessened in light of Texas Instruments' data and analyses summarized above. However, the staff's concern for the future of the white perch population is still very real in light of the staff's present estimate that approximately 20-25% of the annual production of young-of-the-year white perch may be impinged at all plants (omitting Cornwall) on the river, assuming once-through cooling at the three Indian Point Units (see Sect. V.D.2.a).

The applicant (ER, IP-3, Sect. 12, pp. 12-28) compared the number of young-of-the-year white perch collected on the intake screens at Unit No. 1 with the potential number of young-of-the-year removed by the commercial fishery. The conclusions reached by the applicant are as follows:

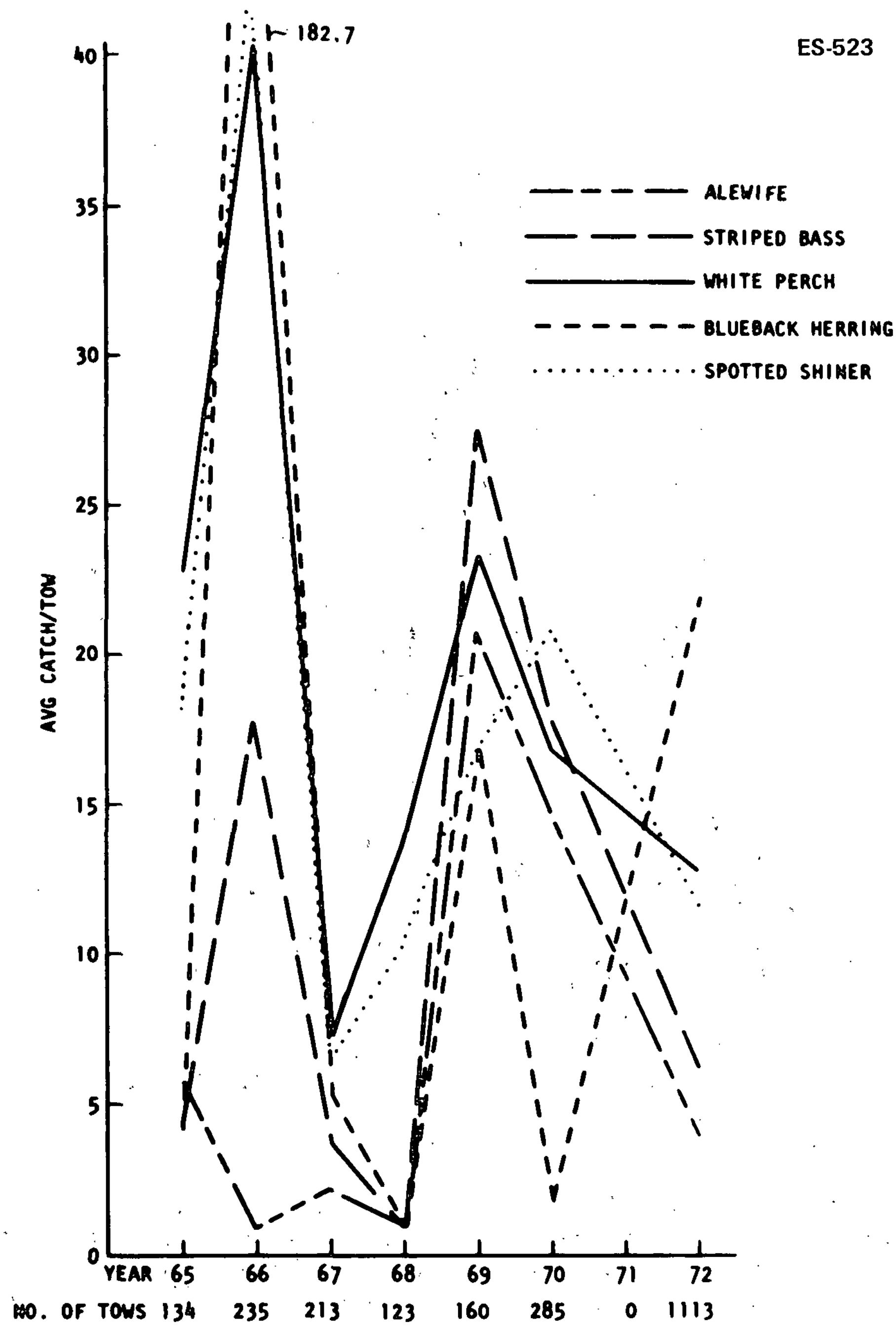


Fig. V-17. Yearly fluctuations in mean catch per effort for abundant species in beach-seine hauls, lower Hudson Estuary. Source: Texas Instruments, Inc., *Hudson River Ecological Study, First Annual Report,* prepared for Consolidated Edison Company of New York, Inc., April 1973.

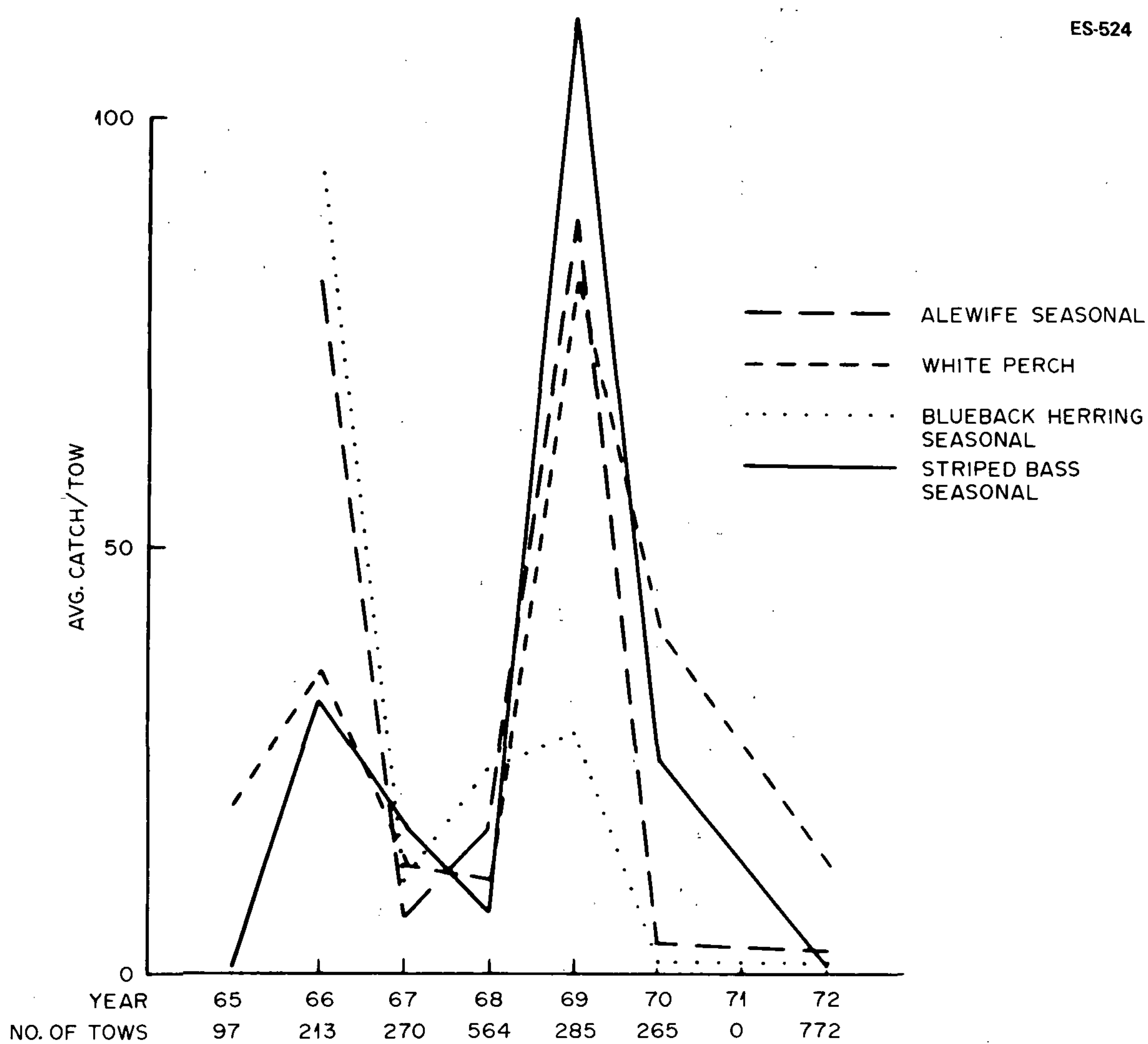


Fig. V-18. Yearly fluctuations in mean catch per effort for abundant species in bottom trawls, lower Hudson Estuary. Source: Texas Instruments, Inc., *Hudson River Ecological Study, First Annual Report,* prepared for Consolidated Edison Company of New York, Inc., April 1973.

(a) It is unlikely that mortality from the present low commercial harvest (2,000 lb/year) and impingement of white perch will cause an adverse or permanent impact on the population while environmental studies are in progress at Indian Point.

(b) Mortality would not be expected to cause significant irreparable or irreversible damage before mitigating measures can be instituted.

The quality and quantity of data available for predicting the effect of Plant operations on fish populations other than striped bass are limited. However, the applicant relies on natural compensation as the explanation for fish population regulation and, as a result, states that operation of the Plants beginning in 1973 with once-through cooling will not cause substantial or irreversible damage for the next 8-year period (up to 1981, at which time the applicant states that it could have an alternate cooling system installed for Unit No. 2, and 1983 for Unit No. 3, if required). Nonetheless, the applicant has not presented an analysis to demonstrate that any of the species other than striped bass might be able to sustain the increased mortality caused by entrainment and impingement and other adverse effects as a result of operations of Indian Point Units Nos. 1, 2, and 3.

The applicant is relying on its ecological studies described below in Sect. V.D.2.f to indicate any significant changes in abundance or composition of various species, at which time the applicant plans to initiate mitigating measures. The staff, as pointed out below, discusses the limitations of the applicant's ecological study program and believes that, because of the relatively long regeneration cycle (i.e., years and not months) of the fish species of importance, long-term field studies lasting through several generations would be required to obtain accurate information on long-term impact on any of the species involved.

The staff's position with respect to the potential impact of Indian Point Units Nos. 1, 2, and 3 operating with once-through cooling on fish populations in the Hudson River Estuary other than striped bass is as follows:

(1) the species of greatest concern are white perch, tomcod, alewife, blueback herring, and anchovy;

(2) the entrainment and impingement impact of Indian Point together with that of Bowline, Lovett, Roseton, and Danskammer will probably reduce the standing crops of young-of-the-year and adult of each of these species;

(3) the reductions are not expected to be irreversible.

(4) Indirect Effects

In regard to indirect effects, chronic exposure to increases in temperature (or radiation and chemical stresses from Plant releases) could alter food conversion, growth rate, or reproductive potential and might alter the interspecific relationships. For example, changes within the plankton populations have a potential for causing changes in populations of other trophic levels. The extent and importance of such changes would be correlated with the ecological function of the organisms involved and the relative densities of their populations.

Indirect effects of pollutants may result in extensive changes in the biological composition of a body of water. The extent of these effects depends on several factors, which must be known (but are not in themselves sufficient) to make accurate predictions of the consequences of operation of any power plant:

(a) The species composition of the affected area must be known and the relationships between various species understood.

(b) The spatial and temporal distribution of the species in the area must be known.

(c) The relationships between each species and its physical environment must be understood.

(d) The sensitivity of the various species to alternations in their chemical and physical habitat must be known.

All this information would be needed to produce reliable predictions of the indirect consequences of Plant operations on the biota. Many reasons, including lack of time, resources, and adequate sampling techniques, preclude the acquisition of the necessary information. Unfortunately, even if all of the relationships were known, reliable biological predictions of the indirect effects of the operation of the Plant could not be developed with the present state of the art. As a result, staff assessment of these aspects of environmental effects of Plant operation will be necessarily qualitative. However, over an extended period of time, the indirect effects may have far greater consequences than the direct effects on the biota.

Many indirect effects of Plant operation can be foreseen. However, because of the complexity of the interactions of the biota and the uncertainty of the magnitude of the direct effects of Plant operations on the various species that occur at Indian Point, any definitive statements concerning indirect effects are not possible. The only plausible change in the biota that would have considerable immediate importance to the system as a whole is the probability of inducing greater seasonal fluctuations of algal populations and of increasing the proportion of blue-green algae in the population. These changes would alter the seasonal and directional components governing the transfer of matter and energy through the food web. These changes could result in changes in productivity at all levels of the system and thereby would favor changes in species composition of consumer organisms. The importance of changes in primary productivity at Indian Point cannot be evaluated without additional data on the origin and magnitude of organic detritus in the Hudson.

e. Ichthyoplankton Sampling

Both the applicant's and the staff's predictions of the loss of entrainable life stages of fish (in particular, striped bass) that will be caused by operation of power plants on the Hudson River have been based on population transport models (see Appendix B, Sections B.4.a and B.4.b). An important part of the input to such models consists of information concerning the temporal and spatial concentrations and distributions of the various entrainable life stages throughout the estuary. In the Hudson, such data are available for 1967[96] and 1973;[54,59,97,98] limited data for other years are not adequate for modeling purposes.

Due to some perhaps serious flaws in the 1967 and 1973 striped bass data, the staff has undertaken a critique of the applicant's river surveys of planktonic and juvenile organisms.

The following five general topics will be discussed below:

(1) General description of the sampling techniques used to collect entrainable fish life stages in the 1967 and 1973 programs;

(2) considerations relating to the interpretation of information about entrainable fish life stages;

(3) sources of error inherent in the ichthyoplankton sampling methods;

(4) design, execution, and interpretation of results of the sampling programs in relation to estimates of the distribution and abundance of striped bass; and

(5) conclusions about the 1967 and 1973 striped bass young-of-the-year sampling programs.

In these discussions, fish eggs, larvae, and young juveniles will be termed "ichthyoplankton" for the sake of convenience. Most larvae and all juveniles are, strictly speaking, nektoplanktonic or nektonic.

(1) General Description of the Sampling Techniques Used to Collect Entrainable Fish Life Stages in the 1967 and 1973 Programs

In the 1967 HRFI study, longitudinal plankton sampling was done at eight fixed locations between river miles (RM) 35.5 and 125, utilizing 1/2-meter plankton nets, equipped with flowmeters and towed behind boats.[96]

Samples were taken twice weekly during daylight hours (and, at three of the locations, also twice weekly at night) at 15-ft intervals from near the bottom (or 75-ft depth, whichever was less) to the surface. Detailed lateral sampling was conducted only at Cornwall (RM 56.5). During the early part of the season, nets with mesh openings of approximately 305 x 508 μm were used; as the season progressed, nets with progressively larger mesh sizes were used. In addition, a 25-ft semi-balloon trawl, a 16 x 16-ft mid-water trawl, and, in the shore zone, a 75-ft long x 6-ft deep haul seine with 0.25-in. square mesh were used to sample juveniles.

The 1973 Texas Instruments (TI) sampling program (Refs. 54, 59, 97, and 98) involved a larger commitment of financial support and manpower and was designed to further investigate certain phenomena which were apparent from the 1966—1968 HRFI studies,[96] as well as to provide more complete longitudinal coverage of the river. The longitudinal "ichthyoplankton river survey" involved sampling the region between RM 17 and RM 140 each week between the end of April and the middle of August. Samples were to be taken at 5-mile intervals, with a change to shorter intervals if striped bass were identified in the samples on board the boat. Open-water sampling was done with Tucker trawls having a 1-m^2 net opening; consecutive samples were taken at near-surface, mid-water, and near-bottom depths. An epibenthic sled with a 1-m^2 net opening was used to sample the bottom few feet of water; the earlier HRFI program (which showed a tendency for early stages of striped bass to increase in concentration with increasing depth) had been unable to sample this stratum effectively. Both kinds of gear were equipped with digital and electronic flowmeters, and 500- or 505-μm-mesh nets were used early in the season, while larger mesh sizes were used with the sled and with a 4-m^2 Tucker trawl to capture larvae and juveniles later in the season. During the first half of August and from October through December, shoal areas between RM 12 and RM 70 were sampled with the epibenthic sled (the "shoal survey").

A "beach seine survey" was conducted between RM 12 and RM 152; sampling frequency was weekly during the period of entrainment susceptibility. An "axial trawl survey" used other types of bottom trawls; 32 standard stations, located primarily between RM 27 and RM 62, were sampled at biweekly intervals during the day from April through December. A more detailed account of these programs can be found in Refs. 54, 59, 97, 98; Sect. III of Ref. 54 contains a summary.

Transect (cross-sectional) studies to provide data for the calculation of f factors were carried out. Texas Instruments conducted two 24-hour studies at each of two transects in the vicinity of the proposed Cornwall pumped-storage facility.[54,59,98] Personnel from New York University sampled a transect in front of the Indian Point facility, as well as at the intakes and discharges of Units 1 and 2,[46] using flowmeter-equipped 1/2-m nets with 571 x 571-μm mesh openings until July 24; beginning on this day a 1-m Hensen net was used in the river. Quirk, Lawler, and Matusky[99] sampled river transects (with 1-m nets) and intake and discharge locations (with 1/2-m nets) at other power plants on the river. 500 x 500-μm mesh openings were used.

(2) Considerations Relating to the Interpretation of Information about Entrainable Fish Life Stages

The considerable difficulties involved in quantitatively sampling populations of young fish are widely acknowledged.[100] If ichthyoplankton nets were completely efficient samplers and if young fish were uniformly distributed throughout the region, such sampling would be greatly simplified. Knowledge of the area of the mouth of the net, the velocity of the net relative to the water, and the duration of the tow would permit calculation of the concentration of organisms (number per unit volume). Multiplication of this concentration by the volume of the region would then yield the standing crop (total number of organisms in the region).

In practice, concentrations and standing crops are calculated in this manner with two modifications. Because the velocity of the water relative to the boat will often differ considerably from the velocity of the water entering the net due to vertical gradients in water velocity and resistance to water flow through the net, flowmeters are generally installed inside the nets to estimate the volume of water filtered. In addition, because the fish are known to be not uniformly (or even randomly) distributed, an estimate of average concentration and standing crop in each of the various regions is made by combining the results of a number of net tows.

The use of beach seine catches to estimate the population size of juvenile fish has certain obvious difficulties; this subject will be considered later in this section, following discussion of major potential sources of error in concentration and standing-crop estimates derived from net samples.

(3) Sources of Error Inherent in the Ichthyoplankton Sampling Methods

Striped bass (and other fish species) pass through several fairly distinct stages in their first year of life. When enumerated in the samples, ichthyoplankters are classified as eggs, yolk-sac larvae, post yolk-sac larvae, or juveniles, representing progressively older stages. Table V-27 indicates several sources of error that almost certainly affect estimates of population size of these various stages. Most of these will vary in importance depending on the kind of gear chosen and the method of use. The staff wishes to acknowledge discussions with personnel from New York University, Texas Instruments, and Quirk, Lawler, and Matusky Engineers, and with Dr. C. P. Goodyear and John Clark, all of whom have contributed ideas and opinions in connection with this subject. These sources of error will be individually discussed below.

Table V-27. Factors that potentially lead to the underestimation of standing crops of young-of-the-year striped bass

Source of error[a]	Life stage[b]			
	Eggs	Yolk-sac larvae	Post yolk-sac larvae	Juveniles
Destruction of organisms by nets	H	H	L	L
Escape through nets	L	L → M	M → L	L
Unavailability to nets	M – H	M – H	M → L → M	M
Orientation to bottom in relation to flow[c]	L	L	L → M	H
Active net avoidance	L	L	M	H

[a]See text for further explanation.
[b]H = high potential, L = no or low potential, and M = moderate potential.
[c]Assuming tows are always made against the direction of water flow.

(a) Destruction of Organisms by Nets

Organisms entering the mouth of a net will usually not move directly into the collecting bottle at the end of the cone, but will rather move down the mesh walls or be retained against the walls until the net is washed down prior to removal of the sample. If the filtration pressure through the net is high enough, fragile organisms can burst, and may be retained on the net in spite of washing, pass through the net, or (in the case of late striped bass eggs) be misidentified as yolk-sac larve.[54] Filtration pressure through the net increases as the open area of the mesh in relation to the mouth opening (the "open-area ratio") decreases, and it increases as the square of the towing velocity. Destruction of dyed striped bass eggs in fixed nets at the Indian Point discharge canal, with relative water velocities lower than those generally used in river sampling, has been documented,[46] and similar destruction of yolk-sac larvae is an important possibility. Clogging of nets by algae and detritus[96] could contribute to this phenomenon by decreasing the open area of the mesh.

(b) Escape through Nets

This possibility depends on the relationship between the size of the organisms, the size of the mesh, and the uniformity of the mesh size. Passage of young post yolk-sac larvae through nets with a mesh opening of approximately 508 x 787 μm was suspected in the HRFI study,[96] and could possibly occur to some extent with the 500 x 500 μm (and larger) nets which were used to sample this stage in 1973.

(c) Unavailability to Nets

Striped bass eggs are slightly more dense than fresh water and, in the absence of sufficient turbulence, may settle to the bottom of the water column.[101] The TI study [54,59,97,98] indicates a tendency for both eggs and yolk-sac larvae to be more concentrated near the bottom of the Hudson. The gear that has been used to date is not capable of sampling the lower foot or so of the river and even the epibenthic sled used in 1973 may ride off the bottom some (and perhaps most) of the time. The unavailability of eggs and yolk-sac larvae to the nets is likely to be a more significant phenomenon in the 1967 than in the 1973 data.

Post yolk-sac larvae have increasing mobility with age and appear to migrate vertically in the water column and thus are likely to be more available to sampling gear. Older larvae, and particularly juveniles, become increasingly bottom-oriented and tend to move to shoal areas, where they could again be relatively unavailable even to the epibenthic sled.

(d) Orientation to Bottom in Relation to Flow

For the most part, late larval and juvenile striped bass, once in shoal areas, are thought to be able to resist passive transport with the water. If they are stationary with respect to the bottom, the number of young stripers potentially encountered by a net being towed at a fixed velocity relative to the water will be lower if the tow is made against the current (in effect, the fish will be swimming in the same direction as the net is being towed).

With the exception of the 1973 "ichthyoplankton river survey" and "shoal survey" by Texas Instruments,[54] ichthyoplankton nets, trawls, and sleds in 1967 and 1973 were either towed against the tide or the direction of tow was not specified. Investigation of the importance of this source of error is highly desirable.

(e) Active Net Avoidance

This general heading incorporates a number of interactions among the sensory abilities and behavioral characteristics of planktonic and nektonic organisms, the design and use of gear intended to capture them, and the prevailing physical characteristics of the local environment. An overview of the subject can be found in Chap. 4 of Ref. 100.

The biological aspects of net avoidance are related to the ability of organisms to detect and respond to some change associated with the approach of the net. Clutter and Anraku[53] make the interesting observation that "zooplankton can move in any direction relative to the trajectory of a sampling device and still disperse away from the path of the device so long as a gradient in intensity of the cue, or of the reaction to it, occurs in the vicinity of the trajectory. But avoidance will be increased if the animals are capable of oriented movement away from the trajectory."

Even striped bass yolk-sac larvae have some (albeit quite limited) swimming ability. Swimming ability (speed) should progressively increase as young post yolk-sac larvae grow through the juvenile stage. With respect to sensory ability, it seems likely that visual acuity and intensity discrimination, the sophistication of the lateral line system, the sensitivity of inner-ear organs to angular acceleration, and hearing ability would all increase with increasing age. All but the last of these would potentially allow localization of and directed response to a disturbance. Phenomena associated with shoaling behavior could also increase avoidance. Obviously, the condition of the organism affects avoidance ability and may be a significant factor in comparing samples taken in power plant discharge canals with those taken at the intakes or in the river.[46]

Physical conditions clearly can influence the ability of fish to avoid nets. The most obvious variable is light, which varies diurnally and with depth, depending on turbidity. This makes the determination of diurnal vertical migrations by organisms that can see and avoid nets quite difficult. Temperature is another physical variable which likely affects avoidance because of its effect on swimming potential.

Given these biological and physical factors, the choice and method of use of sampling gear can affect the subsequent population estimates. Tows made at night or in deep water can be expected to yield higher catches of older organisms, assuming even distribution. Minimizing the acceleration fronts ahead of nets — by eliminating, where practicable, towing cables and flowmeters, minimizing disturbances caused by the frame, and increasing the open-area ratio and, where appropriate, the mesh size — should reduce avoidance. Similarly, the use of large nets and high towing speeds is thought to reduce avoidance by, respectively, increasing the average distance organisms must move to avoid the net and decreasing the available evasion time.[53] Clearly, trade-offs are involved in the use of some of these techniques.

(f) Other Sources of Error

Two additional sources of error related to the sampling gear have not been listed in Table V-27, because they do not necessarily differentially affect estimates of abundance of the various stages. The first is flowmeter precision and accuracy. Examination of the raw data in Refs. 59 and 97 indicates that this factor could be important in affecting estimates of both relative distribution and absolute abundance of ichthyoplankton; the staff has little information on which to base an evaluation of this source of error. The second source is gear failure, which apparently resulted in the failure to sample a few regions or strata of the river during some of the weekly river runs in 1973.

(4) Design, Execution, and Interpretation of Results of the Sampling Programs in Relation to Estimates of the Distribution and Abundance of Striped Bass

Two initial assumptions are made about the results of Hudson River sampling programs when they are used for modeling of young-of-the-year striped bass populations. It is assumed that striped bass taken in the samples can be distinguished from the young of other fish species; in practice, however, larval striped bass are frequently difficult to distinguish from larval white perch,[102] and some misidentification is inevitable. In addition, the standing crops of striped bass calculated from the data are assumed to represent the entire viable stock of young-of-the-year spawned in the Hudson, although the appearance of young striped bass ichthyoplankters in the lowermost regions sampled in mid- to late May in both 1967 and 1973 indicate that transport of prejuvenile stages from the study area commonly occurs even prior to June. The importance of this transport with respect to model predictions depends on the relative number of young outside of the sampling area and on their relative survival in the lowest (and more saline) reaches of the estuary. The 1973 sampling program represents an improvement over the 1967 program in that sampling was extended (and striped bass were taken) farther upriver and downriver.

The discussion of gear selectivity phenomena in the preceding section indicates the importance of light and of gear size, design, and use in the estimation of ichthyoplankton concentration. Light should not noticeably affect catches of eggs or very young larvae, but avoidance by older stages would increasingly reduce catches in the upper part of the water column during the day, and diurnal vertical migration would likely affect concentrations at all depths. In 1967, some locations were sampled only during the day, and light-related effects would differentially affect catches primarily because of larval and juvenile age-distribution differences and differences in water transparency between these stations. An additional variable is present in the 1973 data because, although sampling was done both during the day and at night in many weeks, there was no attempt to perform both kinds of sampling in each segment during each week. The high catches of juveniles during the week of August 6–10[97] probably reflect the resumption of night sampling in shallow areas.

The same type of gear was used at all locations during a given week in 1967, while in 1973 epibenthic sleds were used to sample the bottom zone and Tucker trawls, towed at a faster speed, were used to sample near-bottom, midwater, and near-surface zones. The two devices differ somewhat in design, most notably in the orientation of the plane of the net opening relative to direction of travel, and and in structures surrounding and inside of the net opening. The relative efficiency of the two devices has not been evaluated.

The staff has received two independent sets of calculations of standing crops by week based on the 1973 data. The first set was done by Quirk, Lawler, and Matusky.[99,103] The river was divided into 12 ten-mile longitudinal segments (RM 10–130), each of which was then subdivided into two 5-mile subsegments. Epibenthic sled samples were assumed to represent densities in a bottom stratum having a height of 4 ft, while Tucker trawls were assumed to represent the balance of the water column. Volume estimates for the two strata were supplied for each of the 10-mile segments. For each ichthyoplankton stage, concentrations were calculated from individual samples. Flowmeter readings in excess of 1,000 were assumed to equal 1,000, while flowmeter readings less than 10 were assigned the average value of valid readings for that gear in that week (and within the individual river run if more than one run was made). The individual concentrations were averaged by stratum within the 5-mile subsegments and multiplied by the appropriate stratum volume within the subsegment. The four resulting standing crops were added together to produce the estimated average standing crop of that ichthyoplankton stage within the complete segment for the week. No attempt was made to analyze the Tucker trawl data by strata. The staff believes that the averaging of individual concentrations is less desirable than the alternative procedure of taking the ratio of the sum of organisms divided by the sum of volumes (see Appendix B, Section B.3.b), particularly in view of the degree of variability which is evident in the flowmeter readings.[59,97] In addition, use of a between-segment (or within-segment) averaging procedure for comparable strata would have been preferable to the practice of using a zero value for standing crops when no sample was taken there during a week, which frequently was the case. The staff has, however, been able to generally confirm those standing crop estimates that it has checked. Precise confirmation is not possible without subsegment volume data. QLM's calculations of standing crops were used by the staff in computations with its young-of-the-year population model [App. B, Section B.4.b(10)].

Part of the procedure used by Texas Instruments (TI) to calculate standing crops is given on pages VI-2 to VI-3 of Ref. 54. The apparent differences from QLM's procedure as explained above are: use of 12 segments (RM 12-153) of varying length without longitudinal subdivision; assumption that the epibenthic sled samples represent densities in the bottom 10 ft of water; use of the procedure of calculating the ratio of the sum of organisms divided by the sum of volumes to combine catches in each type of gear (see above); the addition of a third stratum to represent shoal areas (defined as regions with a river depth $\leqslant$ 20 ft); use of a lower-threshold value of 100 for acceptable flowmeter readings and use of a correction term in an attempt to compensate for the absence of sampling within one or more strata. At least in part because concentrations in the epibenthic sled were generally higher than those in the Tucker trawl, TI's standing crops tend to be higher than QLM's. The staff has, for several cases, attempted to duplicate TI's calculations[54] of average segment densities from the raw data[59,97] without success. Subsequently, the staff learned that errors and/or incomplete information in at least two of these documents partly explain these difficulties, and the staff has received additional information.[143,144] The staff is optimistic that the final version of Ref. 54 will clarify these problems.

Interpretation of the results from the 1973 ichthyoplankton river survey are complicated by the design of the program, in that "when striped bass eggs and/or larvae were collected, additional samples were taken in that area to describe the extent of egg and/or larval concentration" (Ref. 54, p. III-1). Such additional samples are not, however, identified directly in the raw data. Standing crop estimates calculated using these data could be biased either high or low, depending on the calculation procedure and on the way in which striped bass are distributed in the river. Clumped (patchy) distributions appear to be quite common among plankton in general[106-108] and are particularly likely to be characteristic of fish eggs and larvae.[108] Such distributions were suspected for striped bass in the Hudson River fisheries investigations' (HRFI) study.[96] While the staff is not aware of any formal analysis of either the 1967 or the 1973 data in this respect, it considers that the great degree of variability which is apparent between 1973 samples, which are closely related temporally and spatially, would be difficult to explain in any other way. Without knowing more about the degree, and especially the scale, of the patchiness, it is not possible to predict the likely direction or magnitude of bias in the standing crop estimates.

Standing crops of juveniles have also been estimated by both QLM and TI from TI's 1973 beach seine data. QLM utilized a volumetric calculation procedure based on seine dimensions and volume of shallows to an 18-foot depth contour; all seine data were used. TI utilized an areal calculation procedure based on a 10-ft depth, and data from hauls of the 100-ft beach seine during the day only. QLM's juvenile standing crop estimates from beach seines are generally more than an order of magnitude higher than TI's estimates. Notwithstanding these apparent differences, the staff considers that quantitative calculations from beach seine data must always be approached with great caution, because not only is gear avoidance virtually certain (e.g., higher catch-per-haul at night than during the day[54]) but also only a very limited and spatially distinct habitat is capable of being sampled. QLM's calculations of standing crops of juveniles were used by the staff in computations with its young-of-the-year population model [App. B, Section B.4.b(10)].

(5) Conclusions about the 1967 and 1973 Striped Bass Young-of-the-Year Sampling Programs

Table V-28 is a comparison of the salient features of both the 1967 and 1973 striped bass young-of-the-year sampling programs.

Table V-28. Comparison of the 1967 HRFI and 1973 TI ichthyoplankton river surveys and the 1967 HRFI and 1973 NYU, QLM, and TI local power plant studies with respect to sampling effort and design, number of striped bass collected, and collection gear

Parameter	River surveys		Local power plant studies					
	1967 (HRFI) River	1973 (TI) River	1967 (HRFI) Transects[a] (Cornwall)	1973 (NYU)[b]		1973 (QLM)[b]		1973 (TI)[c] Transects (Cornwall)
				Transects	Indian Point	Transects	Other plants	
Sampling period	4/30–7/29	4/30–8/16[d]	4/30–7/29	5/29–10/?	5/8–12/?	3/13–8/30	?–8/30	5/21–7/12
Region sampled	RM 35.5–125[e]	RM 17–140	RM 56.5	~RM 42–44	intakes, discharges	3 transects	4 plants	RM 53–57
Effort by depth	approx even	more at bottom	even	approx even	even	approx even	approx even	more at bottom
Total number of samples	3,160[f]	1,826[g]	1,351[f]	1,366	2,865	NG[h]	NG	NA[i]
Total volume sampled (m^3)[g]	190,000[f]	1,000,000	87,700[f]	NA	NA	NG	NG	109,748
Average volume/sample (m^3)[g]	59[f]	550	65[f]	NA	NA	NG	NG	NA
Data reduction interval	one week	one week	season	NA	NA	season	season	24 hr
Diurnal sampling	some locations, regular	some times and locations, irregular	yes	yes	yes	yes	yes	yes
Striped bass collected								
Eggs	1,168	22,443	652	NA	1,562	NG	NG	409
Yolk-sac larvae	NA[j]	9,142	NA	NA	231	NG	NG	845
Post-yolk-sac larvae	NA[j]	9,078	NA	NA	4,365	NG	NG	1,251
Total larvae	2,295	18,220	1,391	NA	4,596	NG	NG	2,096
Juveniles	NA	3,768	NA	NA	938	NG	NG	225
Collection gear								
Effective mouth area (m^2)	0.20	4.0[k], 1.0	0.20	0.20, 0.79[l]	0.20	0.79, 0.20	0.20, 0.79	1.0[c]
Opening shape	round	rectangular	round	round	round	round	round	rectangular
Opening plane[m]	perpendicular	perpendicular[n] or inclined[o]	perpendicular	perpendicular	perpendicular	perpendicular	perpendicular	perpendicular[n] or inclined[o]
Mesh size (μm)	305 × 508[p]	500 × 500[q]	305 × 508[p]	571 × 571	571 × 571	500 × 500	500 × 500	500 × 500, 1000 × 1000[c]
Net length/net opening	4.3	8	4.3	7.6	2.4,[r] 3.8	NA	NA	8
Suspension technique	bridle	cable to frame	bridle	bridle	bridle,[s] frame	bridle	frame	cable to frame
Flowmeters	in nets	in nets and external	in nets	in nets	in nets	in nets	in nets	in nets and external
Towing direction	against current	downriver	against current	against current	fixed	against current	fixed	downriver
Sample duration (min)	10	5 or 2	10	10	50	5	15	5 or 2
Velocity (m/sec)[t]	0.8–0.9	0.5–1.25[n] 1.25–2.5[o]	0.8–0.9	1.0–1.5	<0.15[u] <3.0[v]	0.8–0.9	<0.43[u] <4.9[v,w]	0.5–1.25[n] 1.25–2.5[o]

Footnotes and Sources for Table V-28

[a]A more intensive study was conducted in 1968.

[b]Other local power plant studies have been conducted in previous years by this contractor and by others.

[c]Information in this column includes only three of the four transect studies. Raw data have not been given for July 11–12, 1973; neither raw nor summary data have been given for July 25–26, 1973. (For an explanation of the latter, see TI, Vol. IV, p. A-5.)

[d]Raw data from the week of 8/12–8/16 were received by the staff in November 1974.

[e]RM = river mile (statute) measured from The Battery.

[f]Totals from Appendix Tables 3-3 to 3-10 of the HRFI report are used. Discrepancies between these tables and Table 2 in the text of the HRFI report have been noted for the Kingston and Cornwall locations.

[g]Estimated, or calculated.

[h]Not given.

[i]Not available.

[j]Larvae were not classified by stage.

[k]This Tucker trawl was added later in the season.

[l]A 1-m-diam Hensen net was used at surface and bottom only beginning July 24. Before this date, 1/2-m nets were towed at surface, middepth, and bottom.

[m]Relative to direction of travel.

[n]Epibenthic sled.

[o]Tucker trawl.

[p]"Progressively larger" mesh sizes were used after early July.

[q]Some tows with larger sizes were made after June 18.

[r]These shorter nets had to be used at the Unit 2 intakes because of space limitations.

[s]Surface tows only.

[t]Relative to water.

[u]At intakes.

[v]At discharges.

[w]Velocity data are not available for all discharges.

Sources:

Hudson River Policy Committee, "Hudson River Fisheries Investigations [HRFI], 1965–1968, Evaluations of a Proposed Pumped-Storage Project at Cornwall, New York in Relation to Fish in the Hudson River," presented to Consolidated Edison Company of New York, Inc., 1968.

Texas Instruments, Inc. (TI), Services Group, "1973 Hudson River Program, Fisheries Data Summary, May–July, Volume I," prepared for Consolidated Edison Company of New York, Inc., October 1973.

Texas Instruments, Inc., Services Group, "1973 Hudson River Program, Fisheries Data Summary, July–November, Volume II," prepared for Consolidated Edison Company of New York, Inc., December 31, 1973.

Texas Instruments, Inc., Services Group, "Fisheries Survey of the Hudson River, March–July 1973, Volume III," prepared for Consolidated Edison Company of New York, Inc., March 1974.

Texas Instruments, Inc., Services Group, "Fisheries Survey of the Hudson River, March–December 1973, Volume IV," prepared for Consolidated Edison Company of New York, Inc., September 1974.

New York University (NYU), Institute of Environmental Medicine, "Hudson River Ecosystem Studies, Effects of Entrainment by the Indian Point Power Plant on Biota in the Hudson River Estuary, Progress Report for 1973," prepared for Consolidated Edison Company of New York, Inc., September 1974.

Letter, E. R. Fidell (Le Boeuf, Lamb, Leiby and MacRae) to M. J. Oestmann (AEC), August 15, 1974, including information about Quirk, Lawler, and Matusky Engineers' 1973 f factor studies at the Lovett, Bowline, Danskammer, and Roseton power plants.

Letter from Carl L. Newman, Consolidated Edison, to George W. Knighton (AEC), including as enclosures the Quirk, Lawler, and Matusky glossary of abbreviations used in the f factor report and their reduction of the 1973 Texas Instruments' longitudinal river trawl survey and seining survey, August 30, 1974.

Letter (dated November 11, 1974) from Thomas C. Cannon, Texas Instruments, Inc., to Sigurd W. Christensen, Oak Ridge National Laboratory, including "Exhibit ____ (McF/C-5R)" and corrected data from the 1973 Longitudinal Ichthyoplankton survey.

Differences in the total catches between years are doubtless influenced by physical and biological factors as well as by differences in sampling gear and methodology. Texas Instruments performed two gear selectivity studies,[54,59,98] intended in part to compare their gear with that used in the HRFI programs. The data in Ref. 59 and the analysis in Table B-3 of App. B of Ref. 54, in view of additional information obtained by the staff, suggest that Texas Instruments' gear are more efficient than the HRFI gear in capturing striped bass post yolk-sac larvae when the same tow speed is used. The conclusion would be stronger if it were based on a comparison between two kinds of gear each using the same mesh size, rather than between four kinds of gear using several mesh sizes. Another gear efficiency study is referred to on page B-1 of Ref. 54 in the quotation below:

> "A gear efficiency study of the HRFI gear was undertaken in 1972 by Quirk, Lawler and Matusky Engineers Incorporated; results indicated a significant increase in efficiency by removing flowmeters or towing bridles, and by increasing the mouth area of the net."

No reference is given for this QLM study, and the staff has no further details. Such results would certainly seem relevant to the 1973 QLM power plant studies at Bowline, Lovett, Danskammer, and Roseton (see Table V-28, Sect. V.D.2.b(2)(e), and App. B, Section 3).

Consultants for and contractors to the applicant have concluded that gear avoidance is a significant phenomenon,[109] and that all stages of striped bass young-of-the-year discussed in this section are likely underrepresented in the samples.[110,111] The staff concurs in these views, but hastens to add that gear selectivity, methodology of the sampling program, and the assumptions underlying standing crop calculations interact in such a way that such underrepresentation does not in itself assure that the resulting standing crop estimates are biased low. The 1967 and 1973 data are presently of considerable utility for modeling purposes in that they provide, despite the considerable problems that have been mentioned, information about distributions and abundances that reflect at least in part differences between years. The 1973 program also could monitor events occurring in different parts of the river. Data relevant to estimation of f factors [see Sect. V.D.2.b(2)(e)] have been considerably augmented. Still, the staff is in substantial agreement with the views of Texas Instruments personnel concerning the 1973 ichthyoplankton river survey, as quoted from page VI-5 of Ref. 54 (italics added by staff):

"Inherent biases in these estimates severely limit their usefulness. Sampling was not sufficiently complete during some periods, and missing or incomplete data for sections of the river made it impossible to estimate total standing crop. Gear avoidance problems limited estimates in late June and July. Sampling during this period was conducted primarily during daylight in deeper channel areas of the river. Analysis of the data indicated strong avoidance capabilities of late larvae and early juveniles during daylight as well as a movement to shoal areas of the river. Corrective action was not implemented until August.

"A proper sampling design, which takes the above biases into account, will allow confidence intervals to be placed on the standing crop estimates; thus making statements of accuracy possible. The 1974 sampling program has been specifically designed for this purpose, and *selective use of the 1973 data may provide valuable information*. Such selection will be based on detailed analysis and review of that data, the 1974 data, and gear selectivity and avoidance information from sampling which was conducted in 1973 (see Appendix B) and is planned for 1974."

Because of (1) differential gear selectivity for the various stages of young-of-the-year striped bass, (2) the methodology of the 1973 sampling program, (3) apparent problems with the gear (e.g., flowmeters), (4) the apparent patchiness of ichthyoplankton distributions, and (5) the great uncertainty in deriving absolute abundance estimates from trawl (1967) or seine (1973) hauls, definitive mortality rates for the various stages cannot be obtained from either the 1967 or the 1973 data. The estimates of the relative temporal and spatial distributions of individual stages are more reliable. One of the most unfortunate aspects of the 1973 data is the lack of standardization of sampling gear used in the river survey, the river transect studies, and the intake and discharge sampling programs [see Sect. V.D.2.b(2)(e)]. Even very extensive studies comparing the relative efficiencies of different gear and different methods of use of the gear would likely not resolve all of the problems resulting from this lack of standardization.

The consequences of the problems discussed above are considered in other Sections of this Statement.

f. Applicant's Research Program

A critical issue in the Indian Point Unit No. 2 Hearing was related to the applicant's proposed program of research. The positions of the various parties to the hearing are summarized as follows.

(1) The applicant's position is that: "Operation of the facility with its presently designed once-through cooling system shall be permitted until September 1, 1981. Unless otherwise authorized by an amendment to the operating license following review of the results of the licensee's ecological study program, operation shall be permitted after September 1, 1981, only if a closed-cycle cooling system shall have been installed by that date."[75,112]

(2) The position of HRFA on the applicant's research program[113] is that the program should not be accepted as an alternative to a closed-cycle cooling system. In support of this conclusion, HRFA concludes that the applicant's presentation of information has not been full, frank, and fair but instead has been self-serving. Furthermore, HRFA questions the ability of the applicant to analyze its own data in a manner consistent with the best interests of the public. HRFA does not oppose the imposition of a condition on the license requiring the applicant to conduct research, but this requirement should in no way be accepted as an alternative for installation of an alternative cooling system at a date no later than that suggested by the staff and preferably much earlier.

(3) The staff has testified that the research effort proposed by the applicant is unlikely to conclusively demonstrate that operation of Indian Point Units Nos. 1 and 2 with once-through cooling will not have an unacceptable adverse impact on the fisheries supported by the Hudson River.[114-117]

The applicant began studying the ecological system of the Hudson River in 1958. This early work was directed toward the radiological effects on biota in relation to determining the impacts of the radioactive releases of Unit No. 1 on man.

As a result of the controversy involving the Cornwall Project in the mid-1960's, the applicant sponsored, through the Hudson River Policy and Technical Committees,[118] the Hudson River Fisheries Investigation from 1965-1968.[119,120] At the same time, other consultants were starting other ecological studies when the construction on Indian Point Unit No. 2 was begun in 1968. Raytheon Corporation carried out a series of studies from 1968 through 1971. New York University has been carrying out studies on entrainment effects at the Unit Nos. 1 and 2 condensers, as well as relating the effects of the condenser to populations in the river. Quirk, Lawler, and Matusky has concentrated its efforts on hydraulic thermal models,[33] and has also developed models related to the entrainment of striped bass fish eggs, larvae, and adults (the Hudson River Striped Bass Life Cycle Transport Models).[111] In April 1972, Texas Instruments Inc. began a 5-year ecological study originally costing $10 million to investigate the impacts of Indian Point Units Nos. 1, 2, and 3 on the ecosystem of the river. In Appendix T of the Environmental Report for Indian Point Unit No. 3, the applicant has listed the environmental studies it has sponsored over the years.

The environmental studies of major importance are the present TI, NYU, and QLM studies which will be completed by 1977. The general objectives of these studies (ER, IP-3, Suppl. 9, Sect. 13) are as follows:

(1) "determine the biological significance of impingement of screenable fishes at the intakes of Indian Point Units Nos. 1, 2, and 3.

(2) determine effects and biological significance of Plant operation on nonscreenable organisms (including fish eggs and larvae, and plankton) in the coolant water passing through the once-through cooling systems for Units Nos. 1, 2, and 3.

(3) determine the biological significance on the Hudson River ecosystem of thermal and chemical additions from Indian Point Units Nos. 1, 2, and 3.

(4) determine the biological significance on the Hudson River ecosystem of aquatic organisms passing through or being attracted to the thermal plume and/or into the effluent canal or intake.

(5) develop and test concepts of protective measures for minimizing adverse biological effects and ascertaining biological benefits and costs of such measures.

(6) develop and use mathematical models to aid in the evaluation of the effects of entrainment and impingement on the population of striped bass."

A flow chart showing the duration and key points of the studies being performed is shown in Fig. V-19. This schedule was prepared when Indian Point Unit No. 3 was predicted to come on line in 1973. Since Unit No. 3 is now expected to begin operation in 1975, an extension of the ecological studies for about one year is under consideration.

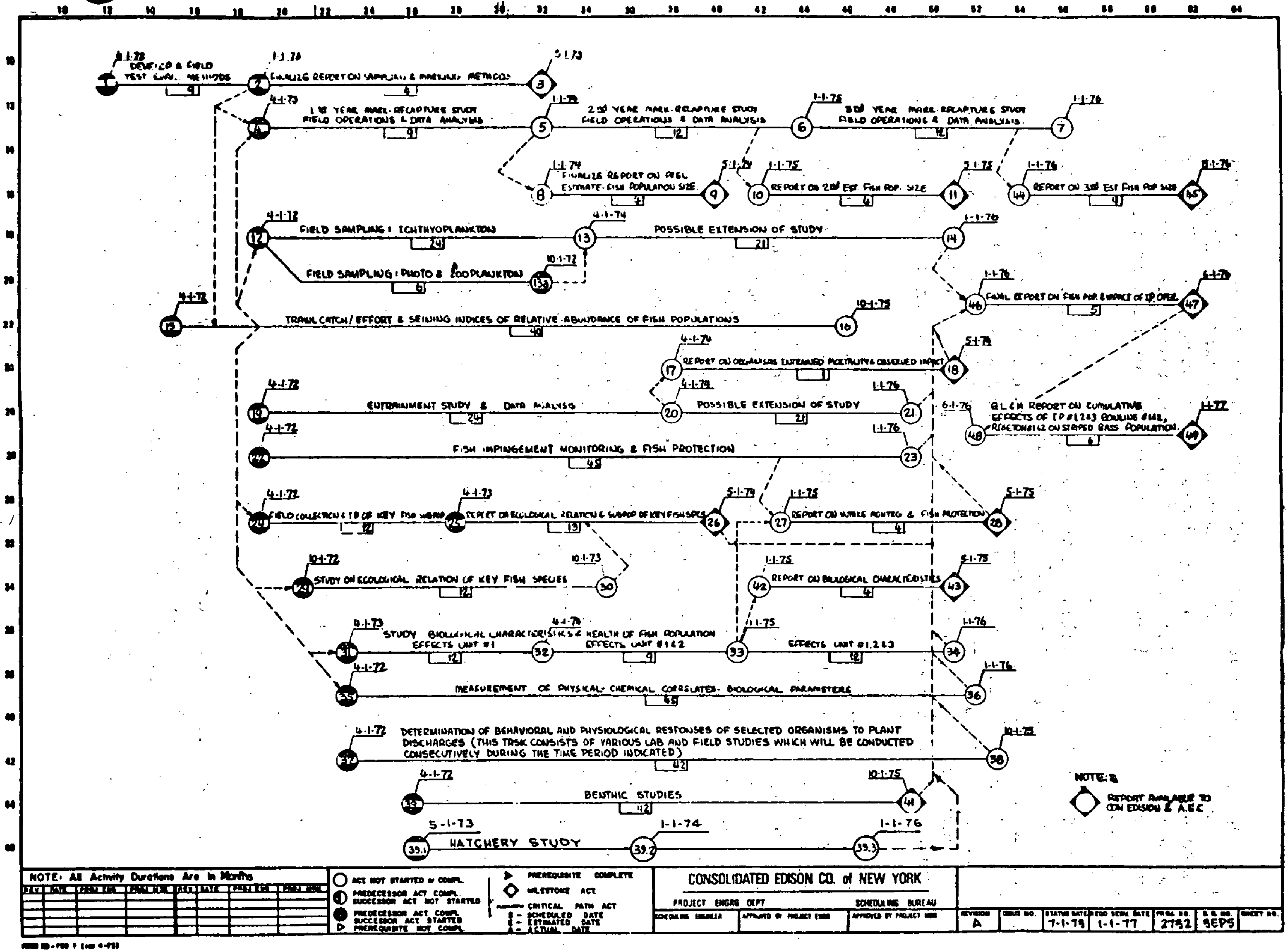


Fig. V-19. General ecological survey and special studies.

The applicant will use the results from these studies to evaluate the effects of operation of once-through cooling of Indian Point Units Nos. 1, 2, and 3 on the Hudson River ecosystem. Data provided from these studies will aid in determining stresses on the aquatic biota as well as methods and means for minimizing adverse effects.

In addition to the Indian Point ecological studies, the applicant has been carrying out additional studies during 1973 and 1974 to estimate the potential impact of the Cornwall project on the Hudson River fishery. This is in partial fulfillment of the Federal Power Commission license requirements for this Project.[121] The applicant has been conducting intensive far-field and near-field ichthyoplankton surveys over the entire spawning ground of the striped bass.

Additional studies sponsored by other utilities are being carried out at the other power plants on the Hudson to determine entrainment and impingement impacts. The chemical discharges also will be monitored along with the river water chemistry. Furthermore, New York State Department of Environmental Conservation, through the Department of Commerce, has started a three-year striped bass tagging program to determine the contribution of the Hudson River striped bass to the mid-Atlantic fishery. The Power Authority of the State of New York began a tag and recapture program in early fall, 1973, for white perch and striped bass. An Inter-Utility Coordinating Committee (IUCC) has been established to coordinate the efforts of several utilities conducting studies on the river. Further details of ongoing ecological studies are presented in Suppl. 9, Sect. 13 of the Environmental Reports, for Unit No. 3 and Unit No. 1.

The applicant proposes to measure the following parameters to detect changes in the striped bass and white populations (ER, IP-3, Suppl. 9, Sect. 13):

"(1) population density
(2) survival
(3) age composition
(4) growth rate
(5) age at sexual maturation
(6) sex ratio."

Changes in these parameters will be measured in an attempt to determine whether serious exploitation of the population is occurring as a result of Plant operation of all three Units.

The applicant (ER, IP-3, Suppl. 9, Sect. 13) proposes to use the following criteria for assessing the impact of Plant operation on the Hudson River striped bass population:

(1) "Decline in density of Juvenile II, Juvenile III, and Age Group I fish coincident with startup of Unit No. 2 and not accounted for by changes in egg production by parental stock or by natural environmental fluctuations.

(2) Large fraction of the population of eggs, larvae, or Juvenile I fish entrained; high mortality rate of entrained organisms.

(3) Substantial reduction in survival rate from egg stage to Juvenile II, etc., accounted for by entrainment.

(4) Substantial percentage of stock from significant area of estuary impinged on intake screens.

(5) Lack of compensatory increase in survival rate among Juvenile II and Juvenile III fish following fulfillment of criterion (3).

(6) Lack of compensatory increase in survival rate among Juvenile III to Age Group I fish following fulfillment of criterion (4).

(7) Increase in growth rate of fish. Note that increased growth rate is both a classical indicator of a substantial decrease in stock density (hence an indicator of adverse impact) and a compensatory response to reduction in density (hence an indicator of some capability of the fish stock to sustain itself in the face of increased mortality).

(8) Attainment of sexual maturity at an earlier average age. The note in (7) above identifying the criterion as an indicator of both adverse impact and compensatory capability of the population applies here as well.

(9) Continuing decline in population size or stabilization at an undesirably low level following a period of decline, as predicted by a simulation model of the fish population which integrated the empirical data from the ecological studies."

Using the above criteria, the applicant[122] states:

"If the study shows that the operation of Indian Point 1 and 2 in the long term will reduce the population of striped bass in the Hudson River and in the Mid-Atlantic area by 40 and 30 percent respectively, then applicant will propose to the cognizant regulatory agency installation of measures to mitigate the adverse effect. Those mitigation measures will be the construction of a closed-cycle cooling system for Indian Point 2 with a single natural draft cooling tower, unless it is shown that another measure (including artificial propagation of striped bass) would be acceptable on the basis of a benefit-cost analysis or that such a closed-cycle cooling system will cause an adverse environmental impact greater than that which will result if such a system is not installed."

However, the applicant[122] further states:

"If the study program shows damage to the striped bass population from the operation of Indian Point 1 and 2 in a significant amount but less than that postulated by the staff as aforesaid, the environmental significance of the damage and the need for a nature of mitigation measures, if any, would be subjected to a benefit-cost analysis of the nature prescribed by the National Environmental Policy Act of 1969, as interpreted in the Calvert Cliffs' case. If required by such analysis, applicant would propose such measures to mitigate the damage as were appropriate taking into account available alternatives."

It is the staff's judgement that the nine criteria listed above provide an unrealistic and unattainable basis for assessing the impact of Plant operation on the Hudson River striped bass population. For example, let the null hypothesis be that there are no treatment effects, where the treatment is the operation during the striped bass entrainment season of Indian Point Units Nos. 1 and 2 with once-through cooling in 1974 and of Units Nos. 1, 2, and 3 with once-through cooling in 1975, where 1975 is presently the official date for termination of the data-collection phase of the applicant's research program (Fig. V-19). Let the alternative hypothesis be that there are adverse treatment effects. Assume that this pair of hypotheses is examined in light of each of the nine criteria (i.e., possible treatment effects) proposed by the applicant. The staff's opinion is that of these nine criteria, it is likely that only criteria 2 and 4 can possibly be determined within the present time frame of the applicant's study. At the end of the study, there will be three independent estimates (1973, 1974, 1975; Texas Instruments' data for 1972 were preliminary) of (a) the fraction of the population of eggs, larvae, or Juvenile I fish entrained and the mortality rate of these entrained organisms (criterion 2), and of (b) the percentage of stock from a significant area of the estuary which is impinged on the intake screens (criterion 4). The 1973 value for each criterion would provide the sole estimate of the preoperational level, although to term the 1973 value preoperational seems questionable. During the 1973 striped bass entrainment season, Units Nos. 1 and 2 were operating the pumps for testing purposes nearly every day of the striped bass entrainment season (May 1 to July 31) in 1973.[145] The 1974 and 1975 values would provide estimates of the mean postoperational effect and of the variance about this mean. Because of the numerous other uncontrolled variables in this complex system, including Bowline Unit No. 2 and Roseton Units Nos. 1 and 2 coming on line and the strong dependence of longitudinal distribution on freshwater flow (which varies from year to year), the staff expects this variance to be large in spite of covariance adjustments. Thus, the staff would not be surprised if the null hypothesis as applied to criteria 2 and 4 were not rejected, even if in reality the operation of Indian Point with once-through cooling reduced the number of young-of-the-year surviving their first year by an average of 25% over these three years. For the remaining six criteria, the staff feels there will not be adequate data to test the null hypothesis of no power plant effect. For instance, the female striped bass from the 1973 year class are not expected to attain sexual maturity (criterion 8) until 1979 and 1980.

Thus, to demonstrate in a standard statistical sense that operation of Indian Point Units Nos. 1, 2, and 3 with once-through cooling will not have an unacceptable adverse impact on the Hudson River striped bass population using these particular nine criteria is impossible within the time frame of the applicant's studies.

The staff agrees with the applicant's comment (Comment 184, App. I) that the "hypothesis testing" approach

> "does not in any way preclude use of the 'interval estimation' approach to statistical analysis of research data, which approach applicant intends to use along with the 'hypothesis testing' approach in order to provide the most complete and understandable analysis of research findings attainable.
>
> "Poor experimental design or careless execution of sampling would work to great disadvantage of the Applicant. Greater sample size would be required to reach satisfactory levels of precision in the data, thereby increasing the cost of research. More important, anything which increases the sampling variability of research data widens the confidence interval around estimates and thereby admits of a larger probability of severe environmental impact even if the point estimates indicate moderate or no impact."

With respect to the applicant's, intervenor's, and staff's claims and concerns about the applicant's aquatic ecology studies, the following material from a paper by McFadden,[61] the applicant's primary consultant on the design and analysis of the aquatic ecology studies, is particularly appropriate in that it addresses a number of the staff's concerns. The Summary quoted below is included to give an overview of the entire paper; the material in the Discussion is the primary reason for citing the paper.

SUMMARY

"A laboratory experiment was carried out to determine the relationship between the independent variables, temperature and population density, and the dependent variable, egg production, in populations of *Tribolium confusum*. A multiple regression equation describing this relationship was assumed, for purposes of this paper, to represent a complete description of a biological relationship, analogous to some component of production in a natural animal population.

"Temperature and adult population density values were derived to represent a 50-year series of observations. Temperature was assumed to be a normally distributed random variable. Population density was assumed to be positively correlated with the previous year's temperature and negatively correlated with the previous year's population density. These temperature and population density values were then used in the multiple regression equation to produce a 50-year series of egg production values. To each calculated Y-value was added or subtracted a quantity which represented the net effect of all other factors on egg production. These quantities were negatively correlated with the current year's temperature, analogous to the situation where correlated environmental factors affect a dependent variable. Temperature and population density accounted for two-thirds of the variability in the annual egg production values synthesized.

"It was assumed that annual observations of temperature, adult population density, and egg production were made for 50 years in the course of an observational field study. Temperature was measured without error and egg production can be considered either as measured without error or as subject to normally distributed random errors. Adult population density was estimated by a procedure analogous to the simple mark-and-recapture method where the gear sampled 13 per cent of the population in each use. Errors of estimation were not independent of population size. Several multiple regression models based on the synthetic observational data were derived and compared with the true equation being estimated. This provided a concrete example of the distortions which arise in descriptions of components of biological productivity based upon data of field-level precision. The use of smaller-scale designed experiments to supplement and aid in interpretation of large-scale observational studies is briefly discussed.

DISCUSSION

"Retrospective studies are those in which the investigator observed environmental factors as they operate and then attempts to relate their effects to a dependent variable. Such studies are, of necessity, the main source of information about large natural populations in environments which cannot be manipulated. The objective of this paper has been to synthesize a set of data which simulates the observations obtained from a retrospective study. The input information for this synthesis is, for the most part, empirically based and, although their derivation obviously represents an oversimplification, I believe the manufactured observations to be fairly realistic in those aspects which form the main basis for discussion here. Analysis of the data yielded a rather crude description of the biological relationship under study and it is implied that observational field data will usually yield similarly crude models.

"The example presented here does not, of itself, lead to any solution of the problems encountered in collecting, analyzing, and interpreting field data. It does translate statistical theories, which give a somewhat abstract idea of the distortions inherent in most field data, into a concrete example of such distortions. The comparison of true biological relationship with an inductive model derived from observational data, as carried out here, should provide a useful reference point in interpretation of genuine field data.

"In field studies replication is often impossible to achieve; it may be very difficult to measure the variables under study, to obtain observations over a sufficiently wide range of environmental conditions or to continue measurements through time; and unmeasured variables may interfere seriously. Many of the difficulties encountered in handling field data cannot be corrected by collecting more of the same observational data, and it is difficult to determine what additional information is needed when, as is the case in actual field studies, the way in which the estimated biological relationship departs from the true relationship is not known. These problems can sometimes be solved by resorting to prospective experimentation, the case for which is advanced convincingly by Park (1961). Even if the geographical scope of the field problem dictated an observational approach, some smaller scale designed experiments would provide information invaluable in interpreting the observations from the main study. In the present example, a modest experiment in which groups of fish were held in small ponds at different temperatures under otherwise constant conditions (this is analogous to the way in which the Tribolium data used here were obtained in the first place) would quickly yield an egg production-temperature regression, the slope of which was markedly greater than that estimated from the 50 years' field data. This regression would not generalize readily to population densities other than the one at which it was derived because of the temperature-density interaction but it would cast doubt on the efficiency of the observational data and might provide a basis for improving the biased description of the biological relationship obtained from them. Between closely controlled laboratory environments and completely uncontrolled natural environments there exist many other situations, intermediate in scope and in the degree to which their environmental factors can be controlled. Some aquatic examples are small natural ponds and lakes, small streams, and artificial impoundments. Here it is often practicable to vary by design population density, species composition, temperatures, depth, substrate, fertility, flow, etc. These environments offer an opportunity for prospective experimentation in the field which has yet to be fully utilized. In the future, information from research on this scale should prove valuable in interpreting larger-scale retrospective studies and in bridging the methodological gap between field and laboratory studies of animal ecology."

The applicant is investing approximately $7 million in environmental research for fiscal year 1974, most of it for aquatic studies and most of it relevant to assessing the impact of Indian Point.[123] More than 100 technical people are involved, including prestigious outside consultants on a Fishery Advisory Board. See Sect. I.C for further details.

Experience with the various International Biological Program Biomes and with other large ecosystem level studies clearly indicates that this magnitude of investment in dollars and manpower is a <u>necessary</u> condition for beginning to understand a complicated ecosystem such as the Hudson River estuary. However, experience also indicates that such an investment over a restricted period of time is not a <u>sufficient</u> condition. In fact, it is certain that by 1976 much of the information required for a sound evaluation will not be available.

The staff believes that the application of analysis of variance and multiple regression techniques, which are used extensively by Texas Instruments in particular, are powerful tools for testing hypotheses and quantitatively characterizing a system. Nevertheless, any statistical analysis is constrained not only by the quality of the data but by the experimental design. In the present case, the major and unavoidable flaw in the design is that there is no experimental replication and no simultaneous control or simultaneous alternative "treatment" with which to compare the results from the research program. Rather, the applicant must rely on a baseline of prior environmental measurements, going back to the mid-1960's, which were collected by different people and different organizations, using different techniques and different equipment, with somewhat different and more limited objectives in mind.

If there is to be any quantum jump in ability to forecast the impact of Plant operation on the Hudson River ecosystem (and on the striped bass young-of-the-year population in particular), as a result of the extensive TI, NYU, and QLM environmental studies presently scheduled to be completed by January 1, 1977 (Fig. V-19), that quantum jump will be based primarily on the 1973-74 cycle of data and analysis. The staff has not seen all of these data nor the consultants' analyses of these data. However, from the information the staff has received to date, it is apparent that obtaining data of the quality required for sound impact assessment has proven to be more difficult than anticipated. The most important example of this problem is the 1973 data from QLM for estimating f factors (other than f_c). The difficulties in obtaining adequate data on major issues in controversy cast serious doubt on the applicant's claim that a final conclusion with respect to the date for closed-cycle cooling at Indian Point Unit No. 3 should await collection of further "empirical" data.

In spite of the above difficulties, the staff's present position with reference to the applicant's research program is that the program has the potential (1) of resolving, at least partially, several of the important issues in controversy, and (2) of evaluating alternative mitigating measures in addition to closed-cycle cooling systems, such as culturing and stocking Hudson River striped bass [Sect. XI.C.3.c(4)(b)(v)] and fish impingement measures (Sect. XI.E).

The issues in controversy with respect to the Hudson River striped bass population may be divided into three categories on the basis of the ability of the applicant's research program to resolve these issues by January 1, 1977.

A. Issues which for the most part may be resolved:

1. Probability of survival for striped bass eggs, yolk-sac larvae, post yolk-sac larvae, and juveniles upon passage through the Plant with and without chlorination and at different exposure temperatures [see Sect. V.D.2.b.(2)].

B. Issues which may be resolved, at least partially, in that the range of uncertainty may be narrowed.

1. Intake concentration as compared with the segment average concentration (i.e., f factors) of striped bass eggs, yolk-sac larvae, post yolk-sac larvae, and juveniles [see Sect. V.D.2.b(2)(e)].

2. Migration to shoal areas and how this may reduce duration of susceptibility to both passage through the Plant and further passive transport down river [see Appendix B, Sect. 4.b.(2)(f)(ii)].

3. Fraction of the young-of-the-year population of striped bass impinged at Indian Point and the other power plants (see Sect. V.D.2.a).

4. Zone and degree of influence of the Hudson River striped bass population on the sport and commercial striped bass fisheries along the East Coast [see Sect. V.D.2.d(3)(c)(v)].

5. Feasibility of culturing and stocking Hudson River striped bass, including subsequent short-term and long-term survival relative to wild striped bass [see Sect. XI.C.3.c(3)(b)(v)].

C. Issues which may not be resolved to any significant extent.

1. The extent of present and future operation of natural compensatory mechanisms in the Hudson River striped bass population, particularly in the zero-age class, in response to increased mortality due to power plants.

2. Accurate determination of the probability of natural survival from spawned egg to yolk-sac larvae, from yolk-sac larvae to post yolk-sac larvae, from post yolk-sac larvae to Juvenile I, and from Juvenile I to Juvenile II (see Sect. V.D.2.e).

Most of these issues, such as items A1, B1, B2, B3, C1, and C2, above involve information which is of limited direct value in assessing the impact of Indian Point operation on the Hudson River spawned striped bass population. However, this information is required for input to the staff's young-of-the-year striped bass model and the applicant's striped bass life-cycle model. Parametric studies with these simulation models indicate that the values used for the various f factors, duration of susceptibility, and compensation strongly affect the model forecasts of the impact of Indian Point on the Hudson River spawned striped bass population.

The following list enumerates possible modifications of the applicant's research program which the staff has under consideration. This list is subject to change in light of new information and additional analyses.

1. Extend the research program beyond January 1977 in those areas where data over a longer period of time are required.

2. Determine the zone of withdrawal for each intake at slack, flood, and ebb tides.

3. Determine in detail the cross-sectional bottom profiles at each intake, particularly in the vicinity of the intakes.

4. Design and carry out a sampling program and an analysis to test the specific hypothesis that the thermal discharge from power plants increases the percentage of striped-bass and white-perch spawning occurring in the vicinity of the power plants. This study is not to be limited to Indian Point.

5. Expand the program to estimate predation on young-of-the-year striped bass, particularly from July through November in the shoal areas north of Cornwall and in Haverstraw Bay-Tappan Zee Bay.

(a) Estimate relative abundance of the various prey, in addition to young-of-the-year striped bass.
(b) Identify predators, including 1- and 2-year-old striped bass.
(c) Determine composition of diet for each predator species.
(d) Estimate relative abundance of the different predators.

6. Expand the fish behavior and physiology portion of the research program to obtain more complete data on swimming speeds of young-of-the-year striped bass as a function of temperature and body lengths, starting with young-of-the-year as small as feasible.

7. Continue to estimate the age composition of the spawning stock.

8. Obtain current profiles over a tidal cycle in shore and shoal areas as part of an analysis to compare the longitudinal transport of larval and juvenile striped bass in these areas with striped bass in the channel.

9. Estimate the sport fishing effort and catch (by size or age class) in the Hudson River, Western Long Island Sound, and New York Bight. Evaluate the dependence of this fishing effort on the abundance of striped bass.

10. Integrate the modeling component of the research program more thoroughly with the remainder of the program.

11. Expand the population modeling effort to include white perch and tomcod, in addition to striped bass, with an eye toward integrating these three models.

12. Design and carry out a study program to obtain relative and absolute estimates of gear efficiencies for the various ichthyoplanktonic sampling equipment used for striped bass eggs, yolk-sac larvae, post yolk-sac larvae, and juveniles.

There are several questions which the research program supposedly has been designed to address but for which the staff has not yet seen any data or tentative answers. Two examples are:

(a) What are the diurnal, vertical, and lateral distributions of striped bass eggs, yolk-sac larvae, and post yolk-sac larvae in the vicinity of Indian Point and how do these distributions vary with salinity and phase of the tide?

(b) At what length do striped bass juveniles start to concentrate (as opposed to simply appear) in the shoal areas? Also, how does this tendency to concentrate in the shoal areas increase with length and how does it modify longitudinal transport?

If the research program as presently designed does not provide adequate answers to such questions, redesigning parts of the research program will be necessary.

g. Summary and Conclusions Concerning Biological Damage to the Aquatic Ecosystem

The staff assessment of the biological impact of the once-through cooling systems at Indian Point Units Nos. 1, 2, and 3 shows that:

(1) Unless the applicant finds better means of preventing fish from entering the intake structure, impingement of fish on the intake screens at Indian Point Units Nos. 1, 2, and 3 with once-through cooling (base design) can result in an annual loss of 2.6 million young-of-the-year fish (2- to 4-inches long), approximately 70% white perch, as estimated by the applicant. The staff does not place great confidence in the estimates of absolute numbers or weight of fish killed because of lack of reliable information on impingement losses from past experience at the intakes of Unit No. 1 and limited experience of operating of the circulating pumps at Unit No. 2. Although the applicant has investigated several techniques to reduce impingement losses, the applicant has yet to determine an adequate methodology to control impingement and has yet to evaluate the long-term significance on the fish populations.

The staff's position is that impingement at Indian Point Units Nos. 1, 2, and 3 operating with once-through cooling, together with impingement at the other power plants, is of major concern for white perch, tomcod, herrings, and striped bass.

The number of striped bass collected at the intakes is considerably less than the number of white perch, tomcod or herrings collected. However, population estimates of striped bass and white perch tagged as young-of-the-year in the fall and recaptured the same fall indicate that the striped bass and white perch populations between river miles 12 to 62 are approximately the same size. This information suggests that impingement of striped bass must be of concern primarily because it is an additional stress on top of a large estimated entrainment impact.

The applicant has made progress in characterizing the dependence of impingement on intake velocity, intake flow, water temperature, salinity, and distribution of fish. However, in the staff's opinion, with the exception of reducing intake flow, the applicant has not proposed or evaluated a methodology that is expected to appreciably reduce the number of fish impinged below the applicant's projections.

The Environmental Technical Specifications will place a maximum number on daily fish kill in order to limit kills.

(2) Aquatic organisms, including phytoplankton, planktonic crustaceans, larval stages of benthic invertebrates, and eggs, larvae, and juveniles of many of the fish populations (particularly striped bass, alewife, blueback herring, tomcod, bay anchovy, and white perch) will be subject to entrainment in the cooling water withdrawn by the Indian Point Plants and thereby will be exposed to mechanical shock, pressure changes, and thermal and chemical (chlorine) effects.

(a) The staff's position is that entrainment of phytoplankton and microzooplankton is not expected to have any measurable effect on the aquatic ecosystem (including the fish populations) in the vicinity of Indian Point. Except for *Neomysis*, the staff's opinion is the same for the macrozooplankton such as *Gammarus* and *Monoculodes*. However, (1) entrainment mortality of *Neomysis* is quite high, (2) *Neomysis* tends to be concentrated at the salt front and its reproductive activity may be relatively high at the salt front, and (3) when young-of-the-year striped bass or white perch and *Neomysis* occur together, *Neomysis* is an important component of the striped bass and white perch diet. Therefore, the staff concludes that when the salt front is in the vicinity of Indian Point for much of June through October, entrainment of *Neomysis* at Indian Point, Lovett and Bowline may well reduce the standing crop of this mysid crustacean and thus have an adverse effect on the growth and survival of striped bass and white perch young-of-the-year.

(b) The staff has estimated that for striped bass ichthyoplankters the probability of short-term survival following passage through the Indian Point Plant is 0.2 for eggs, 0.4 for yolk-sac larvae and post yolk-sac larvae, and 0.3 for nonscreenable juveniles. The probability of long-term survival is estimated to be 10% lower than the above values for each life stage.

(c) The staff's best judgment concerning the value of the ratio of the concentration of striped bass ichthyoplankters at power plant intakes to the cross-sectional average concentration in the river (f_I) is that the data and analyses currently available, including the staff's, support an f_I value of less than 1.0 but not less than 0.5 for eggs, yolk-sac larvae, post yolk-sac larvae, and nonscreenable juveniles at Indian Point, Bowline, Lovett, Roseton, and Danskammer. Since there is considerable variability and uncertainty in the available data and since the value of f_I has a marked effect on forecasts of percent reduction by the staff's young-of-the-year model, the staff has made runs with the model using values of 0.5 and 1.0 for f_I.

(3) Aquatic organisms in the vicinity of Indian Point will be exposed to thermal, chemical, and radioactive discharges. Thermal and chemical discharges decreases in dissolved oxygen levels have potential of causing lethal and sublethal effects on organisms, particularly during sensitive stages of the life cycle. Since their mobility is limited, planktonic forms are most susceptible to thermal and chemical stresses.

(a) The temperature of the Hudson River in the vicinity of Indian Point may be increased to levels detrimental to aquatic life. If the thermal discharges from Danskammer, Roseton, Lovett, and Bowline fossil-fueled plants are considered in addition to those from Indian Point Units Nos. 1, 2, and 3 with once-through cooling (base design), the staff studies indicate that the estimated cross-sectional average temperature rise, under certain conditions, exceeds the assumed ambient water temperature of 80°F by more than 4 F° between river miles 35 and 50. Exposure temperature, duration of exposure, species, size of organism, and its thermal history will be important in determining the effects of thermal stress. Excess temperatures may attract fish to the intakes, which could cause additional impingement.

(b) The dissolved oxygen concentration in the vicinity of Indian Point may be reduced to levels detrimental to aquatic life, principally in late summer and early fall. In the event plant thermal discharges do result in decreases of dissolved oxygen to less than 5.0 ppm at the confluence of the discharge canal with the river, the applicant will be required to aerate the thermal discharges or use other suitable methods to comply with the Environmental Technical Specifications and New York State water quality standards.

(c) Chlorination of the once-through cooling system for either Unit No. 2 or Units Nos. 1 and 3, which is scheduled to occur on alternate days three times per week for a total of 9 hr per week, may result in discharging cooling water containing up to 0.5 parts per million (ppm) of total residual chlorine. Concentrations of residual chlorine and any chlorinated organic compounds formed at this level can have toxic effects on aquatic biota in the discharge canal and in the vicinity of Indian Point. The applicant is studying means of reducing amounts, concentration, and frequency of use of sodium hypochlorite to minimize effects on biota. The applicant has stated that no chlorination will occur when the river water temperature is less than 45°F.

(d) Populations of aquatic organisms residing in the discharge canal or near the outfall of the discharge structure will not be adversely affected by radioactive discharges.

(4) The combined effects of entrainment and impingement are likely to result in a substantial decrease in the striped bass fishery that depends on the Hudson River for recruitment. The staff has shown:

(a) The greatest proportion of young-of-the-year striped bass which annually populate the Haverstraw-Tappan Zee nursery area move past Indian Point as eggs, yolk-sac larvae, post yolk-sac larvae, or nonscreenable juveniles and are susceptible to entrainment.

(b) From the staff's point of view, the concept of natural compensation, as opposed to compensation by the fishery, and the fact that natural compensation is occurring and will continue to occur to some degree are not the issues in controversy. Rather, the primary issue in controversy on this topic, given that the applicant has not and will not be able to quantify the degree of natural compensation, is to what extent should the parties rely on compensatory decreases in natural mortality to offset the increased mortality due to the power plants. It is the staff's position that to rely on natural compensation to any major extent is not environmentally sound. Thus, in reaching its conclusions in this Final Environmental Impact Statement for Indian Point Unit No. 3, the staff has assumed that natural compensation of early life stages and older age classes is not likely to be of major importance in offsetting the increased mortality due to the power plants. However, the staff has included a compensation function in its young-of-the-year model in order to determine the effect of changes in the compensation parameters on the model results used to assess the potential impact of plant operation on the striped bass young-of-the-year population.

(c) Given that (1) fishing mortality appears to be a more important source of mortality than natural causes for adult striped bass once they enter the fishery, (2) the sport catch substantially exceeds the commercial catch, and (3) the staff believes the sport-fishing effort in particular is likely to be dependent on the size of the striped bass population, that the staff has assumed that the combined fishery will respond in a compensatory manner, with or without new fishing regulations, so as to partially offset the increased mortality due to the power plants. On the basis of this assumption the staff included a density-dependent, fishing-mortality function in its life-cycle model.

(d) In the absence of the Cornwall Pumped Storage Plant but including the impacts of Indian Point Units Nos. 1, 2, and 3 plus the Bowline, Lovett, Danskammer, and Roseton Plants, the percent reduction values from the staff's new young-of-the-year striped bass model range from 34 to 50% with once-through cooling at both Units Nos. 2 and 3, (base design), from 30 to 46% with a cooling tower at Unit No. 2 and once-through cooling at Unit No. 3 (Alternative A), and from 23 to 37% with cooling towers at both Units Nos. 2 and 3 (Alternative B). With Cornwall, the percent reduction values range from 47 to 64% for the base design, from 44 to 61% for Alternative A, and from 38 to 55% for Alternative B. All of these percent reduction values are relative to the clean river (i.e., no power plants withdrawing water from the Hudson River) as the baseline.

(e) Based on the results of the staff's striped bass life-cycle model without Cornwall but including the effects of the Bowline, Lovett, Danskammer, and Roseton Plants in addition to Indian Point Units Nos. 1, 2, and 3, the staff concludes the following: The number of years the size of the Hudson River spawned striped bass population is forecast to be less than 50% of its original size before the power plant impact ranges from 15 to 36 years for the case of once-through cooling at Indian Point (base design) and from 0 to 33 years for the case of a closed-cycle cooling at Unit No. 2 and once-through cooling at Unit No. 3 (Alternative A). The increase in the cumulative fishery yield from the Hudson River spawned striped bass population integrated over 80 years as a percent of the yield for the case of once-through cooling at all three Units ranges from 4 to 5% and from 9 to 14% for Alternatives A and B, respectively.

When Cornwall is included, the results are the following: The number of years the size of the striped bass population is forecast to be less than 50% of its original size ranges from 41 to 55 and 38 to 54, and 28 to 53 for the base design, Alternative A, and Alternative B respectively. The increase in the cumulative fishery yield integrated over 100 years as a percent of the yield for the case of once-through cooling at all three Units ranges from 3 to 4% for Alternative A.

(f) The staff estimates that the Hudson River spawned striped bass population is the major source (90%) of striped bass caught in an Inner Zone, which is made up of the Hudson River, the western half of Long Island Sound (Port Jefferson, Long Island to Bridgeport, Connecticut), and the New York Bight (Barnegat Inlet, New Jersey to Moriches Inlet, Long Island). The staff defines an Outer Zone of influence of the Hudson River spawned striped bass population as extending from Maine to Cape May County, New Jersey, inclusive, less the Inner Zone just defined. In light of the uncertainty concerning the percentage contribution of the Hudson stock to this Outer Zone, the staff has assumed values of both 10% and 50% in estimating the economic impact of the Indian Point Plant on the striped bass fisheries.

(g) There is a paucity of information documenting the size of the total fishery in the Inner and Outer Zones. However, the commercial striped bass landings in the Inner Zone are not great on either a relative or an absolute scale. In

1970, the estimated sport catch of striped bass, on the other hand, exceeded the commercial landings by a factor of 16 for the North Atlantic Region, which includes the Inner Zone.

(5) Operation with once-through cooling at Indian Point may cause decreases in the populations of other fish species in the Hudson River estuary.

(6) In spite of limitations, the staff's present position with reference to the applicant's research program is that the program has the potential (1) of resolving, at least partially, several of the important issues in controversy, and (2) of evaluating alternative mitigating measures besides closed-cycle cooling systems such as culturing and stocking Hudson River striped bass and alternative fish impingement protection measures.

(7) In summary, it must be pointed out that the present approach of treating each new plant on the Hudson River as a separate benefit-cost (or risk) exercise contains a bias against preserving the environment. This approach conceivably could result ultimately in the complete destruction of the Hudson River striped bass population. Nevertheless, for each new plant the benefits of cooling towers (or whatever measures were taken) would be calculated to be less than the costs (or risks) because the incremental (fractional) damage to the striped bass population would be less with each additional power plant. But, beyond some point, society is likely to conclude that further deterioration of the striped bass population is intolerable.

Furthermore, the possibility that the additional effect of once-through cooling at Indian Point Unit No. 3 (added to the effects of Indian Point Units Nos. 1 and 2 plus the other power plants on the river) will be the "straw that broke the camel's back" is a risk which cannot be lightly overlooked. The adult model indicates full recovery of the fishery after cessation of the operation of the plants on the river. However, the model may not be an accurate representation of the dynamics of the striped bass population with respect to large perturbations [see App. B, Sect. B.4.c.(7)(c)]. It is possible that if the insult of the power plants exceeds some maximum value for long enough, the Hudson River spawned striped bass population will not fully recover. Rather it may seek some new lower equilibrium value.

It is the staff's position that the number of years the relative yield is forecast to be less than 50% of its original size before the power plant impact is an index of the risk of irreversible damage to the population. This risk and the extent of irreversible damage cannot be more rigorously quantified. Furthermore, there are no generic guidelines as to what risk and extent of irreversible damage is acceptable or unacceptable to society. Such decisions are a matter of judgment. It is the staff's judgment that for the base design and Alternative A (with or without Cornwall), the risk of irreversible damage to the Hudson River spawned striped bass population is of sufficient concern that the long-term operation of Indian Point Unit No. 3 with once-through cooling is unacceptable.

E. RADIOLOGICAL IMPACT OF ROUTINE PLANT OPERATION ON MAN

1. Description of Radioactive Waste Management Systems and Estimates of Radioactive Discharges

a. Radioactive Waste

The operation of Indian Point Unit No. 3 will result in the production of radioactive fission products, the bulk of which will remain within the cladding of the fuel rods. Small amounts of these fission products will escape from the fuel cladding into the primary coolant. In addition, some radioactive materials will be produced as a result of neutron activation of corrosion products in the coolant. Some of these materials in low concentrations may be released in liquids to the Hudson River or released into the atmosphere as gases under controlled conditions after appropriate treatment, sampling, and monitoring. The radioactivity that may be released to unrestricted areas during operation of Unit No. 3 at full power level will be in accordance with the Commission's regulations, as set forth in 10 CFR 20 and 10 CFR 50.

At the Indian Point Plant, Units Nos. 1, 2, and 3 have independent waste handling and treatment facilities except for common laundry facilities provided by Unit No. 1 for the entire site. Steam generator blowdown treatment systems for all three Units will be intertied through Unit No. 1 by May 1, 1975. The waste handling and treatment systems for Unit No. 1 are described in the applicant's Hazards Summary Report for Unit No. 1, dated January 1960, and supplements and Semi-Annual Operating Reports. The waste handling and treatment systems installed in Unit No. 2 are described in the applicant's Final Facility Description and Safety Analysis Report of October 1968, and supplements.

The radioactive waste handling and treatment systems for Indian Point Unit No. 3 are described in the Final Facility Description and Safety Analysis Report, dated December 1970, and amendments and the Environmental Report dated June 1971, and supplements. These systems are designed to provide for the controlled handling and treatment of radioactive liquid, gaseous, and solid wastes. Section 11 of the staff's Safety Evaluation Report dated September 21, 1973 contains the details of the design criteria to limit releases to as low as practicable. The principal conditions and parameters used in calculating the releases of radioactivity from Unit No. 3 are summarized in Appendix D of this Statement. The waste treatment facilities for Unit No. 3 as presented by the applicant are similar in all respects to those provided for the proposed modified treatment systems for Unit No. 2, as described in the Final Environmental Statement dated September 1972 (FES, IP-2, pp. III-49 to III-65). These modifications include: (1)

the steam generator blowdown intertie to the Unit No. 1 Secondary Boiler Blowdown Purification System (SBBPS), with the off-gas treatment from the Unit No. 1 flash tanks through the main condenser and subsequently the Unit No. 1 superheater stack; and (2) charcoal adsorbers for the containment purge and the primary auxiliary building ventilation systems.

The following evaluation is based on the staff's model, which is adjusted to apply to Unit No. 3, and uses somewhat different operating conditions such that the staff's calculated effluent releases are, therefore, different from those of the applicant's; however, the staff's model used results from a review of available data from operating reactors. Based on the staff's evaluation of the gaseous radioactive waste systems for Indian Point Unit No. 3, the staff has concluded that the calculated radiation dose rates from the radioiodine released in the gaseous effluents will meet the Commission's "as low as practicable" guidelines.

b. Liquid Wastes

The liquid radioactive waste treatment systems for Unit No. 3 will include the reactor coolant treatment system, waste disposal system, and steam generator blowdown treatment system, as shown schematically in Fig. V-20 and are designed to reduce radioactive materials in liquids discharged from Unit No. 3. These systems are similar to those used for Unit No. 2. In addition, when the steam generator blowdown contains radioactive material above a predetermined value, a monitor will signal an alarm and the blowdown will be manually routed and processed through the Unit No. 1 SBBPS along with the blowdown from Units Nos. 1 and 2. The laundry and hot shower wastes are also processed at Unit No. 1. The liquid effluents will be continuously monitored before being discharged through the circulating water duct to the Hudson River. If the radioactivity exceeds a predetermined value, the discharge will be automatically stopped by a valve on the discharge line and the liquid effluent will be recycled for further treatment.

(1) Reactor Coolant Treatment System

The reactor coolant treatment system will collect and process deaerated liquids from reactor coolant letdown and from equipment leaks. During normal operation the reactor coolant will be let down continuously and be processed to maintain coolant quality in the chemical and volume control system (CVCS). Part of the letdown stream, the shim bleed, will be sent to the boron recycle system. These streams will be collected in the reactor coolant drain tank and the CVCS holdup tank. Batches will be processed by cation demineralization, filtration, gas stripping, and

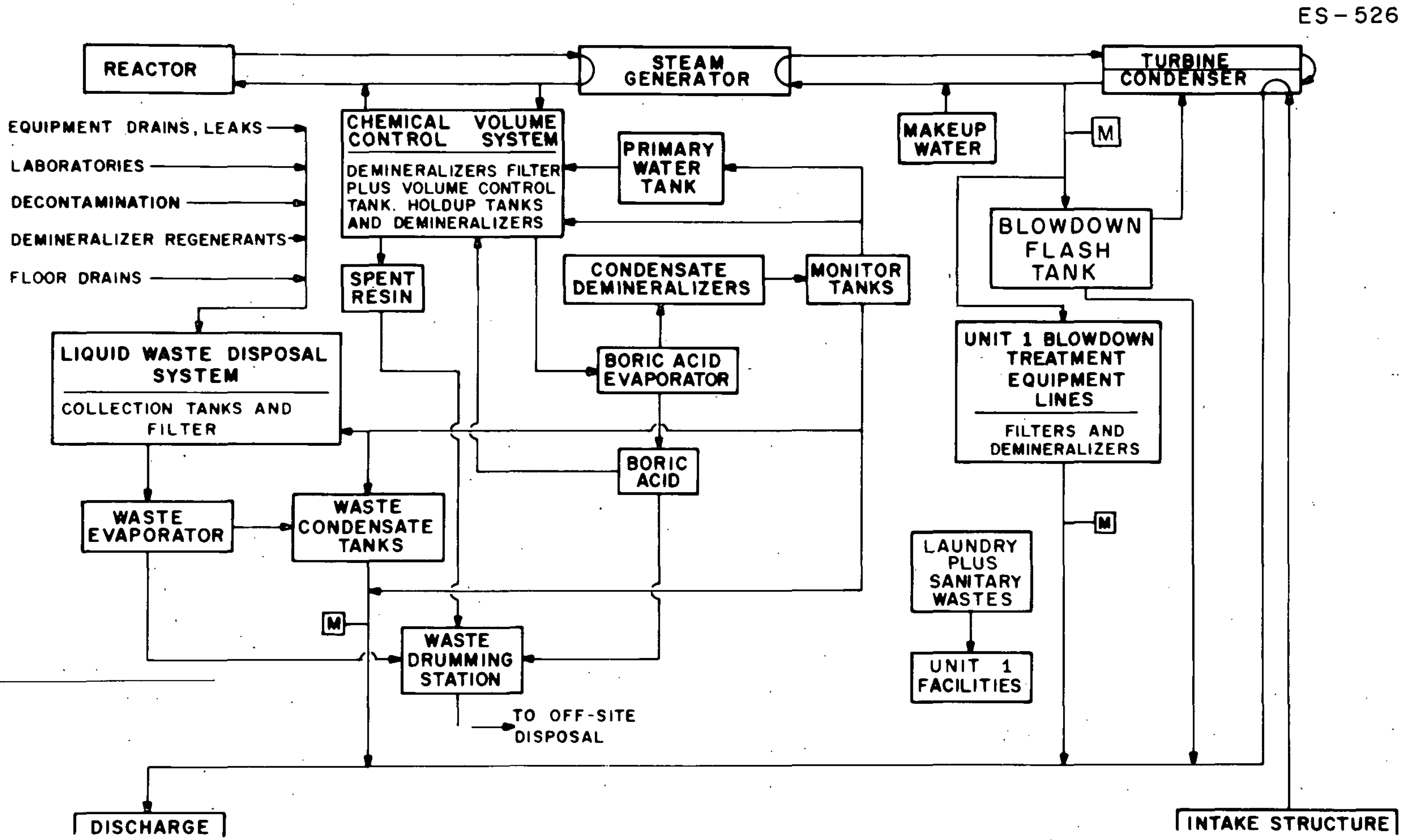


Fig. V-20. Liquid radioactive waste treatment systems for Indian Point Unit No. 3.

evaporation. The condensate from the evaporator will be processed through an anion demineralizer to remove principally radioiodines and routed to one of two monitoring tanks. After sampling and analysis, the waste will be either recycled for additional treatment, or returned to the primary coolant system for reuse in the reactor, or released to the discharge canal. The boron concentrate from the evaporator will either be recycled to the reactor coolant system or pumped to the solid waste system and packaged as solid waste. In its evaluation, the staff assumed that 90% will be returned to Unit No. 3 for reuse and that 10% of the condensate will be continuously monitored and released through the discharge canal to the Hudson River. The condensate can also be processed in the liquid waste disposal system. The wastes processed through the boric acid demineralizers and evaporators result in an estimated release of 0.035 Ci/year of radioactive material, excluding tritium and dissolved gases.

(2) Liquid Waste Disposal System

The radioactive liquid waste disposal system will process aerated wastes from the equipment, floor, laboratory, and sampling drains along with demineralizer regenerant and decontamination solutions. These wastes will be collected in the waste holdup tank and batch processed through a filter and a 2-gpm evaporator. The evaporator condensate will be collected in one of two waste condensate tanks, monitored, sampled, analyzed, and recycled if required. The staff assumed that after sampling and analysis, the condensate will be continuously monitored and released to the discharge canal. If the radioactivity exceeds a predetermined value, the discharge will be automatically isolated by a valve on the discharge line and recycled through the waste disposal system. Evaporator concentrates and spent filters will be packaged as solid waste and shipped offsite for disposal at a licensed burial ground. The staff evaluation showed that approximately 2 Ci/year of radioactive material, excluding tritium and dissolved gases, will be released. This release rate agreed with that of the applicant's.

(3) Steam Generator Blowdown

As shown in Fig. V-20, the steam generator blowdown from Unit No. 3 can be directed through the blowdown line to the flash tank installed at Unit No. 3 or through the SBBPS system at Unit No. 1. The flash tank at Unit No. 3 is expected to process only low-level radioactivity wastes. Wastes discharged from this flash tank would enter the environment without treatment. The applicant reports[124] that the maximum annual release from the Unit No. 3 BFT would be about 1 Ci of total mixed activity in the blowdown condensate and 0.04 Ci of iodine-131 in the vapor. The gases from the Unit No. 3 BFT will be vented directly to the atmosphere through an unmonitored roof vent at Unit No. 3 and the liquid releases from the Unit No. 3 BFT will not be monitored. The staff considers that the lack of monitoring of the releases from the Unit No. 3 BFT will not meet the requirements of General Design Criterion 64 of Appendix A of 10 CFR 50 and the guidelines of Regulatory Guide 1.21. See Fig. V-20 for a diagram of this system. The applicant[124,125] has been informed that these requirements will have to be met prior to issuance of an operating license. On July 29, 1974, the applicant responded by describing a monitoring system for the gases from the rooftop vents which will be installed at Units Nos. 1 and 3 by May 1, 1975.

Samples are collected from each of the four steam generators and continuously monitored by a scintillation counter. When the radioactivity level in the secondary coolant at Unit No. 3 is below a predetermined value (3×10^{-5} μCi/cc), the blowdown is routed to the Unit No. 3 BFT and treated as described above.

When the radioactivity in the secondary coolant at Unit No. 3 exceeds a predetermined value, the monitor will activate an alarm and automatically close isolation valves on the blowdown and sampling lines. The Unit No. 3 blowdown stream will be manually routed to the SBBPS in Unit No. 1. The steam generator blowdown from Unit No. 3 will be processed through the Unit No. 1 SBBPS as described in the Semi-Annual Operating Report for Unit No. 1, dated December 15, 1972. This system, of 132-gpm capacity, will consist of a flash tank, heat exchanger, two filters, and two mixed-bed demineralizers, and is capable of handling blowdown simultaneously from all three Units. The steam and noncondensibles from the Unit No. 1 flash tank will be routed to the main condenser in Unit No. 1 and subsequently discharged through the superheater stack. Effluent from the demineralizers will be required to be monitored and released to the discharge canal. If the radioactivity in the demineralizer effluent exceeds a predetermined value, it will activate an alarm requiring the operator to take appropriate action.

The staff's evaluation for Unit No. 3 was based on a steam generator blowdown rate of 10 gpm in which an estimated release of 1.7 Ci/year of radioactive material, excluding tritium and dissolved gases, would result through the Unit No. 1 SBBPS, regardless of the operability of Unit No. 1. However, the applicant has stated that the blowdown rate may be increased to 50 gpm, which the staff calculates will result in a release rate of 2.1 Ci/year through the Unit No. 1 SBBPS. This increase will have no significant effect on the radioactive material released in the liquid waste from Unit No. 3. About one-third of the blowdown is flashed to steam and the remaining two-thirds of the liquid is then treated. Low-level radioactive liquid wastes due to turbine hall leaks are collected in the turbine building drains from which the wastes will be discharged to the discharge canal without treatment.

Based on the staff's evaluation of the modified liquid waste treatment systems* for Unit No. 3, the annual releases of radioactive materials, excluding tritium and dissolved gases, in liquid effluents discharged to the Hudson River were calculated to be a total of 3.8 Ci/year, a fraction of those shown in Table V-29. However, to compensate for anticipated operational occurrences and equipment downtime, the values have been normalized from 3.8 Ci/year to about 5 Ci/year.

Based on the experience of operating PWRs, the tritium releases from Unit No. 3 were estimated to be about 350 Ci/year; the applicant's estimated releases from Unit No. 3 were 610 Ci/year of tritium and 9.6 Ci/year for all other radionuclides.

Based on its evaluation, the staff concluded that the radioactive liquid waste treatment system for Unit No. 3 will be adequate to meet the Commission's "as low as practicable" guidelines, provided that the SBBPS is operational to reduce the radioactivity content of the liquid effluent, primarily the steam generator blowdown from each Unit, to less than 5 Ci/year, excluding tritium.

(4) Combined Releases of Radioactive Materials in Liquid Wastes from Units Nos. 1, 2, and 3

As indicated in Table V-30, the total radioactive material released from the liquid waste treatment systems to the Hudson River from the Indian Point Units Nos. 1, 2, and 3 has been calculated to be less than 15 Ci/year for all radionuclides except tritium and dissolved gases. The steam generator blowdown from Units Nos. 1, 2, and 3 was assumed to flow to the Unit No. 1 system for treatment of the blowdown from all three Units. The releases of radionuclides, except for tritium and dissolved gases, from Units Nos. 1, 2, and 3 were normalized from 3.8 Ci/year/Unit to about 5 Ci/year/Unit to compensate for anticipated operational occurrences and equipment downtime.

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*Includes the intertie from the Unit No. 3 steam generator blowdown to Unit No. 1 SBBPS and off-gas flow from the flash tank to the Unit No. 1 main condenser and stack. Interties are to be installed by May 1, 1975, or by initial criticality, whichever occurs later. (Suppl. 28 to FFDSAR, January 13, 1975).

Table V-29. Calculated annual release of radioactivity in liquid effluent from Indian Point Units Nos. 1, 2, and 3 (modified system)

Radionuclide	Ci/year per unit	Radionuclide	Ci/year per unit
Cr-51	0.0012	Rh-106	0.000015
Mn-54	0.00043	Te-125m	0.000041
Fe-55	0.0013	Te-127m	0.00032
Fe-59	0.00041	Te-127	0.00044
Co-58	0.012	Te-129m	0.0032
Co-60	0.0013	Te-129	0.0021
Rb-86	0.0033	Te-131m	0.0012
Rb-88	0.081	Te-131	0.00023
Sr-89	0.00041	Te-132	0.021
Sr-90	0.000015	I-130	0.0015
Sr-91	0.00014	I-131	0.89
Y-90	0.00011	I-132	0.084
Y-91m	0.00074	I-133	0.48
Y-91	0.033	I-135	0.096
Y-93	0.00024	Cs-134	1.17
Zr-95	0.000068	Cs-136	0.48
Zr-97	0.000013	Cs-137	0.89
Nb-95	0.000066	Ba-137m	0.22
Nb-97m	0.000013	Ba-140	0.00046
Nb-97	0.000015	La-140	0.00031
Mo-99	0.4	Ce-141	0.000075
Tc-99m	0.33	Ce-143	0.000024
Ru-103	0.000049	Ce-144	0.000043
Ru-106	0.000015	Pr-143	0.000060
Rh-103m	0.000049	Pr-144	0.000043
Rh-105	0.000015	Nd-147	0.000024
		Pm-147	0.000006
		Np-239	0.00039
		Total	~5 Ci/year per unit
		H-3	~350 Ci/year[a]
			~1,500 Ci/year[b]

[a]For Units Nos. 2 or 3.
[b]For Unit No. 1 (based on operating experience).

Table V-30. Calculated radioactivity releases in effluents from Indian Point Units Nos. 1, 2, and 3

Unit No.	Power (MWt)	(Ci/year) Liquids Radionuclides[a]	Liquids Tritium	Gases Noble gases	Gases I-131
		Unit No. 2 present system			
1	615	5	1,500	1,200	0.06
2	2,758	22	350	3,000	0.73
3	3,216	5	350	2,700	0.41
		32	2,200	6,900	1.20
		After Unit No. 2 modifications			
1	615	5	1,500	1,200	0.06
2	3,216	5	350	2,700	0.41
3	3,216	5	350	2,700	0.41
		15	2,200	6,600	0.88

[a]Other than tritium.

Based on the experience of similar operating PWRs, the staff has estimated that the total tritium release from all three Units will be approximately 2200 Ci/year. The applicant has estimated releases of radioactive material in liquid wastes from all three Units to be 20 Ci/year, excluding tritium, and 2200 Ci/year of tritium. Based on its evaluation, the staff concludes that the radioactive liquid waste treatment systems for Units Nos. 1, 2, and 3 will be adequate to meet the Commission's "as low as practicable" guidelines, provided the SBBPS of Unit No. 1 is operational to handle and treat the blowdown on a continuous basis from either Units Nos. 2 or 3 or both.

Unit No. 2 can operate with the blowdown stream untreated until May 1, 1975. During the period up to that time the staff calculated that the release of radioactive material from Unit No. 2, excluding tritium, will be about 22 Ci/year as presented in Table V-31. When Unit No. 3 comes on line starting in 1975, the combined operation of all three Units without the intertie available for treatment of the blowdown through the Unit No. 1 SBBPS will result in additional releases of liquid radioactive material from the Plant. Before the blowdown modifications at Units Nos. 2 and 3 are completed, the releases of radioactive material in the liquid effluent are calculated to exceed the Commission's "as low as practicable" guidelines. However, the applicant will be required by the plant technical specifications to monitor the releases to

Table V-31. Calculated annual release of radioactive material in liquid effluent from Indian Point Unit No. 2 (present system)

Radionuclide	Steam generator blowdown (Ci/year per unit)	Reactor coolant treatment (Ci/year per unit)	Waste disposal system (Ci/year per unit)
Cr-51	0.035		0.00006
Mn-56	0.032		
Fe-55	0.032		0.00005
Fe-59	0.019		0.00003
Co-58	0.32	0.00003	0.00051
Co-60	0.039		0.00006
Rb-86	0.0030		
Rb-88	0.075		
Sr-89	0.016		0.00002
Sr-90	0.00042		
Sr-91	0.005		
Y-90	0.00002		
Y-91m	0.003		
Y-91	0.00025	0.00010	
Y-93	0.00001		
Zr-95	0.002		
Nb-95	0.002		
Mo-99	0.011	0.0047	0.00008
Tc-99m	0.010	0.0045	0.00008
Ru-103	0.002		
Ru-106	0.0004		
Rh-103m	0.002		
Rh-105	0.0005		
Rh-106	0.0004		
Te-125m	0.001		
Te-127m	0.011		0.00002
Te-127	0.015		0.00002
Te-129	0.035		0.00005
Te-131m	0.042		0.00003
Te-131	0.008		0.00001
Te-132	0.75	0.00006	0.00095
I-130	0.17		0.00002
I-131	9.6	0.0075	0.14
I-132	0.92	0.00006	0.00095
I-133	5.4	0.021	0.021
I-135	1.2	0.00008	0.00013
Cs-134	0.93	0.0034	0.0015
Cs-136	0.44	0.0067	0.00067
Cs-137	0.76	0.0028	0.0012
Ba-137m	0.72	0.0026	0.0012
Ba-140	0.017		0.00003
La-140	0.012		0.00002
Ce-141	0.003		
Ce-144	0.001		
Pr-143	0.002		
Pr-144	0.001		
Nd-147	0.0009		
Pm-145	0.0001		
Np-239	0.014		0.00002
Total	22	0.030	0.17 Ci/year per unit
H-3			~350 Ci/year per unit

the environment, and the limiting conditions for operation in the Plant technical specifications will be based on the staff's "as low as practicable" guidelines.

c. Gaseous Waste

During operation of Indian Point Unit No. 3, radioactive materials released to the atmosphere in gaseous effluents will include low concentrations of fission product noble gases (krypton and xenon), halogens (mostly iodines), tritium contained in water vapor, and particulate material, including both fission products and activated corrosion products. The gaseous waste treatment systems will include gas processing, containment purge, condenser air ejector, the steam generator blowdown vent, and ventilation for the turbine, auxiliary, and fuel storage buildings. These systems for Unit No. 3 are independent of Units Nos. 1 and 2, except for the steam generator blowdown system. The blowdown containing radioactive material above a predetermined level will be processed at Unit No. 1. The gaseous waste treatment system and ventilation exhaust points are shown schematically in Fig. V-21. The gaseous releases from all systems will require monitoring except the low-level ventilation air released from the turbine building. This will include a requirement to measure direct releases from the blowdown flash tanks in accordance with General Criterion 64 of Appendix A of 10 CFR 50 and the guidelines of Regulatory Guide 1.21. The gases released from the waste gas processing system, the containment purge, and the auxiliary building ventilation will be discharged through the Plant vent. Ventilation air from the turbine building will be discharged through the turbine building roof ventilation and wall exhaust fans. The condenser air ejector exhaust gases will be discharged through a monitored roof vent on the turbine building.

(1) Gas Processing

The waste gas processing system will provide treatment for the gases stripped from the reactor coolant along with the displaced cover gases from equipment in the CVCS system and the waste evaporator. The primary source of radioactivity is from degassing the shim bleed in the boron recovery evaporator system. In addition, the total CVCS and reactor coolant system will be degassed prior to refueling and during cold shutdowns. The collected gases will be compressed to 110 psig and held in four (525 ft^3 each) storage tanks for decay before release. A portion of the gas will be returned to the CVCS holdup tanks. The waste gases will be pumped to one of the four storage tanks and recycled to the CVCS holdup tanks to provide cover gas during release operations. A second tank will be available as backup. When 110 psig pressure is

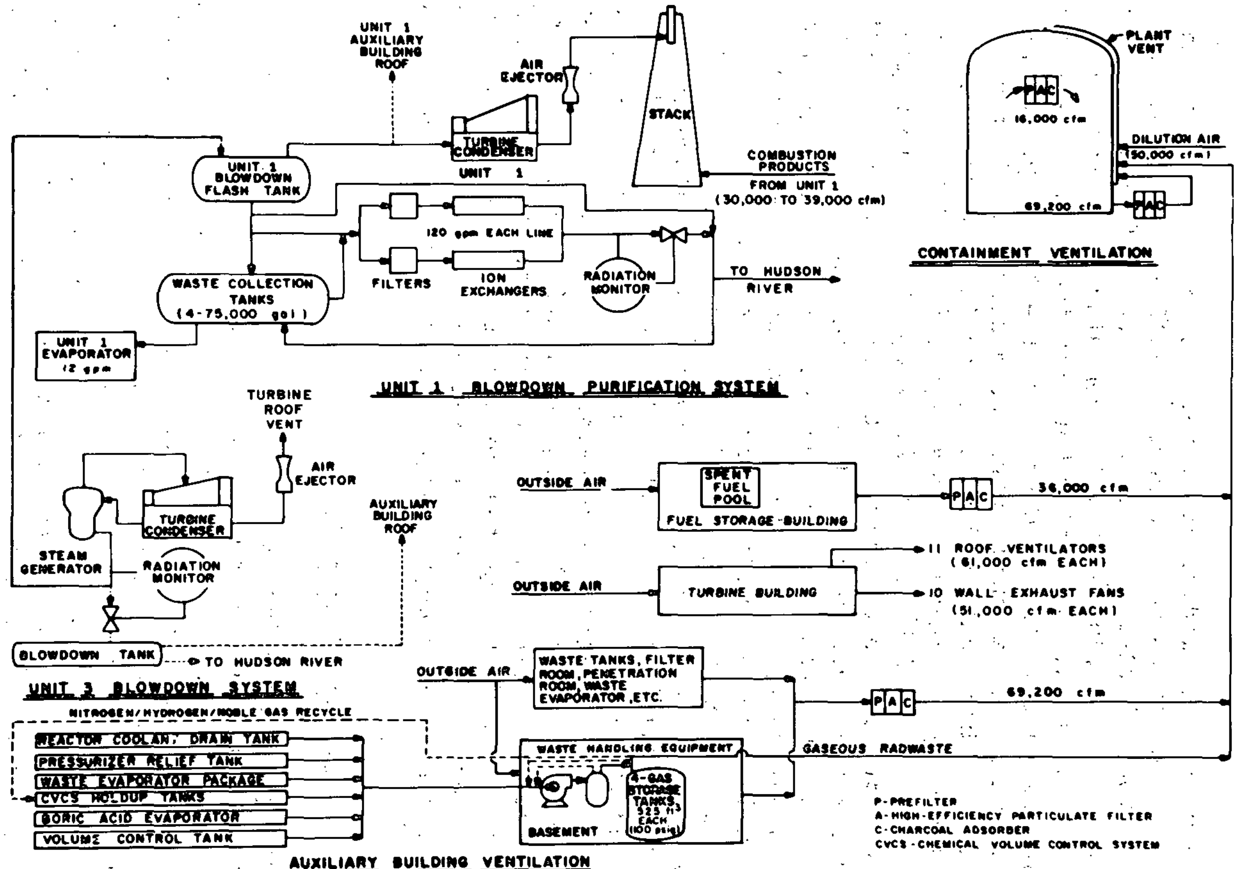

Fig. V-21. Gaseous radioactive waste treatment systems for Indian Point Unit No. 3.

reached in the inservice tank, the feed will be automatically switched to the backup tank. Prior to cold shutdown of the reactor or refueling, the reactor coolant will be degassed and the gas will be stripped, compressed and stored in six 40-ft^3 storage tanks. The gas released from the decay tanks will be combined with ventilation air exhausted from the auxiliary building and discharged to the atmosphere through the Plant vent on top of the containment building.

Before being released to the environment, the gases will be sampled and analyzed. During discharge at a controlled rate through the Plant vent, the gases will be continuously monitored. Radioactivity releases above a predetermined value will cause a valve to automatically close on the discharge line. Based on a minimum holdup time of 45 days, the applicant estimates averaged annual releases of 2000 Ci/year of noble gases and the staff, 1500 Ci/year of noble gases. Assuming normal operation and two complete primary system degassings per year, the staff has determined that the capacity of the gas processing system is adequate to store gases for 45 days.

(2) Containment Purge

Small amounts of radioactive gases from the reactor coolant leakage will accumulate in the reactor containment. The containment atmosphere will be purged about four times per year following preaccess cleanup. The equipment used for purging includes prefilters, HEPA filters, and charcoal adsorbers.* The filters and exhaust fans will be shared with the primary auxiliary ventilation system. Prior to purging, the containment air will be recirculated for 16 hr at the rate of 16,000 scfm through an internal cleanup system consisting of HEPA filters and a charcoal adsorber* to reduce the iodine concentration. Following this, the gas will be released to the Plant vent through HEPA filters and a charcoal adsorber.*

This shared system is acceptable since, during normal operations, the exhaust fans provide a negative pressure in the exhaust plenum. This will prevent the cross flow between the containment and the primary auxiliary buildings.

The applicant has estimated the radioactive material released from four purges per year to be 88 Ci of noble gases and 0.00014 Ci of iodine-131. Based on four purges each year and 16-hr internal

*The installation of the charcoal adsorbers will be required by May 1, 1975 or by initial criticality, whichever occurs later.

recirculation before purging, the staff calculated a release of 91 Ci/year of some noble gases and 0.027 Ci/year of iodine-131.

(3) Primary Auxiliary Building Ventilation

The ventilation systems for the auxiliary and spent fuel storage buildings have been designed to ensure that air flow will be from areas of low potential to areas having a greater potential for release of airborne radioactive material. The auxiliary building exhaust system will draw air from the equipment rooms and open areas of the building through HEPA filters and charcoal adsorbers* before the exhaust air will be released to the atmosphere through the reactor building vent. The applicant estimated that the radioactive material released will be approximately 1300 Ci/year of noble gases and less than 0.01 Ci/year of iodine-131. The staff's evaluation indicates 580 Ci/year of noble gases and 0.05 Ci/year of iodine-131 will be released.

(4) Fuel Storage Building Ventilation

The fuel storage building ventilation system includes a HEPA filter and charcoal adsorbers.* Normally exhaust air will pass through a HEPA filter and will be discharged to unrestricted areas through the monitored Plant vent. However, when the radioactivity is above a predetermined value, the ventilation exhaust air will be automatically diverted through charcoal adsorbers prior to release. The staff determined that the radioactive material released from this building under normal conditions will be negligible.

(5) Turbine Building Ventilation

Ventilation air from the turbine building will be released through 10 wall exhaust fans and 11 roof ventilators without treatment or monitoring. The applicant has estimated that the radioactive material released will be 0.01 Ci/year of iodine-131 and the staff estimated 0.04 Ci/year of iodine-131.

(6) Condenser Air Ejector

Off-gas from the condenser air ejectors containing radioactivity from primary to secondary system leakage in the steam generators and noncondensible gases will be monitored and then be vented without treatment to the atmosphere via a stack vent located on the roof of the turbine building. The applicant has calculated

*The installation of the charcoal adsorbers will be required by May 1, 1975 or by initial criticality, whichever occurs later.

that the activity released from the condenser air ejector will be 1300 Ci/year of noble gases and 0.065 Ci/year of iodine-131. The corresponding staff estimates are 580 Ci/year of noble gases and 0.13 Ci/year of iodine-131 from this source.

(7) Steam Generator Blowdown

The secondary coolant will be blown down from the steam generator to the Unit No. 3 flash tank at a rate of 10 gpm. The steam vapor from the Unit No. 3 flash tank will be released directly to the atmosphere, through a rooftop vent, which will require monitoring in accordance with General Criterion 64 of Appendix A to 10 CFR 50 and the guidelines of Regulatory Guide 1.21. The applicant plans to install a gaseous monitoring system at Units Nos. 1 and 3 by May 1, 1975. When the radioactivity in the secondary coolant is above a predetermined value, the blowdown will be automatically terminated and manually diverted to the SBBPS of Unit No. 1. The blowdown system of Unit No. 1 will also receive the blowdown from Units Nos. 2 and 3. Prior to treatment through the SBBPS, the liquid is passed to the flash tank of Unit No. 1 where it is flashed. The vapor is vented through the Unit No. 1 turbine condenser. The radioactivity released from the Unit No. 1 main condenser will be monitored and discharged through the Unit No. 1 main condenser will be monitored and discharged through the Unit No. 1 superheater stack. When Unit No. 1 is not operating, the flash tank vapor will be released directly to the atmosphere through the existing Unit No. 1 roof vent. The applicant estimated that Unit No. 1 will not be in operation for six weeks each year for this direct release, and that the vapor will contain 0.17 Ci/year of iodine-131. However, based on the operating history of Unit No. 1, the staff considered that the steam generator blowdown vapor from Unit No. 3 will be released directly to the atmosphere about 33% of the time and would amount to 0.16 Ci/year of iodine-131. The staff's evaluation for Unit No. 3 was based on a steam generator blowdown rate of 10 gpm. However, the applicant has stated that this may be increased up to 50 gpm. This reduces the radioiodine released from Unit No. 3 in the gaseous effluent by approximately 20%. In addition, Unit No. 1 will be shut down on October 31, 1974, for several years in order to install an emergency core cooling system to comply with the Commission's interim acceptance criteria. During this period, the staff considered that the blowdown from Units Nos. 2 and 3 would be processed through the Unit No. 1 SBBPS. If this system is not available, an alternate method of treating the blowdown from Units Nos. 2 and 3 will be required that will meet the Commission's "as low as practicable" guidelines.

(8) Gaseous Waste Summary

Based on its evaluation of Unit No. 3 gaseous waste treatment system, the staff has estimated that the annual release of radioactive material discharged to the atmosphere will be approximately 2700 Ci/year of noble gases and 0.41 Ci/year of iodine-131 during the time when Unit No. 1 is operational, as shown in Table V-32. The applicant indicated that approximately 5500 Ci/year noble gases and 0.16 Ci/year iodine-131 will be released to the environment from Unit No. 3. During the time when Unit No. 1 is shut down, the iodine-131 release from the rooftop vent at Unit No. 1 is calculated to be 0.73 Ci/year.

Based on evaluation of the radiological doses (as presented in Section E.2) from the gaseous radioactive waste treatment systems for Unit No. 3, the staff concluded that its calculated radiation dose rates for the radioiodine released in the gaseous effluents will meet the Commission's "as low as practicable" guidelines.

(9) Units Nos. 1, 2, and 3 Releases of Radioactive Gaseous Waste

The total radioactivity released from the modified gaseous waste treatment systems to the atmosphere for Indian Point Units Nos. 1, 2, and 3 has been calculated by the staff to be approximately 6600 Ci/year of noble gases and 0.88 Ci/year of iodine-131 with Unit No. 1 in operation at least 67% of the time (Tables V-33, V-34, and V-35). The applicant estimates that the combined releases of radioactive material from Units Nos. 1, 2, and 3 will be 11,000 Ci/year of noble gases and 0.32 Ci/year of iodine-131. When Unit No. 1 is shut down on October 31, 1974, the annual iodine-131 releases from the initial and modified systems is calculated to be 1.46 Ci/year.

As indicated by the radiological doses in Section E.2, the staff evaluation shows that the releases from the gaseous radioactive waste treatment systems from Units Nos. 1, 2, and 3 will meet the Commission's "as low as practicable" guidelines, provided the Unit No. 1 SBBPS is operational.

During the combined operation of Units Nos. 1, 2, and 3, up to May 1, 1975, the blowdown stream and ventilation exhaust from the primary auxiliary building at Units Nos. 2 or 3 will be untreated (see Tables V-34 and V-35). During that period, the staff calculated that the radioiodine release rates without continuous treatment of the blowdown will result in calculated radiation doses that meet the Commission's "as low as practicable" guidelines. In addition, the applicant will be required to monitor the radioiodine

Table V-32. Calculated annual release of radioactive nuclides in gaseous effluent from Indian Point Units Nos. 2 and 3 (modified system)

Radionuclide	Discharge rate (Ci/year per unit)						
	Containment purge	Auxiliary building	Turbine building	Gas processing system for 45-day decay	Steam generator leak: Air ejector	Steam generator leak: Blowdown tank vent	Total
Kr-83m	*a*	1	*a*	*a*	1	*a*	2
Kr-85m	*a*	6	*a*	*a*	6	*a*	12
Kr-85	2	1	*a*	870	1	*a*	870
Kr-87	*a*	3	*a*	*a*	3	*a*	6
Kr-88	*a*	11	*a*	*a*	11	*a*	22
Xe-131m	1	2	*a*	81	2	*a*	86
Xe-133m	*a*	9	*a*	*a*	9	*a*	18
Xe-133	88	530	*a*	470	530	*a*	1,600
Xe-135m	*a*	1	*a*	*a*	1	*a*	2
Xe-135	*a*	17	*a*	*a*	17	*a*	34
Xe-137	*a*	1	*a*	*a*	1	*a*	2
Xe-138	*a*	2	*a*	*a*	2	*a*	4
Total noble gases	91	580	*a*	1,500	580	*a*	2,700
I-131	0.027	0.05	0.04	*a*	0.13	0.16[b] (0.48)[c]	0.41 (0.73)[c]
I-133	0.027	0.07	0.02	*a*	0.066	0.08 (0.24)[c]	0.27 (0.43)[c]

[a]Less than 1 Ci/year of noble gases or less than 10^{-4} Ci/year of iodine.
[b]Blowdown released from Unit No. 1, all ground releases.
[c]Values in parentheses are for years when Unit No. 1 is not operating.

Table V-33. Anticipated annual release of radioactive material in gaseous effluent from Indian Point Unit No. 1[a] (modified system)

Radionuclide	Ci/year
Kr-85	180
Kr-87	1.7
Kr-88	5.6
Xe-133m	8.4
Xe-133	1,000
Xe-135	2.0
Xe-138	1.2
Total noble gases	1,200
I-131	0.06[b]

[a]Anticipated releases are based on previous operating history.
[b]Includes radioactive half-lives of eight days or more, ground release.

Table V-34. **Calculated annual release of radioactive material in gaseous effluent from Indian Point Unit No. 2 (present system)**

Radionuclide	Containment purge (Ci/year)	Gas processing system for 45-day holdup (Ci/year)	Steam generator leak, blowdown, and air ejector (Ci/year)	Total (Ci/year)
Kr-85	13	790	2.1	810
Kr-87	0.044		2.9	3
Kr-88	0.31		9.4	10
Xe-131m	9.6	63	3.4	76
Xe-133	1,000	390	680	2,100
Xe-135	0.35		3.2	3.6
Xe-138	0.007		2.2	2.2
Total noble gases	1,000	1,200	700	3,000
I-131	0.018		0.62	0.64[a]
I-133	0.018		0.31	0.33[a]

[a]An additional 0.09 Ci/year of I-131 and 0.02 Ci/year of I-133 will be released from the auxiliary and turbine building ventilation systems.

Table V-35. **Points of release and sources of gaseous radioactive iodines for the initial and modified radioactive waste systems**

Point of release (Unit No.)	Source of release (Unit No.)		Release rate (Ci/year)[a] Initial I-131	Initial I-133	Modified I-131	Modified I-133
1	1		0.06	0	0.06	0
	2		0	0	0.16	0.08
	3		0.16	0.08	0.16	0.08
		Subtotal	0.22	0.08	0.38	0.16
2	2		0.73	0.35	0.25	0.19
3	3		0.25	0.19	0.25	0.19
		Total	1.20	0.62	0.88	0.54

[a]When Unit No. 1 is operational 67% of the time. However, when Unit No. 1 is not in operation at all, the total release rate from all three Units is 1.46 Ci/year of I-131 for both the initial and modified system and 0.78 Ci/year of I-133 for the initial system and 0.86 Ci/year of I-133 for the modified system.

in milk and evaluate the results in accordance with the guidelines in Regulatory Guides 4.1 and 4.3 and to keep releases within the technical specifications.

Based on the staff evaluation of the gaseous radioactive waste treatment of Unit Nos. 1, 2, and 3, the staff concluded that the releases will meet the Commission's "as low as practicable" guidelines.

d. Solid Waste

The solid wastes from the reactor operations will include the evaporator concentrates from the liquid waste processing system along with spent resins, filter sludges, air filters, miscellaneous paper, and rags. The evaporator concentrates will be solidified by mixing with vermiculite and cement in 55-gal drums. A six-drum station will be provided for loading spent resin and evaporator concentrates. The spent resins will be stored for one to six months for decay of short-lived activity, washed, dewatered, and transferred to 55-gal drums. The wash water will be returned to the waste holdup tank for treatment and disposal. Paper, rags, and protective clothing will be compressed in 55-gal drums. Other solid wastes, including spent air filters, will be packaged in approved containers. After a suitable period of storage in a storage area of the drumming room to allow for decay, the packaged wastes will be shipped to a licensed burial facility in accordance with AEC or DOT regulations. The applicant has estimated that approximately 150 drums of solid waste will be packaged and shipped each year. Based on the experience of operating reactors, the staff has estimated that 4900 Ci/year of radioactivity in 1000 drums will be shipped. The proposed system is similar to those previously reviewed. The staff concludes that the solid waste system will be acceptable. See Section V.F regarding transportation of radioactive wastes and the corresponding radiological dose commitments to the public.

2. Radiological Impact on Man

a. Introduction

The radioactive waste treatment systems to handle and process radioactive liquid, gaseous, and solid wastes have been designed to limit routine releases to unrestricted areas in accordance with Table II in 10 CFR 20. This limits the maximum radiation doses to individuals in the population to 500 millirems to the whole body in any period of one calendar year. No detectable radiological effects on man are expected to result from releases of radionuclides meeting 10 CFR 20 limitations. In addition, the staff's evaluation of the radioactive waste treatment system is based on the release of radioactive material from the Indian Point facility to meet "as low as practicable" guidelines in 10 CFR 50. The critical pathway for exposure of adults and children to radioiodine has been identified to be the grass-cow-milk pathway (Regulatory Guide 4.1). In accordance with Regulatory Guide 1.42, the requirement is that the annual average radiation dose to a 2-gram thyroid of a two-year old child from radioiodine will be less that 15 millirems. For Indian Point Unit No. 3, the estimated dose is based on the location of the nearest actual cow, approximately seven miles south-southwest of the Station. According to the applicant, the nearest potential cow is the same as the actual cow. Since the surrounding area is zoned for industrial and residential use, sufficient land for pasturing cows is not available. Annual radiation doses to individuals in millirems and to the population in man-rems within 50 miles of the Plant were estimated based on releases of radioactive effluents from normal operation of Unit No. 3 alone and all three Units of the Plant. A discussion of the general considerations for determination of dose estimates can be found in the Final Environmental Statement for Unit No. 2 (FES, IP-2, pp. V-74 to V-90).

b. <u>Summary of Estimated Radioactive Releases</u>

Estimates of dose from exposure to gaseous effluents from the Station are based on: (1) the "initial" radioactive waste system for Unit No. 2 and the "modified" systems for Units Nos. 1 and 3,* and (2) the radioactive waste system which will be in use following the modifications of Unit No. 2. For both cases, Unit No. 3 was assumed to release those gaseous radionuclides listed in Table V-32, and Unit No. 1 to release those listed in Table V-33. The gaseous releases from Unit No. 2 are given in Table V-34 for the initial system and in Table V-32 for the modified system. Because of the eventual SBBPS interties between Units Nos. 2 and 3 to Unit No. 1, the gaseous radioactive releases of radioiodine from Units Nos. 2

*The "initial" radioactive waste system for Unit No. 2 has no steam generator intertie between Units Nos. 2 and 1 and thus no capability of blowdown treatment through the SBBPS at Unit No. 1. The modified system at Unit No. 1 contains such equipment in the SBBPS and will be intertied to Unit No. 3 as the applicant described its system in the Environmental Report and the Final Facility Description and Safety Analysis Report. The "modified" system includes the capability of the SBBPS at Unit No. 1 to treat all steam generator blowdown.

or 3 as given in Tables V-30, V-32, V-33, and V-34 will be released through the flash tank in the SBBPS in Unit No. 1. The amounts of radioiodine released from each Unit and the source of the releases are given in Table V-35. Man-rem dose estimates are based on the applicant's population projections for the year 1980 (ER, IP-3, Vol. I, App. F, p. 13). Site meteorological data used in the computational models are given in Appendix E (Supplement 16 to FFDSAR).

The anticipated quantities of radionuclides in the liquid effluents discharged from the initial and modified radioactive waste systems are listed in Table V-36. As a conservative estimate, it is assumed that the radionuclides released will be mixed with the service water flow of 100,000 gpm, discharged to the river, and further diluted by a factor of 18 by a net freshwater flow in the Hudson River of 4000 cfs.

Radioactivity in the refueling water storage tanks and the primary coolant, and various sources in the turbine-generator and primary-auxiliary buildings all contribute to the direct radiation of individuals at the visitors' center and offsite. The total-body dose from direct radiation is based on information supplied by the applicant (ER, IP-3, App. FF, pp. IV-8 to IV-10).

c. Dose Estimates for Various Pathways

The pathway by which man becomes subjected to radiation through his own physiological mechanisms and those of his food are illustrated in Fig. V-22. The potential radiation doses to individuals living within a 50-mile radius of the Station from the radioactive releases were based on calculations using conservative assumptions as to estimating dilution of effluents, biological accumulation of radionuclides in food chains leading to man, and use factors for people. In estimating the radiation doses that man may receive by ingestion of fish and other aquatic species, capacity of the food species to accumulate selectively a number of waterborne elements must be accounted for. See Table C-1 for bioaccumulation factors. In Table V-37 the annual dose to an individual at various locations is summarized. Estimates of the cumulative man-rem doses to the general population in 1980 from immersion in the gaseous effluents at various distances from Unit No. 3 are given in Table V-38. A summary of the man-rem doses to the general population is given in Table V-39. Details of the estimated doses from the transportation of radioactive materials are given in Section V.F. and summarized in Table V-41.

Table V-36. Estimates of radioactivity in Hudson River from liquid releases from Indian Point Units Nos. 1, 2, and 3 for the initial and modified radioactive waste systems[a]

The letter E followed by a number denotes multiplication by a power of 10; e.g., 6.1E−07 means 6.1 × 10^{-7}

Radionuclide	Concentration (μCi/cm^3)		Radionuclide	Concentration (μCi/cm^3)	
	Initial	Modified		Initial	Modified
H-3	6.1E−07[b]	6.1E−07	Rh-106	1.1E−13	1.3E−14
Cr-51	1.0E−11	1.0E−12	Te-125m	3.1E−13	3.3E−14
Mn-54	2.4E−13	3.6E−13	Te-127m	3.3E−12	2.7E−13
Mn-56	8.9E−12		Te-127	4.5E−12	3.6E−13
Fe-55	9.7E−12	1.1E−12	Te-129m	1.8E−12	2.7E−12
Fe-59	5.6E−12	3.3E−13	Te-129	1.1E−11	1.8E−12
Co-58	9.5E−11	1.0E−11	Te-131m	1.2E−11	1.0E−12
Co-60	1.1E−11	1.1E−12	Te-132	2.2E−10	1.8E−11
Rb-86	2.6E−12	2.8E−12	I-130	4.8E−11	1.3E−12
Sr-89	4.8E−12	3.3E−13	I-131	3.2E−09	7.8E−10
Sr-90	1.3E−13	1.3E−14	I-132	3.1E−10	6.7E−11
Sr-91	1.5E−12	1.2E−13	I-133	1.8E−09	3.9E−10
Y-90	6.7E−14	8.9E−14	I-135	3.9E−10	7.8E−11
Y-91m	1.3E−12	6.1E−13	Cs-134	9.2E−10	1.0E−09
Y-91	1.8E−11	2.8E−11	Cs-136	3.9E−10	3.9E−10
Zr-95	5.8E−13	5.6E−14	Cs-137	7.1E−10	7.8E−10
Zr-97	7.2E−15	1.1E−14	Ba-137m	3.2E−10	1.8E−10
Nb-95	5.8E−13	5.6E−14	Ba-140	5.0E−12	3.9E−13
Mo-99	2.3E−10	3.3E−10	La-140	3.7E−12	2.6E−13
Tc-99m	1.9E−10	2.8E−10	Ce-144	3.1E−13	3.6E−14
Ru-103	5.8E−13	4.2E−14	Pr-143	5.8E−13	5.0E−14
Ru-106	1.3E−13	1.3E−14	Pr-144	3.1E−13	3.6E−14
Rh-103m	5.8E−13	4.2E−14	Nd-147	2.6E−13	2.0E−14
Rh-105	1.5E−13	1.3E−14	Np-239	4.2E−12	3.3E−13

[a]Based on a flow of 100,000 gpm in the discharge canal and a net freshwater flow of 4,000 cfs (1,800,000 gpm) in the Hudson River.

[b]6.1E−07 means 6.1 × 10^{-7}.

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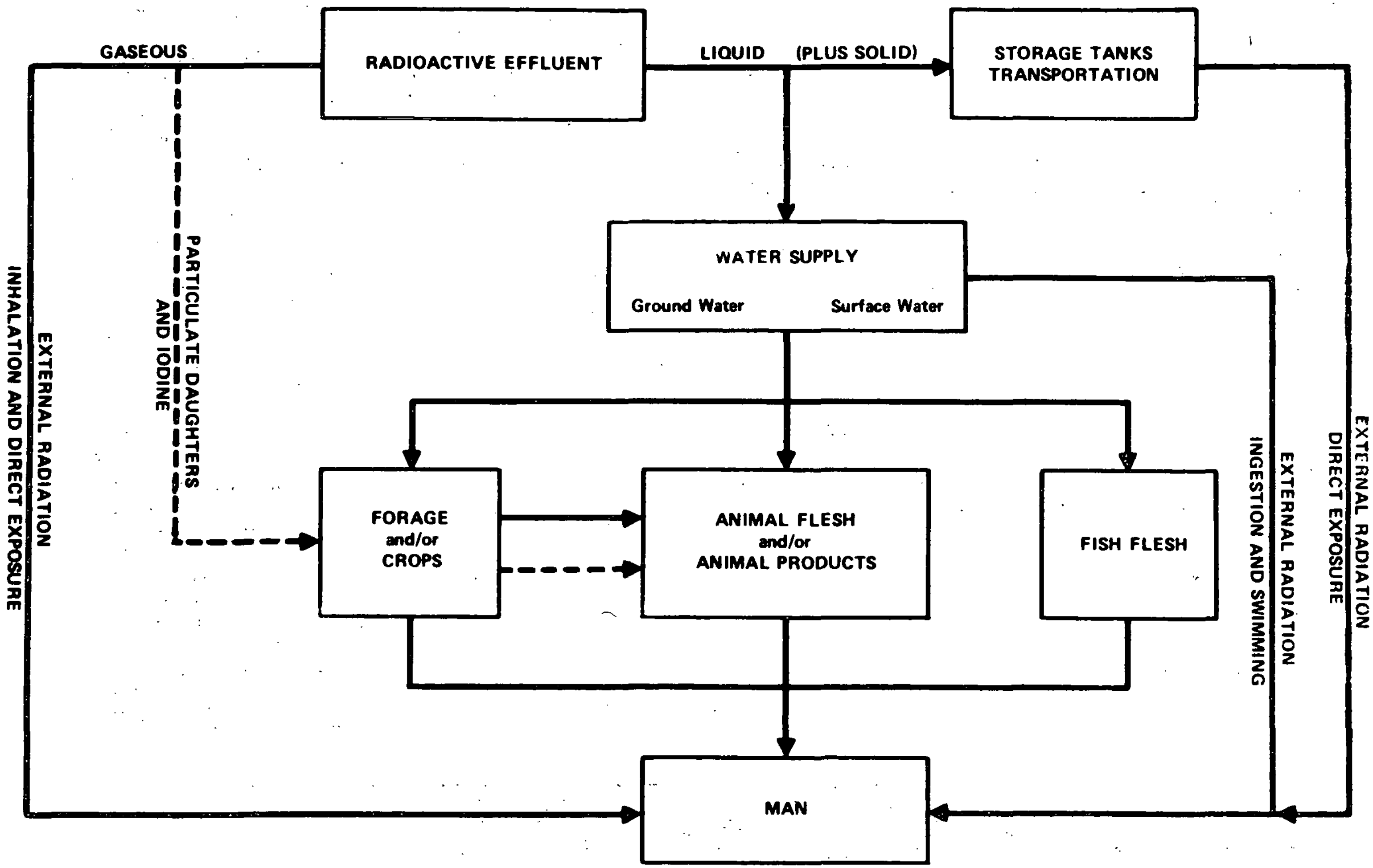

Fig. V-22. Generalized exposure pathways to man.

Table V-37. Estimated annual doses to individuals from radioactive releases from Indian Point Plant

Pathway	Dose[a] (millirems/year)							
	Initial radioactive waste system				Modified radioactive waste system			
	Unit No. 1	Unit No. 2	Unit No. 3	Total	Unit No. 1	Unit No. 2	Unit No. 3	Total
Whole body dose								
Air immersion and surface contamination								
Proposed visitors' center[b]	1.5	3.6	1.1	6.2	1.5	3.3	1.1	5.9
Nearest residence[c]	0.11	0.19	0.13	0.43	0.11	0.19	0.13	0.43
Site boundary (maximum dose)[d]	0.45	0.71	1.25	2.4	0.45	0.69	1.25	2.4
Inhalation of contaminated air								
Proposed visitors' center[b]	0.01	0.03	<0.01	0.04	0.01	0.01	0.01	0.03
Nearest residence[c]	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Site boundary (maximum dose)[d]	<0.01	0.05	<0.01	0.05	<0.01	<0.01	<0.01	0.01
Direct radiation								
Proposed visitors' center[b]	0.12	0.51	0.58	1.2	0.12	0.51	0.58	1.2
Nearest residence[c]	0.01	0.06	0.07	0.14	0.01	0.06	0.07	0.14
Site boundary (maximum dose)[d]	0.05	0.22	0.25	0.52	0.05	0.22	0.25	0.52
Pasture-cow milk[e] (nearest cow[f])				<0.01				<0.01
Aquatic food chain[g]				0.75				0.82
Swimming[h]				<0.01				<0.01
Thyroid dose								
Inhalation of contaminated air								
Proposed visitors' center[b]	4.2	16.8	1.9	23	6.7	6.1	1.9	15
Nearest residence[c]	0.25	0.74	0.15	1.1	0.40	0.25	0.15	0.80
Site boundary (maximum dose)[d]	0.98	2.4	1.7	5.1	1.6	0.9	1.7	4.2
Pasture-cow milk[e] (nearest cow[f])	1.4	4.6	1.6	7.6	2.3	1.6	1.6	5.5
Aquatic food chain[g]				3.0				1.3

[a] All dose calculations for gaseous releases were based on ground releases, assuming the Unit No. 1 SBBPS is operational.

[b] Located 150 m E of Unit No. 1, 150 m SE of Unit No. 2, and 250 m ENE of Unit No. 3.

[c] Located 600 m ESE of Unit No. 1, 650 m ESE of Unit No. 2, and 730 m E of Unit No. 3.

[d] Located 445 m SW of Unit No. 1, 500 m SW of Unit No. 2, and 370 m SW of Unit No. 3.

[e] Based on a 2-g thyroid of a child; consumption of 1 liter of milk per day; and the cow grazing on contaminated pasture 50% of the time.

[f] Located 7 miles SSW of the plant.

[g] Based on consumption of 16 lb of fish per year.

[h] Based on person swimming 1% of the year in the Hudson River.

Table V-38. **Summary of estimates of annual total-body radiation dose to the population from immersion in the gaseous effluents released by the Indian Point Plant**[a]

Radial distance from plant (miles)	1980 projected cumulative population	Cumulative population dose (man-rems/year)[b]			
		Unit No. 1	Unit No. 2	Unit No. 3	Total
0–1	1,000	0.09	0.15	0.28	0.52
0–2	12,000	0.25	0.48	0.64	1.4
0–3	25,700	0.32	0.63	0.79	1.7
0–4	44,300	0.38	0.76	0.93	2.1
0–5	70,000	0.44	0.88	1.1	2.4
0–10	297,000	0.78	1.6	1.8	4.2
0–20	1,180,000	1.3	2.6	2.8	6.7
0–30	4,640,000	2.1	4.4	4.4	11
0–40	12,900,000	3.6	7.5	7.1	18
0–50	19,000,000	4.2	8.9	8.3	21

[a]The average individual dose in millirems/year may be obtained by dividing the cumulative population dose by the cumulative population and multiplying by 1,000.

[b]Values given are for the initial radioactive waste system; values for the modified system differ by less than 4%.

Table V-39. **Integrated annual dose to the general population from the operation of Indian Point Units Nos. 1, 2, and 3**

Pathway	Dose (man-rems/year)	
	Initial system	Modified system
Air immersion and surface contamination[a]	23[b]	22[c]
Inhalation of contaminated air[a]	0.05	0.05
Aquatic food chain[d]	14	15
Swimming[d]	0.26	0.14
Visitors' center (direct radiation and immersion)[e]	0.17	0.16
Transportation of irradiated fuel[f]	2.74	2.74
Transportation of solid radioactive waste[g]	1.3	1.3
Total	42	41

[a]Based on a 1980 population of 18,990,000 within a 50-mile radius.
[b]Unit No. 1, 4.4; Unit No. 2, 9.5; and Unit No. 3, 8.6.
[c]Unit No. 1, 4.6; Unit No. 2, 8.4; and Unit No. 3, 8.6.
[d]Based on 189,900 persons.
[e]Based on 100,000 visitors; occupancy factor = 2 hr/visitor per year.
[f]Dose from rail shipment, based on 300,000 persons. Truck shipment yields a dosage of 5.64 man-rem.
[g]Based on 180,000 persons along route.

d. Assessment of Annual Dose Estimates

(1) Dose from Gaseous Effluent

The estimated annual doses given in Table V-37, for Unit No. 3 as well as all three Units which might be expected by an individual at points of maximum exposure to the gaseous effluents, are not reduced by shielding factors or occupancy factors. For example, the maximum dose at the site boundary occurs in the SW direction at a distance of 1100 ft from Unit No. 3. 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 during operation of Unit No. 3, an annual total body dose of about 1.5 millirems/year would be received by a person spending only 8 hr/day at this location.

For either the "initial" or the "modified" radioactive waste treatment system for all three Units, the sum of the annual average total body dose to a person, who could be located at the site boundary for 24 hr/day and exposed to radiation through air immersion, surface contamination, inhalation, and direct radiation would amount to about 2.93 millirems/year (ground releases) or 2.83 millirems/year (elevatedreleases). About 5 to 10% of these dose estimates are attributable to ground contamination. Based on ground releases, the thyroid dose from inhalation of contaminated air for a person located at the site boundary would amount to 5.1 millirems/year for the initial radioactive waste system and 4.2 millirems/year for the modified system. These doses are within the Commission's "as low as practicable" guidelines. The applicant also estimated that radiation doses to an individual at or beyond the site boundary from the combined operation will be 2.4 millirems/year to the whole body and 1.4 millirems/year year to to the thyroid from inhalation.

For persons living offsite in the nearest residential area (730 m), which lies east of the site, the integrated whole body dose estimate will be less than 0.6 millirem/year for either radioactive waste system. This is less than 1% of natural background radiation of about 0.1 rem/year and is also within the Commission's "as low as practicable" guidelines. The corresponding thyroid doses of persons living at the nearest residence will be 1.1 and 0.8 millirems/year, respectively, for the initial and modified radioactive waste systems.

A visitor, who spent 168 hr/wk for the entire year at the visitors' center, would receive a total annual dose from air immersion, surface contamination, inhalation, and direct radiation of about 7.44 millirems/year for the initial radioactive waste system and

7.13 millirems/year for the modified radioactive waste system. The corresponding thyroid doses through inhalation of the contaminated air would be 23 millirems/year and 15 millirems/year, respectively. These dose levels are less than 2% of the Commission's 10 CFR 20 limits. Assuming 100,000 visitors during the year, and two hours a visit, the staff estimated an annual visitor-population dose of 0.16 man-rem. For occupational doses, see Sect. F.3, Health Physics Considerations for Transportation workers and plant workers.

The estimated average dose from immersion in the gaseous effluents for the individual in the population living within the 50-mile radius of the Plant is 1.1 x 10^{-3} millirem/year and for the total population projected for 1980, it is about 22 man-rems, which is less than 0.01% of the natural background dose of about 2 million man-rems.

The deposition of radioparticulates and radioiodine 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 these mechanisms exists for nuclides carried into the soil by rainfall and subsequently into food plants through their roots. Using a general purpose environmental model to estimate the resulting dose to an individual, the total-body estimate is less than 0.05 millrem/year of releases at 350 m in the southern direction, which is based on the assumption that all of the individual's above ground vegetables are produced at this location.

The critical pathway is the thyroid dose to a two-year-old child via the grass-cow-milk-child pathway. Estimates of dose from radioiodine made for the milk pathway were based on the meteorological data presented in Appendix E of this Statement. The data supplied by the applicant (FFDSAR, Suppl. 16) were modified by omitting the calms. From this information, and assuming consumption of one liter of milk per day by a two-year-old child from the nearest cow grazing up to 50% of the time on contaminated pasture located in the SSW sector at a distance of 11,200 m (7 miles) from the site, the thyroid dose will be 7.6 millirems/year from the initial radioactive waste systems and 5.5 millirems/year from the modified system. Radioiodine dose calculations are less than 15 millirems/year. During the time when Unit No. 1 is shut down and the iodine releases occur from the rooftop vents at the three Units, the total thyroid dose to a child will be about 8.5 millirems/year from iodine-131 and 0.2 millirem/year from iodine-133. Thus the radioiodine releases from the site will be "as low as practicable," in accordance with the Commission's proposed Appendix I of

10 CFR 50. However, since the cow-milk pathway is the critical pathway, the applicant will be required to conduct a milk monitoring program in compliance with Regulatory Guide 4.1. Details as to the frequency and sampling methods of the program will be presented in the Environmental Technical Specifications. Furthermore, the above estimates were based on the steam generator blowdown interties already existing between Units No. 3 and No. 1 SBBPS but not between that for Units Nos. 2 and 1 for the initial system. According to the applicant, both interties will be completed by May 1, 1975 during the first refueling outage for Unit No. 2. Prior to that time, the releases from the site could exceed the Commission's "as low as practicable" guidelines.

(2) Radiation Dose from Liquid Effluents

In terms of the liquid radioactive effluents, the annual doses expected are shown in Table V-14 for the ingestion of fish and swimming. The highest total-body dose to an individual from fish consumption is estimated to be 0.82 millirem/year. The daily consumption rate for fish was assumed to be 20 gm (or 16 lb/year per capita), all of which came from the Hudson River downstream from the site. Radionuclide concentrations in the fish were assumed to be in equilibrium with those in the river and were determined by multiplying the radioactive waste levels in water by the respective bioaccumulation factors as indicated in Table C-1. The complexities of estuaries made it difficult to postulate average conditions, which will simply take into account the variations of freshwater flow, saltwater intrusion, biota populations, etc.

The total dose from ingestion of fish can be determined based on the assumption that 1% of the approximately 18,990,000 people to be living within the 50-mile radius of the Plant by 1980 would obtain 1% of their fish from the river (a total of 304,000 lb/year). The annual population dose is estimated to be 15 man-rems for the modified radioactive waste system.

Because at no place downstream from Indian Point is the river used as a source of municipal drinking water, no estimate of the dose was made for consumption of Hudson River water by man. All the cities using water from the river for consumption are over 20 miles north of the site.

Dose estimates for swimming in the Hudson River were found to be less than 0.01 millirem/year for the individual, assuming that he would swim in the river 1% (1 hr/day for three months each year) of the year. The estimated annual population doses of 0.26 and 0.14 man-rem for the initial and modified radwaste systems, respectively, were obtained by assuming that 1% of the population living within 50 miles of the site spends 1% of the year swimming in the river.

The annual doses expected to result from liquid releases from either the initial or modified radwaste system will be small fractions of natural background.

(3) Direct Radiation

Direct radiation results from possible contamination in the refueling water storage tanks located outside of the containment buildings for the different reactors and from the direct and the skyshine doses from sources within the containment, primary auxiliary buildings, and turbine buildings. In the case of refueling water contamination, a radioactive decay period of six weeks (normal refueling time) is assumed before the excess refueling water is pumped into the storage tanks without treatment. The estimates of dose are maximum values, because shielding and further radionuclide decay in the storage tank would reduce the dose rate. The staff estimate of the total annual whole-body dose by direct radiation to the individual at the site boundary will be 0.52 millirem/year for either radwaste system. This includes radiation exposures from all three reactors. The applicant also calculated a total dose of 0.25 millirem/year from these sources from only Unit No. 3, which is in agreement with the staff's estimate (ER, IP-3, pp. IV-8 to IV-10). Visitors at the visitors' center will also be exposed to direct radiation, amounting to 1.2 millirems/year for an individual; and based on 100,000 visitors per year — each staying for a 2-hr visit — the corresponding dose for the general population would be about 0.027 man-rem/year.

e. Radiological Monitoring of the Environment

Process and area monitoring systems onsite with backup support through offsite environmental radiological monitoring will detect, indicate, annunciate, and/or record the levels of radioactivity to verify compliance with existing regulations to keep radiation levels in unrestricted areas "as low as practicable." (See the Safety Evaluation Report, dated September 21, 1973, regarding details of the evaluation of the applicant's process and area radiation monitoring systems.)

The applicant began a program of environmental radiological monitoring at Indian Point in 1958 and has continued this program (FES, IP-2, pp. V-83 to V-85). Consequently, more than 15 years of baseline data will be available prior to the startup of Indian Point Unit No. 3, which can be used to predict and evaluate the potential radiological effects of Plant operation. The present program includes measurements of the radioactivity in lake and well water, river water, river sediments, fish, aquatic and terrestrial vegetation, soil, milk, and airborne particulates and radioiodine samples collected in the vicinity of the Station. The program also includes gamma spectroscopy of drinking water, Hudson River water, and lake water. Tritium analysis is performed on drinking water. Airborne particulates are sampled at 21 stations, located generally within three miles of the site. A map of the sampling locations is presented in Fig. V-23. In addition, direct measurements of gamma background are made annually at selected areas within a 5-mile radius of the Indian Point Station. Thermoluminescent dosimeters are also located at specified offsite locations as well as at a number of points on the site perimeter, for the purpose of measuring ambient radiation levels. The details of the environmental radiological monitoring program are given in the applicant's Environmental Report (ER, IP-3, Sect. 13.2) and summarized in Table V-40. The program conforms with Regulatory Guide 4.1 for measuring and reporting radioactive material in the environs of nuclear power plants and is acceptable. However, the frequency of sampling and the types of measurements applied will be modified in the Environmental Technical Specifications for the entire Station to upgrade the program to assure that the radiological impacts will be adequately assessed over the years of operation of all the reactors on the site. The applicant will be required to comply with the Environmental Technical Specifications for the entire site, which will include specifications for a post-operational radiological environmental monitoring survey, including a milk monitoring program in compliance with Regulatory Guides 4.1 and 4.3. These specifications will include simultaneous operation of Unit No. 3 with Units Nos. 1 and 2.

f. Conclusions

In summary, the average annual doses expected from the liquid releases will be only very small fractions of natural background for releases from either the initial or modified radwaste systems. Thus, no discernible radiological impacts are expected.

In reference to gaseous releases, those individuals of the present population who spend all of their time within two miles of the Indian Point Plants would receive on the average less than 3% of the typical background dose of 0.125 rem/year and less than 1% of the exposure limits established in 10 CFR 20. This represents no measurable radiological impact on the individuals living near the Indian Point Plants. The greatest exposure will result to visitors from air immersion, surface and ground contamination, and direct

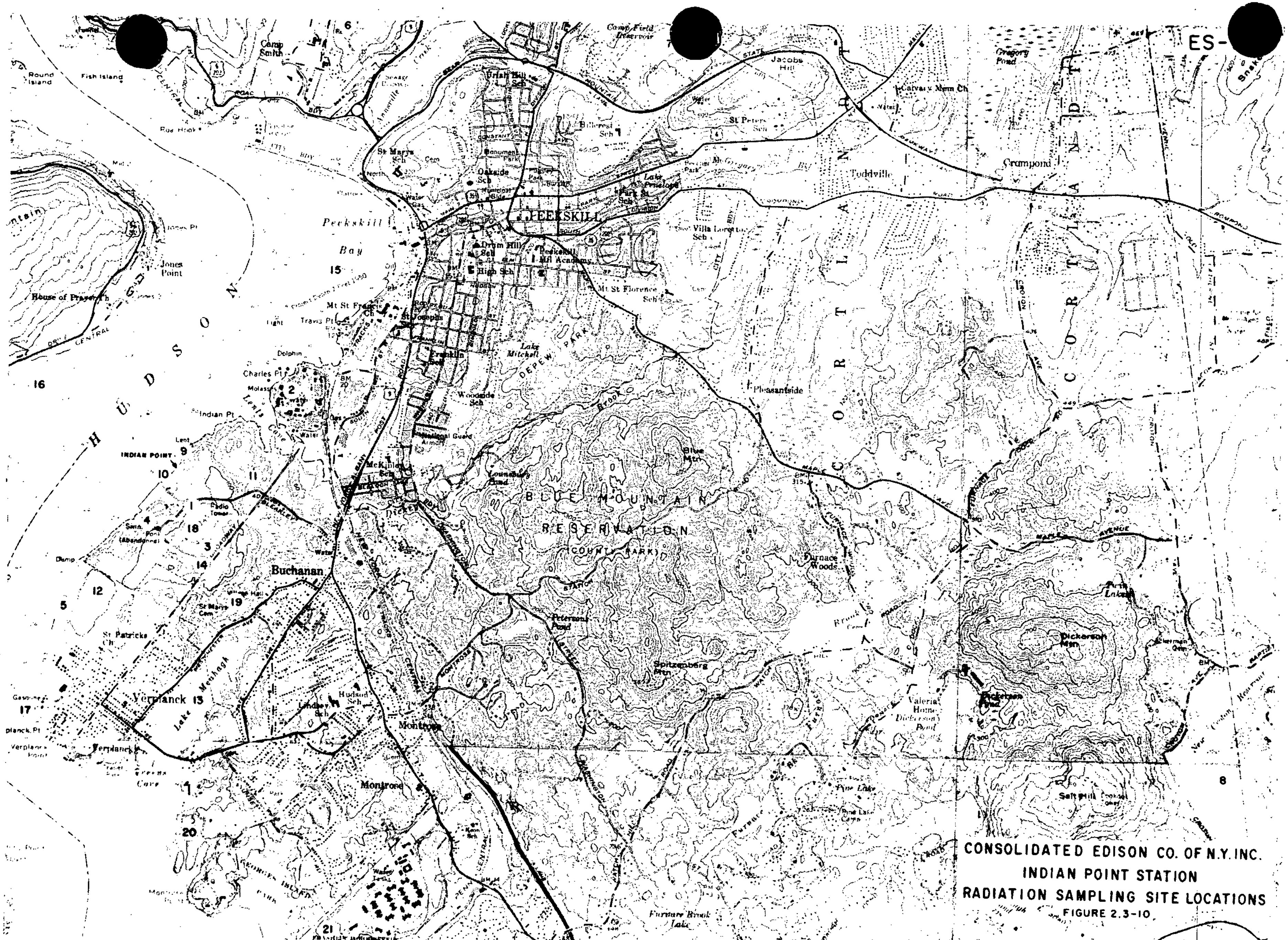

Fig. V-23. Consolidated Edison Company of New York, Inc. Indian Point Plant radiation sampling site locations.

Table V-40. Environmental monitoring survey

Sample	Sample frequency	Sample location	Type of analysis
Hudson River water	Weekly Monthly composite	Inlet pipe into plant and at plant discharge canal; points 9 and 10	Gross beta, tritium
Hudson River aquatic vegetation	Once each spring, summer, and fall	Points 10, 15, 16, and 17; at mouth of discharge canal, Peekskill Bay, Tompkins Cove, off Verplanck and at Lovett site	Gross beta
Hudson River bottom sediment	Once each spring, summer, and fall	Same as item 2	Gross beta
Hudson River benthos	Monthly	Same as item 2	Gross beta
Hudson River fish	Monthly	Where available near site	Gross beta
Fallout (rain water)	Monthly	Point 1; 15 miles south of site – east view	Gross beta, tritium
Drinking water	Monthly	Points 7 and 8	Gross beta, tritium
Air particulate and radioiodine	Weekly	Points 1, 2, 3, 4, 5, and 21 and offsite at points in Peekskill, Buchanan, Crugers, and Springdale for one week periods consecutively	Gross beta, gamma scan
Lake water	Monthly	Points 11, 12, and 13	Gross beta, tritium
Well water	Monthly	Points 6, 14, and Verplanck	Gross beta, tritium
Lake aquatic vegetation	Once each spring, summer, and fall	Points 11, 12, and 13	Gross beta, gamma spectrum
Land vegetation	Once each spring, summer, and fall	Points 6, 18, 19, 20, and 21	Gross beta, gamma spectrum
Soil	Annually	Points 6, 18, 19, 20, and 21	Gross beta, gamma spectrum
Direct gamma (spot readings)	Annually	Along principal roads within a 5-mile radius of plant	Gross gamma background
Direct gamma	Monthly	Selected locations in Buchanan, Verplanck, Montrose, and Peekskill and at a number of points onsite at plant perimeter	Gross gamma background
Milk	Monthly (during grazing season)	Selected locations of cows within 7 miles (farm located within SSW direction)	Radiochemistry, gamma spectrum

radiation. However, the total annual dose levels will be 1.25 millirems/year, assuming the visitor is present 2 hr each day of the year, or less than 0.5% of 10 CFR 20 limits and less than 2% of natural background. Thus, no discernible radiological impacts are expected from this exposure pathway. The critical pathway is the thyroid dose to a two-year-old child via the grass-cow-milk-child pathway. The radioactive waste system with continuous treatment of all the steam-generator blowdown from all three Units at the Unit No. 1 SBBPS will result in an exposure to a 2-g-thyroid of a two-year-old child, drinking a liter of milk per day from the nearest cow grazing 50% of the time in the pasture located seven miles to the south-southwest, to be less than 15 millirems/year for either radwaste system. Thus the releases of radioiodine will be "as low as practicable" in accordance with the Commission's regulations of 10 CFR 50. The radiological monitoring within each Unit, onsite and offsite, will provide further assurance that releases during normal operation will be well within the Commission's regulations so as to cause negligible effects on the population living in the surrounding areas.

During startup of Unit No. 3, the applicant will not have available the capability of treatment of the steam generator blowdown through the SBBPS at Unit No. 1. Neither will such be available for Unit No. 2. Under these circumstances the annual liquid releases from the flash tank at Unit No. 3, or that at Unit No. 2, could be as much as 22 Ci/year from each flash tank, and thus these releases will not be "as low as practicable." As a condition of the operating license, the staff has recommended that such equipment be installed no later than May 1, 1975.* Similarly, the charcoal adsorbers used in the containment and primary auxiliary buildings will also be installed by May 1, 1975.* The radiological monitoring system for the rooftop vents at the three Units will also be required by May 1, 1975.*

A summary of the total integrated annual whole-body dose to the general population living within 50 miles of the Indian Point Plant is estimated to be about 42 man-rems for either radwaste system. These average dose levels for people living within 50 miles of the Plants is about 0.002% of the natural background.

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*Or by initial criticality, whichever occurs later (Suppl. 28 to FFDSAR).

F. TRANSPORTATION OF NONRADIOACTIVE AND RADIOACTIVE MATERIAL FROM AND TO INDIAN POINT PLANT

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 of 204 fuel rods about 12 ft long. Each year in normal operation about 40 fuel elements are replaced in Unit No. 1, and about 65 fuel elements each will be replaced in Units Nos. 2 and 3.

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 irradiated fuel could be transported by truck or rail to Barnwell, South Carolina, a distance of about 800 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 800 miles to, for example, the Allied-Gulf Nuclear Services Plant in Barnwell, South Carolina. 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 (DOT) regulations 49 CFR 173.[126]

The Commission has also issued an environmental survey regarding transportation of radioactive materials to and from nuclear plants[127] and has issued for proposed rulemaking an amendment to 10 CFR 50, the former Appendix D, regarding environmental effects associated with transportation of fuel and waste in the cost-benefit analyses for power reactors.[128]

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 five truckloads of seven containers each will be required each year to meet the needs of Unit No. 3, and a total of 13 truckloads for all three Units.

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 radioactive material, mostly fission products. As the radioactive material decays, it produces radiation and "decay heat." The amount of radioactive material 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 irradiated fuel in the form of 65 fuel elements from Unit No. 3, the applicant estimates 10 rail carload shipments per year, with seven fuel elements per cask and one cask per carload. In future years, 22 truckload shipments per year with, at most, three fuel elements per cask and one cask per truckload with the same situation for Unit No. 2 and six carloads or 13 truckloads for Unit No. 1. A total of 26 carloads per year or 57 truckloads would result in shipping 170 fuel elements per year from all three 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 90 to 150 drums of solid radioactive wastes will be produced in operating Unit No. 3 each year with the initial radioactive waste system. Spent resins and waste evaporator bottoms will be solidified in a mixture of vermiculite and cement, and soft solid wastes such as paper and rags will be compacted in DOT-approved containers for shipment and disposal. The applicant estimates from 5 to 10 truckloads of drums of wastes will be shipped out for disposal from Unit No. 3 each year. On this basis, the staff estimates an equal number of truckloads from Units Nos. 1 and 2, to average 23 truckloads per year from all three Units. However, based on present experience of operating reactors, the staff estimates that approximately 4,900 Ci of radioactive wastes in 1,000 55-gallon drums will be shipped each year. Thus, the staff estimates, if shipped by truck at the rate of about 50 drums per truckload, about 20 truckloads from Unit No. 3 and about 50 truckloads from Units Nos. 1, 2, and 3 will be disposed of each year. If by rail, at about 250 drums per carload, about four carloads per year from Unit No. 3 and about 10 carloads from all three Units will be disposed of.

d. Principles of Safety in Transport

The transportation of radioactive material is regulated by the DOT and AEC.[126] The regulations provide protection of the public and transport workers from radiation. This protection is achieved by a combination of standards and requirements applicable to packaging, limitations on the contents of packages and radiation coming from packages, and procedures to limit the exposure of persons under normal conditions and after accidents.

Primary reliance for safety in the transport of radioactive material is placed on the packaging. The packaging must meet regulatory standards[129] established according to the type and form of material for containment, shielding, nuclear criticality, and heat dissipation. The standards provide that the packaging shall prevent the loss or dispersal of the radioactive contents, retain shielding efficiency, assure nuclear criticality safety, and provide adequate heat dissipation under normal conditions of transport and under specified accident damage test conditions. The contents of packages not designed to withstand accidents are limited, thereby limiting the risk of hazards arising from an accident. The contents of the package also must be limited so that the standards for external radiation levels, temperature, pressure, and containment are met.

Procedures applicable to the shipment of packages or radioactive material require that the package be labeled with a unique radioactive materials label. In transport the carrier is required to exercise control over radioactive material packages, including loading and storage in areas separated from persons, and limit the aggregation of packages to limit the exposure of persons. The procedures the carrier must follow in case of accidents include segregation of radioactive and nonradioactive damaged and leaking packages from people and the notification of the shipper and the DOT. Depending on the particular circumstances, if a container of a high-level radioactive source is leaking, the carrier should avoid contact with the damaged package and should notify the proper authorities. Radiological assistance teams are available through an intergovernmental program to provide equipment and trained personnel, if necessary, in such emergencies.

Within regulatory standards, radioactive materials are required to be safely transported in routine commerce using conventional transportation equipment with no special restrictions on the speed of vehicle, routing, or ambient transport conditions. According to the DOT, the record of safety in the transportation of radioactive materials exceeds that for any other type of hazardous commodity. DOT estimates that approximately 800,000 packages of radioactive materials are currently being shipped in the United States each year. Thus far, based on the best available information, there have been no known deaths or serious injuries to the public or to the transport workers due to radiation from a radioactive material shipment.

Safety in transportation is provided by the package design and limitations on the contents and external radiation level and does not depend on controls over routing. Although regulations require all carriers of hazardous materials to avoid congested areas[130] whenever practical to do so, carriers generally choose the most direct and fastest route. Routing restrictions which require use of secondary highways or other than the most direct route may increase the overall environmental impact of transportation as a result of increased accident frequency or severity. Any attempt to specify routing would involve continued analysis of routes in view of the changing local conditions as well as changing of sources of material and delivery points.

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

a. New Fuel

The transport of new fuel has been described in subsection 1.a of this Section. 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/shipment. For the 13 shipments for all three Units, with two drivers for each vehicle, the total dose would be about 0.026 man-rem*/year. The radiation level associated with each truckload of cold fuel will be less than 0.1 millirem/hr at 6 ft from the truck. A member of the general public who spends three minutes at an average distance of 3 ft from the truck might receive a dose of about 0.005 millirem/shipment. The dose to other persons along the shipment route would be extremely small.

b. Irradiated Fuel

Irradiated fuel will be transported either by rail or by a combination of truck and rail. Based on actual radiation levels associated

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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).

with shipments of irradiated fuel elements, the staff estimates the radiation level at 3 ft from the truck or rail car will be about 25 millirems/hr. The individual truck driver would be unlikely to receive more than about 30 mrem in the 800-mile shipment. For the 57 annual shipments by truck only from all three Units with two drivers on each vehicle, the total dose would be about 3.4 man-rems/year. However, the same driver is unlikely to be used for more than 10 shipments per year, in which case he would receive about 300 millirems in a year.

For the combination truck-rail shipment, the individual truck driver would be unlikely to receive more than 15 millirems in the short trip to the railhead. For two drivers, the dose for 26 truckloads would be 0.78 man-rem. 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 ft from the cask and might receive individual doses of about 10 millirems/hr. With 26 carloads from all three Units, the total dose is estimated to be 1.04 man-rems for the freight handlers.

Train brakemen might spend a few minutes in the vicinity of the car at an average distance of 3 ft, for an average exposure of about 0.5 millirem/shipment. With 10 different brakemen involved along the route, the total dose for 26 shipments during the year is estimated to be about 0.13 man-rem. The total dose to transport workers for the 26 shipments by truck and rail, assuming two drivers on each truckload, would be about 1.75 man-rem.

A member of the general public who spends three minutes at an average distance of 3 ft 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 57 shipments by truck would be about 0.74 man-rem and for the 26 shipments by rail, about 0.34 man-rem. For all three Units, approximately 300,000 persons who reside along the 800-mile route over which the irradiated fuel is transported might receive an annual dose of about 1.5 man-rems if transported by truck, and 0.65 man-rem if transported by rail. The regulatory radiation level limit of 10 millirems/hr at a distance of 6 ft from the vehicle was used to calculate the integrated dose to persons in an area between 100 ft 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, no appreciable thermal effects on the environment will result, because the amount of heat is small and is being released over the entire transportation route.

c. Solid Radioactive Wastes

As noted in subsection 1.c, about 23 truckloads per year of solid radioactive wastes from all three Units will be shipped to a disposal site based on the applicant's estimates of up to 150 drums of solid wastes. Under normal conditions, the individual truck driver might receive as much as 15 millirems/shipment. If the same driver were to drive the 23 truckloads in a year, he could receive an estimated annual dose of about 345 millirems during the year. A total dose to all drivers for the year, assuming two drivers per vehicle, might be about 0.7 man-rem.

A member of the general public who spends three minutes at an average distance of 3 ft from the truck might receive a dose of as much as 1.3 millirems. If 10 persons were so exposed per shipment, the total annual dose for the 23 shipments by truck would be about 0.3 man-rem. Approximately 180,000 persons who reside along the 600-mile route over which the solid radioactive waste is transported would receive an annual dose of about 0.3 man-rem. These doses were calculated for persons in an area between 100 ft and 1/2 mile on either side of the shipping route, assuming 330 persons per square mile, 10 millirems/hr at 6 ft from the vehicle, and the shipment traveling 200 miles/day.

d. Summary

Total maximum annual exposures, as a result of normal transportation of fuel and radioactive wastes, are summarized in Table V-41.

3. Health Physics Considerations

Surveys and analyses indicate that transport workers such as truck drivers, cargo handlers, air crews, barge operators, train crewmen, etc., receive only small doses of radiation in the course of transporting radioactive materials. In a few cases, however, persons who are continually handling radioactive material shipments may receive exposure exceeding that which the average transport worker receives, in some cases approaching and, in some cases, exceeding the limit recommended for individuals in the general population. Therefore, some transport workers are considered to be radiation workers. It is apparent that the exposure transport workers receive is "occupational," as defined in 10 CFR 20,[131] 20.3(a)(10), in that "in the course of employment,.... the individual's duties involve exposure to radiation."

Table V-41. Summary of annual exposure from normal transportation to and from the Indian Point Plant

	Vehicles per year	Length of trip (miles)	Radiation exposure (man-rems)				
			Trucker	Freight handlers	Trainmen	Casual onlooker	General public along route
New fuel							
Shipped by truck	13	800	0.02			Negligible	Negligible
Irradiated fuel							
Shipped by truck	57	1,000	3.4			0.74	1.5
Shipped by truck-rail	26	1,000	0.78	1.04	0.13	0.34	0.65
Solid radioactive waste							
Shipped by truck	23	600	0.7			0.3	0.3
Shipped by truck[a]	50	600	1.5			0.65	0.65

[a]Staff evaluation based on present experience with operating reactors.

All transport workers are given instructions and provided with equipment commensurate with the extent of the radiation exposure, pursuant to 10 CFR 19.2. With respect to instruction, DOT regulations require that the carrier inform workers of the precautions to be taken in transporting and handling the hazardous goods. The DOT regulations also specify safety precautions to limit the radiation exposure in terms of conditions of transport, specifying separation distances from occupied areas (49 CFR 175.655, 177.842), radiation levels in the driver's compartment (49 CFR 173.393), radiation levels in occupied areas in ships (46 CFR 146.25), and placing limits on the accumulation of packages in any one vehicle or area (49 CFR 175.655, 177.842) to limit the total radiation levels. In addition, the DOT regulations, 49 CFR 173.393(i), specify a maximum radiation level on the surface of packages to limit the radiation exposure to transport workers (including cargo handlers).

Radiation levels on the outside of packages exceeding the general requirements in the DOT regulations [49 CFR 173.393(i)] are permitted [173.393(j)], provided the shipment is transported as an exclusive use or "full load" shipment. In such cases (for example, irradiated fuel and solid wastes from nuclear power plants), the shipments must be loaded by the consignor and unloaded by the consignee in accordance with the regulatory requirements. In such cases, the loading and unloading are carried out by plant personnel, in most cases under an AEC or Agreement State license, and exposure of transport workers is at a minimum.

The DOT regulations also provide specific instructions to the carrier for dealing with emergency situations involving leaking packages or damaged packages of radioactive material, which include measures to control the exposure of the worker and the general public and to require reporting of such incidents to the shipper and to DOT (49 CFR 171.15, 175.655, and 177.861).

Transport workers are informed of the occurrence of radioactive material or presence of radioactive material in storage areas or on vehicles by notations made on waybills as required by DOT regulations (49 CFR 174.510, 175.652(a), and 177.817) and by labels required to be placed on the packages under the DOT regulations (49 CFR 173.399). The labels are of a unique design and bear the trefoil, an internationally accepted symbol for radiation. All packages having significant external radiation levels are identified by a label with a yellow background in the upper half, whereas the label for radioactive packages with no significant external radiation levels has a white background. Also, vehicles carrying packages, requiring attention to the radiation levels on the outside or special limitations on the stowage, are required to be placarded on the outside of the vehicle (49 CFR 174.541, 177.823) to further aid in informing the transport worker of the presence of these packages.

With regard to personnel monitoring for transport workers, studies and analyses indicate that the exposures in most cases are well below those requiring individual monitoring under 49 CFR 20.202(a)(1). Personnel monitoring normally is not required for the individual transport worker except in those unusual circumstances where the transport worker is assigned to a particular series of shipments involving long periods or unusual levels of exposure. In those exceptional cases (for example, drivers of trucks transporting truck loads of packages from sources of radiopharmaceuticals such as Abbott Laboratories or from sources of radioactive material such as Oak Ridge National Laboratory or specialized haulers hauling irradiated fuel such as Tri-State), personnel monitoring badges are issued to drivers. In most cases even then the radiation exposures during transportation are small. For the general case, as a result of the limits on radiation levels on the outside of packages and studies that make possible estimating the time of exposure, the average dose to transport workers can be estimated sufficiently close to satisfy a need for identifying the doses that transport workers have received in the course of their employment. Under normal circumstances, personnel monitoring is not required for transport workers.

In terms of the occupational radiation exposure to plant personnel, based on a review of the applicant's Final Facility Description and Safety Analysis Report, the staff has determined that individual occupational doses can be maintained within the limits of 10 CFR 20. Radiation dose limits of 10 CFR 20 are based on a thorough consideration of the biological risk of exposure to ionizing radiation. Maintaining radiation doses of Plant personnel within these limits ensures that their radiation exposure risk is no greater than those risks normally accepted by workers in other present day industries.[132] Using information compiled by the AEC[133,134] and others[135,136] of past experience with operating nuclear reactor plants, it is estimated that the average collective dose to all onsite personnel at large operating nuclear reactor plants will be approximately 450 man-rems/year/Unit. The exposure dose is only 0.02% of the annual total of about 2.4 million man-rems delivered to the 1980 population living within a 50-mile radius of the Indian Point Plant. The total man-rem dose for Indian Point Plants will be influenced by several factors for which definitive numerical values are not available. These are expected to level to doses to onsite personnel lower than estimated above. Improvements in the radioactive waste effluent treatment system to achieve offsite population doses to as low as practicable levels may cause a small increase to onsite personnel doses. However, the applicant's implementation of Regulatory Guide 8.8, as well as the guidance provided through the staff radiological review process, is expected to result in an overall reduction of total doses from those currently experienced.

G. ENVIRONMENTAL EFFECTS OF THE URANIUM FUEL CYCLE

The environmental effects of uranium mining and milling, the production of uranium hexafluoride, isotopic enrichment, fuel fabrication, reprocessing of irradiated fuel, transportation of radioactive materials, and management of low-level and high-level wastes are within the scope of the Commission's report "Environmental Survey of the Uranium Fuel Cycle."[137,138] The contribution of such environmental effects are summarized in Table V-42.

Table V-42. Summary of environmental considerations for uranium fuel cycle

Normalized to model LWR annual fuel requirement

Natural resource use	Total	Maximum effect per annual fuel requirement of model 1,000-MWe LWR
Land (acres)		
Temporarily committed	63	
Undisturbed area	45	
Disturbed area	18	Equivalent to 90 MWe coal-fired power plant.
Permanently committed	4.6	
Overburden moved (millions of megatons)	2.7	Equivalent to 90 MWe coal-fired power plant.
Water (millions of gallons)		
Discharged to air	156	≈2% model 1000 MWe LWR with cooling tower.
Discharged to water bodies	11,040	
Discharged to ground	123	
Total	11,319	<4% of model 1000 MWe LWR with once-through cooling.
Fossil fuel		
Electrical energy (thousands of MW-hour)	317	<5% of model 1000 MWe LWR output.
Equivalent coal (thousands of megatons)	115	Equivalent to the consumption of a 45-MWe coal-fired power plant.
Natural gas (millions of scf)	92	<0.2% of model 1000-MWe energy output.
Effluents—chemical (megatons)		
Gases (including entrainment)[a]		
SO_x	4,400	
NO_x[b]	1,177	Equivalent to emissions from 45-MWe coal-fired plant for a year.
Hydrocarbons	13.5	
CO	28.7	
Particulates	1,156	
Other gases		
F^-	0.72	Principally from UF_6 production enrichment and reprocessing. Concentration within range of state standards – below level that has effects on human health.
Liquids		
SO_4^-	10.3	From enrichment, fuel fabrication, and reprocessing steps. Components that constitute a potential for adverse environmental effect are present in dilute concentrations and receive additional dilution by receiving bodies of water to levels below permissible standards. The constitutents that require dilution and the flow of dilution water are:
NO_3^-	26.7	NH_3 – 600 cfs.
Fluoride	12.9	NO_3 – 20 cfs.
Ca^{2+}	5.4	Fluoride – 70 cfs.
Cl^-	8.6	
Na^+	16.9	
NH_3	11.5	
Fe	0.4	
Tailings solutions (thousands of megatons)	240	From mills only – no significant effluents to environment.
Solids	91,000	Principally from mills – no significant effluents to environment.
Effluents – radiological (curies)		
Gases (including entrainment)		
Rn-222	75	Principally from mills – maximum annual dose rate <4% of average natural background within 5 miles of mill. Results in 0.06 man-rem per annual fuel requirement.
Ra-226	0.02	
Th-230	0.02	
Uranium	0.032	Principally from fuel reprocessing plants – whole body dose is 6 man-rem per annual fuel requirements for population within 50-mile radius. This is <0.007% of average natural background dose to this population. Release from Federal Waste Repository of 0.005 Ci/year has been included in fission products and transuranics total.
Tritium (thousand)	16.7	
Kr-85 (thousands)	350	
I-129	0.0024	
I-131	0.024	
Fission products and transuranics	1.01	
Liquids		
Uranium and daughters	2.1	Principally from milling – included in tailings liquor and returned to ground – no effluents; therefore, no effect on environment.
Ra-226	0.0034	From UF_6 production – concentration 5% of 10 CFR 20 for total processing of 27.5 model LWR annual fuel requirements.
Th-230	0.0015	
Th-234	0.01	From fuel fabrication plants – concentration 10% of 10 CFR 20 for total processing 26 annual fuel requirements for model LWR.
Ru-106	0.15[c]	From reprocessing plants – maximum concentration 4% of 10 CFR 20 for total reprocessing of 26 annual fuel requirements for model LWR.
Tritium (thousands)	2.5	
Solids (buried)		
Other than high level	601	All except 1 Ci comes from mills – included in tailings returned to ground – no significant effluent to the environment, 1 Ci from conversion and fuel fabrication is buried.
Thermal (billions of Btu's)	3,360	<7% of model 1000-MWe LWR.
Transportation (man-rem): exposure of workers and general public.	0.334	

[a] *Estimated effluents based upon combustion of equivalent coal for power generation.*

[b] 1.2% from natural gas use and process.

[c] Cs-137 (0.075 Ci/AFR) and Sr-90 (0.004 Ci/AFR) are also emitted.

Source: *Federal Register*, Docket 74-9076, 21308, filed September 16, 1974, 8:45 am.

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VI. ENVIRONMENTAL IMPACT OF POSTULATED ACCIDENTS

A. PLANT ACCIDENTS

A high degree of protection against the occurrence of postulated accidents in the Indian Point Unit No. 3 is provided through correct design, manufacture, and operation of the facilities and through the quality assurance program used to establish the necessary high integrity of the reactor system, as considered in the Commission's Safety Evaluation[1] for the construction permit for Unit No. 3, dated February 20, 1969. Deviations that may occur are handled by protective systems to place and hold the Plant in a safe condition. Notwithstanding this, the conservative postulate is made that serious accidents might occur, even though they may be extremely unlikely, and engineered safety features are installed to mitigate the consequences of those postulated events judged credible.

The probability of occurrence of accidents and the spectrum of their consequences to be considered from an environmental effects standpoint have been analyzed using best estimates of probabilities and realistic fission-product release and transport assumptions. For site evaluation in the Commission's safety review, extremely conservative assumptions are used for the purpose of comparing calculated doses resulting from a hypothetical release of fission products from the fuel with the 10 CFR 100 siting guidelines. Realistically computed doses that would be received by the population and environment from the postulated accidents are significantly less than those presented in the Safety Evaluation.

The Commission issued guidance to applicants on September 1, 1971, requiring the consideration of a spectrum of accidents with assumptions as realistic as the state of knowledge permits. The applicant's response was contained in Suppls. 1 and 2 of the Environmental Report, dated December 8, 1971 and September 11, 1972 (ER, IP-3, Sects. 19 and 23).

The applicant's report has been evaluated, using the standard accident assumptions and guidance issued as a proposed amendment to the former Appendix D of 10 CFR 50 by the Commission on December 1, 1971.[2] Nine classes of postulated accidents and occurrences, ranging in severity from trivial to very serious, were identified by the Commission. In general, accidents in the high-potential-consequence end of the spectrum have a low occurrence rate, and those in the low-potential-consequence end have a higher occurrence rate. The examples selected by the applicant for these cases are shown in Table VI-1. The examples selected are reasonably homogeneous in terms of probability within each class.

Commission estimates of the dose that might be received by an assumed individual standing at the site boundary in the downwind direction, using the assumptions in the proposed Annex to the former Appendix D, are presented in Table VI-2. Estimates of the integrated exposure that might be delivered to the population within 50 miles of the site are also presented in Table VI-2. The man-rem estimate was based on the projected population within 50 miles of the site for the year 2010.

To rigorously establish a realistic annual risk, the calculated doses in Table VI-2 would have to be multiplied by estimated probabilities. The events in Classes 1 and 2 represent occurrences that are anticipated during Plant operations, and their consequences, which are very small, are considered within the framework of routine effluents from the Plant. Except for a limited amount of fuel failures and some steam-generator leakage, the events in Classes 3 through 5 are not anticipated during Plant operation; however, events of this type could occur sometime during the 40-year Plant lifetime. Accidents in Classes 6 and 7 and small accidents in Class 8 are of similar or lower probability than accidents in Classes 3 through 5, but they are still possible. The probability of occurrence of large Class 8 accidents is very small. Therefore, when the consequences indicated in Table VI-2 are weighted by probabilities, the environmental risk is very low. The postulated occurrences in Class 9 involve sequences of successive failures more severe than those required to be considered in the design bases of protection systems and engineered safety features. Their consequences could be severe. However, the probability of their occurrence is judged to be so small that their environmental risk is extremely low. Defense in depth (multiple physical barriers), continued surveillance and testing, conservative design, and quality assurance for design, manufacture, and operation are all applied to provide and maintain a high degree of assurance that potential accidents in this class are, and will remain, so low in probability that the environmental risk will remain extremely low.

The AEC is currently performing a study to more quantitatively assess these risks. The initial results of these efforts were made available for comment in draft form on August 20, 1974. This study,[3] "Reactor Safety Study: An Assessment of Accident Risks in U.S. Commercial Nuclear Power Plants, Draft" (USAEC Report WASH-1400, August 1974), is an effort to develop realistic data on the probabilities and sequences of accidents in water-cooled power reactors to improve the quantification of available knowledge

Table VI-1. Classification of postulated accidents and occurrences

Class	AEC description	Applicant's examples
1.0	Trivial incidents	Not considered
2.0	Small releases outside containment	Evaluated under routine releases
3.0	Radioactive waste system failure	Release from gas decay tank or liquid-waste-holdup tank
4.0	Fission products to primary system (BWR)	Not applicable
5.0	Fission products to primary and secondary systems (PWR)	Failed fuel and steam generator tube leak, and steam generator tube rupture
6.0	Refueling accident	Fuel bundle drop or heavy object drop onto fuel in core
7.0	Spent fuel handling accident	Refueling accident outside containment
8.0	Accident initiation events considered in design-basis evaluation in the Safety Analysis Report	Loss of coolant accident, rod ejection, or steam line failure outside containment
9.0	Hypothetical sequence of failures more severe than Class 8	Not considered

Table VI-2. Summary of radiological consequences of postulated accidents[a]

Class	Event	Estimated fraction of 10 CFR Part 20 limit at site boundary[b]	Estimated dose to population in 50-mile radius (man-rems)
1.0	Trivial incidents	*c*	*c*
2.0	Small releases outside containment	*c*	*c*
3.0	Radioactive waste system failures		
3.1	Equipment leakage or malfunction	0.18	54
3.2	Release of waste gas storage tank contents	0.7	210
3.3	Release of liquid waste storage contents	0.019	5.9
4.0	Fission products to primary system (BWR)	N.A.[d]	N.A.[d]
5.0	Fission products to primary and secondary systems (PWR)		
5.1	Fuel cladding defects and steam generator leaks	*c*	*c*
5.2	Off-design transients that induce fuel failures above those expected, and steam generator leak	0.004	1.2
5.3	Steam generator tube rupture	0.23	71
6.0	Refueling accidents		
6.1	Fuel bundle drop	0.036	11
6.2	Heavy object drop onto fuel in core	0.64	200
7.0	Spent fuel handling accident		
7.1	Fuel assembly drop in fuel rack	0.023	7.1
7.2	Heavy object drop onto fuel rack	0.092	28
7.3	Fuel cask drop	N.A.[d]	N.A.[d]
8.0	Accident initiation events considered in design basis evaluation in the Safety Analysis Report		
8.1	Loss-of-coolant accidents		
	Small break	0.37	210
	Large break	3.2	6,100
8.1(a)	Break in instrument line from primary system that penetrates the containment	N.A.[d]	N.A.[d]
8.2(a)	Rod ejection accident (PWR)	0.32	610
8.2(b)	Rod drop accident (BWR)	N.A.[d]	N.A.[d]
8.3(a)	Steam line breaks (PWR outside containment)		
	Small break	0.001	0.38
	Large break	0.002	0.71
8.3(b)	Steam line break (BWR)	N.A.[d]	N.A.[d]

[a]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 monitoring 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 a timely manner such that remedial action could be taken if necessary to limit exposure from other potential pathways to man. It is, therefore, the staff's opinion that accidental releases of radioactive liquids would be detected and corrective actions taken to minimize exposure to man. In addition, the small quantities of dispersed radioactive material which might enter the food chain would not be significant in terms of endangering aquatic life.

[b]Represents the calculated fraction of a whole body dose of 500 mrem/year or the equivalent dose to an organ.

[c]These releases are expected to be in accord with proposed Appendix I of 10 CFR Part 50 for routine releases (i.e., 5 mrem/year to an individual from either gaseous or liquid effluents.

[d]Not applicable.

related to probabilities of nuclear reactor accidents. The Commission has organized a special group of about 50 specialists under the direction of Professor Norman Rasmussen of Massachusetts Institute of Technology to conduct the study. The scope of the study has been discussed with the Environmental Protection Agency and described in correspondence with EPA which has been placed in the AEC Public Document Room.[4]

As with all newly developed information that might have an effect on the health and safety of the public, the results of these studies will be made public and will be assessed on a timely basis within the regulatory process on generic or specific bases as may be warranted.

Table VI-2 indicates that the realistically estimated radiological consequences of the postulated accidents would result in exposures of an assumed individual at the site boundary to concentrations of radioactive materials that are comparable to or within the Maximum Permissible Concentrations (MPC) of 10 CFR 20. The table also shows the estimated integrated exposure of the population within 50 miles of the Plant from each postulated accident. Any of these integrated exposures would be much smaller than that from naturally occurring radioactivity. When considered with the probability of occurrence, the annual potential radiation exposure of the population from all the postulated accidents is an even smaller fraction of the exposure from natural background radiation and, in fact, is well within naturally occurring variations in the natural background. Results of the realistic analysis indicate that the environmental risks due to postulated radiological accidents based on gaseous releases are exceedingly small and need not be considered further.

Radioactive liquid wastes in the Indian Point Plants are contained within Category I structures. Failure of equipment within these structures would not lead to a release of radioactive liquid to the environment. The quantity of low-level liquid radioactive materials outside Category I structures is very small, and release of this material would not substantially affect the environmental impact determined for routine operation of the Plants.

B. TRANSPORTATION ACCIDENTS

The Commission has analyzed, on a generic basis, problems relating to the transportation of nuclear materials for power reactors under the present regulatory standards. The results of this analysis were made available in a recent publication,[5] "Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants" (Directorate of Regulatory Standards, USAEC, December

1972). Pages 30, 31, 44-48, 54, and 55 and Appendix B of ref. 5 treat transportation accidents in greater detail and provide the basis for calculation of doses. In addition, in 10 CFR 50, the former Appendix D, the Commission has proposed a Section F for rule making, pertaining to environmental effects of transportation of radioactive materials under both normal and accident conditions.

Based on recent accident statistics,[6] a shipment of fuel or waste may be expected to be involved in an accident about once in a total of 750,000 shipment-miles. The staff has estimated that only about one in 10 of these accidents that involve Type A packages or one in 100 of those involving Type B packages might result in any release of radioactive material. In case of an accident, procedures[7] that carriers are required to follow will reduce the consequences of the accident in many cases. The procedures include the segregation of damaged and leaking packages from people and notification of the shipper and the Department of Transportation (DOT). Radiological assistance teams are available through an intergovernmental program to provide equipment and trained personnel. These teams, dispatched in response to calls for emergency assistance, can mitigate the consequences of an accident.

1. New Fuel

The new fuel to be transported to Indian Point has been described in Section V.F.1.a. Under accident conditions other than accidental criticality, the pelletized form of the nuclear fuel, its encapsulation, and its low specific activity limit the radiological impact on the environment to negligible levels.

The packaging is designed with a specific safety margin to prevent criticality under normal and severe accident conditions. The release of a number of fuel assemblies under conditions that could lead to accidental criticality would require severe damage to or destruction of more than one package, an event that is unlikely to happen in other than an extremely severe accident.

The probability that an accident could occur under conditions that could result in accidental criticality is extremely remote. If criticality were to occur in a transportation accident, persons within about 16 ft of the accident would receive a fatal or near-fatal exposure unless shielded by intervening material. Exposure levels drop off rapidly with distance (exposure is approximately 20 rem at a radius of 50 ft and of the order of 100 mrem at a radius of 100 ft from the accident). Although there would be no nuclear explosion, heat generated in the reaction would probably separate the fuel elements so that the reaction would stop. The reaction would not be expected to continue for more than a few seconds or to recur. Residual radiation levels due to induced radioactivity in the fuel elements might reach a few roentgens per hour at 3 ft. There would be very little dispersion of solid radioactive material.

2. Irradiated Fuel

Effects on the environment from accidental releases of radioactive materials during shipment of irradiated fuel (see Sect. V.F.1.b) have been estimated for the situation where contaminated coolant is released and the situation where gases and coolant are released.

Leakage of contaminated coolant resulting from improper closing of the cask is possible as a result of human error, even though the shipper is required to follow specific procedures that include tests and examination of the closed container prior to each shipment. Such an accident is highly unlikely during the 40-year life of the Plants.

Leakage of liquid at a rate of 0.001 cc/sec or about 80 drops/hr is about the smallest amount of leakage that can be detected by visual observation of a large container. If undetected leakage of contaminated liquid coolant were to occur, the amount would be so small that the individual exposure would not exceed a few millirems and only a very few people would receive such exposures.

Release of gases and coolant is an extremely remote possibility. In the improbable event that a cask is involved in an extremely severe accident such that the cask containment is breached and the cladding of the fuel assemblies penetrated, some of the coolant and some of the noble gases might be released from the cask.

In such an accident, the amount of radioactive material released would be limited to the available fraction of the noble gases in the void spaces in the fuel pins and some fraction of the low-level contamination in the coolant. Persons would not be expected to remain near the accident, due to the severe conditions which would be involved, including a major fire. If releases occurred, they would be expected to take place in a short period of time. Only a limited area would be affected. Persons in the downwind region and within 100 ft or so of the accident might receive doses as high as a few hundred millirems. Under average weather conditions, a few hundred square feet might be contaminated to the extent that decontamination would be required in accordance with Environmental Protection Agency standards.[8]

3. Solid Radioactive Wastes

A severe accident involving a shipment of solid radioactive waste is highly unlikely during the 40-year life of the Plants. If a shipment of low-level waste (in drums) becomes involved in a severe accident, some releases of waste might occur, but the specific activity of the waste will be so low that the exposure of personnel would not be expected to be significant. Other solid radioactive wastes will be shipped in Type B packages. The probability of release from a Type B package, in even a very severe accident, is sufficiently small that, considering the solid form of the waste and the very remote probability that a shipment of such waste would be involved in a very severe accident, the likelihood of significant exposure would be extremely small.

In either case, spread of the contamination beyond the immediate area is unlikely, and although local cleanup might be required, no significant exposure of the general public would be expected to result.

4. Severity of Postulated Transportation Accidents

The events postulated in this analysis are unlikely but possible. More severe accidents than those analyzed can be postulated, and their consequences could be severe. Quality assurance for design, manufacture, and use of the packages; continued surveillance and testing of packages and transport conditions; and conservative design of packages ensure that the probability of accidents of this latter potential is sufficiently small that the environmental risk is extremely low. For those reasons, more severe accidents have not been included in the analysis.

Provisions in transportation regulations are designed to assure maximum containment of wastes and minimum contamination from wastes in accidents. Shipments of wastes are likely to be made by exclusive-use truck, which means that the vehicle is loaded by the consignor and unloaded by the consignee. In most cases the shipments are made in closed vehicles. Since the shipment is exclusive use, the shipper can provide specific instructions to carrier personnel regarding procedures in case of accidents.

Commission and DOT regulations provide specific instructions to carriers for segregating damaged and leaking packages, keeping people away from the scene of an accident, and notification of the shipper and DOT.

Each package containing radioactive material is labeled with the radioactive material label, a distinctive label which identifies the material and provides a visual warning. The regulations specify placarding on the outside of the truck for identifying the presence of shipments of large quantities of radioactive materials. An extensive program has been carried out over the past several years by which emergency personnel, including police departments, fire departments, and civil defense offices, have been advised of procedures to follow in accidents involving radioactive materials and other hazardous materials. Specific instructions with regard to radioactive materials have been provided through the AEC's efforts as well as those of carrier organizations such as the Bureau of Explosives of the Association of American Railroads, the American Trucking Association, and the Air Transport Association. Training programs are available to prepare trained personnel to be equipped to handle emergencies of such a nature. Provisions for periodic training for both plant personnel and off-site emergency situations have been included in the applicant's Emergency (Contingency) Plan. See Sect. 13.2 in the Safety Evaluation Report, September 21, 1973, for further details. An intergovernmental radiological assistance program to provide personnel and equipment is available at the request of persons (truck drivers, police, bystanders, or other persons) at the scene of such accidents. The radiological assistance teams are dispatched in response to calls for emergency assistance. This assistance has been made available in the few transportation accidents involving radioactive materials shipments which have occurred in recent years. Should a major release occur, this type of assistance might help reduce the impact of the release.

The waste itself is confined in the form of either solidified materials, such as concrete, or compacted solids. The low level of radioactivity in the waste, together with the form of the waste, serves to minimize the contamination in the unlikely event that there is a spill in an accident.

The procedures prescribed by existing applicable regulations, together with the other precautions discussed above, are considered by the Commission to be adequate to mitigate the effects of infrequent accidents which might occur involving shipments of wastes from the Plant.

5. Alternatives to Normal Transportation Procedures

Alternatives, such as special routing of shipments, providing escorts in separate vehicles, adding shielding to the containers, and constructing a fuel recovery and fabrication plant on the site rather than shipping fuel to and from the Plant, have been examined. The impact on the environment of transportation under normal or postulated accident conditions is not considered to be sufficient to justify the additional effort required to implement any of the alternatives.

In summary, the environmental risk associated with accidents involving the transportation of cold fuel to the plant, of irradiated fuel from the reactor to a fuel-reprocessing plant, and of solid radioactive wastes from the reactor to burial grounds is within the scope of Ref. 5. The environmental effects of such accidents in transportation are summarized in Table VI-3.

Table VI-3. Environmental risks of accidents in transport of fuel and waste to and from a typical light-water-cooled nuclear power reactor

	Environmental risk
Radiological effects	Small
Common (nonradiological) causes	1 fatal injury in 100 years; 1 nonfatal injury in 10 years; $475 property damage per year

REFERENCES FOR CHAPTER VI

1. U.S. Atomic Energy Commission, "Safety Evaluation by the Division of Reactor Licensing," U.S. Atomic Energy Commission in the Matter of Consolidated Edison Company of New York, Inc., Indian Point Generating Unit No. 3, Docket No. 50-286, February 20, 1969.

2. Annex to Appendix D of 10 CFR 50, "Consideration of Accidents in Implementation of the National Environmental Policy Act of 1969," *Federal Register* 36(231): 22852-22854 (Dec. 1, 1971).

3. U.S. Atomic Energy Commission, "Reactor Safety Study: An Assessment of Accident Risks in U.S. Commercial Nuclear Power Plants, Draft," USAEC Report WASH-1400, August 1974.

4. Letter from W. D. Doub, USAEC, to D. D. Dominick, Environmental Protection Agency, June 5, 1973.

5. Directorate of Regulatory Standards, "Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants," U.S. Atomic Energy Commission, December 1972.

6. Federal Highway Administration, "1969 Accidents of Large Motor Carriers of Property," December 1970; Federal Railroad Administration Accident Bulletin No. 138, "Summary and Analysis of Accidents on Railroads in the U.S.," 1969; U.S. Coast Guard, "Statistical Summary of Casualties to Commercial Vessels," December 1970.

7. Department of Transportation Regulations, 49 CFR 171.15, 174.566, and 177.861.

8. Federal Radiation Council Report No. 7, "Background Material for the Development of Radiation Protection Standards; Protective Action Guides for Strontium-89, Strontium-90, and Cesium-137," May 1965.

VII. ADVERSE ENVIRONMENTAL EFFECTS WHICH CANNOT BE AVOIDED

A. FACTORS RESPONSIBLE FOR ADVERSE EFFECTS

Several factors associated with the operation of Indian Point Units Nos. 1, 2, and 3 with once-through cooling are capable of producing adverse effects. The more important of these factors in the order of their importance include:

1. Entrainment of large numbers of planktonic organisms in the once-through cooling system.

2. Impingement of large numbers of various fish species on the intake screens.

3. Discharges of heated water to the Hudson River.

4. Discharges of toxic amounts of residual chlorine, chloramines, and chlorinated organic compounds to the Hudson River.

5. Releases of radionuclides to the environment.

6. Reduction of dissolved oxygen concentrations in the vicinity of Indian Point.

Other adverse effects include the consumptive use of nonreplenishable natural resources and the long-term commitment of other resources. These aspects of Plant operation are discussed in Chapters VIII and IX and are not included in this chapter. See Chapter XI for details of environmental aspects of alternate closed-cycle cooling systems.

B. PROBABLE ADVERSE EFFECTS

1. Land Use

The Indian Point facilities for Units Nos. 1, 2, and 3 occupy 35 acres of the 239-acre site. The operation of Indian Point Unit No. 3 should not produce appreciable alterations in the public use of the general area beyond those caused by the operation of Units Nos. 1 or 2. The site is to be developed for multiple public use, including a new visitors' center, a nature area, and increased parking facilities. A reactor simulator for training reactor operators is also on the site. The applicant's planned activities in landscaping and replanting the remaining portion of the site and the development of an 80-acre forested park with a small freshwater lake should ultimately more than compensate for the loss of any wildlife habitat because of the land committed to the facility. Since the site was formerly an amusement park which had been abandoned, the change to a power plant site may have resulted in less damage to the terrestrial ecosystem of the area than, for example, if the amusement park had expanded or had been converted to some other business activity involving destruction of all the land area.

The applicant has attempted to improve the visual appearance of the site by using decorative concrete screens and boxes planted with appropriate shrubbery to shield the circulating water pumps and other machinery at the intakes for Units Nos. 2 and 3. Only a limited view of hardware will be seen from the river's side. Similar mechanical equipment for Unit No. 1 is housed in permanent brick buildings. Form, color, and texture of the buildings have been considered so that the setting is harmoniously blended into the landscape.

Historical landmarks will be impacted to a limited extent, and the symmetry of the reactor building structures will be more attractive than other nearby industrial buildings. The architectural style, building massing, and building materials and design will result in a much improved appearance compared with what could result if an amusement park were still in existence.

No additional land was required for transmission line corridors to carry the Plant's electrical output to the switchyard and eventually to the applicant's power system. No added right-of-way was required for 345-kV transmission lines from Units Nos. 2 or 3 to the Buchanan substation located 200 ft from the Indian Point site boundary. The lines from the Buchanan substation are parallel to an existing 138-kV transmission line now in service. The applicant has selected the line design and construction of the needed transmission poles to conform to the Federal and State guidelines for protection of aesthetic and other environmental values.

2. Air Use

The operation of Indian Point Unit No. 3 is not expected to greatly increase the level of nonradioactive air pollutants in the area. Only minor amounts of combustion products as discussed in Section V.B.2 will be released from the Plant during testing operation of diesel-powered engines for emergency use. Air pollution at the site would be primarily from the combustion of sulfur-containing fuel oil used in the superheater of Unit No. 1. The applicant has converted from fuel oil containing 1% sulfur to one of 0.3% sulfur. The sulfur-dioxide levels from the boilers on site will be within

Federal limits. Air pollution in the region of older oil-burning power plants, however, could be reduced by being able to change the status of some of these plants from one of base-load capacity to reserve capacity and eventually retiring these plants.

3. Water Use

Plant operation has the potential for causing changes in the biological and physical aspects of the environment and for imposing some limitations on future industrial uses of the Hudson River. The principal adverse effect that could limit future industrial uses of the Hudson River is related to the discharged heat. The once-through condenser cooling system may preclude the nearby construction and operation of additional industrial facilities which would add to the thermal load of the Hudson River near Indian Point. Plant operations should not interfere with present industrial or community utilization of the resource. Groundwater supplies will not be affected by Plant operation because any thermal, chemical, and radioactive releases would flow directly into the Hudson River.

The construction of the intake and discharge structure along the river bank disturbed a minor amount of benthos. Dredging and filling caused some silting of the river water. However, the resultant impact on aquatic communities has been minimal during any modification of the physical structure. Much of the impact from construction took place several years ago when the work on the three Units began.

As indicated in Table III-2, operation of Units Nos. 1, 2, and 3 will require the withdrawal of large volumes of water from the Hudson River to dissipate the waste heat. The State of New York and the Federal Government require that this warm water, which will be returned to the Hudson, be dissipated in accordance with their regulations governing the discharge of thermal effluents into estuaries.

a. Flow Characteristics of the Hudson River Estuary

Predominantly, the flow at Indian Point is tidal in nature, with peak ebb and flood flows ranging from 200,000 to 300,000 cfs. Monthly average freshwater flow rates in the lower Hudson range from 4,000 cfs in August to 38,000 cfs in April. The weekly average drought freshwater flow which may be anticipated in one year out of ten is 3,000 cfs.

Salt water intrudes upriver to an extent determined by the existing rate of freshwater flow. At Indian Point, salt water will be present when the freshwater flow is less than approximately 20,800 cfs. The salinity of the water is an indication of the extent of the movement of the salt front upstream from Indian Point.

A large circulatory flow pattern exists throughout the salt intrusion zone which is superimposed on the oscillatory tidal flow and the downstream freshwater flow. On the average, over a full tidal cycle, there is a net upstream movement of more saline water along the bottom of the river and a net downstream movement of less saline water along the surface of the river — in effect, a two-layer flow. At any one instant, however, there is no distinct interface between the two "layers" because there is vertical mixing throughout the depth of the river. Further details of the characteristics of the river flow in relation to a description of the dispersal of the thermal plume and the transport of aquatic organisms are found in Sections II.E.1, V.C.1, V.D.2, Appendix A, and Appendix B of this Statement.

b. Water Withdrawal

The withdrawal rate of a maximum of 2,058,000 gpm or 4,585 cfs of river water for once-through cooling for Units Nos. 1, 2, and 3 represents an appreciable fraction of the freshwater volume. In springtime, when freshwater is abundant, the saltwater front is pushed downstream of Indian Point, and the river flow is entirely freshwater flow. Then the volume withdrawn at the Plant is about 22 to 15% of the freshwater flow, when it ranges between 20,000 cfs and 30,000 cfs. In the summer, when freshwater flow is low, the saltwater front has pushed its way upstream of Indian Point, and the river flow is saline water flow. Then the volume of fresh water withdrawn is about 70%, based on a freshwater flow of 6,500 cfs. The applicant is required to decrease intake flow by 40% during the winter by partial recirculation of the discharge water to reduce impingement effects. The tidal water of an average of 180,000 cfs is added to the freshwater flow to provide additional water for dilution.

c. Heat Dissipation

With pump flow reduction in the winter, the temperature rise of the thermal discharges will increase. For Unit No. 3 operating alone, based on a maximum flow of 870,000 gpm the thermal discharge is about 17 F° above the background river water temperature in the vicinity of Indian Point. The reduction of flow to 534,000 gpm would increase the temperature rise from 17 F° to 28 F°.

The heated cooling water from Indian Point is discharged into the Hudson River through a submerged multiport structure. The heat dissipation models presented by the applicant as discussed in Sect. V.C.1 have a number of deficiencies that make some of the results uncertain. The staff's analysis indicates that the New York State thermal criteria of a 90°F maximum river surface temperature will probably be met even under summer operating conditions when the ambient river temperature is at its maximum provided the jet velocity is not less than 10 fps and the influence of the thermal discharges of other power plants on the Hudson is kept to a minimum. However, the area occupied by the 4 F° isotherm will be greater than 50% of the vertical cross-sectional area of the river, and under certain conditions, the increase in temperature at the surface of the river will be more than 4 F° for more than two-thirds of the surface width of the river and can even extend across the width of the river. The applicant will have to demonstrate through field measurements that the thermal discharge regulations can be met throughout the entire year in accordance with the Technical Specifications and the State thermal criteria.

4. Biological Impact

No important changes in the terrestrial biota are expected to result from Plant operation with once-through cooling. The principal adverse effects expected will occur in the aquatic environment of the Hudson River, particularly if Units Nos. 1, 2, and 3 are allowed to continue once-through cooling operation.

The staff assessment of the biological impact of the once-through cooling systems at Indian Point Units Nos. 1, 2, and 3 shows that:

(1) Unless the applicant finds better means of preventing fish from entering the intake structure, impingement of fish on the intake screens at Indian Point Units Nos. 1, 2, and 3 with once-through cooling (base design) can result in an annual loss of 2.6 million young-of-the-year fish (2- to 4-in. long), approximately 70% white perch, as estimated by the applicant. The staff does not place great confidence in the estimates of absolute numbers or weight of fish killed because of lack of reliable information on impingement losses from past experience at the intakes of Unit No. 1 and limited experience of operating of the circulating pumps at Unit No. 2. Although the applicant has investigated several techniques to reduce impingement losses, the applicant has yet to determine an adequate methodology to control impingement and has yet to evaluate the long-term significance on the fish populations.

The staff's position is that impingement at Indian Point Units Nos. 1, 2, and 3 operating with once-through cooling, together with impingement at the other power plants, is of major concern for white perch, tomcod, herrings, and striped bass.

The number of striped bass collected at the intakes is considerably less than the number of white perch, tomcod or herrings collected. However, population estimates of striped bass and white perch tagged as young-of-the-year in the fall and recaptured the same fall indicate that the striped bass and white perch populations between river miles 12 to 62 are approximately the same size. This information suggests that impingement of striped bass must be of concern primarily because it is an additional stress on top of a large estimated entrainment impact.

The applicant has made progress in characterizing the dependence of impingement on intake velocity, intake flow, water temperature, salinity, and distribution of fish. However, in the staff's opinion, with the exception of reducing intake flow, the applicant has not proposed or evaluated a methodology that is expected to appreciably reduce the number of fish impinged below the applicant's projections.

The Environmental Technical Specifications will place a maximum number on daily fish kill in order to limit kills.

(2) Aquatic organisms, including phytoplankton, planktonic crustaceans, larval stages of benthic invertebrates, and eggs, larvae, and juveniles of many of the fish populations (particularly striped bass, alewife, blueback herring, tomcod, bay anchovy, and white perch) will be subject to entrainment in the cooling water withdrawn by the Indian Point Plants and thereby will be exposed to mechanical shock, pressure changes, and thermal and chemical (chlorine) effects.

(a) The staff's position is that entrainment of phytoplankton and microzooplankton is not expected to have any measurable effect on the aquatic ecosystem (including the fish populations) in the vicinity of

Indian Point. Except for *Neomysis*, the staff's opinion is the same for the macrozooplankton such as *Gammarus* and *Monoculodes*. However, (1) entrainment mortality of *Neomysis* is quite high, (2) *Neomysis* tends to be concentrated at the salt front and its reproductive activity may be relatively high at the salt front, and (3) when young-of-the-year striped bass or white perch and *Neomysis* occur together, *Neomysis* is an important component of the striped bass and white perch diet. Therefore, the staff concludes that when the salt front is in the vicinity of Indian Point for much of June through October, entrainment of *Neomysis* at Indian Point, Lovett, and Bowline may well reduce the standing crop of this mysid crustacean and thus have an adverse effect on the growth and survival of striped bass and white perch young-of-the-year.

(b) The staff has estimated that for striped bass ichthyoplankters, the probability of short-term survival following passage through the Indian Point Plant is 0.2 for eggs, 0.4 for yolk-sac larvae and post yolk-sac larvae, and 0.3 for nonscreenable juveniles. The probability of long-term survival is estimated to be 10% lower than the above values for each life stage.

(c) The staff's best judgment concerning the value of the ratio of the concentration of striped bass ichthyoplankters at power plant intakes to the cross-sectional average concentration in the river (f_I) is that the data and analyses currently available, including the staff's, support an f_I value of less than 1.0 but not less than 0.5 for eggs, yolk-sac larvae, post yolk-sac larvae, and nonscreenable juveniles at Indian Point, Bowline, Lovett, Roseton, and Danskammer. Since there is considerable variability and uncertainty in the available data and since the value of f_I has a marked effect on forecasts of percent reduction by the staff's young-of-the-year model, the staff has made runs with the model using values of 0.5 and 1.0 for f_I.

(3) Aquatic organisms in the vicinity of Indian Point will be exposed to thermal, chemical, and radioactive discharges. Thermal and chemical discharges and decreases in dissolved oxygen levels have a potential of causing lethal and

sublethal effects on organisms, particularly during sensitive stages of the life cycle. Since their mobility is limited, planktonic forms are most susceptible to thermal and chemical stresses.

(a) The temperature of the Hudson River in the vicinity of Indian Point may be increased to levels detrimental to aquatic life. If the thermal discharges from Danskammer, Roseton, Lovett, and Bowline fossil-fueled plants are considered in addition to those from Indian Point Units Nos. 1, 2, and 3 with once-through cooling (base design), the staff studies indicate that the estimated cross-sectional average temperature rise, under certain conditions, exceeds the assumed ambient water temperature os 80°F by more than 4 F° between river miles 35 and 50. Exposure temperature, duration of exposure, species, size of organism, and its thermal history will be important in determining the effects of thermal stress. Excess temperatures may attract fish to the intakes, which could cause additional impingement.

(b) The dissolved oxygen concentration in the vicinity of Indian Point discharge may be reduced to levels detrimental to aquatic life, principally in late summer and early fall. In the event that plant thermal discharges do result in decreases of dissolved oxygen to less than 5.0 ppm at the confluence of the discharge canal with the river, the applicant will be required to aerate the thermal discharges or use other suitable methods to comply with the Environmental Technical Specifications and New York State water quality standards.

(c) Chlorination of the once-through cooling system for either Unit No. 2 or Units Nos. 1 and 3, which is scheduled to occur on alternate days three times per week for a total of nine hours per week, may result in discharging cooling water containing up to 0.5 parts per million (ppm) of total residual chlorine. Concentrations of residual chlorine and any chlorinated organic compounds formed at this level can have toxic effects on aquatic biota in the discharge canal and in the vicinity of Indian Point. The applicant is studying means of reducing amounts, concentration, and frequency of use of sodium hypochlorite to minimize effects on biota.

The applicant has stated that no chlorination will occur when the river water temperature is less than 45°F.

(d) Populations of aquatic organisms residing in the discharge canal or near the outfall of the discharge structure will not be adversely affected by radioactive discharges.

(4) The combined effects of entrainment and impingement are likely to result in a substantial decrease in the striped bass fishery that depends on the Hudson River for recruitment. The staff has shown:

(a) The greatest proportion of young-of-the-year striped bass which annually populate the Haverstraw-Tappan Zee nursery area move past Indian Point as eggs, yolk-sac larvae, post yolk-sac larvae, or nonscreenable juveniles and are susceptible to entrainment.

(b) From the staff's point of view, the concept of natural compensation, as opposed to compensation by the fishery, and the fact that natural compensation is occurring and will continue to occur to some degree are not the issues in controversy. Rather, the primary issue in controversy on this topic, given that the applicant has not and will not be able to quantify the degree of natural compensation, is to what extent should the parties rely on compensatory decreases in natural mortality to offset the increased mortality due to the power plants. It is the staff's position that to rely on natural compensation to any major extent is not environmentally sound or sociologically sound. Thus, in reaching its conclusions in this Final Environmental Impact Statement for Indian Point Unit No. 3, the staff has assumed that natural compensation of early life stages and older age classes is not likely to be of major importance in offsetting the increased mortality due to the power plants. However, the staff has included a compensation function in its young-of-the-year model in order to determine the effect of changes in the compensation parameters on the model results used to assess the potential impact of plant operation on the striped bass young-of-the-year population.

(c) Given that (1) fishing mortality appears to be a more important source of mortality than natural causes for adult striped bass once they enter the fishery, (2) the sport catch substantially exceeds the commercial catch, and (3) the staff believes the sport-fishing effort in particular is likely to be dependent on the size of the striped bass population, the staff has assumed that the combined fishery will respond in a compensatory manner, with or without new fishing regulations, so as to partially offset the increased mortality due to the power plants. On the basis of this assumption, the staff included a density-dependent, fishing-mortality function in its life-cycle model.

(d) In the absence of the Cornwall Pumped Storage Plant but including the impacts of Indian Point Units Nos. 1, 2, and 3 plus the Bowline, Lovett, Danskammer, and Roseton Plants, the percent reduction values from the staff's new y-o-y striped bass model range from 34 to 50% with once-through cooling at both Units Nos. 2 and 3, (base design), from 30 to 46% with a cooling tower at Unit No. 2 and once-through cooling at Unit No. 3 (Alternative A), and from 23 to 37% with cooling towers at both Units Nos. 2 and 3 (Alternative B). With Cornwall, the percent reduction values range from 47 to 64% for the base design, from 44 to 61% for Alternative A, and from 38 to 55% for Alternative B. All of these percent reduction values are relative to the clean river (i.e., no power plants withdrawing water from the Hudson River) as the baseline.

(e) Based on the results of the staff's striped bass life-cycle model without Cornwall but including the effects of the Bowline, Lovett, Danskammer, and Roseton Plants in addition to Indian Point Units Nos. 1, 2, and 3, the staff concludes the following: The number of years the size of the Hudson River spawned striped bass population is forecast to be less than 50% of its original size before the power plant impact ranges from 15 to 36 years for the case of once-through cooling at Indian Point (base design) and from 0 to 33 years for the case of a cooling closed-cycle cooling at Unit No. 2 and once-through cooling at Unit No. 3 (Alternative A). The increase in the cumulative fishery yield from the

Hudson River spawned striped bass population integrated over 80 years as a percent of the yield for the case of once-through cooling at all three Units ranges from 4 to 5% and from 9 to 14% for Alternatives A and B respectively.

When Cornwall is included, the results are the following: The number of years the size of the striped bass population is forecast to be less than 50% of its original size ranges from 41 to 55 and 38 to 54, and 28 to 53 for the base design, Alternative A, and Alternative B respectively. The increase in the cumulative fishery yield integrated over 100 years as a percent of the yield for the case of once-through cooling at all three Units ranges from 3 to 4% for Alternative A.

(f) The staff estimates that the Hudson River spawned striped bass population is the major source (90%) of striped bass caught in an Inner Zone, which is made up of the Hudson River, the western half of Long Island Sound (Port Jefferson, Long Island to Bridgeport, Connecticut), and the New York Bight (Barnegat Inlet, New Jersey to Mariches Inlet, Long Island). The staff defines an Outer Zone of influence of the Hudson River spawned striped bass population as extending from Maine to Cape May County, New Jersey, inclusive, less the Inner Zone just defined. In light of the uncertainty concerning the percentage contribution of the Hudson stock to this Outer Zone, the staff has assumed values of both 10% and 50% in estimating the economic impact of the Indian Point Plant on the striped bass fisheries.

(g) There is a paucity of information documenting the size of the total fishery in the Inner and Outer Zones. However, the commercial striped bass landings in the Inner Zone are not great on either a relative or an absolute scale. In 1970, the estimated sport catch of striped bass, on the other hand, exceeded the commercial landings by a factor of 16 for the North Atlantic Region, which includes the Inner Zone.

(5) Operation with once-through cooling at Indian Point may cause decreases in some of the populations of other fish species in the Hudson River estuary.

(6) In spite of limitations, the staff's present position with reference to the applicant's research program is that the program has the potential (1) of resolving, at least partially, several of the important issues in controversy, and (2) of evaluating alternative mitigating measures besides closed-cycle cooling systems such as culturing and stocking Hudson River striped bass and alternative fish impingement protection measures.

(7) In summary, it must be pointed out that the present approach of treating each new plant on the Hudson River as a separate benefit-cost (or risk) exercise contains a bias against preserving the environment. This approach conceivably could result ultimately in the complete destruction of the Hudson River striped bass population. Nevertheless, for each new plant the benefits of cooling towers (or whatever measures were taken) would be calculated to be less than the costs (or risks) because the incremental (fractional) damage to the striped bass population would be less with each additional power plant. But, <u>beyond some point</u>, society is likely to conclude that further deterioration of the striped bass population is intolerable.

Furthermore, the possibility that the additional effect of once-through cooling at Indian Point Unit No. 3 (added to the effects of Indian Point Units Nos. 1 and 2 plus the other power plants on the river) will be the "straw that broke the camel's back" is a risk which cannot be lightly overlooked. The adult model indicates full recovery of the fishery after cessation of the operation of the plants on the river. However, the model may not be an accurate representation of the dynamics of the striped bass population with respect to large perturbations [see App. B, Sect. B.4.c(7)(c)]. It is possible that if the insult of the power plants exceeds some maximum value for long enough, the Hudson River spawned striped bass population will not fully recover. Rather it may seek some new lower equilibrium value.

It is the staff's position that the number of years the relative yield is forecast to be less than 50% of its original size before the power plant impact is an index of the risk of irreversible damage to the population. This risk and the extent of irreversible damage cannot be more rigorously quantified. Furthermore, there are no legal generic guidelines as to what risk and extent of irreversible damage is acceptable or unacceptable to society. Such decisions are a matter of judgment. It is the staff's judgment that for the base design and Alternative A (with or without Cornwall), the risk of irreversible damage to the Hudson River spawned striped bass population is of sufficient concern that the long-term operation of Indian Point Unit No. 3 with once-through cooling is unacceptable. It is the staff's judgment that with closed-cycle cooling at Indian Point Unit No. 3 as well as at Unit No. 2 (Alternative B), the risk of irreversible damage to the striped bass population is still of substantial concern. However, the contribution of Unit No. 3 to this undesirable impact would be reduced to a practicable minimum.

However, there will be some additional adverse impacts due to the operation of wet natural-draft cooling towers are (1) a possible adverse aesthetic effect [Sect. XI.C.3.c(1)(b)]; (2) some salt deposition (less than 20 lb/acre per year) in the vicinity of the Plant [Sect. XI.C.3.c(1)(d)]; and (3) a minor increase in fogging in the vicinity of the Plant [Sect. XI.C.3.c(2)(b)].

5. Radioactive Releases and Radiological Impact

Indian Point Unit No. 3, along with Units Nos. 1 and 2, will release small quantities of radioactive material into the environment during normal operation; the concentrations will be low-level and well below the limits set in the Commission's regulations. Based on normal operation of the Plant with 0.25% defective fuel, with a steam generator leak of 20 gpd, and over 60-days (Unit No. 1) to 45-days (Units Nos. 2 and 3) holdup of radioactive gases, respectively, the estimated radioactive releases at Indian Point would result in total-body doses to an individual of about 3 mrem/year near the site boundary which is less than the 5-mrem guide in proposed Appendix I of 10 CFR 50. Furthermore, individual doses would be less than 1% of the present limits set forth in 10 CFR 20. The man-rem dose to the population within 50 miles of the site from immersion in the gaseous effluent will be about 2.5% of the suggested guideline [400 man-rems/year for each 1000 MW(e)] that should be achievable by conformance with the numerical values in proposed Appendix I of 10 CFR 50. These dose estimates are small fractions (<0.005%) of the dose due to natural background. The dose to the thyroid of a two-year old child from the pasture-cow-milk pathway is estimated to be less than 15 mrem/year (Sect. V.E.2). Individuals spending all of their time within two miles of the reactor would receive on the average about 0.03% of the typical background dose of 100 mrem/year. This is far below the normal variation in backg ound dose. Therefore, no discernible radiological impact on the population is expected due to the normal operation of Units Nos. 1, 2, and 3. Similar considerations for the liquid radioactive wastes indicate that no discernible radiological impacts are expected.

The applicant shall be required to improve some of the components of the radioactive waste system by no later than May 1, 1975. Improvements including polishing demineralizers, improved waste evaporator and steam generator blowdown purification equipment for treating liquid wastes, and charcoal traps for gaseous wastes will reduce the radioactive material released by the Plant. Use of the modified radioactive waste system will assure that the radioactive releases to the environment will be as low as practicable, as defined in proposed Appendix I of 10 CFR 50. Radioactive releases from neither the present nor the modified radioactive waste systems will have a significant adverse impact on man. In-Plant monitoring and controls, as well as environmental radiological monitoring of samples taken within and without the site boundaries, are designed to assure that all radioactive releases will be well within the Commission's regulations in 10 CFR 20 and 10 CFR 50.

Transportation to and from the Plant of nonirradiated and irradiated fuel and solid radioactive wastes which are packaged and shipped in Federally approved containers and shielded casks will be subject to both the Commission's regulations in 10 CFR 70 and 71 and the Department of Transportation's (DOT) regulations in 49 CFR 170-179. The probability of accidental release of any radioactive material during transport is sufficiently small, considering the form of the transported material and its packaging, that the likelihood of significant radiation exposure is remote. With use of proper packages and containers, continued surveillance and testing of packages, and conservative design of packages, the environmental risk is small.

The potential exposures to the population from postulated accidents during operation of the Plants will depend on the type and magnitude of the accident that may result. In Chapter VI, different types of accidents and the probabilities of occurrence indicate that, when multiplied by the probability of occurrence, the potential radiation exposure of the population from all the postulated accidents is an even smaller fraction of exposure than that from natural background radiation and is, in fact, well within naturally occurring variations in the natural background. It is concluded from the results of the realistic analysis that the environmental risks due to postulated accidents involving abnormal release of radioactive material during operation of the Indian Point Unit No. 3 at full power are exceedingly small.

Although no important incremental radiation exposures to man will result from the radionuclides released from the Plants into the environment, increased radiation exposure above that which aquatic organisms normally are exposed to from natural radiation could occur from the released radionuclide concentrations. The dose to aquatic biota is less than 0.1 rad/day and should have no discernible effects on the organisms [Sect. V.D.2.c(4)]. These increased radiation doses are less than the levels which are needed to produce observable effects on terrestrial and aquatic organisms and thus no damage is anticipated from Plant operation.

6. Environmental Effects of the Uranium Fuel Cycle

The environmental effects of the uranium fuel cycle taking into account uranium mining and milling, the production of uranium hexafluoride, isotopic enrichment, fuel fabrication, reprocessing of irradiated fuel, transportation of radioactive materials, and management of low-level wastes and higher-level wastes have been summarized in Table V-42.

VIII. THE RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF MAN'S ENVIRONMENT AND MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

This chapter sets forth the relationship between the proposed use of man's environment implicit in the proposed operation of the Indian Point Unit No. 3 and the actions that can be taken to maintain and enhance long-term productivity. The uses of the environment by succeeding generations must be considered as well as the extent to which present use might limit or enhance the range of beneficial uses in the future.

A. ENHANCEMENT OF PRODUCTIVITY

The benefits of production of electrical energy for the metropolitan New York area and the use of the Indian Point site for that purpose are identified in Chapters X and XI. The area served is highly developed and includes New York City, a center of commerce of national and international importance. The use of the site for nuclear power plants will enhance the productive and beneficial uses of this region and its resources.

In Chapter X, not only is the need for electricity from Unit No. 3 spelled out but also the consequences of the lack of availability of this Plant are considered. The inability of the applicant to meet the electrical demands of its customers, primarily the people of New York City, would cause a serious hazard to the health and safety of the public. In addition, secondary benefits will be accrued through the applicant's plans to enhance the value of the site through its development of a visitors' center, an 80-acre natural park area, and landscaping and planting after construction of Unit No. 3 is completed by 1975.

B. USES ADVERSE TO PRODUCTIVITY

The local effects of construction and operation of a nuclear power plant might reduce environmental productivity through impacts on land, water, and air. Land consumed for the Plant could, in some cases, alter the use of surrounding areas. Water resources and air are usually affected in some degree by materials and heat discharged from the Plants. These impacts are caused by all types of power plants, the effects differing mainly in degree. The staff considered all potential deterrents to productivity in this case. Only those that are significant or need explanation are summarized below.

1. Land Use

About 35 acres of the 239-acre applicant-owned tract is used for the Indian Point facilities. Transmission lines for Unit No. 3 will use existing rights-of-way. The use of land for these purposes is insignificant in comparison with the energy produced and is, therefore, a reasonable allocation of productive capacity. Furthermore, the range of productive uses of surrounding areas will not be reduced by normal Plant operations.

Because the 239-acre site is zoned for industrial purposes, its use as a site for nuclear generating plants should not cause significant alterations from use patterns that would have prevailed for other industrial applications. If the increased availability of electricity or other factors were to stimulate rapid economic growth in Westchester County, the nonavailability of the land in the Indian Point site would not retard such growth.

2. Water Use

The range of groundwater and surface-water use in the long term will not be curtailed in the least except for the possible degradation of the ability of the Hudson River to support aquatic organisms, as discussed in detail in Chapters V and VII. Commercial and industrial uses of the river, as well as public and recreation uses, should not be affected by the operation of Unit No. 3 except that discharge of heat while this Unit employs a once-through cooling system will limit the extent to which future industries in the immediate vicinity could further heat the water. The productivity of the river, therefore, could not increase in this respect as long as the Plant is in operation. The value of such a future loss would be difficult, at best, to assess quantitatively. The immediate proposed use of the water for cooling Unit No. 3 has a value and benefit to the welfare of people in the applicant's service area, relative to needed power.

From the impacts and alternatives discussed in Chapters IV, V, VI, VII, X, and XI, the staff has concluded that the major adverse effect of operation of once-through cooling at the Plant is the potential for further degradation of the Hudson River estuary. In particular, such degradation may substantially reduce the striped bass fishery that depends on the Hudson River for recruitment. In addition, a significant reduction in other fish populations, such as white perch, could occur. The staff has used the striped bass life-cycle population model described in Appendix B, Sect. B.4.c, to estimate decreased relative yield to the striped bass fishery for various scenarios of assumed operation of Indian

Point and other power plants along the river. These model results indicate that, although once-through cooling can significantly reduce fishery yield, the effect is not expected to be irreversible. That is, the model predicts a gradual recovery (as long as 40 years in some cases) of the adult population (yield to the fishery) with the installation of cooling towers or with the cessation of power plant operation.

The combined impact of operation of all Units at Indian Point, Danskammer, Roseton, Bowline, and Lovett in the once-through cooling mode may be large [Sect. V.D.2.d(3)(c)(iv)]. The staff believes that the larger the impact and the greater the duration of the impact, the more likely it is that the Hudson River spawned striped bass population will not fully recover as suggested by the staff's life-cycle model simulations. Such irreversible reductions cannot be predicted by the life-cycle model, since it is a one-species model that does not take into account species interactions and socioeconomic factors which undoubtedly affect the dynamics of the striped bass population. The staff judgment is that the risk of producing permanent changes will be acceptably low if once-through cooling at all three Indian Point Units is permitted for only a few years. This time will permit completion of the studies being conducted by the applicant, but will not allow the full insult to the fishery to occur.

The long-term effect of the chemical effluents that will be discharged from the Plants cannot be forecast with exactness. Some chemicals, such as phosphates, tend to promote long-term growth of plankton even in modest amounts. Similarly, other chemicals (e.g., chlorine) can have detrimental short- and long-term effects on aquatic biota. The Plants will probably not discharge amounts of chlorine or phosphate greater than that from the sewage systems of nearby municipalities. However, further use of the Hudson River as a dumping place for chemical wastes can be minimized by alternatives that have been outlined in Chapter XI and by regulating the concentration, frequency, and length of time of the intermittent chemical treatment during Plant operation.

An improved ecological surveillance and special studies program, which is being conducted by the applicant, will be used to assess the potential impacts that can occur over the short-term. However, the present program as proposed by the applicant, which is designed to collect only about two years of postoperational experience with once-through cooling, will not provide sufficient information to determine the long-term impacts of once-through cooling. See Sect. V.D.2.f on staff's analysis of applicant's research program.

The applicant will be required to assess the short-term adverse effects of operation of the Units through a comprehensive monitoring and ecological surveillance program outlined in the Environmental Technical Specifications and to modify the operating procedures in the event excessive damage to the aquatic biota occurs as revealed by the ecological and monitoring program. Based on costs involved, limited modification of the design of the intake-discharge structure may be warranted if excessive damage occurs prior to modification of Plant design to incorporate a cooling tower.

The applicant and other members of the New York Power Pool, which have power plants on the Hudson River, have ongoing environmental studies of the effects of power plants of all types on the water quality and biota of the Hudson River (ER, IP-3, Suppl. 10, Section 13). The staff concurs with utilities' coordinated efforts to look at the overall effects of power plant operation on the Hudson River which need greater emphasis and study to locate new power plants on the river. Such an effort should be conducted in cooperation with the New York State Department of Environmental Conservation and Public Service Commission and with Federal agencies, including the Commercial and Sport Fish and Wildlife Services. Such programs are outlined[1] by the applicant. The applicant has sponsored extensive research effort in the electrical, nuclear, and biological fields and is to be commended for efforts to find solutions to important problems in the utility industry. The applicant uses the advice of the Hudson River Policy and Technical Committees, now organized as the Hudson River Fish and Wildlife Cooperative, as well as the Fish Advisory Board to plan for fish protection and for types of environmental monitoring programs and to investigate the potential effects of Plant operation on the Hudson River. An improved coordinated effort, however, should be carried out with industrial, government, and other organizations to assure that discharges of all types into the river are restricted and that ecological studies are conducted from which positive steps can be found to alleviate the degradation of the Hudson River.

3. Decommissioning

Although use of the site seems reasonable for the 40 years of power Plant operation, the degree of usefulness of this land after operations are terminated and the possible curtailment of long-term productivity should also be considered. The Commission requires that, upon decommissioning, all source, special nuclear, and by-product materials not exempt from licensing under Parts 30, 40, and 70 of Title 10, Code of Federal Regulations, must be removed from the site or secured and kept under surveillance.

Following the completion of operation, the applicant will permanently shut down the facility[2] (ER, IP-3, App. FF, p. V-1). The precise nature of the shutdown process is difficult to determine at present, in view of the likelihood of regulatory and technological changes in the coming years. However, the process will probably involve removal of all spent fuel from the facility and shipment offsite; decontamination of the facility through appropriate chemical cleaning and flushing; treatment and disposal of any contaminated water; disposal of resins, filters, and miscellaneous radioactive material; sealing of the containment and adjustments to alarm systems in anticipation of postshutdown security monitoring; and completion of a final postshutdown radiation check. During these procedures, security forces at the facility will be maintained at or near full operational levels.

The applicant estimates that decommissioning of the facility will require nine months to complete, and will cost approximately $3,000,000, in 1973 dollars, based on 1973 technology. These funds will come from applicant's retained earnings, which totalled $605,357,000 at the close of 1973.[3] With the benefit of future operating revenues, retained earnings are expected to be considerably greater at the time of permanent shutdown. At present, there are no plans to designate a specific fund to cover decommissioning costs, nor does the applicant anticipate the need to seek funds from external sources in connection with permanently shutting down down the facility.

Following the shutdown process outlined above, the applicant will conduct, in perpetuity if necessary, a security and radiological monitoring program. This will involve a round-the-clock guard to ensure against intruders. An alarm system, telephone communications, locked doors and windows, a lighting system, and a perimeter fence will be maintained for this purpose. In addition, regular radioactive monitoring in the vicinity of the facility will be performed.

The applicant estimates the annual cost of such a program, in 1973 dollars and using 1973 technology, to be approximately $300,000. Currently, there are no plans to designate a specific fund to cover these maintenance costs, as the applicant's future operating revenues will be adequate to cover such expenses. Similarly, the applicant does not anticipate the need to seek funds from external sources in connection with these postshutdown costs.

No specific plan for the decommissioning of the Indian Point Plants has been developed. This is consistent with the Commission's current regulations which contemplate detailed consideration of decommissioning near the end of a reactor's useful life. The licensee initiates such consideration by preparing a proposed decommissioning plan which is submitted to the AEC for review and approval. The licensee will be required to comply with Commission regulations then in effect, and decommissioning of the facility may not commence without authorization from the AEC.

To date, experience with decommissioning of civilian nuclear power reactors is limited to six facilities which have been shut down or dismantled: Hallam Nuclear Power Facility, Carolina Virginia Tube Reactor (CVTR), Boiling Nuclear Superheater (BONUS) Power Station, Pathfinder Reactor, Piqua Reactor, and Elk River Reactor.

There are several alternatives that can be and have been used in the decommissioning of reactors: (1) Remove the fuel (possibly followed by decontamination procedures); seal and cap the pipes; and establish an exclusion area around the facility. The Piqua decommissioning operation was typical of this approach. (2) In addition to the steps outlined in (1), remove the superstructure and encase in concrete all radioactive portions that remain above ground. The Hallam decommissioning operation was of this type. (3) Remove the fuel, all superstructure, the reactor vessel, and all contaminated equipment and facilities; and finally fill all cavities with clean rubble topped with earth to grade level. This last procedure has been applied in decommissioning the Elk River Reactor. Alternative decommissioning procedures (1) and (2) would require long-term surveillance of the reactor site. After a final check to ensure that all reactor-produced radioactie material has been removed, alternative (3) would not require any subsequent surveillance. Possible effects of erosion or flooding will be included in these considerations.

Estimated costs of decommissioning at the lowest level are about \$1 million plus an annual maintenance charge of about \$100,000.[4] Estimates vary from case to case, caused by differing assumptions as to the level of restoration. For example, complete restoration, including regrading, has been estimated to cost \$70 million.[5] At present land values, consideration of an economic balance alone would not be likely to justify a high level of restoration. Planning required of the applicant at this stage will ensure, however, that variety of choice for restoration is maintained until the end of useful Plant life.

The degree of dismantlement would be determined by an economic and environmental study involving the value of the land and scrap value versus the complete demolition and removal of the complex. In any event, the operation will be controlled by rules and regulations to protect the health and safety of the public that are in effect at the time.

In cost-benefit considerations, future decommissioning costs should be discounted to obtain their present worth. At a discount rate of 10%/year for 30 years of operation, costs incurred at the end of that operating period would be divided by 17.45 to determine their present worth. Thus, even if the Plant area were to be restored to its original condition, the present worth of the future costs involved would be only about 1% of the original construction cost. This indicates that, including decommissioning, costs would not alter any of the conclusions of the cost-benefit analysis in this Statement.

The staff concludes that the benefits derived from the Plant in serving the electrical needs of the area outweigh any alternative short-term uses of the environment in its vicinity and the long-term productivity of the environment can be maintained and enhanced, on balance, by requiring use of an alternate closed-cycle cooling system to minimize the degradation of the Hudson River ecosystem.

REFERENCES FOR CHAPTER VIII

1. 1974 Report of Member Electric Corporations of the New York Power Pool and the Empire State Electric Energy Research Corporation Pursuant to Article VIII, Section 149-B of the Public Service Law, Volumes 1 and 2.

2. Consolidated Edison Company of New York, Inc., Amended and Substituted Application for Licenses Under the Atomic Energy Act of 1954, Docket No. 50-286, April 13, 1973.

3. Consolidated Edison Company of New York, Inc., Annual Report for 1973.

4. "Atomic Energy Clearing House," Congressional Information Bureau, Inc., Washington, D.C., 17(6): 42 (1971); 17(10): 4 (1971); 17(18): 7 (1971); 16(35): 12 (1970).

5. Pacific Gas and Electric Company, "Supplement No. 2 to the Environmental Report," Units 1 and 2, Diablo Canyon Site, Docket Nos. 50-275 and 50-323, July 28, 1972.

IX. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

A. INTRODUCTION

Irreversible commitments generally concern changes set in motion by the proposed action which, at some later time, could not be altered so as to restore the present order of environmental resources. Irretrievable commitments are generally the use or consumption of resources that are neither renewable nor recoverable for subsequent utilization.

Commitments inherent in environmental impacts are identified in this Chapter, while the main discussions of the impacts are in Chapters IV, V, VI, and XI.

B. COMMITMENTS CONSIDERED

The types of resources of concern in this case can be identified as: (1) material resources — materials of construction, renewable resource material consumed in operation, and depletable resources consumed — and (2) nonmaterial resources, including a range of beneficial uses of the environment.

Resources which, generally, may be irreversibly committed by the operation are: (1) biological species destroyed in the vicinity; (2) construction materials that cannot be recovered and recycled with present technology; (3) materials that are rendered radiocative but cannot be decontaminated; (4) materials consumed or reduced to unrecoverable forms of waste, including uranium-235 and -238 consumed; (5) the atmosphere and water bodies used for disposal of heat and certain waste effluents, to the extent that other beneficial uses are curtailed; (6) land areas rendered unfit for other uses; (7) capital investment of physical Plant facilities; and (8) human talents, skills, and labor.

C. BIOTIC RESOURCES

The staff's analysis of biological impacts indicates that the combined effects of impingement and entrainment have a potential for significantly decreasing recruitment to the adult population of striped bass that depend on the Hudson River for spawning [Sect. V.D.2.d(3)(c)]. In addition, a reduction of other fish populations, such as white perch, can occur. The combined impact of all Units at Indian Point and the other power plants on the river could cause a permanent reduction in the size of the striped bass population and in yield to the fisheries in the Inner Zone (see Sect. V.D.2.d(3)(c)(v)]. The risk of causing such irreversible changes can not be rigorously quantified, but it is the staff's position that the number of years the relative yield to the fishery is forecast to be less than 50% of its original size before the cumulative power plant impact is an index of the risk of irreversible damage to the population. There are no generic guidelines as to what risk and extent of irreversible damage is acceptable or unacceptable to society. Such decisions are a matter of judgment. It is the staff's judgment that for the base design and Alternative A (with or without Cornwall), the risk of irreversible damage to the Hudson River spawned striped bass population is of sufficient concern that the long-term operation of Indian Point Unit No. 3 with once-through cooling is unacceptable. It is the staff's judgment that with closed-cycle cooling at Indian Point Unit No. 3, as well as at Unit No. 2 (Alternative B), the risk of irreversible damage to the striped bass population is still of substantial concern. However, the contribution of Unit No. 3 to this undesirable impact would be reduced to a practicable minimum.

D. MATERIAL RESOURCES

1. Materials of construction

Materials of construction are almost entirely of the depletable category of resources. Concrete and steel constitute the bulk of these materials, but there are numerous other mineral resources incorporated in the physical Plants. No commitments have been made on whether these materials will be recycled when their present use terminates.

Some materials are of such value that economics clearly promotes recycling. Plant operation will contaminate only a portion of the facilities to such a degree that radioactive decontamination would be required in order to reclaim and recycle the constituents. Some parts of the Plants will become radioactive by neutron activation. Radiation shielding around the reactor and other components inside the primary neutron shield constitute the major materials in this category, for which it is not feasible to separate the activation products from the base materials. Components that come in contact with reactor coolant or with radioactive wastes will sustain varying degrees of surface contamination, some of which could be removed if recycling is desired. The only components greater than 100 metric tons of steel that are expected to be radioactive at the end of Plant operation, thereby requiring a Commission license, are the reactor pressure vessel and the steam generators. The quantities of materials that could not be decontaminated for unlimited recycling probably are very small fractions of the resources available in kind and in broad use in industry. Many materials on the List of Strategic and Critical Materials[1] prepared by the President's Office of Emergency Preparedness are used in nuclear plants, such as aluminum, antimony, asbestos, beryllium, cadmium, chromium, cobalt, copper, lead, manganese, mercury, nickel, platinum, silver, tin, tungsten, and zinc. Quantities of such materials used in nuclear plants of about the same power output as the Indian Point Unit No. 3 but not necessarily of the same typical design are shown in Table IX-1. World production, U.S. consumption, and reserves are also given. Because of national security needs and limited domestic supplies, most of the materials are included in the material stockpile. In view of the quantities of materials in material reserves, resources, and stockpile and the quantities produced yearly, the expenditure of such material for the power plants is justified by the benefits from the electrical energy produced.

Table IX-1. Basic constituents of the composite materials contained in a typical 1000-MWe pressurized water reactor plant

Material	Approximate quantity used in plant[a] (metric tons)	World production[b] (metric tons)	U.S. consumption[b] (metric tons)	U.S. reserves[b] (metric tons)	Strategic and critical material[c]
Aluminum	18	9,089,000	4,227,000	8,165,000	Yes
Chromium	415	1,590,000	398,000	2,000,000	Yes
Copper	726	6,616,000	1,905,000	77,564,000	Yes
Lead	47	3,329,000	1,261,000	32,024,000	Yes
Manganese	467	7,711,000	1,043,000	907,000	Yes
Molybdenum	164	64,770	23,420	2,858,000	No
Nickel	484	480,000	129,000	181,000	Yes
Silver	<1	8,989	5,005	41,057	Yes
Steel	34,662[d]	574,000,000	128,000,000	2,000,000,000	No
Tin	2	454,200	82,100	47	Yes
Zinc	2	5,001,000	1,630,000	30,600,000	Yes

[a]From R. H. Bryan and I. T. Dudley, "Estimated Quantities of Materials Contained in a 1000 MWe PWR Power Plant," ORNL-TM-4515, Oak Ridge National Laboratory, June 1974.

[b]Production, consumption, and reserves were compiled, except as noted, from the U.S. Bureau of Mines publications *Mineral Facts and Problems* (1970 ed., Bur. Mines Bull. 650) and the *1969 Minerals Yearbook*. They are expressed in terms of contained element, regardless of the form. "Production" usually includes material recovered from both primary ores and secondary sources such as scrap recovery. Production and consumption figures are for 1969 unless otherwise noted. Estimates of reserves were published in 1969 but are based on data compiled over a number of years. The reserves stated are the quantities extractable at currently competitive prices; they include inferred as well as measured and indicated ores, when such information was available. Usually, resources recoverable with advanced methods or at greater cost are much greater than the reserves listed.

[c]Designated by G. A. Lincoln, "List of Strategic and Critical Materials," Office of Emergency Preparedness; *Fed. Regist.* 37(39): 4123 (Feb. 26, 1972).

[d]Iron content of steel products used in construction of the plant.

Construction materials are generally expected to remain in use for the full life of the Plants in contrast to fuel and other replaceable components discussed later. There will be a long period of time before terminal disposition must be decided. At that time, quantities of materials in the categories of precious metals, strategic and critical materials, or resources having small natural reserves must be considered individually, and plans to recover and recycle as much of these valuable depletable resources as is practicable will depend upon need.

2. Replaceable components and consumable materials

Uranium is the principal natural resource material irretrievably consumed in Plant operation. Other materials consumed, for practical purposes, are fuel cladding materials, reactor control elements, other replaceable reactor core components, chemicals used in processes such as water treatment and ion exchanger regeneration, ion exchange resins, and minor quantities of materials used in maintenance and operation. Except for the uranium-235 and -238, the consumed resource materials have widespread usage; therefore, their use in the proposed operation must be reasonable with respect to needs in other industries. The major use of the natural isotopes of uranium is for production of useful energy.[2]

Estimated nuclear fissile fuel resources far exceed the reserves of fossil fuels, which also are useful raw materials for other industries. The estimates of energy resources and demands for the United States compiled by the Bureau of Mines show that the total recoverable resources, expressed as theoretically available equivalent energy,* are 27×10^{21} joules for all forms of fossil fuels, 62×10^{21} joules for uranium, and 39×10^{21} joules for thorium.[3-5]

Indian Point Unit No. 3 will be fueled with uranium enriched in uranium-235. The fuel enrichment, the burnup and recoverable uranium and plutonium for four regions, with reloads of the core, indicates the amounts of fuel recovered (ER, IP-3, App. FF pp. V-4-5). For Unit No. 3, about 116,000 kg of uranium will be consumed, that is, converted into nonfissile products and fissile

*This considers only reasonably assured reserves and additional potential resources in conventional deposits recoverable at a cost of $10 or less per pound of U_3O_8 or ThO_2. The contained quantities of uranium and thorium are 710,000 metric tons and 478,000 metric tons respectively. Inclusion of by-product uranium reserves and resources recoverable at a cost of $10 to $15 per pound of U_3O_8 increases the energy equivalent by 40×10^{21} joules (492,000 metric tons of uranium).

material. About 109,000 kg of uranium will be recovered including 879 kg of uranium-235, and 694 kg of fissile plutonium and 966 kg of total recoverable plutonium will be obtained.

After use in the Plant, the fuel elements will still contain urainum-235 slightly above the natural fraction. This slightly enriched uranium, upon separation from plutonium and other radioactive material (separation takes place in a chemical reprocessing plant), is available for recycling through a gaseous diffusion plant. Scrap material containing valuable quantities of uranium is also recycled through appropriate steps in the fuel production process. Fissionable plutonium recovered in the chemical reprocessing of spent fuel is valuable for fuel in power reactors.

The quantities of ore that will have to be produced and processed and the volume of space that will be required for storage of waste can be inferred from the Commission's report *Environmental Survey of the Nuclear Fuel Cycle.*[6] The quantities pertaining to the Indian Point Unit No. 3 have been estimated by the staff (Table IX-2). If Indian Point Unit No. 3 operates at 85% of capacity, about 5430 metric tons of contained natural uranium in the form of U_3O_8 must be produced to feed the Plant for 40 years. The assured U.S. reserve of natural uranium recoverable at a cost of $8 or less per pound of U_3O_8 are 210,000 metric tons of uranium.[4] In addition, the assured reserves recoverable at $10 or less per pound of U_3O_8 are estimated to be 500,000 metric tons of uranium, but this increment will require a major effort in exploration and development to bring it into production. The long-term uranium resource situation in the U.S. could depend on the larger expected reserves of ore recoverable at greater cost and on utilization of breeder reactors. In the long term, the stock of depleted uranium may be utilized as feed material in breeder reactor fuel cycles. Consideration of the reserves of all depletable fuels shows that uranium consumption in the proposed operation is a reasonable productive use of this resource.

Other significant depletable resource materials used in fuel and reactor controls have been estimated by the staff (Table IX-3); these materials could not be recycled.

E. WATER AND AIR RESOURCES

The expected releases of chemicals, heat, and radioactive materials and their consequences are discussed in Chapter V. Operation of the Plant necessarily uses both air and water resources at Indian Point to disperse these discharges. This use, however, is not a matter of consumption; furthermore, the use does not curtail the range of beneficial uses of these environmental resources, except as mentioned in Chapters IV, V, VI, and XI, and it does not involve an

Table IX-2. Estimated resources required to support the Indian Point Unit No. 3 for 40 years at 85% capacity

Resource	Amount
Uranium mined	5,430 metric tons
Separative work for 3.2% enrichment and 0.2% tails assay	5.3×10^6 SWU[a]
New fuel input to reactors – contained uranium	1,140 metric tons
Consumption – burnup and unrecoverable process losses	
Uranium-235	28 metric tons
Uranium-238	79 metric tons
Recovered material	
Fissionable plutonium	7 metric tons
Process waste and scrap	
High specific activity	60 to 130 m^3
Low specific activity	800 m^3
Uranium in enrichment plant tails	5,320 metric tons

[a]Kilogram separative work units, computed in accordance with established uranium enrichment criteria.

Source: U.S. Atomic Energy Commission, *AEC Gaseous Diffusion Plant Operations,* Report ORO-684, January 1972; and U.S. Atomic Energy Commission, Uranium Enrichment Services Criteria, *Federal Register* 31: 16479 (Dec. 23, 1966); as amended in *Federal Register* 35: 13546 (Aug. 25, 1970) and *Federal Register* 36: 4562 (March 9, 1971).

Table IX-3. Irretrievable materials contained in fuel and control rods expended in the Indian Point Unit No. 3 in 40 years

Material	Weight
Cadmium	690 kg
Indium	2,060 kg
Silver	11.0 metric tons
Tin (in fuel cladding)	3.6 metric tons
Zirconium	250 metric tons

irreversible or irretrievable commitment of water or air resources provided an alternate closed-cycle cooling system for the protection of the aquatic biota is in operation.

F. LAND RESOURCES

Only the land occupied by the Plant buildings (approximately 35 acres) may be considered irreversibly committed. The degree of dismantlement of the Plants will be determined by the intended future use of the site, which will involve a balance among health and safety considerations, salvage values, and environmental effects (see Sect. VIII.B.3).

Radioactive wastes generated at the Plant will be released to the environment or shipped to licensed repositories. Reprocessing of spent fuel from this Plant will generate additional wastes, which will eventually be deposited in a long-term Federally approved repository. The entire nuclear fuel cycle (from mine to waste repository) depends upon a highly developed system of interdependent facilities that have already been established for supporting the nuclear energy program in this country. As use of nuclear fuel increases, additional facilities will need supporting services. The licensing of privately owned facilities (such as the Allied-Gulf Nuclear Services Plant in Barnwell, South Carolina) and the establishment of government-owned facilities (such as high-level waste repositories) will be the subject of detailed statements on environmental, resource, and other aspects of those facilities. The subject of radioactive waste management has been addressed in the AEC report, "Management of Commerical High Level and Transuranium-Contaminated Radioactive Waste."[7]

It is appropriate, however, to point out that onsite waste management programs for operation of Unit No. 3 will affect commitments of resources for ultimate waste storage and commitment of the environs of these Plants for radioactive wastes released routinely during operation. The Commission's policy is to keep the level of radioactivity of effluents from Unit No. 3 and similar plants as low as practicable, with the consequence that more storage space in repositories must be committed than would be required under more permissive release policies. Based on the experience of operating reactors, the staff estimates that approximately 4900 Ci of radioactive material in 1,000 55-gal drums will be shipped each year. These low-level solid wastes are described in Chapter V. The general commitment of suitable storage space for such wastes is irreversible, but the staff does not expect detailed commitments on the ultimate disposal of Unit No. 3 wastes to be made at this time, so that a diversity of choice can be retained for the future.

G. FINANCIAL AND OTHER RESOURCES

The total investment of the applicant in Unit No. 3 at the end of 1974 is presently estimated at $323,000,000,[8] which includes both costs of depletable and renewable resources and costs for non-resource-connected services. Another commitment is the time of over five years to build the physical Plant. Construction of Unit No. 3 started in August 13, 1969; completion is expected by the early part of 1975. Human talents, skills, and labor to design, build, and operate Unit No. 3 have been irreversibly and irretrievably committed since the start of the Plant in 1969. See Chapter XI for a discussion of irreversible and irretrievable resources committed on an alternate closed-cycle cooling system, based on the staff's recommendation.

H. CONCLUSIONS

The staff concludes that permitting proposed operation of once-through cooling over a limited time period, if carried out under the radiological and nonradiological ecological surveillance program to be required by the Technical Specifications and described in Sections V.D and V.E of this Statement, will achieve the objectives of the National Environmental Policy Act with respect to use of resources. The environmental monitoring program will serve to provide a means for limiting any short-term damage to the environment and the ecological surveillance program can be used to predict any short-term irreparable or irretrievable damage to the environment. Alternate Plant design and operating procedures described in Chapter XI are available to avoid degradation of the environment beyond repair, and to optimize operation of Unit No. 3 with minimal damage to the environment, in accordance with balancing benefits and costs of operating with the present versus an alternate cooling system over the long term.

REFERENCES FOR CHAPTER IX

1. Lincoln, G. A., "List of Strategic and Critical Materials," Office of Emergency Preparedness, *Fed. Regist.* 37(39): 4123 (February 26,1972).

2. U.S. Department of the Interior, Bureau of Mines, "Mineral Facts and Problems," 1970 ed., p. 230.

3. U.S. Department of the Interior, Bureau of Mines, "Mineral Facts and Problems," 1970 ed., pp. 14-19.

4. United States Atomic Energy Commission, *Statistical Data of the Uranium Industry — January 1l, 1972,* Grand Junction Office, Grand Junction, Colo., Report GJO-100.

5. Faulkner, R. L., "Outlook for Uranium Production to Meet Future Nuclear Fuel Needs in the United States," Fourth United Nations International Conference on the Peaceful Uses of Atomic Energy, Geneva, September 6-16, 1971, Paper A/Conf. 49/P/059.

6. U.S. Atomic Energy Commission, Fuels and Materials, Directorate of Licensing, *Environmental Survey of the Uranium Fuel Cycle*, WASH-1248, April 1974.

7. U.S. Atomic Energy Commission, "Management of Commercial High Level and Transuranium-Contaminated Radioactive Waste," WASH-1539, September 1974.

8. Letter dated August 16, 1974 from W. J. Cahill, Jr., Consolidated Edison Company of New York, Inc., to A. Giambusso, Directorate of Licensing, U.S. Atomic Energy Commission.

X. THE NEED FOR POWER

A. FRANCHISE AREA

The applicant's electric service area includes the New York City Boroughs of Manhattan, Bronx, Brooklyn, Richmond, and Queens (except Far Rockaway Peninsula) and all but the northeast portion of Westchester County (see Fig. X-1). The service area covers about 593 sq miles and has a population of about 8,861,000.[1] In addition to power sold to the applicant's regular customers, electric power is sold under contract to the New York City Transit Authority, Staten Island Rapid Transit Railway Company, Port Authority Trans Hudson Corporation (PATH), Penn Central Transportation Company, and the Long Island Railroad Company. New York City is the largest and most important city in the United States, ranking first in the value of products manufactured and in the number of individual industries. The economy of the area is very highly diversified.[2] The load density in the service area varies from less than 1 MW*/sq mile to more than 100 MW/sq mile, as shown in Fig. X-2.

B. GENERATING FACILITIES

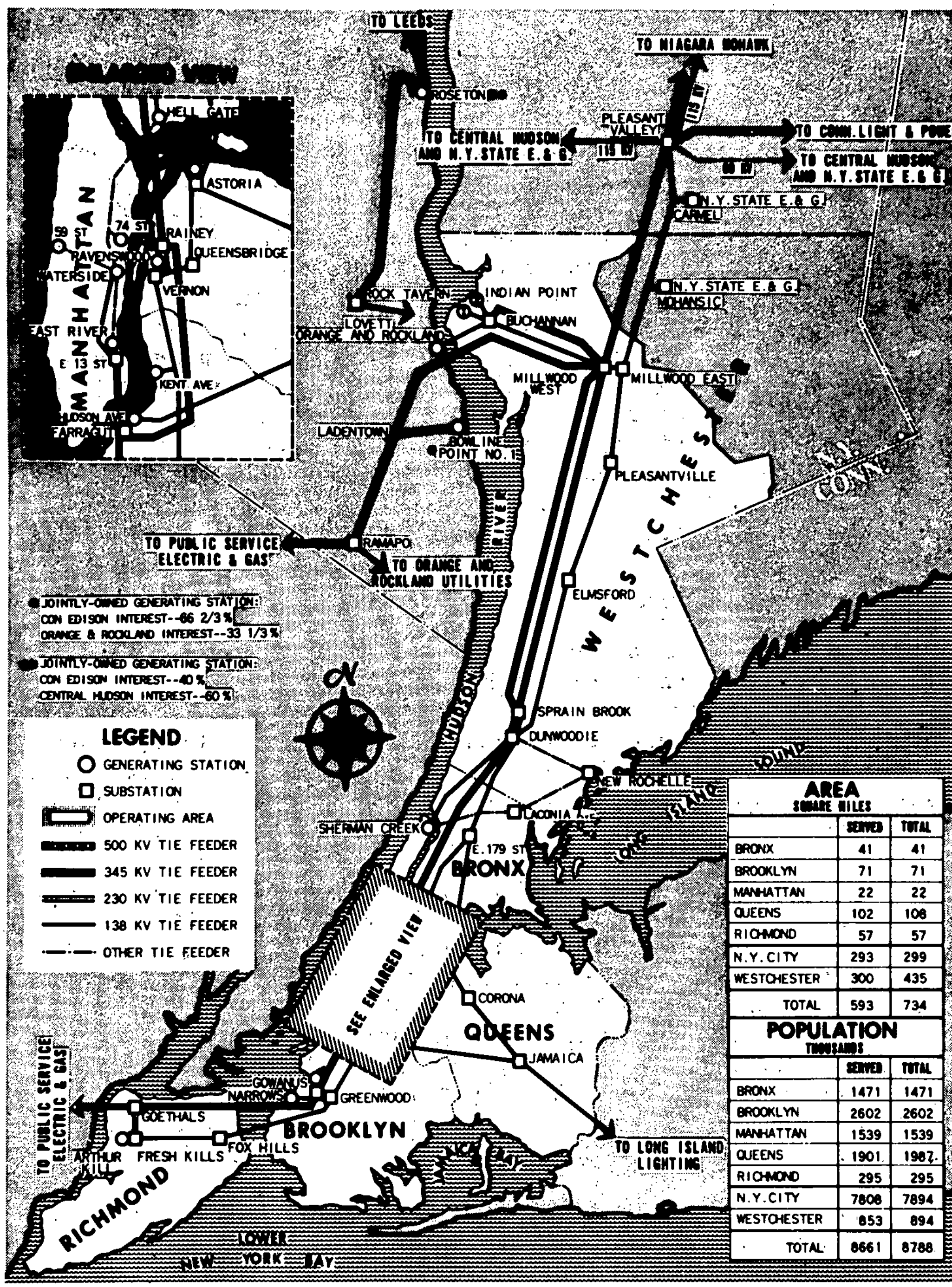
Generating facilities owned in fee by the applicant consist of ten steam generating plants, of which one has two nuclear units and eight include gas turbine units. In addition, the applicant owns four gas-turbine generating plants at Gowanus Bay, Kent Avenue, Narrows, and Buchanan. All of the above steam and gas-turbine plants are within the applicant's electric service area, as shown in Fig. X-1.

Generating stations not owned in fee are the Bowline Point Station in Orange and Rockland's territory and the Roseton Station in Central Hudson's territory. The applicant is participating in the construction of both of these fossil-fueled base-load plants, each of which will have two 600 MW units. The applicant's share is 66-2/3% of the Bowline Point Station capacity and initially 40% of the Roseton Station capacity. Bowline Point Unit No. 1 started commercial operation in October 1972 while Unit No. 2 began in May 1974. The estimated in-service dates for the Roseton Units are September 1974 for Unit No. 1 and November 1974 for Unit No. 2.[3]

The applicant's individual generating-station capabilities are summarized in Table X-1 (ER, IP-3, Suppl. 7, App. FF). The total net capability as of March 1, 1973, was 8,917 MW of dependable summer capacity and 9,633 MW of dependable winter capacity.

*All MW in this Chapter refe · to MWe.

ES-530



AREA SQUARE MILES	SERVED	TOTAL
BRONX	41	41
BROOKLYN	71	71
MANHATTAN	22	22
QUEENS	102	108
RICHMOND	57	57
N.Y. CITY	293	299
WESTCHESTER	300	435
TOTAL	593	734

POPULATION THOUSANDS	SERVED	TOTAL
BRONX	1471	1471
BROOKLYN	2602	2602
MANHATTAN	1539	1539
QUEENS	1901	1987
RICHMOND	295	295
N.Y. CITY	7808	7894
WESTCHESTER	853	894
TOTAL	8661	8788

Fig. X-1. Generating stations and bulk power transmission routes.

ES-531

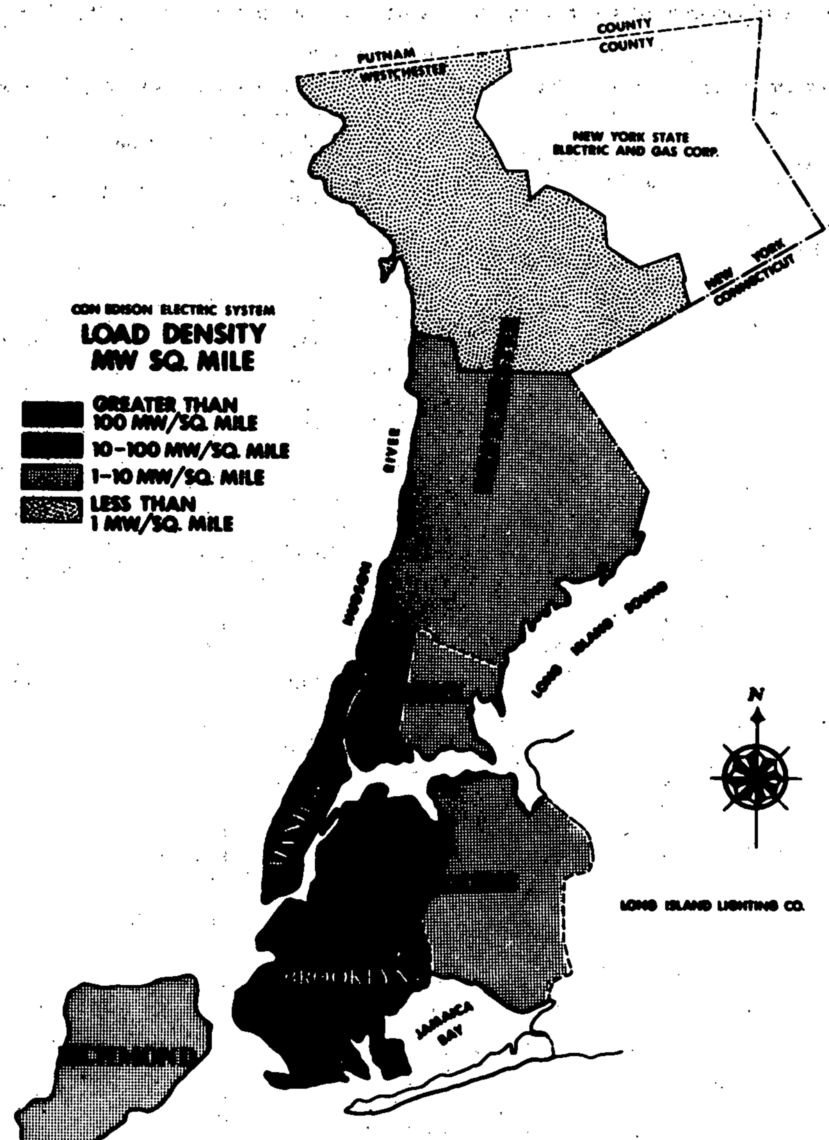


Fig. X-2. Electrical load density in area served by Consolidated Edison Company.

Table X-1. Individual generating station capability summary, Consolidated Edison System, April 1, 1974

*, common header station

P, pulverized coal; O, oil (No. 2 oil used for gas turbines); G, natural gas; K, kerosene; N, nuclear

Station	Unit number	Type of fuel	Date installed	Operating capacity (MW) Summer	Operating capacity (MW) Winter	House load (MW)	Net capability (MW) Summer	Net capability (MW) Winter
Conventional thermal								
Arthur Kill	2	O-P	8-31-59	325	340			
	3	O-P	6-5-69	505	515			
Total				830	855	24	806	831
Astoria	1	O-G-P	11-10-53	180	183			
	2	O-G-P	3-23-54	170	173			
	3	O-G-P	9-29-58	390	398			
	4	O-P	3-27-61	385	393			
	5	O-P	5-22-62	395	403			
Total				1,520	1,550	72	1,448	1,478
Bowline Point	1	O	9-8-72	416[a]	416[a]	15[b]	401	401
East River*	5	O-G	9-20-51	134	138			
	6	G	11-28-51	140	144			
	7	O-G	6-24-55	176	180			
Total				450	462	18	432	444
Hudson Avenue*	2	O	6-2-24	50	50			
	3	O	10-20-24	20	20			
	5	O	9-1-28	87	90			
	6	O	10-8-30	80	82			
	7	O	1-7-32	150	160			
	8	O	5-4-32	150	160			
	10	O	8-24-51	48	48			
Total				585	610	70	515	540
Ravenswood	1	O-G	2-21-63	415	420			
	2	O-G	5-6-63	411	416			
	3	O-P	6-15-65	1,000	1,000[c]			
Total				1,826	1,836	48	1,778	1,788

Table X-1 (continued)

Station	Unit number	Type of fuel	Date installed	Operating capacity (MW) Summer	Operating capacity (MW) Winter	House load (MW)	Net capability (MW) Summer	Net capability (MW) Winter
Waterside*	4	O-G	9-10-37	34	34			
	5	G	6-29-38	31	31			
	6	O	7-30-41	58	58			
	7	O	9-18-41	60	66			
	8	O	6-2-49	46	46			
	9	O	10-17-49	32	32			
	10	O	9-25-24					
	11	O	10-29-19	101	107			
	12	O	10-23-24					
	13[d]	O	12-16-19					
	14	O	11-9-48	120	130			
	15	O	3-7-49					
Total				482	504	35	447	469
59th Street*	7	O	6-17-18					
	8	O	1-28-18	52	55			
	13	O	3-4-52	50	50			
	14	O	5-23-62	20	20			
	15	O	8-1-68	10	10			
Total				132	135	9	123	126
74th Street*	3	O	7-30-15	26	26			
	9	O	11-20-59	142	142			
	10	O	5-6-56					
	11	O	4-26-62	36	36			
Total				204	204	57	147	147
Total conventional thermal							6,097	6,224
Nuclear								
Indian Point	1	N-O[e]	9-30-62	277	282	20	257	262
	2	N	5-22-73	873	873		873	873
Total nuclear							1,130	1,135

Station	Unit number	Type of fuel	Date installed	Sustained capacity (MW) Summer	Sustained capacity (MW) Winter	Maximum capacity (MW) Summer	Maximum capacity (MW) Winter
Gas turbines							
Arthur Kill	1	O	6-30-70	14	16	16	18
Astoria	1	G	7-17-67	15	18	15	18
	2-4	G-K	7-13-70	408	504	468	552
	5-9	O	8-6-70	75	95	80	100
	10	O	1-4-71	22	28	25	31
	11	O	2-1-71	22	28	25	31
	12	O	5-14-71	22	28	25	31
	13	O	5-12-71	22	28	25	31
Total				586	729	663	794

Table X-1 (continued)

Station	Unit number	Type of fuel	Date installed	Sustained capacity (MW)		Maximum capacity (MW)	
				Summer	Winter	Summer	Winter
Gowanus Bay	1	O	6-11-71	144	192	152	200
	2	O	6-21-71	144	192	152	200
	3	O	7-12-71	144	192	152	200
	4	O	7-22-71	144	192	152	200
Total				576	768	608	800
Kent Avenue	1-2	K	7-8-69	22	28	18	24
Narrows	1-2	K-O	6-15-72	320	416	352	448
Ravenswood	1	G	7-24-67	14	16	15	18
	2	G-K	12-31-70	124	159	124	159
	3	G-K	8-7-70	126	161	126	161
	4	G-O	9-19-70	14	16	16	18
	5	G-O	8-25-70	14	17	16	19
	6-7	G-O	8-29-70	30	38	34	40
	8-11	G-K	8-11-70	64	84	76	92
Total				387	493	407	507
Waterside	1	K	10-9-68	11	14	11	14
74th Street	1-2	K	10-23-68	28	36	34	40
Hudson Avenue	1	K	7-27-68	14	18	17	20
	2	K	7-27-68	14	18	17	20
	3-5	O	7-4-70	42	51	48	57
Total				70	87	82	97
Indian Point	1	O	7-17-69	17	21	19	25
Buchanan	2	O	7-14-71	22	28	25	31
	3	O	12-2-70	15	18	16	20
Total				54	67	60	76
59th Street	1-2	K	6-12-69	28	36	34	40
Total gas turbines						2,285	2,858
Total net capability, all types						9,512	10,217

[a]Bowline Point Unit No. 1 is a 600-MW unit. Orange and Rockland has a one-third share and Consolidated Edison has a two-thirds share. Total operating capacity is 624 MW.
[b]Total = 24 MW.
[c]At 5% overpressure.
[d]Derated 23 MW in summer and 25 MW in winter due to 25-Hz single phase operation.
[e]Oil-fired superheater.
Source: Consolidated Edison Company of New York, *Environmental Report, Indian Point Unit No. 3*, App. FF, pp. VI-8 to VI-12, revised in accordance with Northeast Power Coordinating Council, *Data on Coordinated Regional Bulk Power Supply Programs*, FPC Order 383-3, Docket R-362, Appendix A-1, April 1, 1974, Table 8.

C. INTERCONNECTIONS WITH OTHER MAJOR UTILITIES

The applicant has bulk-power transmission interconnections with six other major utilities, as shown in Fig. X-1. These utilities are Niagara Mohawk Power Corporation, Central Hudson Gas and Electric Corporation, Orange and Rockland Utilities Corporation, Long Island Lighting Company, Public Service Electric and Gas Company (New Jersey), and Connecticut Light and Power Company. Major transmission projects currently authorized are listed in Table X-2.[4]

Interconnections with other utilities serve to interchange low-cost power and provide additional capacity during emergencies. These functions are discussed in more detail in Chapter XI.

D. CONSUMPTION OF ELECTRICITY

Figure X-3 shows the consumption of electricity by user classification in the area served by the applicant. The data for 1960 and 1970 are from the applicant's records, and the data for 1975 and 1980 are the applicant's current forecast, which differs slightly from those reported in the Environmental Report (ER, IP-3, Suppl. 2, p. B.1.1-2). Sales to other electric utilities are not included.

Projected residential consumption shows less than 1% increase in its share of consumption during the decade of the 1970's. This seemingly small increase is reinforced by the Regional Plan Association's projection that between 1967 and 1985, only 5% of the region's population growth will take place in New York City. The decline of 1.5% for commercial and industrial consumption over the same decade can be accounted for in the projections[5] for skills and labor force in New York City:

Skill	1967 Labor force	1967 % of total	1985 Labor force	1985 % of total
White collar	2,442,917	59	2,862,574	64
Blue collar	1,145,541	28	1,014,452	23
Service	536,202	13	607,084	13

The projected swing to greater dominance of white collar employment would reflect a decrease in the commercial and industrial share of total consumption, as office employment requires less power consumption than does factory employment. Projected railway and governmental consumption parallels the projected residential growth,

Table X-2. Major transmission projects currently authorized

Project	Original completion date	Present completion date	Remarks
Southern tier interconnection North-south section: Ramapo to Rock Tavern East-west section: Rock Tavern to Coopers Corners	January 1971	 Completed 1975–76[a]	Delayed by hearings for PSC Certificate of Environmental Compatibility and Public Need, which was subsequently appealed by intervenors in NYS Supreme Court and Court of Appeals. Appellate Court upheld the PSC Certification on Dec. 6, 1972.
Rebuild Aqueduct right-of-way	Spring 1969	Spring 1975	Scheduled starting date for the rebuilding of the 138-kV double circuit overhead line for 345-kV operation delayed five years due to difficulties in obtaining final approval from New York City and construction problems encountered in removing the existing lines. Difficulties in obtaining local permits delayed installation of related underground feeders between Eastview and Elmsford, which were completed late in 1972.

[a]New York State Department of Public Service, *The New York Power System Generation and Transmission Plans 1971–1980*, December 1971, pp. 13–18.

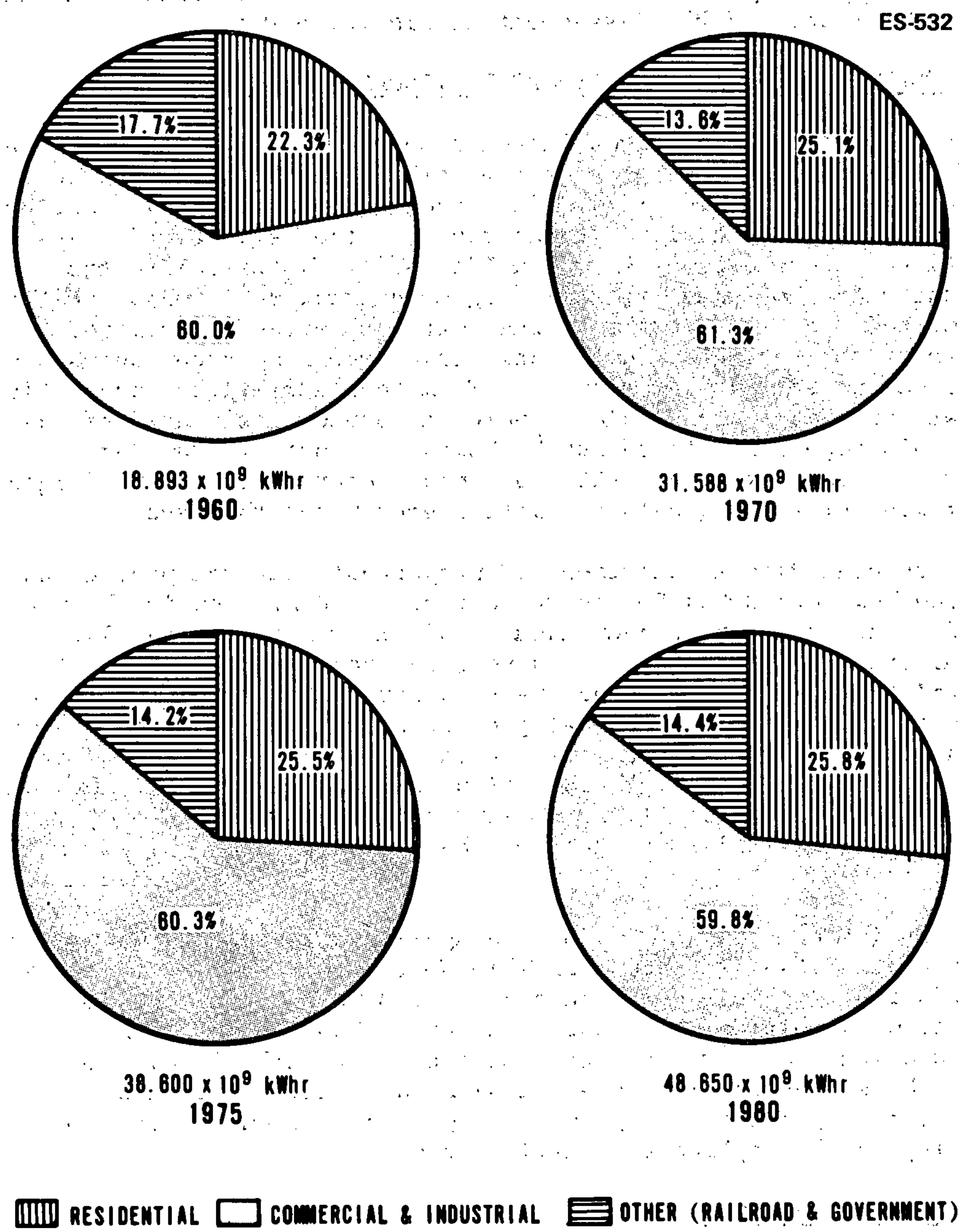


Fig. X-3. Consumption of electricity by user classification in area served by Consolidated Edison Company.

which seems reasonable. Therefore, the staff concludes that the applicant's projections for consumption of electricity by user classification appear to be reasonable. A more detailed evaluation is made in Sect. X.H, "Assessment of Predicted Demand."

E. POPULATION GROWTH AND PROJECTED TRENDS

Population growth in the applicant's service area has always been under the influence of what is now called the 31-County New York Urban Region. This region, which encompasses parts of New Jersey, New York, and Connecticut, coincides with the Regional Plan Association's study area as shown in Fig. X-4. Historically, the northern New York sector, including Manhattan, the Bronx, and the seven counties immediately to the north, received the greatest share of the region's growth until 1910, when the Bronx and southern Westchester County grew rapidly. From then until 1965, population growth shifted to Long Island, which absorbed nearly half of the region's population increment.[6] However, growth in New Jersey increased rapidly after 1965, and this sector received the largest increment of the region's population growth for the decade.

The Regional Plan Association had projected[7] that the population of the New York Urban Region would rise to 30 million in the year 2000. This would have been about a 50% increase over the 1970 population of 19,751,806.[8] However, the persistent decline of fertility rates has prompted the U.S. Bureau of the Census to revise its forecasts of national population growth[9] and the Regional Plan Association to reduce its population projections accordingly. The present "most likely" projection is a regional population that will total nearly 25 million by 2000 and 27 million by 2020, with zero growth to follow.[10] Most of the growth will be coming in New Jersey.

The population projections for the applicant's electric service area to the year 2000 are shown in Table X-3. The total service area population is expected to increase only 3.9% over the 1970–2000 period with Westchester County increasing 244,000 or 71.6% of the 341,000 increase for the total service area. All of New York City, with the exception of Queens and Richmond, will experience a decrease in population. Figure X-5 shows the present population density in the applicant's service area.

F. ECONOMIC FACTORS

History attests to the importance of energy in advancing the material well-being of mankind — both by providing the underpinnings of economic growth and by satisfying various desires made possible by that growth. The economic growth of the applicant's service area

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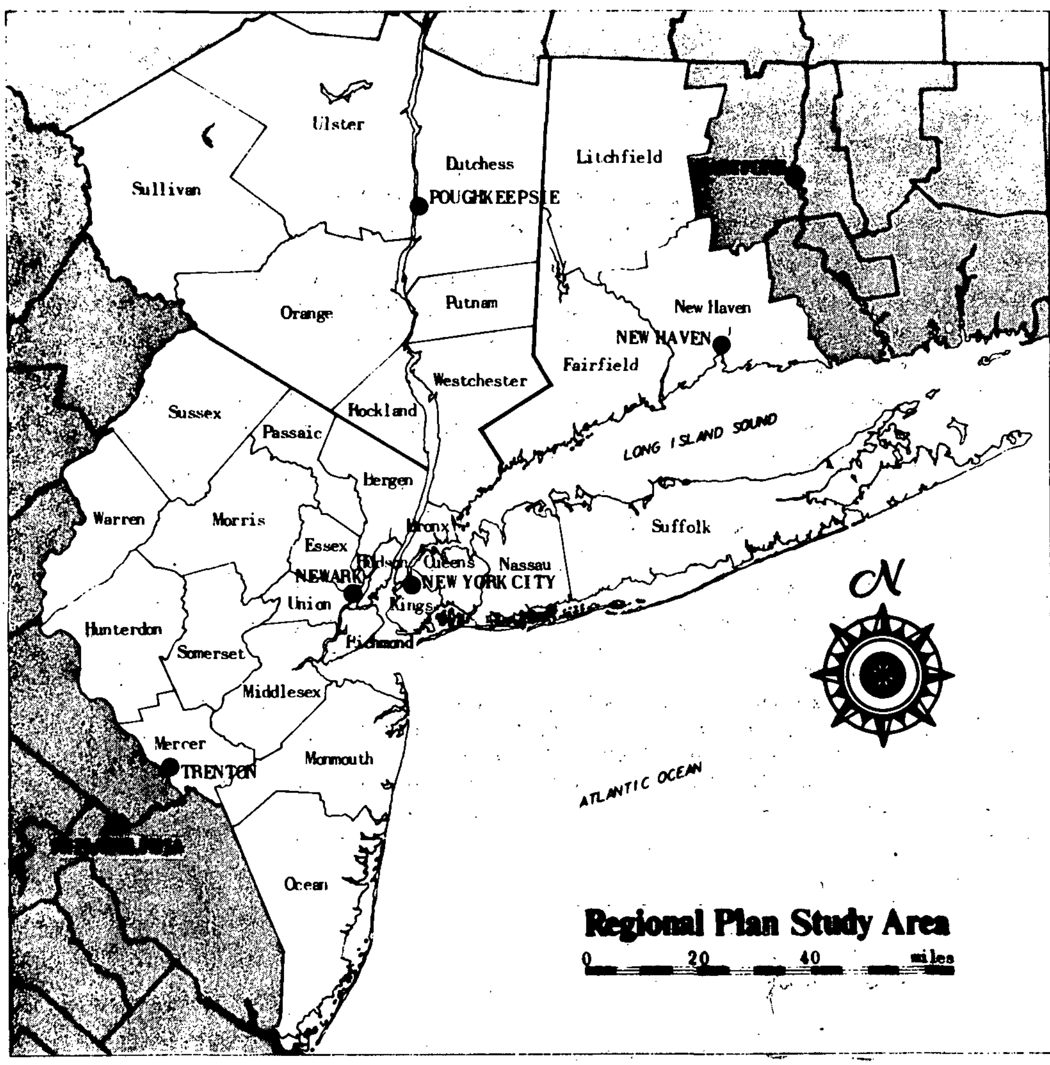

Fig. X-4. The 31-county New York urban region.

Table X-3. Population projections for Consolidated Edison Company electric service area

	Population (thousands)			
	1960	1970	1985	2000
New York City				
Bronx	1,425	1,471	1,400	1,350
Brooklyn	2,627	2,602	2,520	2,450
Manhattan	1,698	1,539	1,410	1,500
Queens	1,731	1,901	2,010	2,105
Richmond	222	295	410	500
Subtotal	7,703	7,808	7,750	7,905
Westchester County	772	853	1,002	1,097
Total for service area	8,475	8,661	8,752	9,002

Sources:

U.S. Bureau of the Census, "Projections of the Population of the United States, by Age and Sex: 1972 to 2020," *Current Population Reports*, Series P-25, No. 493, U.S. Government Printing Office, Washington, D.C., 1972.

Regional Plan Association, *New Regional Projections: A Summary*, New York, Mar. 16, 1973, p. 3.

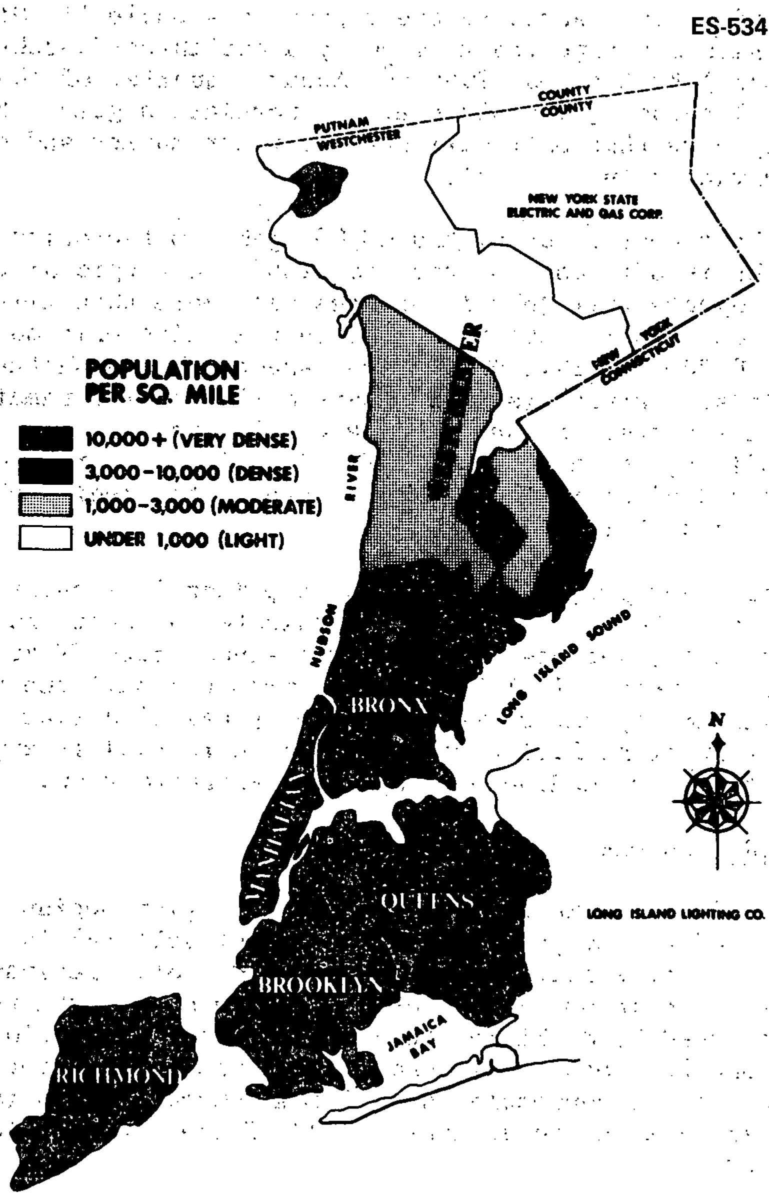

Fig. X-5. Population density in area served by Consolidated Edison Company.

is directly related to the 31-county urban region, which in itself is an economic entity. Office jobs serving a national or larger-than-regional market are the most dynamic part of the region's economy and are attracted to the region as a whole.[11] Office jobs in the region are expected to grow by about three-fourths (1.5 million more) by the year 2000.[12] About a quarter of these will serve local needs, going wherever the population goes. But substantially more than half will serve a wider market and could be located anywhere in the region.

In 1965, Westchester County had 60,000 jobs in factories and only 46,500 jobs in offices. By the year 2000, the Regional Plan Association projects that jobs in offices will more than triple, to about 160,000, while jobs in factories will rise only modestly to about 80,000.[13] This projection assumes that Manhattan's central business district (south of Central Park) will remain the major office center in the nation and will increase its jobs in office buildings by about one half. However, this rate of growth does mean a decline in Manhattan's share in the region's office jobs from about 50% to about 40%.

Total employment projections for the applicant's service area are shown in Table X-4. These figures indicate an annual rate of growth of less than 1%, whereas the projected annual rate of growth for the 31-county region is 1.5% from the present until the year 2000.[14] This lag in employment growth rate is typical of a long-term trend, with older sections losing ground to the more rapidly expanding sections that have undeveloped space in which to grow.

G. PERSONAL INCOME

The personal income in the New York Urban Region beginning in 1965 and projected to the year 2000 (in constant dollars) is shown in Table X-5. Historically, as per capita and total personal incomes have risen, the income distribution curve has also shifted upward, leaving a steadily declining percentage of the population in the lower income brackets. This process is expected to continue, and the proportion of households with incomes under $5,000 (about 25% in 1970) is expected to decline to 13% of the region's total in the year 2000.

The personal income projection is based on two principal assumptions: (1) an average rate of growth in the nation's real per capita income of 2.5%/year during the forecast period, which is in line with its historical growth trend, and (2) the continuation of a long-run decline in the extent to which the region's per capita income is higher than the nation's. As of 1970, the New York per capita income was about 16.5% higher than that of the

Table X-4. Total employment projections for Consolidated Edison Company electric service area

Employment area	Total employment[a]			
	1959	1967	1975	1985
New York City	3,835,800	4,079,290	4,194,400	4,434,785
Westchester County	244,200	306,100	362,023	451,942
Total	4,080,000	4,385,390	4,556,423	4,886,727

[a]Adjusted to delete employment in the areas within the Borough of Queens and Westchester County that lie outside the service area.

Source:

R. B. Armstrong, *Linking Skills, Jobs and Housing in the New York Urban Region*, summary of a study by the Regional Plan Association for the National Committee Against Discrimination in Housing, financed by the Carnegie Corporation of New York, N.Y., March 1972, p. 19.

Table X-5. Personal income in the New York Urban Region, 1965–2000, in constant dollars

	Personal per capita income (dollars)	Total personal income (millions of dollars)	Households with incomes under $5,000 (%)
1965	3,350	63,344	31.5
1970	3,730	75,442	25.4
1975	4,157	90,259	22.3
1980	4,590	107,338	19.1
1985	5,080	127,979	17.6
1990	5,600	151,363	16.1
1995	6,200	177,739	14.5
2000	6,776	204,543	12.8

Source:

Regional Plan Association, "How Many More People?", *The Second Regional Plan*, New York, November 1968, p. 27.

nation. By the year 2000 this advantage in the region is forecast to drop to 10%. Even so, a higher portion of the population in the labor force and higher projected income levels will enable people to purchase consumer goods in increased quantities. This leads, in turn, to increased power uses by manufacturing and service industries.

H. ASSESSMENT OF PREDICTED DEMAND

Econometric models exist for predicting the demand for electricity[15] but require the collection and processing of large amounts of data from all segments of the economy, which would exceed the time allowed for preparation of an environmental impact statement. The staff, therefore, elected to use consumption of electricity, population and employment projections, and personal income as parameters to assess the applicant's predicted demand for the years 1975 and 1980. The data for all of the parameters are limited to the confines of the applicant's service area; however, the effects of the total region were considered in their development, as discussed in the preceding Sections X.D through X.G.

The first step was to evaluate the applicant's projections for the consumption of electricity by user classification for 1975 and 1980. This was accomplished by determining the projected average for the number of customers and consumption per customer for both the residential classification and the commercial and industrial classification. Since there was no correlation in the historical data for residential customers for different years, population projections were used by the staff. Commercial and industrial sales reported by the applicant include sales to landlords of residential units where the charge for electrical energy is included in the rent.[16] This was determined by the staff from historical data to be about 8% of the total number of customers that would be classified as residential. The total number of residential customers was estimated by dividing the projected population by the average number of persons per household projected for the New York Urban Region in 1975 (2.98) and 1980 (2.87) by the Regional Plan Association.[17] These totals were then reduced by 8% to make them equivalent to the residential category as reported by the applicant. The residential rate of consumption was based on the extrapolation of kWhr per customer vs total personal income, as growing wealth will be spent mainly for personal goods. Commercial and industrial consumption was based on employment projections and extrapolation of kWhr per worker vs year. The declining fertility rate has little effect on the number of jobs, since the great majority who will be in the labor force in 2000 are already born.[18] Sales to railroads and railways were assumed to account for 14% of the applicant's total sales. The comparison of staff estimates and applicant's predictions for consumption of electricity by user classification are shown in Table X-6.

Table X-6. Comparison of staff estimates and applicant's predictions for consumption of electricity by user classification

	Estimated consumption of electricity (10^6 kWhr)			
	Staff		Applicant	
	1975	1980	1975	1980
Residential	10,577	13,754	9,852	12,575
Commercial and industrial	21,948	27,966	23,291	29,091
Railroads and railways	5,295	6,792	5,457	6,984
TOTALS	37,820	48,512	38,600	48,650

Staff estimates for total consumption are 2.0% lower than the applicant's prediction for 1975 and 0.3% lower for 1980. The staff estimates for residential consumption are higher than the applicant's, whereas the commercial and industrial consumption estimates are lower than the applicant's. These differences would seem logical in light of the new projections by the Regional Plan Association. Although population growth will be lower than previously predicted, the number of households will increase due to fewer persons per household, thereby accounting for the higher residential consumption. The decrease in estimated commercial and industrial consumption can be attributed to a greater swing from factory to office jobs than previously predicted. Overall, the staff and applicant estimates for total consumption in 1975 and 1980, however, are in reasonable agreement.

Estimates for the summer peak loads (1-hr net maximum load distributed locally) were obtained in the following manner. The projected capabilities, peak loads, and margins of the New York State interconnected systems from 1974 through 1983[19] were examined. Beginning with 1974, the ratio of the coincident peak load to the total annual energy requirement was found to be constant at 0.18 throughout the period. The ratio of 0.18 applies when peak loads are expressed in megawatts and annual energy requirements in millions of kilowatt hours. In general, ultimate consumption is about 90% of total annual energy requirements, because transmission and other losses consume 10% of a system's output.[20] Thus, the applicant's total annual energy requirements for 1975 and 1980 would be about 42,022 x 10^6 and 53,902 x 10^6 kWhr, respectively. However, before applying the constant to obtain the projected peak loads for the applicant's service area, the constant for the New York Power Pool must be corrected to reflect the difference in load factor, as follows:

$$\text{adjusted constant} = 0.18 \, \frac{\text{projected power pool load factor}}{\text{projected applicant load factor}} ,$$

where the projected load factors are for 1975 or 1980, as appropriate.

This gave an adjusted constant for the applicant's system of 0.22 for both 1975 and 1980. The adjusted factor was then applied to the estimated total energy requirements for 1975 and 1980 to obtain the estimated summer peak loads. Detailed data and calculations are given in Appendix H. The results compared with the applicant's predictions[21] are shown below.

	Estimated summer peak load (MW)	
Year	Staff	Applicant
1975	9,245	9,200
1980	11,858	11,025

I. APPLICANT'S TEN-YEAR PLAN

The applicant's ten-year plan for capacity, load, and reserve is outlined in Tables X-7 (summer program)[19] and X-8 (winter program).[22] Since the company has made the transition from a winter-peaking to a summer-peaking system, the basis for planning new capacity is the estimated peak load for the summer of each year. The footnotes point out some of the uncertainties that may affect in-service dates for new and purchased capacity. Figure X-6 graphically displays the peak load and total system capacity historically from 1961 through 1973 and that projected from 1974 through 1980. The applicant has depended heavily upon purchased power, particularly in the last few years (about 14% of the net power for the system in July 1971), obtaining as much bulk power by firm contract as possible and supplementing this by daily purchases when available and load shedding (see Section XI.A.2). Some of the factors necessitating the purchase of power are:

Table X-7. Consolidated Edison Company planned capacity, load, and reserve (MW): Summer program 1974–1983

Effective date: April 1, 1974[a]

		1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Installed capacity		9,512	10,392	11,806	11,781	11,379	11,563	13,467	13,533	13,413	13,226
New capacity											
Bowline Point Unit No. 2 (Con Ed share)	May 1974	400									
Roseton Unit No. 1 (Con Ed share)	Sept. 1974	240									
Roseton Unit No. 2 (Con Ed share)	Nov. 1974	240									
Indian Point Unit No. 3	Nov. 1975		873								
Astoria GT (uprating)	Spring 1975		33								
Astoria Unit No. 6	Spring 1975		800								
Indian Point Unit No. 2 (uprating)	Spring 1978					92					
Indian Point Unit No. 3 (uprating)	Spring 1978					92					
Indian Point Unit No. 2 (uprating)	Spring 1979						35				
Indian Point Unit No. 3 (uprating)	Spring 1979						35				
Cornwall Units Nos. 1-4 (pumped storage)	Spring 1979[b]						1,000				
Cornwall Units Nos. 5-8 (pumped storage)	Fall 1979						1,000				
Indian Point Unit No. 2 (uprating)	Spring 1980							33			
Indian Point Unit No. 3 (uprating)	Spring 1980							33			
Total new capacity		880	1,706	0	0	184	2,070	66	0	0	0
Retirements and deratings											
Hudson Avenue T-2, 3	Apr. 1975		–34								
Hudson Avenue T-5, 6 & B-50R, 60R	Sept. 1975		–158								
Waterside T-10 through 13	Dec. 1975		–100								
59th Street T-8	Dec. 1976			–25							
Hudson Ave. T-7, 8 (and part of 70R & 80R boilers)	Apr. 1977				–282						
Roseton (transfer portion to Central Hudson)	Sept. 1977				–120						
Waterside T-4 through 7 and B-40R, 50R, 60R, 70R	May 1979						–166				
Roseton (transfer portion to Central Hudson)	Sept. 1981								–120		
Waterside Station	Apr. 1982									–187	
Total retirements & deratings		0	–292	–25	–402	0	–166	0	–120	–187	0
Total installed capacity		10,392	11,806	11,781	11,379	11,563	13,467	13,533	13,413	13,226	13,266

Table X-7 (continued)

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Planned purchase capacity										
Rochester (Ginna)	200									
PASNY		241	179	979	966	953	1,581	1,566	1,552	2,276
Orange & Rockland (Bowline Point Unit 1)	200	64								
Maine Public Service	39	39	42							
Total planned purchases	439	344	221	979	966	953	1,581	1,566	1,552	2,276
Total capacity resources at end of calendar year	10,831	12,150	12,002	12,358	12,529	14,420	15,114	14,979	14,778	15,502
Total capacity resources during summer peak load period	10,351	11,535	12,027	12,478	12,529	13,420	15,114	15,099	14,778	15,502
Estimated peak load	8,850	9,200	9,550	9,900	10,275	10,650	11,025	11,400	11,025	11,415
Reserve (MW) during summer peak load period	1,501	2,335	2,477	2,578	2,254	2,770	4,089	3,699	3,753	4,087
Reserve (%)	17.0	25.4	25.9	26.0	21.9	26.0	37.1	32.5	34.0	35.8
Reserve without Indian Point Unit No. 3 (%)		25.3	16.8	17.2	12.6	16.6	27.7	23.4	24.7	26.8

[a]Revised to reflect the new proposed in-service date of November 1975 for Indian Point Unit No. 3.

[b]These are tentative dates. Construction started in March 1974 and was suspended in July 1974.

Source: Northeast Power Coordinating Council, *Data on Coordinated Regional Bulk Power Supply Programs,* FPC Order 383-3, Docket R-362, Appendix A-1, April 1, 1974.

Table X-8. Consolidated Edison Company planned capability, load, and reserve (MW): Winter program 1974–1983

Effective date: April 1, 1974

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Installed net capability										
Base load fossil	7,104	7,870	7,764	7,764	7,484	7,291	7,291	7,291	7,171	7,171
Gas turbines & diesels	2,858	2,858	2,858	2,858	2,858	2,858	2,858	2,858	2,858	2,858
Nuclear	1,135	2,008	2,008	2,008	2,192	2,262	2,328	2,328	2,328	2,328
Hydro (conventional)	0	0	0	0	0	0	0	0	0	0
Hydro (pumped storage)	0	0	0	0	0	2,000	2,000	2,000	2,000	2,000
Total installed	11,097	12,736	12,630	12,630	12,534	14,411	14,477	14,477	14,357	14,357
List purchases and sales										
Capacity purchases in state[a]	301	92	68	68	63	58	696	690	1,466	1,420
Capacity purchases out of state	39	42	0	0	0	0	0	0	0	0
Total purchases	340	134	68	68	63	58	696	690	1,466	1,420
Capacity sales in state[a]	0	145	220	305	160	255	340	340	0	0
Capacity sales out of state	0	0	0	0	0	0	0	0	0	0
Total sales	0	145	220	305	160	255	340	340	0	0
Total capability	11,437	12,725	12,478	12,393	12,437	14,214	14,333	14,827	15,823	15,777
Peak load requirements[b]	6,100	6,600	7,175	7,425	7,675	7,950	8,225	8,500	7,795	8,085
Reserve										
Actual, MW[c]	5,337	6,125	5,303	4,968	4,762	6,264	6,608	6,327	8,028	7,692
Actual, %	87.5	92.8	73.9	66.9	62.0	78.8	80.3	74.4	103.0	95.1
Scheduled maintenance	1,452	2,200	2,500	2,500	2,500	2,800	2,800	3,000	3,000	3,000
Temporarily unavailable	0	0	0	0	0	0	0	0	0	0
Margin after outages	3,885	3,925	2,803	2,468	2,262	3,464	3,808	3,327	5,028	4,692
Margin after outages, %	63.7	59.5	39.1	33.2	29.5	43.6	46.3	39.1	64.5	58.0
Reduction in margin for adverse hydro conditions	0	0	0	0	0	0	0	0	0	0
Short term capability not included	0	0	0	0	0	0	0	0	0	0
Annual energy requirements (million kWhr)	35,845	37,125	40,975	42,250	43,675	45,175	46,875	48,325	45,475	47,000
Load factor based on annual peak load, %	46.2	46.1	48.8	48.7	48.5	48.4	48.4	48.4	47.1	47.0

[a]These purchases and/or sales are for planning purposes only; formal contracts with PASNY already exist in some cases.

[b]Although current PASNY plans anticipate their initial supply of MTA loads by 1981, for planning purposes it has been deemed prudent to assume continued supply by Con Edison through 1981 in the event of MTA plant slippage. Beginning in 1982 Con Edison's estimated system peak loads have been reduced by the MTA load coincident with the Con Edison peak to reflect the supply of MTA loads by PASNY.

[c]Where installed reserve capacity margins are less than NYPP requirement, balance will be supplied by other members within the pool if available, or by peaking and/or intermediate range capacity to be installed.

Source: 1974 Report of Member Electric Corporations of the New York Power Pool and the Empire State Electric Energy Research Corporation Pursuant to Article VIII, Section 149-b of the Public Service Law, April 1, 1974, vol. 2, Exhibit 6 B, p. 42.

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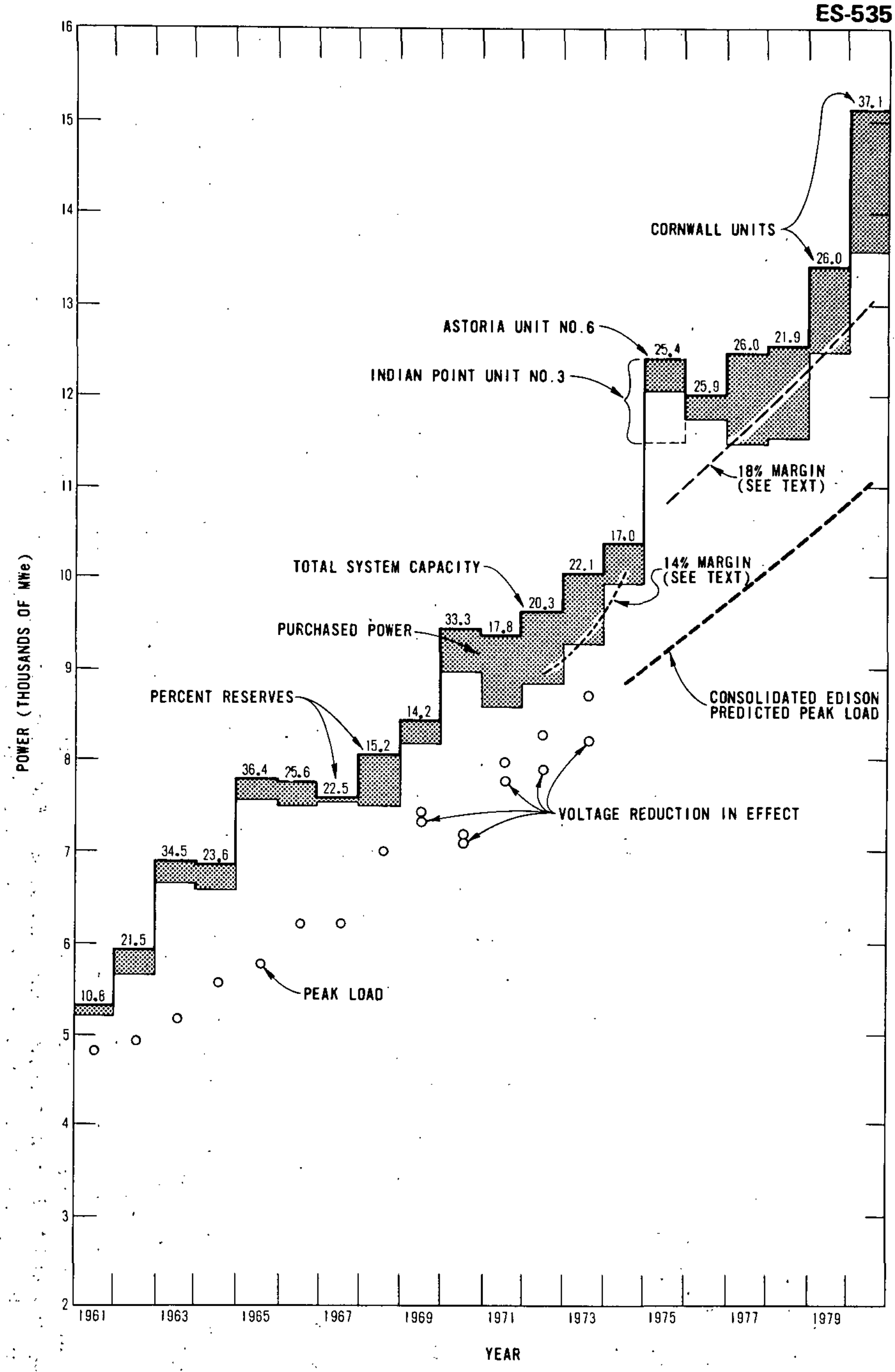

Fig. X-6. Peak load and total system capacity.

1. High forced outage rates and equipment derating due to age (some units have been in service over 50 years).

2. Slippage in the completion dates for new generating stations caused by procedural problems and interventions on various grounds.

3. Delays due to strikes on construction projects.

An example of how the system was affected by unavailable capacity during the summer of 1972 is shown in Table X-9.

The applicant has been conducting an intensive maintenance program[23] to reduce the unavailability of system capacity and plans to retire or derate older units as new capacity is installed. However, system capacity unavailability is still a factor affecting reliability and reserve requirements and must be considered in the assessment of the applicant's ten-year plan. Capacity unavailable during June and July of 1972 (Table X-9) averaged about 23% of installed capability. Assuming that planned retirements and deratings will gradually lower the amount of unavailable capacity over the long term, the possible immediate effects on summer reserves are shown in Table X-10. If 20% of the installed capacity is unavailable on the peak load day, the reserves would be negative and 1.3% in 1975 and 1976 and would amount to only 3.1% in 1977. Reducing the unavailability factor to 10% would result in reserves of 12.5%, 13.6%, and 14.6%, respectively, for 1975, 1976, and 1977.

The staff concludes that the applicant's seemingly adequate ten-year plan will be marginal during the summer peak load period through 1979, when a cumulative total of 765 MW of existing capacity will have been retired or derated. Major slippage of the in-service dates for Astoria Unit No. 6 (spring, 1975) and the Cornwall Units (spring and fall, 1979) could further aggravate the situation. The New York State Department of Public Service predicted in December 1971[24] that the applicant would have reserve margins ranging from 2.4% (1972) to 19.2% (1976) of its forecast summer peak load and 31.5% (1972) to 50.6% (1976) of its forecast winter peak load after taking into account probable delays in implementing its generation plan. The Department of Public Service considered these reserves, particularly for summer, to be "so low as to be critical in the whole 1971-1975 period and the situation appears to be deteriorating instead of improving."[24] This proved to be a valid prediction.

Table X-9. Unavailable capacity on peak days in June and July, 1972
(Exclusive of scheduled maintenance)

Week ending	Installed capability (MW)	Forced outage (MW)	Derating		Total unavailable capacity	
			Unit (MW)	Steam (MW)	Amount (MW)	% of installed capability
June 3	9,009	724	566	275	1,565	17.4
June 10	9,009	1,001	1,085	274	2,360	26.2
June 17	9,183	477	905	298	1,680	18.3
June 24	9,183	1,364	522	236	2,122	23.1
July 1	9,183	1,074	778	282	2,134	23.2
July 8	9,183	2,134	470	409	3,013	32.8
July 15	9,173	878	686	437	2,001	21.8
July 22	9,173	1,054	576	319	1,949	21.3

Source: State of New York Public Service Commission weekly reports to Governor Rockefeller.

Table X-10. Possible effects of unavailable capacity on summer reserves, 1975–1977

	1975	1976	1977
Total capacity resources, MW (during summer peak load period)	11,535	12,027	12,478
Estimated peak load, MW	9,200	9,550	9,900
Reserve. MW	2,335	2,477	2,578
Reserve, percent of peak load	25.4	25.9	26.0
Unavailable capacity on peak day, MW (20% of installed capacity)	2,361	2,356	2,276
Net capacity available, MW	9,174	9,671	10,202
Reserve, MW	−26	121	302
Reserve, percent of peak load	Neg.	1.3	3.1
Unavailable capacity on peak day, MW (10% of installed capacity)	1.181	1,178	1,138
Net capacity available, MW	10,354	10,849	11,340
Reserve. MW	1,154	1,299	1,440
Reserve, percent of peak load	12.5	13.6	14.6

The present ten-year plan substitutes the Cornwall Units (2,000 MW) for two previously planned units (an 800-MW fossil-fueled unit and a 1,115-MW nuclear unit) and purchased power for 990 MW of previously planned gas turbine units. After lengthy legal complications, the applicant on July 24, 1973, voted to authorize and approve purchase of property needed for the Cornwall Units. Construction at Cornwall began in March 1974 but was suspended on July 23, 1974.

During the next ten years, besides increasing the generating facilities of the applicant's system, the applicant has reported in its 1972 Annual Report that it will upgrade and modernize its transmission system such that by 1982 the capacity of its system to deliver power to New York City will increase from the present 2,720 MW to about 9,000 MW, even after allowing for loss of two of its largest circuits. About 5,500 MW of the 1982 transmission capacity would carry its own generation, and about 3,500 MW could carry purchased firm power and short-term economy and emergency imports.

The applicant has recently announced plans to build five 1,100-MW base-load units to come on line in 1984, 1985, 1987, 1989, and 1991.[25] The most likely site in mind at the present time is on the west side of the Hudson, north of Newburgh, behind the first row of hills along the shore, in the valley between them and the New York Thruway and out of sight of the river. Such plants would need cooling towers and would require only evaporative makeup water from the river. Several sites are under consideration including sites as far away as Lake Ontario and the St. Lawrence River. Other alternatives being considered include the use of offshore siting, either on barges or man-made islands, for nuclear plants. Plans are still tentative and are beyond the scope of the comprehensive survey of the future plans and long range programs of the utilities for needed growth as presented in the 1974 Report of Member Electric Corporations of the New York Power Pool and the Empire State Electric Energy Research Corporation.[4]

J. THE IMPACT OF ENERGY CONSERVATION AND SUBSTITUTION ON NEED FOR POWER

Recent energy shortages have focused the Nation's attention on the importance of energy conservation as well as measures to increase the supply of alternative energy sources. The needs to conserve energy and to promote substitution of other energy sources for oil and gas have been recommended by the Report to the President on *The Nation's Energy Future* as major efforts in regaining national energy self-sufficiency by 1980.[26] In the following sections, the staff considers conservation of energy as related to the need for the electricity to be produced by Indian Point Unit No. 3.

1. Recent Experience

Implementation of energy conservation measures by households, business, and government has already contributed to the lack of growth in the consumption of electricity nationally since the third quarter of 1973. During the fourth quarter of 1973, when the applicant anticipated a growth rate of +4%, the electric system sendout (adjusted for differences in weather) declined to +2.3% in October, -0.6% in November, and -6.0% in December. System sendout further declined to -7.3% in January 1974, when the anticipated normal growth was +3.6%.[27] For the nine-month period ending September 30,1974, electric sales in kilowatthours decreased 7.8% from the corresponding period in 1973.[46] A portion of these declines in sendout can be attributed to voltage reductions of 3% and 5%. The interpretation of the significance of such limited data on energy conservation impacts on the forecasted need for power in the applicant's service area over the next six to ten years is highly uncertain. Much will depend, of course, on the future decisions of consumers and governmental agencies in responding to the energy crisis and potential developments in energy supply and demand factors which might ease the energy crisis or cause it to worsen. However, as time progresses, historical information of these kinds and the actual data on power demand impacts in the applicant's service area will provide a more significant basis for demand projections.

2. Promotional Advertisement and Conservation Information Services

In the past, the applicant has attempted, through advertising, to accelerate the demand for electricity in his service area. Generally, the major thrust of advertising was to promote demand during off-peak periods, thereby covering expensive peaking capacity with expanded lower cost base-load capacity. Notably electric space heating, air conditioning, and water heating have been promoted to offset the higher seasonal peaking demands and thus to level loads.

The applicant discontinued promoting the sale of electricity in 1971 and converted the former Sales Department into essentially a service department.[16] Concurrently, the applicant began the "Save A Watt" program which, by direct mail and mass media advertising, disseminated information designed to promote efficient usage of electricity. Accordingly, elimination of promotional advertising is no longer an available measure for the applicant to dampen demand. On the other hand, promotional advertising by manufacturers of electrical appliances and equipment has not been eliminated. These manufacturers spent an estimated $450 million in promotional advertising in 1972.[28]

The applicant has developed a program to promote conservation of electricity. This program was initiated in November 1973 and formalized for the period December 1973 through March 1974.[29] Table X-11 summarizes the four phases of the program.

The applicant reported electrical energy conservation (adjusted for weather and anticipated growth) of 9.7% for the first nine months of 1974.[46] However, there is no way to tell what percentage can be credited to the programs discussed above and how much should be credited to authorized rate increases totaling about $338.7 million of additional annual revenue.

3. Change in Utility Rate Structure

The Federal Power Commission regulates the rates for interstate wholesale electric energy,[30] while the Public Service Commission of the State of New York regulates the rates utilities charge the ultimate consumer in the applicant's service area.

Historically, utility rate structures were designed to encourage consumption of electricity by using the declining block rates, which reflected the declining average cost of furnishing additional kilowatt hours of electrical energy to each customer. Until recently, the economic logic for declining block rates was never seriously disputed. Today, however, under conditions of increasingly scarce fuel resources, declining block rates, by lowering the price of each additional kilowatt hour, tend to encourage greater use of electricity by individual consumers and also to encourage individual consumers to use more and more electricity instead of other energy sources.

The most commonly mentioned alternatives to declining block rates to dampen demand for electricity are peak load pricing, flat rates, and increasing block rates.

Table X-12 presents statistics on the average cost of electricity to consumers and the average energy (kilowatt-hours) used per customer from 1963 through 1973. Statistics such as these indicate that in the applicant's service area, even though the price of electricity has increased during the last few years, the demand was still increasing. The question that statistics such as these do not answer is at what point the costs of residential and commercial electricity will cause the consumer to significantly decrease his demand. However, with sufficient economic incentive, total demand could be reduced, or at least its rate of growth reduced.

Table X-11. Consolidated Edison Company of New York, Inc. emergency fuel conservation plan December 1973 through March 1974

	Reductions per week				
	Load conservation			Coal burning, equiv. oil (thous. bbl)	Total reduction (thous. bbl)
	Electric (million kWhr)	Steam (million lb)	Total equiv. oil (thous. bbl)		
Phase I – Expanded energy conservation[a]					
Public appeals (Energy Efficiency Program)	21	13	51		
Voluntary reduction of advertising, decorative, and display lighting	4		8		
Voluntary setback of thermostats (68°)	3	104	34		
Voluntary reduction of railroad and subway heating by two-thirds	6		13		
Voluntary reduction of outdoor transit platform lighting (<0.5 million kWhr per week)					
Reduction – Phase I	34	117	106		106
Phase II – Initial phase of emergency plan					
Mandatory prohibition of advertising, decorative, and display lighting[b]	3		6		
Year-round Daylight Savings Time (1.4 million kWhr per week)[b]	2[c]		4[c]		
Burn coal at Arthur Kill No. 3 and Ravenswood No. 3[d]					
Arthur Kill No. 3				93	
Ravenswood No. 3 (North Boiler)				88	
Total reduction – Phase II	5		10	181	191
Total reduction – Phases I–III	39	117	116	181	297
Phase III – Second phase of emergency plan					
5% voltage reduction for 6-hour period daily – except for 3% continuous voltage reduction in radial distribution areas	8		18		
5% electric voltage reduction and reduction of steam system pressure to 110 psi on a continuous basis	13	7	32		
Intensive second appeal for conservation (including thermostat set back to 65°F)	8	65	36		
Total reduction – Phase III	29	72	86		86
Total reduction – Phases I–III	68	189	202	181	383

Table X-11 (continued)

	Reductions per week				
	Load conservation			Coal burning, equiv. oil (thous. bbl)	Total reduction (thous. bbl)
	Electric (million kWhr)	Steam (million lb)	Total equiv. oil (thous. bbl)		
Phase IV – Final phase of emergency plan					
Burn coal at Astoria Nos. 3, 4, and 5[d]				173	
Railroad and subway reduction in interior car lighting by one-half[c]	2		5		
Series Traction Operation (6 AM through 8 PM)[b]	11		24		
Series Traction Operation (8 PM through 6 AM and weekends)[b]	7		16		
Curtailment of business identification lighting[b]	1		2		
School holiday (high and college)[b]	3	5	8		
School holiday (grade K–8)[b]	3	1	7		
Mandatory Monday holiday[b]	28	37	73		
Intensive third appeal for conservation (including thermostat setback to 60° F)	10	104	50		
Street lighting reduced by one-half[b]	4		8		
Transit station and platform lighting reduced by one-half[b]	1		4		
Mandatory Friday holiday[b]	27	32	71		
4-Kv load shedding (electric)	8		19		
Network load shedding (electric)					
Group 1	23		52		
Group 2	11		25		
Group 3	11		25		
Load shedding (steam)		12	3		
Total reduction – Phase IV	150	191	392	173	565
Total reduction – Phases I–IV	218	380	594	354	948

[a]Included but not listed under Expanded energy conservation are measures undertaken to reduce Con Edison's own electric and steam consumption and a series of generation operating procedures, developed within the New York Power Pool, to minimize fuel oil consumption.

[b]Step cannot be implemented without affirmative action by governmental authorities.

[c]Represents combined effect of Voluntary reduction of outdoor transit platform lighting and Year-round Daylight Savings Time.

[d]Step can be implemented by Con Edison only after necessary approvals of governmental authorites are obtained.

Source: 1974 Report of Member Electric Corporations of the New York Power Pool and the Empire State Electric Energy Research Corporations Pursuant to Article VIII, Section 149-B of the Public Service Law, vol. I.

Table X-12. Average cost and consumption by class of customer for the Consolidated Edison service area, 1963 to 1973

	Average cost to consumers (¢/kWhr)			Average kWhr per customer		
	Residential	Commercial and industrial	Other	Residential	Commercial and industrial	Other
1973	5.2	4.3	3.1	3,609	51,195	1,793,325
1972	4.6	3.8	2.6	3,367	49,156	1,779,525
1971	4.2	3.5	2.2	3,355	46,717	1,862,778
1970	3.9	2.9	2.0	3,180	44,384	1,814,960
1969	3.9	2.7	1.9	2,950	41,882	96;825,378
1968	4.0	2.8	1.9	2,736	38,981	2,404,717
1967	4.0	2.8	1.7	2,522	35,746	3,468,187
1966	3.8	2.7	1.7	2,439	33,617	2,415,875
1965	3.9	2.7	1.7	2,277	31,970	2,243,943
1974	3.8	2.7	1.7	2,161	30,651	2,015,907
1963	3.9	2.7	1.7	2,050	28,040	1,820,495

Source: Moody's Investors' Service, Inc., "Moody's Public Utility Manual," 1970 and 1974.

In addition to price, the demand for electricity is affected by such other factors as: (1) changes in the regional and national economy; (2) the substitution of electricity for scarce fuels; (3) growth in population and households; (4) technological change affecting substitute sources of energy, efficiency in the use of energy resources, and development of new uses of electrical energy; (5) market forces affecting the demand for consumer investment or durable goods which require electricity to operate; and (6) changes in consumer values, attitudes, and such practices as may be affected by laws, regulations, or taxes. In the face of such a complexity of causal forces, it is exceedingly difficult to factor out the extent to which price changes alone would affect the demand for electricity in the applicant's service area. This uncertainty exists in analyzing historical data and is even greater in forecasting future developments because of the perturbations of outlook fostered by the energy crisis and decisions yet to be made by consumers and industrial and government agencies in relation to reducing demand for scarce fuels or developing additional reserves or new sources of energy to substitute for scarce fuels.

4. Load Shedding, Load Staggering, and Interruptible Load Contracts to Reduce Peak Demand

Load shedding is an emergency measure to prevent system collapse when peak demand placed upon the system is greater than the system is capable of providing. This measure is usually not taken until all other measures are exhausted. The Federal Power Commission's report on the major load shedding that occurred during the Northeast Power Failure of November 9 and 10, 1965, indicates that reliability of service of the electrical distribution systems should be given more emphasis, even at the expense of additional costs.[31] This report identified several areas that are highly impacted by loss of power, such as elevators, traffic lights, subway lighting, prison, and communication facilities. The serious impact on areas such as these results in load shedding being used only as a temporary method to overcome a shortage of generating capacity during an emergency.

Load staggering has also been considered by the staff as a possible conservation measure. Basically this alternative involves shifting the work hours of industrial or commercial firms to avoid diurnal or weekday peaks. However, the staff considers the interference with customer and worker preferences as well as productivity to be of sufficient impact to make such proposals of questionable feasibility.

For interruptible load contracts to be effective in system planning, the load reduction must be large enough to be effective in system stability planning. Thus, this type of contract is primarily related to industrial customers. At the present time, the applicant has no interruptible sales. The acceptability of interruptible load contracts to industrial customers depends upon balancing the potential economic loss resulting from unannounced interruptions against the savings resulting from the reduced price of electricity. If the frequent or duration of interruptions increases as a result of insufficient installed capacity, the customer will convert to a normal industrial load contract. Even if the applicant had 1,200 MW of interruptible load, it is speculative to project that customers would continue this contractural relationship if faced with frequent and long periods with no electrical service.

None of the above measures can be considered as a viable alternative for required additional capacity, and they do little to solve the energy shortage.

5. Factors Affecting the Efficient Utilization of Eelectrical Energy

During the past two years, much of industry, the Federal Government, and many State and local governments have made the promotion of energy conservation a priority program. The Department of Commerce has developed a departmentwide effort to: (1) encourage business firms to conserve energy in the operation of their own processes and building; (2) encourage the manufacture and marketing of more energy-efficient products; and (3) encourage businessmen to disseminate information on energy conservation. The National Bureau of Standards has been given a leading role in promoting the development and implementation of energy saving standards. Programs include: voluntary labeling of household appliances; research, development, and education relative to energy conservation in building; efficient use of energy in industrial processes; and improved energy efficiency in environmental control processes. While considerable efficiencies in electricity usage have already been gained and while further efficiencies will be realized, any present estimates of the magnitude of electricity savings to be realized over time must be treated as tentative and subject to continual reassessment.

The need for generating capacity is based on annual peak load demand and not on the volume of consumption over the year. Any conservation measures which reduce consumption but not peak load demand will have little or no impact on the need for capacity. The applicant's most recent forecasts for total sales and annual peak load demand indicate that total sales are expected to grow at a lesser rate than peak demand. The growth in peak demand will continue to be strongly influenced by installation of air conditioning in an increasing percentage of residences and commercial and industrial buildings. The applicant projects that increased use of air conditioning for all sectors will result in an annual increase of 180 MW in the company's summer peak. New York City Planning Department data indicate that in 1970, 15% of the city's residential floor space was air conditioned; the Department predicts that by 1985, 65% will be air conditioned. In part, this projection is based on the assumption that after 1977 all public housing will be air conditioned. The City Planning Department also predicts that 84% of all commercial office space will be air conditioned by 1985.[32] To what extent the applicant's 180-MW projected annual addition coincides with the City's projections is unclear.

Considerable efficiency can be achieved in space conditioning by using improved insulation and building materials with better insulation properties as well as by using equipment which transfers or stores excess heat or cold. For example, the seven-story Federal Office Building to be built in Manchester, New Hampshire, illustrates the potential for energy conservation in future commercial buildings using existing technology.[33] For this particular building, energy savings are anticipated to be a minimum of 20 to 25% over that of a conventionally designed building in the same location. Heat savings alone are expected to be 44% because of better insulated walls, less window area, use of efficient heating and heat storge equipment, and the use of solar collectors on the roof.

In 1971, FHA established new insulation standards which were to reduce average residential heating losses by one-third. Studies have shown that it is possible to gain even greater reductions in heat loss through improved insulation at costs which are economical over a period of years.[34] Improved insulation not only conserves in winter but also reduces the air conditioning burden in the summer.

Lighting, which has accounted for about 24% of all electricity sold nationally, is another area where savings are being realized. Many experts believe recommended lighting levels in typical commercial buildings have been excessive.[35] Calculations indicate that adequate illumination in commercial buildings can be achieved at 50% of current levels through various design and operational changes.[36] Another study indicated that if all households in 1970 had changed to fluorescent from incandescent lighting, the residential use of electricity for lighting would have been reduced approximately 75% and total electrical sales would be reduced approximately 2.5%.[37] However, since the majority of residential lighting occurs in off-peak hours, the reduction on peak demand would be less than 1%.

The potential for greater energy efficiency in household appliances is well recognized. The National Bureau of Standards is working with an Industrial Task Force, from the Association of Home Appliance Manufacturers, in a voluntary labeling program which would provide consumers with energy consumption and efficiency values for each appliance and educate them as to how to use this information. Room air conditioners are the first to be labeled. The next two categories of house appliances which are to be labeled are refrigerators and refrigerator/freezers and hot water heaters.

The importance of energy efficiency labeling of appliances is that it will allow the consumer to select the most energy efficient appliance. A recent study, titled "The Room Air Conditioner as an Energy Consumer," has estimated that an improvement in average efficiency from 6 to 10 Btu/kWhr could hypothetically save electric utilities almost 58,000 MW in 1980.[38] Air conditioners that are more energy efficient require a combination of increased heat exchanger size and higher efficiency compressors resulting in higher initial cost. The consumer must be convinced that purchase of the more expensive machine is profitable for him in the long run. Today, however, there is a high degree of uncertainty in predicting to what extent consumers will actually purchase these more expensive appliances. In addition, selection of central air conditioning by developers and many home owners has historically been based on minimizing front end costs consistent with meeting local building codes.

Considerable opportunity for electricity conservation exists in industry in addition to lighting and air conditioning efficiency already mentioned. Electric motors should be turned off when not in use, and motors should be carefully sized according to the work they are to perform. Small savings can be realized by de-energizing transformers whenever possible. Fuel requirements for vacuum furnaces can be reduced by 75% if local direct combustion low quality heat is employed rather than high quality electrical resistance heating.[39]

Some of the above examples of potential energy saving will possibly be realized in the future, but in other instances there will be a substantial shortfall in achieving theoretical potentials due to economic, political, and technological performance considerations. As historical experience accumulates, a better forecast can be made of the extent to which savings will result from these kinds of conservation measures. In addition the staff is aware that the National Institute of Occupational Safety and Health has recommended heat stress standards to the Occupational Safety and Health Administration, which, if adopted, would require a significant number of employers to air condition their plants.[40] This possible requirement, coupled with the above argument, makes any significant reduction in the future peak demand for electricity due to this conservation of energy measure highly uncertain at this time.

6. Consumer Substitution of Electricity for Scarce Fuels

While conservation measures are rather quickly adopted in a "crisis" situation, the consumer's substitution of electrical energy for fuels such as oil or gas takes several years to result in a substantial upward impact on the need for power. The staff expects that substitution of electricity for scarce energy sources will likely accelerate in the applicant's service area because of the uncertainty of oil and gas supplies and the outlook for higher prices relative to the price of electricity produced from coal-fired or nuclear plants. For instance, assuming no restrictions on the use of electricity for space heating, total growth in electric space heating consumption is projected to be 758×10^6 kWhr during the next 20 years, increasing from 142 to 900×10^6 kWhr, or from 0.4% of total system sales to 1.1% of total system sales. Alternatively, the applicant estimates that a ban on the use of electricity for space heating would reduce projected summer peak load by a maximum of 70 MW by 1992 compared to the projected 15,435 MW load.[32] This amount is attributable to a reduction in electric water heating and cooling, the only component of electric heat used in the summer. The advent of electric automobiles or other new uses of electricity cannot be discounted but are not now quantified in projecting need for power because of their high degree of uncertainty. The staff's evaluation is that substitution effects will to some degree offset savings from conservation of energy techniques.

A second kind of substitution which is relatively important in considering the applicant's need to add the proposed nuclear plant to his system is the desirability of adding nuclear capacity as soon as possible in order to reduce fuel consumed by gas- or oil-fired units now forming a significant part of the applicant's system. This, in turn, will increase the availability of these material resources for other uses for which there is no available substitute.

K. NEW YORK POWER POOL

The applicant is a member of the New York Power Pool, which comprises seven private power companies and the Power Authority of the State of New York. Under the pooling agreement, each member continues to have full responsibility for maintaining adequate electric generating capacity and transmission facilities within its own service area. At present, each member is required to maintain adequate capacity to meet its peak demand plus a reserve capacity of 14% of its peak demand. By common agreement, all members have committed themselves to raising their reserve capacity to 18% of peak demand by 1975. Further, the members agree to maintain installed capacity for a full year (seasonally adjusted for ambient temperature) at least equal to that required to meet 18% reserve during the member's most recent peak. Three members peak in the winter and four in the summer, with a resulting annual diversity in the range of 4% to 7%. This diversity is sufficiently large that an 18% reserve based on individual private company peaks will result in a reserve over the New York State interconnected system's coincident peak at least equal to the 20% required by the Pool reliability criterion.[41]

In addition to the reserve capacity, each member must maintain an operating reserve consisting of a spinning reserve, which is capacity that can be available within 5 min, and a ready reserve, which is the capacity that can be available within 30 min. The applicant's share of the Pool's operating reserves amounts to about 600 MW. The addition of Indian Point Units Nos. 2 and 3 would have increased the company's obligation by 28 MW during the summer of 1974 (ER, IP-3, Suppl. 7, App. FF, p. VI-31), based on forecast peak loads.

Table X-13 depicts the New York Power Pool's summer load and capacity forecast for the period 1973 through 1982. This table shows that in every year during the period, the reserve exceeds the required 20% reserve margin by a substantial amount. The members of the Pool do not anticipate that reserves of these magnitudes will actually occur. At the current stage of planning, provision must be made for such unknowns as delays in scheduled additions, deviations in load forecast, and derating of equipment. Only through advance planning for such contingencies can minimum acceptable margins be achieved. As these contingencies also affect the applicant's load and capacity forecast in the area of planned purchased capacity, Table X-14 is presented to show the in-service dates for generating units as estimated by the Northeast Power Coordinating Council[42] and the New York State Public Service Commission.[43] Table X-15 is presented to show the peak-load-supply situation for the summer of 1975 for both the applicant's system and for the New York Power Pool. If as much as 10% of the applicant's installed capacity should be unavailable on the peak day (see Table X-10), the applicant would just meet the 18% reserve margin required by the Power Pool if Indian Point Unit No. 3 is operating at 100% of its power rating.

L. NORTHEAST POWER COORDINATING COUNCIL

The Northeast Power Coordinating Council is an organization of all major and many small interconnected utility systems in New York, New England, and Ontario. Formed on January 19, 1966, following the great blackout of 1965, it promotes "maximum reliability and

Table X-13. New York Power Pool capability, peak loads, and margins (MW) at median hydro conditions: Summer 1974–1983

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Maximum installed net capability										
Thermal (conventional)	14,554	17,370	17,270	18,853	18,680	19,100	21,000	21,000	21,000	22,250
Thermal (gas turbine & diesels)	3,703	4,006	4,276	4,276	4,276	4,406	4,406	4,406	4,406	4,536
Thermal (nuclear)	2,230	3,924	3,924	3,924	4,928	6,098	6,164	7,314	7,314	12,021
Hydro (conventional)	4,023	4,023	4,023	4,023	4,023	4,023	4,023	4,023	4,023	4,023
Hydro (pumped storage)	1,000	1,000	1,000	1,000	1,000	2,000	4,000	4,000	4,000	4,000
Total controlled sources	25,510	30,323	30,493	32,076	32,907	35,627	39,593	40,743	40,743	46,830
Capacity purchases	61	56	55	809	805	800	800	800	800	800
Capacity sales	150	150	150	150	150	150	150	150	150	150
Total capability for load of area	25,421	30,229	30,398	32,735	33,562	36,277	40,243	41,393	41,393	47,480
Peak load										
Sum of independent peak loads	21,610	22,830	24,300	25,650	27,080	28,430	29,940	31,380	32,880	35,040
Coincident peak load	21,190	22,380	23,820	25,150	26,550	27,870	29,300	30,700	32,170	33,690
Margins										
Gross margin (MW)	4,231	7,849	6,578	7,585	7,012	8,407	10,943	10,693	9,223	13,790
Gross margin (% of load)	20.0	35.1	27.6	30.2	26.4	30.2	37.3	34.8	28.7	40.9
Scheduled maintenance (MW)	553	490	540	440	440	490	490	490	490	490
Temporarily unavailable (MW)[a]	0	0	0	0	0	0	0	0	0	0
Margin after outages (MW)	3,678	7,359	6,038	7,145	6,572	7,917	10,453	10,203	8,733	13,300
Margin after outages (% of load)	17.4	32.9	25.3	28.4	24.8	28.4	35.7	33.2	27.1	39.5

[a]Capacity that is known will be unavailable. Forced outages, variation of hydro, and outages for other reason accounted for 3,266 MW and 2,551 MW respectively in 1972 and 1973.

Source: Northeast Power Coordinating Council, *Data on Coordinated Regional Bulk Power Supply Programs,* FPC Order 383-3, Docket R-362, Appendix A-1, April 1, 1974.

Table X-14. New York Power Pool generating unit additions, 1974–1983 (excluding Consolidated Edison)

F, Fossil fueled; N, Nuclear; GT, Gas turbines; PSH, Pumped storage hydro

Company	Station and unit number	Type	Capability (MW)		Commercial target date
			Summer	Winter	
Central Hudson[a]	Roseton 2	F	600	600	8-74
	Roseton 1	F	600	600	9-74
	Undetermined	F	400	400	5-83
LILCO	Holbrook 1-5	GT	260	318	5-74
	Holbrook 6-10	GT	270	332	5-75
	Glenwood 4-8	GT	270	332	5-76
	Northport 4	F	386	386	5-77
	Shoreham 1	N	820	820	5-78
	Jamesport 1	N	1150	1150	5-81
	Jamesport 2	N	1150	1150	5-83
Niagara Mohawk	Oswego 5	F	850	850	10-74
	Oswego 6	F	850	850	11-76
	Nine Mile Pt. 2	N	1100	1100	4-79
	Lake Erie 1	F	850	850	11-82
NYSE&G[b]	Homer City 3	F	325	325	4-77
	Cayuga 1	F	800	800	12-79
	Somerset 1	N	1200	1200	11-82
Orange & Rockland	Bowline Pt. 2	F	600	600	5-74
	Shoemaker 2-3	GT	130	146	5-79
	New Hampton 1	F	400	400	5-80
	Shoemaker 4-5	GT	130	146	5-83
Rochester Gas & Electric	Sterling 1	F	600	600	10-78
PASNY	FitzPatrick	N	821	821	8-74
	MTA 1	F	700	700	5-80
	Breakabeen	PSH	1000	1000	5-80
	MTA 2	N	1200	1200	11-82

[a]The Roseton plant is jointly owned by Central Hudson, Niagara Mohawk, and Consolidated Edison. Central Hudson's initial ownership is 20%, increasing to 40% in 1978, and to 60% in 1982.

[b]New York State Electric & Gas Corporation is a joint owner, with Penelec, of Homer City 3, located in Indiana County, Penn. Allocation of costs – 50% NYSE&G; 50% Penelec.

Source: 1974 Report of Member Electric Corporations of the New York Power Pool and the Empire State Electric Energy Research Corporation pursuant to Article VIII, Section 149-b of the Public Service Law, vol. 2, April 1, 1974, Exhibit 2.

Table X-15. Estimated 1976 peak-load–supply situation with Unit No. 3 operating at various power levels (excluding possible effects of unavailable capacity shown in Table X-9)

	Consolidated Edison Co.	New York Power Pool
Conditions for 100% (873 MW) of rated power		
Total capacity resources, MW	12,027[a]	30,398[b]
Net peak load, MW	9,550	23,820
Reserve margin, MW	2,477	6,578
Reserve margin, percent of peak load	25.9	27.6
Conditions for 50% (436 MW) of rated power		
Total capacity resources, MW	11,590[a]	29,961[b]
Net peak load, MW	9,550	23,820
Reserve margin, MW	2,040	6,141
Reserve margin, percent of peak load	21.4	25.7
Conditions for 20% (175 MW) of rated power		
Total capacity resources, MW	11,329[a]	29,700[b]
Net peak load, MW	9,550	23,820
Reserve margin, MW	1,779	5,880
Reserve margin, percent of peak load	18.6	24.6
Conditions for 0% of rated power		
Total capacity resources, MW	11,154[a]	29,525[b]
Net peak load, MW	9,550	23,820
Reserve margin, MW	1,604	5,705
Reserve margin, percent of peak load	16.8	24.0

[a]Includes planned purchases of 221 MW.
[b]Includes firm and proposed purchases of 55 MW.

efficiency of electric service in the interconnected systems of the signatory parties by extending the coordination of their system planning and operating procedures." The association is a voluntary one, and the Council has no power to compel a member company to modify its system.[44]

At the time the Northeast Power Coordinating Council recommended the 20% reserve margin criterion to the New York Power Pool, it was designed to ensure that the probability of loss of load within the Pool would not be greater than one day in ten years. Whether or not this probability will be exceeded depends upon adequate interconnections between members of the Pool.

M. CONCLUSIONS

After reviewing the applicant's generating capabilities, interconnections with major utilities, present and projected consumption of electricity by user classification, the applicant's and New York Power Pool's ten-year plans, and population, employment, and personal income projections, the staff has made the following observations with regard to the need for power and, in particular, the need for the generating capacity represented by Indian Point Unit No. 3:

1. The applicant currently has 42 conventional thermal generating units, of which 13 (or 31%) have been in service for more than 40 years. These 13 units have a combined summer operating capacity of about 716 MW.

2. The applicant has been able to meet its system demands in recent years by net receipts of about 4 billion kWhr of power per year from the other members of the New York Power Pool (except the Power Authority of the State of New York) and the New England Power Exchange.[45] The bulk of these power transfers were classified as nonfirm and were derived from whatever surplus the individual company or system had at the time.

3. The applicant has apparently lowered the 1980 summer peak load estimate by about 700 MW less than its previous estimate in anticipation of the effect of energy conservation.

4. From the summer of 1974 through the summer of 1983, the summer peak load period reserves vary from 17.0% to 35.8%, assuming no slippage of planned capacity. However, forced outages and deratings will reduce these reserves to marginal or unacceptable levels until about 1979, even if the 1972 rate of unavailable capacity on peak summer days is reduced by as much as 50%.

5. The New York Power Pool ten-year plan indicates that, for each year during the period 1974 through 1983, the reserve, after planned outages, will be in the range of 17.4 to 39.5%. As the possible effects of the applicant's high rate of unavailable capacity and possible slippage of generating unit additions by the member utilities are not reflected in the plan, the reserve margins will probably be closer to the required 20%.

In view of the above listed observations, the staff concludes that:

1. For the applicant to attain the generating reliability necessary to meet the reserve requirements of the New York Power Pool, at least 31% of the existing conventional thermal units in the company's system, totaling about 716 MW of summer operating capacity, should be retired as soon as possible to assist in reducing the high rate of unavailable capacity and to benefit not only the applicant's system but the New York Power Pool as well.

2. The applicant should make every effort to obtain additional firm purchased capacity to reduce the company's excessive use of the Pool's reserve, which is intended to protect all Pool members.

3. Even if conservation of energy measures are effective in reducing the demand for electricity in the latter half of the 1970's, it is desirable to add nuclear capacity to reduce the amount of fuel consumed by gas- or oil-fired units thus increasing the availability of this resource for which there are no available substitutes.

4. The applicant's ten-year plan is marginal during the summer peak load period through 1979 and could be worsened by slippage of the (spring) 1975 in-service date for Astoria Unit No. 6 and the (spring and fall) 1979 in-service dates for the Cornwall Units. As construction has been suspended on the Cornwall Units, slippage is a very distinct possibility. Also, the situation could be further aggravated if the planned large capacity purchases beginning in 1977 fail to substantially materialize.

Therefore, as the addition of reliable base-load capacity would help to ameliorate the undesirable conditions described in the above conclusions, the staff believes that the need for the additional base-load capacity represented by Indian Point Unit No. 3 has been clearly demonstrated.

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XI. ALTERNATIVES TO PROPOSED ACTION AND BENEFIT-COST ANALYSIS OF ENVIRONMENTAL EFFECTS

A. ALTERNATIVES NOT REQUIRING CREATION OF NEW GENERATING CAPACITY

1. Purchased Power

One major deterrent to the applicant's purchasing large blocks of power from upstate New York, the northeastern states, and Canada is the limitation of the upstate-southeast transmission capability. This limitation is controlled by the lines between the Pleasant Valley and Millwood substations which cannot transfer enough power to the applicant from the upstate area during the summer periods. During the summer of 1970, there were times when excess capacity was available upstate or in Canada but transmission limitations prevented its transfer and the applicant was forced into voltage reductions.[1] Therefore, purchase of power cannot be considered as a reliable source, even for emergency situations until the existing transmission network is upgraded. This upgrading will not be completed until 1982 (see Sect. X.I).

In Table X-2 the major transmission projects currently authorized and under construction by the applicant are listed. In addition, an application for certification of a 345-kV transmission line under Long Island Sound to connect the applicant's Dunwoodie substation in Yonkers with Long Island Lighting Company's Glenwood substation in Nassau County and a 138-kV transmission line between Jamaica and Lake Success is pending before the New York State Public Service Commission. The proposed completion date for these two interconnections is the summer of 1975. In Chapter IV, the transmission lines to be built in the near future to handle the power output from the Indian Point Plant are also presented.

Historically, the normal power flow in the New York Power Pool system has been in a west-to-east direction. This condition will continue to exist as long as utilities (particularly the applicant's system) in the eastern New York area are unable to place sufficient new generation in service and remain dependent on the western part of the state.[1] Beginning about Summer 1975, the applicant plans to make substantial purchases from the FitzPatrick Nuclear Plant of the Power Authority of the State of New York (PASNY). The applicant has also begun to arrange to purchase 500 MW from the Breakabeen Pump Storage Project of PASNY. This project has yet to be licensed by FPC and must be considered to be only a possible source of power. At various times in 1970, 1971, and 1972, the applicant has purchased up to 400 MW from Canada. For the longer term, an agreement was made in 1972 to purchase from Hydro Quebec up to 800 MW of summertime power for 20 years, starting in 1977. It is anticipated that the PASNY will build the new 765-kV transmission line and substations to get this power from Canada to Utica; from Utica it can be transmitted to the applicant's system over existing lines. On December 18, 1972, the Quebec National Assembly approved the sale. Approval is also required from the National Energy Board of Canada and the U.S. Federal Power Commission (FPC).

Other possible sources for purchase are from the Canadian Hydroelectric Development Project at Churchill Falls, but the entire output at this facility would be required for anticipated load growth in Canada. The plans for major expansion of the Canadian Hydro resources in the early 1980's have prompted the applicant to reinvestigate this possibility for long-range large purchases and discussions leading to such purchases have been held. However, it cannot be assumed that any significant amounts of power resources will be available on a firm basis until the 1980's at the earliest.

The ability of the system to transfer power from upstate to New York City has been limited by the two ties between the Pleasant Valley and Millwood substations in the applicant's system. These two double-circuit lines, one 345-kV and one 138-kV, operate electrically in series, with the lower of the two limitations being the controlling factor. Present plans call for removal from service of the 138-kV line during the summer of 1974 and its subsequent reconstruction for 345-kV operation in 1977.[2] The applicant at a New York State Public Service Commission public hearing in May 1973 petitioned to upgrade its transmission facilities to handle the output of the Indian Point Plant through the Buchanan substation to the applicant's grid and to transmit power purchased in the north.[4,59] The Sprain Brook-Millwood section and the Kent-Pleasant Valley section of 345-kV transmission lines are slated for construction between June 1974 and June 1976.

To the east through the Pleasant Valley substation, interconnections to the New England utility system are available to transfer power to New York. To the west, the applicant's system is interconnected with the Pennsylvania-New Jersey-Maryland System (PJM) via a 500-kV tie from the Public Service Electric and Gas Company's Branchburg substation to the applicant's Ramapo substation in Richland County. Several other interconnections to PJM are also made through different substation connections.

As interconnections are primarily for the exchange of emergency power, transfers of firm capacity purchases are additional loads on the transmission system capability. Therefore, transmission capacity must be reserved for the applicant's share from the Roseton and Bowline Plants plus all planned purchases.

Estimates of the applicant's import capability for the summer of 1975 are shown in Table XI-1. It would appear that adequate net import capability exists to make purchased power a viable alternative to Indian Point Unit No. 3. However, it is the staff's opinion that such bulk quantities of power will not be available for firm purchase agreements from existing sources within or outside of the New York Power Pool. Also, if the possible effects of unavailable capacity on summer reserves (see Table X-10) are factored in, Indian Point Unit No. 3 would still be needed.

Table XI-1. Applicant's summer import capability (MW), 1973–1975

	1975	
	With Indian Point Unit No. 3	Without Indian Point Unit No. 3
Total import capability	2,780	3,480
Bowline Point	800	800
Roseton	480	480
Firm purchases	348	348
Net import capability	1,152	1,852

The viability of purchased power as an alternative to the operation of Unit No. 3 is also reduced by the higher cost per kilowatt-hour as compared with power generated in base-load plants within the applicant's system and the fact that should an emergency arise within the system of the seller of power, the first concern would probably be for its own customers and not for the buyer's requirements.

Therefore, the staff concludes that, although the applicant should continue to make every effort to obtain additional firm purchased capacity to reduce the company's excessive use of the Power Pool's reserve and to help offset the high rate of unavailable capacity, this means of obtaining power is not a viable alternative to the base-load capacity of Indian Point Unit No. 3.

2. Load Shedding

The applicant has a 26-point program of voltage reduction and load-shedding plan consisting of emergency procedures to go into effect when required by a power shortage (brownout). These procedures normally result in voltage reductions of 3 or 5%, with the maximum allowable of 8% to avoid damage to electric motors and equipment. Other means of load shedding employed are the "Save-a-Watt" program,[3] which urges customers to conserve electricity, and manual load shedding. The "Save-a-Watt" program, in conjunction with voltage reductions and manual load shedding, has been estimated by the applicant to have reduced the summer peak loads for 1969, 1970, 1971, and 1972 by approximately 90, 700, 200, and 400 MWe respectively.[4] The applicant's record of load-shedding methods and cumulative duration time by months for calendar years 1968 through 1972 is shown in Fig. XI-1. Manual load shedding has been required only one time in the history of the Company and occurred on September 22, 1970, after reaching the maximum 8% voltage reduction.

Load shedding can temporarily overcome a shortage of generating capacity during an emergency but cannot be considered as a viable alternative for required base-load capacity.

3. Reactivating or Upgrading an Older Plant

In 1966, the applicant entered into a Memorandum of Understanding with the Office of the Mayor of the City of New York in which the company accepted "the principle that, to the fullest possible extent, power from coal- and oil-fueled plants should be generated outside the City limits and brought into New York City by transmission lines."[5] However, in July 1969, the applicant proposed a new 1,600-MW fossil-fueled plant to be located at its existing Astoria station in Queens. The proposed plant was allegedly needed to prevent a power crisis from developing in New York City in 1974.

After much debate among public officials and later public debate, in August 1970 the mayor announced that he would allow only one-half (800 MW) of the proposed Astoria expansion, noting that this would provide the reserve urged by all power officials for 1974 and cut in half potential pollution from that source. The mayor gave his approval after the signing of a new Memorandum of Understanding containing eight conditions in which the applicant agreed, among other things, that: (condition 1) it shall not place any additional fossil-fueled plants in the City; and (condition 5) it must close down at least 1,000 MW of old units in the City by 1974.[6] However, the schedule for Astoria has changed from 1974 to Spring 1975. Astoria has been purchased by PASNY.

In view of the above Memorandum of Understanding and the fact that all of the applicant's older plants are located within the City

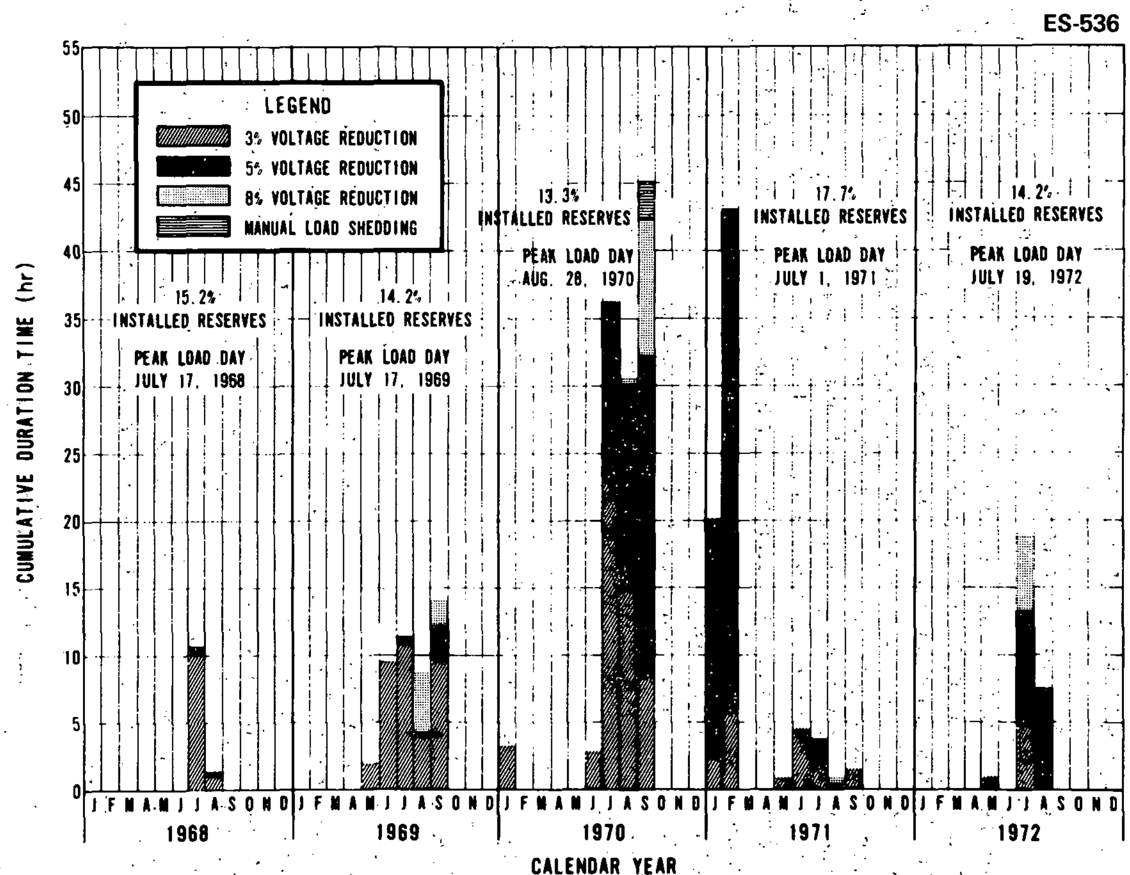

Fig. XI-1. Load shedding by Consolidated Edison Company, 1968-1972.

limits and produce higher atmospheric discharge rates per kilowatt of power generated, the staff does not feel that reactivation or upgrading of an existing older plant is a viable alternative for Indian Point Unit No. 3, particularly in light of the current fuel oil supply situation.

4. Base-load Operation of a Peaking Facility

Currently, the applicant's peaking facilities consist of gas turbines with a total maximum summer capacity of 2,285 MW (see Table X-1), which represents 24.0% of the total summer net capability of the system. Although these gas turbines have more than double the base-load capacity of Unit No. 3, extended operation of these units would result in extensive maintenance problems and reduced availability of the gas-turbine capacity.[7] As a result of transferring peaking capacity to base-load duty, adequate peaking capacity is not available when needed, the frequency of brownouts increases, and, without new capacity being added, the net load soon outgrows the system's total generating capacity. The staff, therefore, does not consider that operating gas-turbine peaking facilities in the base-load mode is a suitable alternative to Indian Point Unit No. 3, which is designed for continuous and more economical operation.

B. ALTERNATIVES REQUIRING CREATION OF NEW GENERATING CAPACITY

1. Base-load Plants

The staff clearly demonstrated in Chapter X that the base-load capacity represented by Unit No. 3 is needed as scheduled. To construct a base-load plant by late 1975 would be impossible. However, had the applicant selected a coal-fired or oil-fired alternative to be located at the Indian Point Plant instead of Unit No. 3, the estimated costs for the same November 1975 in-service date (anticipated as of January 1, 1975) are as shown in Tables XI-2 and XI-3. An economic comparison of the three types of units based on the 1975 price of oil, coal, and nuclear fuel is as follows.

Estimated capital costs

Alternative	Capital cost
Nuclear	$417,813,000
Coal-fired	364,000,000
Oil-fired	275,000,000

Table XI-2. Plant capital investment summary for a 1,033-MWe alternative coal-fired unit at Indian Point with November 1975 in-service date

Direct costs (millions of dollars)	
Land and land rights	0.0
Physical plant	
Structures and site facilities	31
Reactor/boiler plant equipment	80
Turbine plant equipment	50
Electric plant equipment	17
Miscellaneous plant equipment	4
Subtotal (physical plant)	181
Contingency allowance	12
Spare parts allowance	1
Subtotal (total physical plant)	195
Indirect costs (millions of dollars)	
Construction facilities, equipment, and services	18
Engineering and construction management services	19
Other costs	8
Interest during construction	62
Total costs	
Total plant capital cost (at start of project)	
Millions of dollars	302
$/kWe	292
Escalation during construction (6.7%), millions of dollars	62
Total plant capital cost (at commercial operation)	
Millions of dollars	364
$/kWe	352

Table XI-3. Plant capital investment summary for a 1,033-MWe alternative oil-fired unit at Indian Point with November 1975 in-service date

Direct costs (millions of dollars)	
Land and land rights	0.0
Physical plant	
Structures and site facilities	24
Reactor/boiler plant equipment	51
Turbine plant equipment	49
Electric plant equipment	11
Miscellaneous plant equipment	4
Subtotal (physical plant)	139
Contingency allowance	10
Spare parts allowance	1
Subtotal (total physical plant)	150
Indirect costs (millions of dollars)	
Construction facilities, equipment, and services	11
Engineering and construction management services	16
Other costs	6
Interest during construction	46
Total costs	
Total plant capital cost (at start of project)	
Millions of dollars	229
$/kWe	222
Escalation during construction (6.7%), millions of dollars	46
Total plant capital cost (at commercial operation)	
Millions of dollars	275
$/kWe	266

Unit production costs (dollars per kilowatt-hour)

Alternative	Fuel	Operating and maintenance	Total
Nuclear	0.00219	0.00054	0.00273
Coal-fired	0.01256	0.00088	0.01344
Oil-fired	0.02259	0.00099	0.02358

It is assumed that the fossil-fueled alternatives would have the same average annual generation as Unit No. 3 which the staff calculated to be 6,258 x 10^6 kWhr. This is equivalent to an annual capacity factor of 69.2%.

Annual production costs

Alternative	Production cost (dollars)
Nuclear	17,061,000
Coal-fired	84,108,000
Oil-fired	147,564,000

Using an operating period of 30 years and a discount rate of 10%, the generating costs are:

Generating costs

Alternative	Present worth (dollars)	Annualized (dollars)
Nuclear	578,646,000	61,382,000
Coal-fired	1,156,879,000	122,721,000
Oil-fired	1,666,073,000	176,736,000

From this analysis it can be seen that the controlling parameter which causes the nonnuclear generating costs to exceed the nuclear generating cost is the production cost. As long as the large differential exists between nuclear and fossil fuel costs, nuclear production costs will always be less, even if operating and maintenance costs were equal. As there is no indication that this fuel cost differential will decrease in the foreseeable future, the staff concludes that the nuclear unit was the preferred alternative from an economic standpoint.

2. Packaged Plants

Packaged plants that conceivably could be installed in combinations equivalent to the net electrical output of Unit No. 3 are gas turbines and combined-cycle units. As mentioned in Sect. XI.A.4

above, 24.0% of the applicant's total summer net capability is produced by gas turbines, which are not designed for base-load duty. To add an additional 1,033 MW of gas turbines would seriously overbalance the system with peaking units. Combined-cycle units are simply an extension of the gas turbine whereby its exhaust gases are used as the heat source for a waste-heat boiler to produce steam to drive a steam turbine generator. Although the efficiency of a combined-cycle unit is higher than that of a base-load plant, the production costs are higher and the capacity factor is lower. Vendors say they can have the gas-turbine portion installed in 12 months from date of order, with the steam-cycle portion requiring another 6 to 12 months.[8]

To illustrate the inappropriateness of either of these two alternatives, Fig. XI-2 shows the economic crossover curves for gas turbines and combined-cycle units versus the planned operation of the base design for Unit No. 3. Levelized costs for a 30-year life were used in computing operating costs. The break-even point for gas turbines is at an annual operating time of 2,700 hr/year and a total send-out cost of 19.0 mills/kWhr. For combined-cycle units it is at 3,200 hr/year and a total send-out cost of 16.8 mills/kWhr.

The annual operating times at the break-even points are reaching the allowable capacity factors of the two types of units.[9,10] Therefore, to attain a total output equivalent to Unit No. 3 operating 6,058 hr/year, makeup power would be required as follows:

Alternative	Makeup power required (kWhr)
Gas turbines	$3,469 \times 10^6$
Combined cycle	$2,952 \times 10^6$

Makeup power would have to be purchased as supplemental or emergency purchases if firm purchases could not be arranged. Cost experience in these categories as reported by the applicant (ER, IP-3, p. 17.8) is:

Type	Period	Average cost (mills/kWhr)
Firm	1972	10.4 (range 9.1 to 22.8)
Supplemental and emergency	1971 (June 1 through September 30 only)	15.7
	1970	11.5

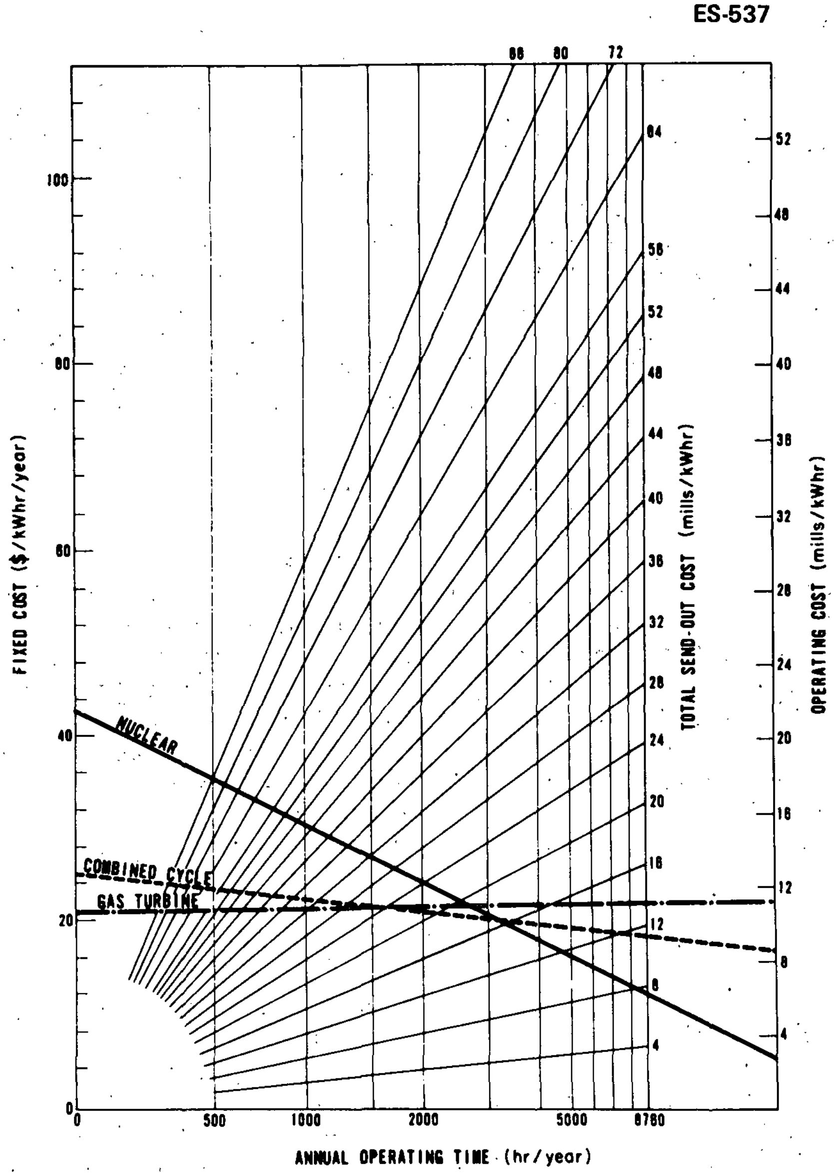

Fig. XI-2. Crossover curves, Unit No. 3 vs combined and gas turbines.

These costs would be expected to increase over the years but, even if they remained the same as shown, they would still be higher than the estimated 10 mills/kWhr for the base design for Unit No. 3 over its 30-year lifetime.

One item not factored into Fig. XI-2 is the capital replacement cost for gas turbines and generators. The applicant is expecting the service life of its existing gas turbines to be about 25 years.[10] However, manufacturers consider the economic service life to be 20 years, which agrees with the technological life of the generator. Replacement of this equipment would increase the fixed cost; this would move the break-even point in Fig. XI-2 to a lower annual operating time and greatly increased send-out cost and makeup power requirements, all of which would add to the economic disadvantages shown above. The staff, therefore, does not consider installation of packaged plants as being a viable alternative to Indian Point Unit No. 3.

C. ALTERNATIVE HEAT DISSIPATION SYSTEMS

As outlined in Chapter V, adverse environmental effects are directly associated with intake and discharge flows of the Indian Point generating units using once-through condenser cooling. The staff has evaluated several alternative cooling systems which would dissipate a larger fraction of condenser heat directly to the atmosphere, resulting in a significant reduction in river-water intake requirements and a concomitant reduction in adverse effects upon the aquatic environment. These alternative systems are cooling ponds, spray ponds, dry cooling towers, wet natural-draft cooling towers, wet mechanical-draft cooling towers, and wet/dry cooling towers.

1. Cooling Ponds or Lakes

Area requirements for dissipation of waste heat via surface effects from a cooling lake or pond are of the order of 1 to 3 acres per MWe.[11] On this basis, an impoundment covering approximately 2,000 to 6,000 acres would be required to serve Units Nos. 2 and 3. Since the entire Plant site area occupies only 239 acres, and considering that the surrounding terrain does not lend itself to the construction of a separate cooling pond of this size, the staff has rejected this alternative.

2. Spray Ponds, Spray Canals

Heat dissipation to the atmosphere using spray ponds or spray canals is effected primarily through evaporation and conduction. The increased evaporative surface created by spraying results in a significant reduction in area of the cooling impoundment itself (i.e., 0.02 to 0.04 acre/MWe) as compared with a cooling pond of similar dissipative capacity. To add a spray pond for Units Nos. 2 and 3 would require approximately 60 acres of land and would cost approximately $75 million. The additional fuel cost due to performance, deterioration, and additional auxiliary power requirements would be $2.6 million per year and the cost due to capacity loss would be $22.9 million per year (ER, IP-3, pp. 17-19). Further improvement in efficiency of heat transfer may be attained through the utilization of newly developed spray modules. The applicant has evaluated the feasibility of installing an array of spray modules within the confines of the Verplanck quarry, located southwest of the Indian Point site,[12] and has concluded that the probable environmental effects of fogging, misting, and deposition of saline drift droplets would tend to offset the economic advantages of such a system. Considering the increased water consumption with an increased potential for fogging and for contact icing during colder periods of the year, coupled with the high potential for vegetation damage from high salt drift, the staff agrees that spray ponds or spray canals do not represent a particularly viable alternative to once-through cooling at Indian Point, especially when contrasted with wet natural-draft cooling towers which are considered as posing very limited potential for negative effects upon surrounding environs.

3. Cooling Towers

Among possible alternatives to the once-through cooling water system are closed-loop systems that would utilize one or more cooling towers to dissipate the waste heat to the atmosphere. Two types of cooling towers are the wet tower that carries away heat by evaporation and sensible heat transfer and the other is the dry tower that relies on air to carry away heat and, in principle, functions like an automobile radiator. The two types of wet cooling towers, mechanical- and natural-draft, when operated in the closed-cycle mode, require makeup water to compensate for losses sustained through evaporation and drift. As evaporation occurs, the natural salts in the cooling water become concentrated; to prevent buildup and deposition on the components of the system, they are continuously returned to the source of cooling water supply by blowdown. Chemicals used in treating the cooling water to prevent growth of algae, freezing, etc., are also discharged during blowdown, and their effect upon the ecology of the receiving waters must be taken into account (See FES, IP-2, Appendix XI-1). The mechanical draft towers are relatively low structures, and the drift (0.1%) may cause fogging, misting, and icing that could be hazardous if highways, roads, or streets are nearby.

Natural-draft towers, on the other hand, are tall hyperbolic structures, about 400-500 ft high, which minimize the effects of drift (0.0025%) at ground level. However, rain and snow have been observed to occur under the visible plume. The plume behavior is governed only by the ambient atmospheric conditions and its own heat and moisture content. However, when the wind is strong, the plume may be caught in the aerodynamic downwash surrounding the tower structure and be carried directly to the ground. This phenomenon has been found to occur with smoke stack plumes when the ratio of the stack emission speed to the wind speed is less than unity.[13] Observers,[14] in studying large natural-draft cooling towers, have found that downwash does not occur until the ratio is significantly less than one. However, when brackish or seawater is used as the coolant water, the salt is deposited on a relatively small land area. The severity of the damaging effects would be governed by the duration of the downwash phenomenon. Other factors to be considered such as visual impact, noise levels, chemical effects from blowdown, salt drift, increased generating costs, etc., are discussed below.

The size of the cooling tower will be dependent upon the amount of waste heat to be dissipated by evaporation. Evaporation of about 1 lb of water will transfer 1,000 Btu to the atmosphere.[15] Since about 8.7×10^9 Btu/hr of heat will be rejected to the atmosphere in the cooling tower for Unit No. 3, at least about 17,000 gpm would be evaporated from Indian Point Unit No. 3. Evaporation of 1% of water volume will result in a reduction of the water temperature by approximately 10 F°. Drift, the carry over of water droplets by air, accounts for a small loss of water. In present cooling tower technology, discharge of about 0.37% of cooling tower as blowdown is effected per 10% of cooling rate to prevent the development of concentrations of solids in the recirculated water at concentrations exceeding 3 or 4 times that of the makeup water. The applicant in its benefit-cost-analysis and Section 17 of the Environmental Report for Unit No. 3 discusses both types of cooling towers, operating in the closed-cycle mode. The alternative method of closed-cycle cooling preferred by the applicant is operation with wet natural-draft cooling towers. The applicant also has under consideration a single natural-draft tower for each of Units Nos. 2 and 3 to be located near the turbine building so as to be as close to the turbine condenser as possible. See Appendix G for a discussion of the location of single cooling towers for each Unit.

The time it takes to construct cooling towers has been debated in the ASLB hearings for Indian Point Unit No. 2.[16] Times have ranged from about 3 to 5 years.[16] In a recent article[17] a 350-ft natural-draft cooling tower, which will serve two 500-MWe fossil plants on the Ohio River, was built in slightly more than one year after start of foundation work. This type of cooling tower is designed to handle twice the cooling capacity at less than double the construction costs or time than other natural-draft towers. Proposed schedules for construction of the single cooling towers are presented in Appendix G. The Atomic Safety and Licensing Appeal Board has specified a date of May 1, 1979 for cessation of once-through cooling for Unit No. 2 (ALAB-188).[18] The staff proposes a date of September 15, 1980, subject to the conditions specified in the stipulation, for the cessation of once-through cooling for Unit No. 3.

a. Dry Cooling Towers

In dry cooling towers, condenser circulating water is pumped through finned heat exchangers, where atmospheric air absorbs and carries away heat without directly contacting the circulating water. Air flow can be promoted by fans, in mechanical-draft designs, or by large hyperbolic towers, in natural-draft designs. In contrast to wet cooling towers, no evaporation occurs from a dry system. Environmental effects of dry systems therefore do not include fogging, drift, contact icing, salt deposition, blowdown disposal, and makeup water requirements because of water consumption. The use of this type of cooling tower offers the advantage of increased flexibility in siting thermal power plants, since a large source of cooling water would no longer be necessary. In addition, thermal and chemical discharges to the aquasphere are eliminated. From an environmental and cost/benefit standpoint, dry cooling towers can permit optimum siting with respect to environmental, safety, and load distribution criteria. A disadvantage is that the thermal efficiency of the tower is lower, since it is governed by the dry-bulb rather than the wet-bulb temperature of the air. The dry-bulb temperature is the theoretical lowest temperature that a dry cooling system can achieve but it is always higher than the wet-bulb temperature. As a result, dry cooling towers are less efficient and require a much larger heat transfer surface because of inefficiencies in heat transfer, adding to the cost of installation and space requirements. Turbine back-pressures in the range of 8 in. Hg absolute will be increased as will the range of back pressures over which the turbines must operate. This will result in reduced Plant capability and require additional replacement power, adding further to the costs of building and operating such towers. The infancy of the art of large dry cooling towers is obvious in estimates of capital and operating costs, which have ranged from $20 to $50 per kilowatt capacity[19] for a nuclear plant, and in estimates of the increased cost to the consumer, which have ranged from 5 to 15% depending on ambient temperatures and assuming optimized turbine design.[20] Details on siting, performance, and economics of dry cooling towers are described by Smith and Larinoff,[19] who point out the advantages and disadvantages of this cooling system for dissipating heat to the atmosphere. The applicant has estimated an additional cost of $72 million to the Plant if Unit No. 3 had been initially designed with dry cooling towers (ER, IP-3, Sect. 17, p. 17-15). Additional costs are also presented in ref. 20.

Impacts due to operation of these structures include noise, in the case of mechanical-draft designs, and aesthetic impact in the case of natural-draft designs. Also, because of the higher operating temperature and resulting lower turbine efficiency of dry cooling towers, the Plant requires more fuel with the associated impacts. In addition, capital costs for these towers are a function of the initial temperature difference between the hot fluid entering the cooling coils and cooling air entering the tower and are about 150 to 200% of wet tower costs. A detailed study[21] has recently been made comparing costs of mechanical-draft and natural-draft dry cooling towers with those for conventional cooling systems and for four plant locations throughout the U.S. The increased costs for three fuel and three fixed costs are presented for the case where a dry cooling tower system has replaced the once-through or wet cooling tower system. Considering the cost factor together with the technological problems of constructing the first dry cooling tower for a large nuclear complex, the ample availability of cooling water for wet towers, difficulties of operating dry cooling towers under all conditions with the present turbine generator, and the limited impacts of wet towers, the staff has concluded that dry towers are not a viable alternative to once-through cooling for Indian Point Units Nos. 2 and 3.

b. Wet/Dry Cooling Towers

Wet/dry cooling towers are now considered for applications where, during the winter months, there are visible plume problems or a need to conserve makeup water. In these towers, both dry and wet-type surfaces are provided in parallel paths in the air stream, with a means for proportioning the amount of air flowing over each. After passing over the surfaces, the two air streams are mixed together before discharge from the top of the tower. (The water to be cooled first flows through the dry-type coils and then through the wetted coils.)

Regulation of the air flow over the two types of surfaces permits attainment of temperature-humidity relationships in the mixture of discharged and ambient air less likely to fall within the supersaturated region and therefore less likely to cause fog. Also, during the winter, lower outside temperatures permit more of the heat to be rejected by the dry-type coils and the amount of water evaporated to be reduced. Generally, the practical design range is said to be for ambient temperatures of 20 to 70°F.[22]

Since more cooling surface is required for a dry-type tower than for wet surfaces cooled by evaporation, and since an excess of surface may be required to achieve a flexibility in the operating mode, wet/dry towers would undoubtedly be more expensive in first costs than conventional wet-type cooling towers.

A demonstration cell for a wet/dry cooling tower was built and put into operation during 1973 by the Westinghouse Electric Corporation for the Duke Power Company's Cliffside Station in North Carolina.[23] About 30 cells would be required for a 1,200-MWe nuclear plant and would be constructed of prestressed concrete and other fire-restrictive materials. Marley[22] has reported a wet/dry cooling system in operation at a St. Joseph (Missouri) Light and Power Company generating station.

c. <u>Wet Cooling Towers</u>

There are several possible modes of heat rejection at Indian Point using wet cooling towers. The staff has considered three cases to be most representative and of particular interest in this study:

Alternative A	Units Nos. 1 and 3 operating with once-through cooling and Unit No. 2 operating with a natural-draft cooling tower.
Alternative B	Unit No. 1 operating with once-through cooling and Units Nos. 2 and 3 operating with natural-draft cooling towers.
Alternative C	Unit No. 1 operating with once-through cooling and Units Nos. 2 and 3 operating with mechanical-draft cooling towers.

The environmental effects of these alternatives are discussed below.

(1) Terrestrial

(a) Land Use

Construction of cooling towers at the Indian Point site will require a significant amount of grading and excavation for tower support structures and piping. The nature of the limestone substrate will require a certain amount of blasting. Portions of areas proposed for tower siting are presently cleared and are used for parking and staging areas (ER, IP-3, Figs. 13, 17-7, and 17-8). Some additional clearing would be required for siting and construction access. The applicant has not specified plans for disposal of overburden and spoil, nor have procedures been outlined for restoration and landscaping of areas surrounding the towers. The applicant has yet to detail such plans to the staff but some of the excess material from excavation may be disposed of in the Verplanck quarry.

Using plot plans provided by the applicant (ER, IP-3, Figs. 17-7 and 17-8), the staff has estimated that approximately 60 acres (exclusive of piping tunnels) would be needed for siting mechanical-draft towers to serve Units Nos. 2 and 3. This acreage requirement would be reduced considerably in the case of natural-draft towers (∿20 acres, exclusive of piping tunnels). Provided that the towers are not located within or directly adjacent to the proposed natural area, the staff does not consider the utilization of these acres for cooling tower siting as having a serious impact on total land use for the entire site. A plot showing the location of the proposed cooling towers is given in Fig. G-6 in Appendix G.

The heights of the natural-draft towers (∿500 ft) will require adequate aircraft warning precautions to meet Federal Aviation Authority requirements.

(b) Aesthetics

As discussed in Chapter IV, proper landscaping and extant wooded areas surrounding the site will combine to minimize the visual impact of the nuclear complex using once-through cooling. The installation of cooling towers will exert significant aesthetic impact in that, even with proper landscaping and careful siting, the structures will be highly visible from surrounding locations. The utilization of mechanical-draft towers for Units Nos. 2 and 3 will result in some visual impact resulting from the number and size of units required [six towers; approximately 450 ft long (total length), 50 ft wide, and 60 ft high], as well as from the vertical extent of these above the surrounding vegetation. In addition, operating noise and moisture plumes from these units will be conspicuous and noticeable and will tend to add to the "industrial" image of the area.

The use of large hyperbolic natural-draft towers will result in reduction in plume size and its visibility. These are large structures, however, extending more than 450 ft above the surrounding vegetation, and while the hyperbolic construction may be pleasing to the eye, these structures will be visible for long distances and will constitute a dominant feature of the landscape. The staff concludes that the aesthetic effect is a major impact of this particular alternative, even though it cannot be quantified. Cooling tower appearance and effluents may have direct impacts on Bear Mountain State Park and the Hudson Highlands.

(c) Noise

The staff has evaluated impact of sound levels produced by natural- and mechanical-draft cooling towers with emphasis toward their respective effects upon humans. In terms of impact upon wildlife aside from the potential loss of portions of habitat immediately adjacent to the towers, no other effects upon terrestrial species are identifiable. Since the site is zoned for industrial development the area is not considered to be an important wildlife habitat.

(i) Natural-Draft Cooling Towers

Noise generated by natural-draft cooling towers is typically broadband in nature (similar to noise associated with falling rain). No fans are required for inducing air flow; hence, noise levels outside the immediate perimeter of the towers usually do not exceed background levels.

Noise produced by natural-draft cooling towers is due largely to the fall of water through fill sections, and subsequent splashing in the tower basins. The applicant estimated that sound levels for a hyperbolic tower for Unit No. 3 would not exceed 50 dB(A) at a distance of 2,500 ft from the tower, and that about 21 residents will be subjected to noise levels above 50 dB(A) (ER, IP-3, Section 22, p. 4.2-6). The additive effect of a second tower would increase this estimate to 53 dB(A).

An evaluation of noise levels generated by two natural draft towers having flow capacities approximately 40% less than those postulated for the present plant, reported sound levels of 44 dB(A) at 4,000 ft from the towers.[24] These can be interpolated to 50 dB(A) at 2,000 ft, which is not inconsistent with the applicant's estimate, considering the reduced circulating water flow of the smaller towers.

Combining the staff's estimate for plant noise at distances of 2,250 ft from the generating complex (i.e., 51 dB(A); FES, IP-3, Section V.A.3) with an estimated 53 dB(A) cooling tower addition, suggests added sound levels on the order of 55 dB(A) in the vicinity of the Broadway property line. In actuality, these are likely to be reduced by as much as 10 dB(A) resulting from attenuation by vegetation and topographic features on the site.

Based upon added noise totalling 55 dB(A) at 2,500 ft from the center of the generating complex, an area of 0.7 square mile would experience noise levels characterized as "normally unacceptable" (HUD criteria). Approximately 21 residents would be affected. However, considering that traffic noise along Broadway exceeded 60 dB(A) more than 50% of the time during which measurements were undertaken (ER, IP-3, Section 22, pp. 4.2.5-4.2.7), the staff does not consider the added sound levels from two hyperbolic natural-draft cooling towers as having a serious impact upon these residents.

(ii) Mechanical-Draft Cooling Towers

Noise levels produced by mechanical-draft towers generally exceed those for similar capacity natural-draft units, due to the operation of numerous large fans for inducing air flow. The applicant initially estimated that noise generated by three banks of mechanical-draft towers for Unit No. 3 would produce sound levels of 50 dB(A) at 5,000 ft from the cooling cell complex (ER, IP-3, Section 22, p. 4.2-8). The inclusion of a similar system of cooling towers for Unit No. 2 will add to these sound levels. Based upon the applicant's estimate for Unit No. 3 alone, an area of approximately 2.8 sq. miles (745 residents) will be exposed to "unacceptable" noise levels, as defined by HUD criteria.[25]

Physical arrangements of individual elements of mechanical-draft towers as proposed by the applicant (ER, IP-3, Fig. 17-8) are such that the longitudinal axes of the individual units will essentially parallel the Broadway property line. Alignment in this manner subjects the nearby community to sounds emitted from louvered faces of the towers (as contrasted with cased, or closed ends of individual banks of cooling cells), maximizing the potential impact of cooling tower noise.

The applicant has estimated offsite sound levels from mechanical-draft towers on Units Nos. 2 and 3 to be approximately 63 dB(A) 5,000 ft from the towers. Interpolation of this estimate suggests sound levels on the order of 69 dB(A) at 2,500 ft from the center of a mechanical draft complex. The physical location of elements of a mechanical-draft complex will have some bearing upon offsite sound levels. Nonetheless, both the applicant and the staff concur that the implementation of Alternative C will subject approximately 745 residents to sound levels of varying intensity; classified as ranging from "unacceptable" to "clearly unacceptable" by HUD.[25]

(d) Salt Deposition

The use of saline water for cooling tower makeup will result in deposition of salts in the vicinity of the tower due to entrainment of water droplets in the exit air stream and their subsequent fallout. Details of the salt deposition calculations are given in App. G.

(i) Natural-Draft Cooling Towers

The maximum deposition of circulating-water solids for Alternative B (towers on both Units Nos. 2 and 3) is estimated to be about 19 lb/acre per year and to occur in an area 1.5 to 2.5 miles from the center of the site in the southern 22.5° sector (App. G, Fig. G-3).

Dissolved solids within the circulating water are comprised primarily of sodium (∿28.3%), chlorides (∿50.3%), and sulfates (∿7.3%) (see Table XI-5). By applying the above percentages to predicted drift deposits, the contribution of each of these entities to total drift may be determined. For Alternative B, the maximum annual deposits will consist of 5.4 lb Na^+, 9.6 lb Cl^-, and 1.4 lb SO_4^{2-} per acre. Based upon data of Junge and Werby[26] and using annual precipitation data for the site area (46 in.), natural depositions of these materials may be calculated at 6.3 to 10.4 lb/acre per year for Na^+ and Cl^- and 20.9 to 31.3 lb/acre per year for SO_4^{2-}. Thus, operation of natural-draft towers for Units Nos. 2 and 3 will result in maximum increases equal to 86, 152, and 7%, respectively, of natural input of Na^+, Cl , and SO_4^{2-} to area soils.

An evaluation of potential for damage to surrounding vegetation due to root uptake of drift solids can be approached by considering drift deposits to be diluted by annual precipitation (less 63% annual evapotranspiration[27]) and applied to the landscape as irrigation water. Disregarding the effect of drift moisture, and using precipitation alone for dilution, salt concentrations in soil water (within areas of maximum deposition) attributable to cooling tower drift plus natural precipitation inputs may be approximated as 3.1 ppm Na^+, 3.9 ppm Cl^-, and 6.4 ppm SO_4^{2-}.

Assuming 75% of annual drift deposition to occur during May-September, and using total monthly precipitation (ER, IP-3, App. E) (corrected for evapotranspiration) for dilution, solution concentrations of the above materials are 4.9 ppm Na^+, 6.6 ppm Cl^-, and 8.7 ppm SO_4^{2-} for a total of 20.2 ppm dissolved salts, inclusive of precipitation inputs. Dissolved solids concentration of 20 ppm can be placed in perspective by considering that within the eastern U.S., water containing as much as 640 to 1,280 ppm total salts may be used for supplemental irrigation of plants having low salt tolerance.[28] Therefore, in considering that no allowance has been given for dilution of drift solids by the moisture fraction of circulating water carried over as drift, and further, in considering that the preceding calculations are based upon maximum deposition applying to the total landscape, vegetation damage resulting from root uptake or interference of normal absorption pathways by added salts is considered highly unlikely.

An additional avenue for potential damage is associated with the impaction of drift directly upon vegetation. Unfortunately, the effects of aerial salt impaction upon plant species in areas removed from the influence of coastal salt spray have received little study. For present purposes, however, it is notable that a number of species common to the Indian Point environs (e.g., red and white oak, beech, and cherry) are also found at high ground sites along the eastern seacoast. The occurrence of similar to identical species within the two environments suggests that results of salt spray experiments with plants common to coastal sites can be used to some extent in evaluating the potential for drift damage to inland vegetation. Aerosol concentrations of dissolved solids which would be present in the cooling tower plumes are not considered a major problem. Results of studies involved in evaluating the potential environmental impact of a large saltwater natural-draft cooling tower at Forked River on the New Jersey coast[29] suggest that average monthly, maximum and average annual bareground concentrations of drift salts are factors of 40 to 100 times, respectively, below levels known to affect the general vigor and distribution of coastal vegetation (0.23 to 0.1 $\mu g/m^3$ compared with 10 $\mu g/m^3$). The relatively lower solids concentration of the circulating water for the proposed Plant (~12,000 ppm, compared with 45,000 ppm for the saltwater tower) would suggest that there would be minimal damage to vegetation from exposure to atmospheric salts, even during critical periods of low freshwater flow in the Hudson. Short-term peak concentrations were found to be six times lower than the minimum levels observed to promote visible damage in principal indigenous species, which include conifers and mesophytic hardwoods as well as typical shoreline vegetation.[29]

While it can be argued that many species indigenous to coastal areas are to some extent adapted for exposure to aerosol salts, the staff is of the opinion that adaptive mechanisms of this type are generally lacking in high ground species such as those identified as being common to both the Indian Point site and coastal areas of the eastern U.S. The considerable latitude allowed in determinations such as those done for a salt-water natural-draft installation[29] which suggest that near-ground salt concentrations are likely to be 40 to 100 times lower than those determined as critical for vegetation chronically exposed to salt spray (and a factor of 6 lower than those shown to elicit acute response) is sufficient to offset any possible differences in the relative salt tolerance of various species. The calculated drift solids concentrations are conservative in that no consideration was given for dilution of drift solids by the moisture fraction of circulating water carried over as drift. Further, in reaching any conclusion regarding the potential for drift damage it is assumed that maximum deposition rates are characteristic for the total landscape, and not restricted to sectors along the path of prevailing winds, as in Fig. G-3 (FES, IP-3, App. G). However, even with all conservative assumptions operable, the staff considers it highly unlikely that any vegetation damage will result from root uptake or interference with normal absorption pathways by drift from wet natural-draft towers.

The deciduous habit of a major proportion of area vegetation, coupled with the large volumes of precipitation (average 43 in. annually) available for dissolution and transport of saline deposits via percolation and runoff, will serve to further reduce any potential for damage due to impaction or deposition of drift solids.

Topographic features of the site and surrounding area are not deemed especially critical to this particular analysis. The staff considers it unlikely that any portion of the surrounding landscape would be exposed to salt deposition in excess of maximums indicated in Fig. G-3 (FES, IP-3, App. G). Aerosol concentrations of drift solids are expected to disperse rapidly, and are not considered as posing a threat to surrounding vegetation, including cover on adjacent high ground.

No significant corrosion problems would be expected to result from drift chemicals. For the most part, predicted deposition of drift salts is less than or no greater than five times the range of variation which can be calculated for natural precipitation inputs of Na^+ and Cl^- (i.e., 4.1 lb/acre per year.

For Alternative A (tower for Unit No. 2) the effects of drift would be about one-half those noted above for Alternative B.

(ii) Mechanical-Draft Towers

The maximum deposition for Alternative C (towers on both Units Nos. 2 and 3) is again predicted to occur within the southern 22.5° sector, but at a distance of less than 0.3 mile from point of release, and is estimated to be about 2,870 lb/acre per year (App. G, Fig. G-5). Treatment of these deposition rates as outlined above for natural-draft towers, and assuming 75% of annual deposition to occur during the interval May through September, yields soil water concentrations of Na^+, Cl^-, and SO_4^{2-} equivalent to 328, 581, and 92 ppm, respectively, inclusive of precipitation inputs during this interval.

The inclusion in summer deposition calculations of total dissolved and suspended drift solids in the circulating water would yield a maximum solution concentration equivalent to 1,162 ppm (including precipitation inputs of Na^+, Cl^-, and SO_4^{2-}). This concentration represents a conservative estimate, in that calculations are based upon maximum circulating-water solids concentration. In addition, no allowances have been made for dilution by moisture deposited along with drift solids or for removal of chemical deposits by surface runoff.

In terms of evaluating probable effects of these solution concentrations, it may be noted that water having as much as 640 ppm dissolved salts may be used for supplemental irrigation of low-salt-tolerance plants in humid regions of the U.S.[28] This guideline translates to a five-month total summer deposition of 1,580 lb of drift solids per acre, or an annual deposition equal to 2,560 lb/acre inclusive of precipitation inputs of Na^+, Cl^-, and SO_4^{2-}.

Annual drift deposition is predicted to exceed 2,560 lb/acre over areas lying along the prevailing north-south wind direction sectors within 0.3 mile of an assumed mechanical-draft complex (App. G, Fig. G-5). Some vegetation damage may be expected within these areas as a result of root uptake of dissolved salts and/or interference with normal absorption pathways by the added solids. Damage is also expected as a result of deposition of circulating-water salts directly upon foliage. Due to the relatively low effective stack heights and larger drift droplet diameters common to mechanical-draft towers, aerial portions of vegetation near such installations may be exposed to toxic concentrations of drift salts. Drift droplets from towers in question will contain a maximum of 12,000 ppm total solids, approximately 79% of which are Na^+ and Cl^-. Both of these elements are readily absorbed by foliage[30] and are known to produce symptoms ranging from leaf burn and discoloration to complete defoliation, depending upon species tolerance, relative salt concentrations, and duration of exposure.[29]

Under natural conditions (i.e., in situ) separating vegetation damage due to foliar absorption from that caused by uptake of salts from soil solution may become quite difficult. However, if one considers drift within a 1,000-ft radius of the cooling tower complex as being analogous to salt spray, a qualitative estimate of species likely to sustain damage may be realized. Plants typical for the site area which have been shown to be sensitive to salt spray (salinity ∿30,000 ppm) include red maple, black cherry, dogwood, and various herbaceous species.[29] Conifers, including white pine, Scotch pine, and Austrian pine (the latter two species being ornamentals) appear to be somewhat resistant to spray.[29]

Considering that circulating-water salinity at the Indian Point site may approach 12,000 ppm during the summer period when rainfall is relatively low, some "spray" damage can be expected to occur within the described radius, which would experience greater than 70% of drift fallout.[31] Areas contained within the 1,000-ft radius extend across Broadway and overlap portions of the adjacent Georgia-Pacific property (ER, IP-3, Fig. 17-8).

The staff has considered the possibility of contamination of groundwater supplies resulting from infiltration of drift salts. Based upon a 50.3% chloride composition and using net annual precipitation for dissolution of drift deposits, areas receiving in excess of 2,025 lb/acre per year can be considered as receiving a steady-state input of chloride equivalent to recommended limits for potable water (i.e., 250 ppm).[32] This is a very conservative calculation, however, in that the inclusion of moisture deposited as drift as a dilution factor would greatly reduce calculated chloride concentrations. Further, no allowance has been made for removal of salts via surface runoff. Therefore, considering the limited areas exposed to drift deposition in excess of 2,025 lb/acre per year, the mitigating effects of drift moisture and surface runoff, and the limited municipal utilization of groundwater within a five-mile radius of the site (ER, IP-3, Suppl. 3, p. 4-3), it is the staff's opinion that deposition of drift salts from mechanical-draft cooling towers at Indian Point will have no appreciable effects upon area groundwater supplies.

In summary, vegetation damage can be expected to occur as a result of operation of mechanical-draft towers at the Indian Point site. This potential damage is considered unacceptable by the staff, in that much of the area involved lies outside of the site boundaries. Furthermore, damage to or elimination of wooded area surrounding the site would tend to remove additional wildlife habitat, as well as detract from aesthetic benefits gained by minimizing vegetation removal during construction. Exposure of buildings and structures to drift vapors having salt concentrations in excess of those of normal rainwater may cause some early deterioration of concrete and increased corrosion of mild and stainless steel.[33] This aspect deserves consideration in view of the relatively large localized salt deposits from mechanical-draft towers using brackish circulating water. Additional consideration may be warranted concerning potential impacts on nearby switchyards and substations, as the conductive nature of dissolved salts may result in increased current leakage along with corrosion problems.

(iii) Effects of Drift on Wildlife

In evaluating the effects of evaporative cooling towers the staff has considered possible detrimental effects of drift chemicals on wildlife. Unfortunately, the salt tolerances for many species common to inland areas have not been studied. In conjunction with vegetation studies conducted for a saltwater natural-draft installation, extensive literature surveys and field observations led investigators to conclude that cooling tower drift would not exert direct physiological effects upon land-dwelling vertebrates.[29]

As evidenced from investigations of highway deicing[34] effects, there exists a potential for attraction of vertebrate species to added salt. However, in the present instance, except for areas close to a mechanical-draft installation, no environmental accumulation of salt is expected, and therefore the staff is of the opinion that the major potential avenue for impact to terrestrial wildlife due to drift from evaporative cooling towers at Indian Point, is associated with habitat alteration by way of damage to surrounding vegetation. In this regard it may be noted that some vegetation damage is expected within an approximate 0.3 mile radius of a mechanical-draft installation. No damage nor disturbance to offsite vegetation is expected for the natural-draft alternative. Therefore, it may be concluded that damage to terrestrial wildlife will be restricted to the possible loss or alteration of habitat within a small area directly adjacent to a mechanical-draft installation.

(2) Air

(a) Extent of Plume

The visible plume from natural-draft towers will generally disappear within a few hundred feet of the top of the tower. Under summer conditions with a high relative humidity, the visible plume may persist to a height of about 4,000 ft above the ground and may extend several miles downwind. The centerline of the invisible plume is estimated to reach 1,500 to 2,600 ft above ground and to intersect the ground some three to four miles downwind. Details of the estimated plume behavior are given in App. G.

The plume from mechanical-draft towers will extend to much lower heights and will have a potential for creating fogging in the vicinity of the Plant, as discussed in the following section.

(b) Fogging

Fogging produced by the plumes discharged to the atmosphere from the cooling tower alternatives is described in App. G.

The increase in fogging at the center of Peekskill is estimated to be less than 4 hr/year for Alternative B (presumably somewhat less for Alternative A, although this case was not analyzed). (See FES, IP-2, pp. XI-56 to XI-61 for discussion of fogging from cooling towers at Unit No. 2.) The increase in fogging for Alternative C is estimated to be a maximum of 66 hr/year about two miles north of the Plant. Other annual increases in fogging for this alternative are estimated to be about 11 hr at Peekskill and 40 hr at the Bear Mountain Bridge.

(c) Climate

To date, studies of possible regional environmental modifications from cooling tower operations have been limited in number. The situation is complicated by the fact that large generating facilities are often some distance from a U.S Weather Bureau Station that has long-term climatological records of the several meteorological elements required to assess the effects of cooling tower plumes. Thus, while precipitation measurements from other sources may be used to assess possible increases in total rainfall within a given area, the relationships to cooling tower operations of changes in such elements as relative humidity, hours of sunshine, days with precipitation, and thunderstorms remain to be evaluated.

(d) Plume Interaction

There exists a potential for interaction of cooling tower plumes with fossil-fueled plant emissions of sulfur dioxide, with the subsequent formation of sulfuric acid (H_2SO_4). This phenomenon has been noted at the Keystone generating plant near Shelocta, Pa., where analysis of drift vapors showed the pH of droplets to range from 2.0 (acid) to 7.0 and above (neutral to alkaline).[31] However, considering that normal precipitation in the nearby New England region contains on the order of 3 to 4 ppm SO_4^{2-}, mostly in the form of H_2SO_4, with an accompanying pH of 4.4,[35] and assuming similar conditions exist at Indian Point, the staff believes that the impact of the potentially "acid mist" from cooling towers at the Indian Point site can only be considered as a small incremental addition to total precipitation input of SO_4^{2-} to the local area.

(3) Water

(a) Thermal Discharges

The effects of thermal discharges on the temperature of the Hudson River are discussed in Section V.C.1 and App. A. The decreases in the heat discharged to the river and the cooling-water withdrawal rate result in a reduction of the surface temperature increase from 4.6 F° for the base design* to 3.8 F° for Alternative A and 1.7 F° for Alternative B or C (Table XI-4).

The heat rejected to the river for Alternative A is about 15% greater than that for Units Nos. 1 and 2 operating alone with once-through cooling, and the cooling-water withdrawal rate for Alternative A is about 5% greater. The thermal effects for Units Nos. 1 and 2 alone with once-through cooling have been analyzed by the staff (FES, IP-2, pp. III-25 to III-49). In this case the staff's conclusions relative to the New York State thermal criteria (see Section V.C.1 of this Statement) were that "Although the staff's assessment shows that the thermal discharges will result in a temperature of less than 90°F at the river surface, even during the summer months, and thus meet part of the New York thermal criteria, the staff finds that the New York State criteria for the surface width and cross-sectional area enclosed within the 4 F° isotherm may not be met." (FES, IP-2, p. ii).

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*Base design is operation with once-through cooling at full pump capacity for all three Units.

Table XI-4. Summary of thermal effects on the Hudson River for the base design and alternatives

	Base design	Alternative A	Alternative B[a]
Heat discharged to the river, millions of Btu/hr	15,755	9,592	2,345
Total cooling water withdrawal rate			
gpm	2,058,000	1,244,000	435,000
cfs	4,585	2,770	968
Increase in temperature from intake to discharge, F°	15.3	15.6	11.6
Approximate increase in surface temperature at centerline of plume,[b] F°	4.6	3.8	1.7
Volume of water contained in 4° isotherm,[b] ft^3	66,600	52,000	17,600

[a]The effects of Alternative C are approximately the same as those of Alternative B.

[b]From Appendix A, Koh and Fan slot-jet model, Table V-5. See details of analysis of thermal effects in Section V.C.1 and Appendix A.

The volume of water contained within the 4 F° isotherm will be 78% of that for the base design for Alternative A and 26% for Alternative B. The far-field studies, including the effects of the Danskammer, Roseton, Lovett, and Bowline Plants, indicate a tidal maximum cross-sectional average temperature increase of 4.9 F° for Alternative A at Indian Point (Table A-1, App. A). The staff concludes from the above information that the thermal discharges for Alternative A may not meet the New York State thermal criteria under all conditions.

For Alternative B or C the heat discharged to the river is 15% of that for the base design and 22% greater than that for Unit No. 1 operating alone. The water withdrawal rate is 21% of that for the base design and 37% greater than that for Unit No. 1 alone. The far-field analyses for Alternative B, including the effects of the four other plants, indicate a tidal maximum cross-sectional average temperature increase of 2.8 F° at Indian Point Table A-1, App. A. The staff concludes from this information that the New York State thermal criteria will probably be met by the thermal discharge for Alternative B or C. However, the Department of the Interior[40] in a letter dated May 10, 1973 to the Atomic Energy Commission, has reviewed the applicant's Environmental Report and commented as follows:

"The combination of fresh water and tidal flows in the vicinity of the plant site is a complex phenomenon which makes modeling and computation of expected thermal effects extremely difficult and open to doubt and manipulation. Only actual measurement of operational temperatures will determine if a different outfall design will be needed; however, based on the Atomic Energy Commission's staff position and this Department's position on the closed cycle method of cooling for Unit 2, we would strongly suggest that this unit also use a closed cycle cooling system, especially if additional units are contemplated at this site."

(b) Chemical Discharges

The chemical discharges to the river described in Section V.C.2.a were based on the assumption that only the service water flow (about 100,000 gpm) was available for dilution in the discharge canal. Thus, the increases in concentrations in the Hudson River given in Tables V-7 and V-8 are applicable to the three alternatives.

In addition to the above discharges, the concentrations of chemicals in the tower blowdowns will be increased over the ambient river concentrations as a result of the twofold concentration cycle assumed for the cooling towers. The resulting concentrations are given in Table XI-5.

It is the opinion of the staff that the estimated increases in concentrations of chemicals present in the effluent stream for the alternatives will cause no significant adverse environmental impact.

The effects of potential corrosion inhibitors and biocides have been discussed by the staff (FES, IP-2, App. XI-1). The staff points out the toxicity of different chemicals used as inhibitors on aquatic biota and recommends that the applicant utilize appropriate methods, such as those itemized on pp. A-XI-14 to A-XI-17 in the Final Environmental Statement for Unit No. 2 to aid in keeping chemical releases to a minimum. The 318,000 gpm cooling water flow of Unit No. 1 will also aid in diluting the blowdown prior to entry in the river.

(c) Water Consumption

The makeup water requirement is assumed to be 26,000 gpm for Alternative A and 57,000 gpm for Alternative B or C (App. G).

Table XI-5. Chemical concentrations from cooling tower operation

Chemical	Concentration, ppm			
	Hudson River[a]	Blowdown	Effluent Stream	
			Alternative A[b]	Alternative B or C[c]
Bicarbonate	82	78	82	81
Calcium	82	164	91	99
Chloride	3,020	6,040	3,351	3,646
Magnesium	184	368	204	222
Potassium	60	120	67	72
Silica	4	8	4.4	4.8
Sodium	1,700	3,400	1,887	2,051
Sulfate	420	880[d]	470	516
Residual chlorine		0.5[e]	0.05	0.05
Chlorine reaction products		*f*	*f*	*f*
Total dissolved solids[g]	~6,000	~12,000	~6,659	~7,242

[a]Maximum concentrations (ER, IP-3, Table 4-1).
[b]Based on 100,000-gpm service water flow and 12,000-gpm blowdown from Unit No. 2.
[c]Based on 100,000-gpm service water flow, 12,000-gpm blowdown from Unit No. 2, and 14,000-gpm blowdown from Unit No. 3.
[d]Includes H_2SO_4 treatment of ~0.25 gpm.
[e]Limit stated by applicant (ER, IP-3, App. FF, p. VII-1).
[f]Not available, since these concentrations depend upon frequency and amount of chlorine treatment and consequent tower buildup.
[g]Staff estimate.

These uses represent about 1.5 and 3.1%, respectively, of the minimum freshwater flow in the river of 4,000 cfs and should not represent a significant withdrawal from the Hudson River. The staff anticipates no significant effect on groundwater supplies because the few wells that may provide drinking water to nearby residents are relatively shallow and at ground elevations that are considerably higher than the Indian Point site. Groundwater at the site flows to the Hudson River.

(4) Biological Impact

(a) Terrestrial Biota

Impacts to terrestrial wildlife resulting from cooling tower alternatives will consist of the loss of additional potential habitat to permanent structures, as well as modifications to remaining habitat resulting from fogging and drift deposition. These impacts are in addition to the impacts (Chapters IV and V) of the base design.

The size of natural-draft towers and their location along migration paths have raised concern regarding the possibility of avian collisions with these structures. However, based upon information from other generating facilities using such towers,[36] few bird fatalities have been reported resulting from tower collisions. In general the problem might be expected to occur in conjunction with a complex of meteorological conditions leading to low overcast, fog, and greatly reduced visibility. During such conditions, wildfowl generally remain grounded unless disturbed.

Noise levels associated with the operation of mechanical-draft towers and to a lesser extent with natural-draft towers may prevent certain species of songbirds and small mammals from reoccupying areas adjacent to the towers following the construction period.

(b) Aquatic Biota

The impact on aquatic biota resulting from withdrawal of makeup water from the Hudson River would be approximately the same for mechanical-draft and natural-draft cooling towers. The staff's evaluation of this impact is organized in the same manner as Section V.D.2; where appropriate, material from that section has been repeated here for purposes of comparing the Plant with once-through cooling with Alternatives A and B.

(i) Impingement

Table XI-6 provides a comparison of the projected impingement impacts for the base design and Alternatives A and B for the Indian Point Plant alone and in combination with other power plants on the river. The values for the base design (Indian Point alone) correspond to the applicant's annual projections (ER, IP-3, App. BB, p. 65).

The number and weight of fish impinged at Indian Point Units Nos. 1, 2, and 3 for Alternatives A and B were estimated using the same general equation introduced in Sect. V.D.2.a. The equation is:

$$N = F(N_1/F_1) \quad , \qquad (1)$$

where N is the annual "catch" at Indian Point for Alternative A or B, F is the annual "effort" at Indian Point for Alternative A or B, N_1 is the annual "catch" at Indian Point for the base design, and F is the annual "effort" at Indian Point for the base design. As in Sect. V.D.2.a, the annual catch at Indian Point for the base design is taken to be 2,610,041 fish per year and 28,615 lbs of fish per year, as estimated by the applicant (ER, IP-3, App. B, p. 65). The annual effort at Indian Point for the base design is taken to be the total volume of water withdrawn during the year, assuming that all three units operate every day of the year at 100% flow (4585 cfs) from April through September and at 60% flow (2838 cfs) from October through March (see Table V-2); thus, $F_1 = 1.171 \times 10^{11}$ ft^3 per year (see Sect. V.D.2.a).

The annual effort at Indian Point for Alternative A or B is taken to be the total volume of water withdrawn during the year, assuming the following: (a) a unit with once-through cooling operates every day of the year at 100% condensing-water flow from April through September and at 60% condensing-water flow from October through March, and (b) units with closed-cycle cooling operate every day of the year with the same intake flow. For Unit No. 2 with closed-cycle cooling the intake flow would be 56 cfs (intake flow equals service water plus blowdown plus evaporation and drift); for Unit No. 3 with closed-cycle cooling the intake flow would be 61 cfs (see Table V-2).

Thus, for Alternative A

$$F = \left[\left(\frac{709\ \text{ft}^3}{\text{sec}} + \frac{1938\ \text{ft}^3}{\text{sec}}\right) \cdot \frac{183\ \text{days}}{\text{year}} + \left(\frac{459\ \text{ft}^3}{\text{sec}} + \frac{1190\ \text{ft}^3}{\text{sec}}\right) \cdot \frac{182\ \text{days}}{\text{year}} + \frac{56\ \text{ft}^3}{\text{sec}} \cdot \frac{365\ \text{days}}{\text{year}}\right] \cdot \frac{86{,}400\ \text{sec}}{\text{day}} = \frac{0.6955 \times 10^{11}\ \text{ft}^3}{\text{year}} .$$

Finally, substituting this value for F and the values given above for N_1 and F_1 into Eq. 1, the annual impingement impact at Indian Point alone for Alternative A is estimated to be 1.6×10^6 fish per year and 17×10^3 pounds of fish per year. These values represent approximately a 40% reduction from the impingement impact at Indian Point alone for the base design.

For Alternative B,

$$F = \left[\left(\frac{709\ \text{ft}^3}{\text{sec}} \cdot \frac{183\ \text{days}}{\text{year}}\right) + \left(\frac{459\ \text{ft}^3}{\text{sec}} \cdot \frac{182\ \text{days}}{\text{year}}\right) + \left(\frac{56\ \text{ft}^3}{\text{sec}} + \frac{61\ \text{ft}^3}{\text{sec}}\right) \cdot \frac{365\ \text{days}}{\text{year}}\right] \cdot \frac{86{,}400\ \text{sec}}{\text{day}} = \frac{0.2212 \times 10^{11}\ \text{ft}^3}{\text{year}}$$

Finally, substituting this value for F and the values given above for N_1 and F_1 into Eq. 1, the annual impingement impact at Indian Point alone for Alternative B is estimated to be 0.49×10^6 fish per year and 5.4×10^3 pounds of fish per year. These values represent approximately an 80% reduction from the impingement impact at Indian Point alone for the base design.

For the Indian Point Station plus Danskammer, Roseton, Lovett, and Bowline, the estimated annual impingement impacts are as follows (Table XI-6). Alternative A: 4.8 million fish and 52 thousand pounds of fish per year, which represents approximately a 20% reduction from the impingement impact at Indian Point for the base design plus the other plants. Alternative B: 3.7 million fish and 40 thousand pounds of fish per year, which represents a 35 to 40% reduction from the impingement impact at Indian Point for the base design plus the other plants.

Table XI-6. Estimates of annual fish-impingement losses for the Indian Point Plant alone and in combination with the Danskammer, Roseton, Lovett, and Bowline plants[a]

Case	Indian Point Station alone		Indian Point Station plus other plants	
	Impingement losses		Impingement losses	
	(10^6 fish/year)	(10^3 lb/year)	(10^6 fish/year)	(10^3 lb/year)
Base design	2.6	29	5.8	64
Alternative A	1.6	17	4.8	52
Alternative B	0.49	6.0	3.7	40
No units at Indian Point			3.2	35

[a]Number and weight values for the base design (for Indian Point alone) are the applicant's annual projections with operation at reduced cooling water flow during October through March (ER, IP-3, App. BB, p. 65). Number and weight values for the alternatives were calculated from those for the base design using the assumption that impingement is directly proportional to intake flow.

The staff notes that converting a Unit from once-through cooling to wet cooling towers will reduce both intake flow and velocity, and there is considerable evidence to indicate that, in addition to temperature, impingement is a function of both intake flow and velocity (Section V.D.2.a). Consequently, the impingement values for the alternatives must be considered as first-order approximations only. The methodology for estimating impingement losses for Indian Point in combination with other power plants is described in Section V.D.2.a. The problems and causes of fish kill at Indian Point and techniques to reduce these kills at Units Nos. 1, 2, and 3 are also discussed in Section V.D.2.a.

It is the staff's position, as indicated previously in Sect. V.D.2.a, that impingement at Indian Point Units Nos. 1, 2, and 3, together with impingement at the other power plants, is of concern for white perch, tomcod, herring, and striped bass. Installation of closed-cycle cooling at Unit No. 2 (Alternative A) or at both Units Nos. 2 and 3 (Alternative B) reduces this concern and the risk of causing long-term reductions in the sizes of these fish populations approximately in proportion to the reduction in annual intake flow (or "effort").

(ii) Entrainment

Primary producers and consumers. As in Sect. V.D.2.b(1), the staff's position is that entrainment of phytoplankton and microzooplankton is not expected to have any measurable effect on the aquatic ecosystem (including the fish populations) in the vicinity of Indian Point. Except for *Neomysis*, the staff's opinion is the same for the macrozooplankton such as *Gammarus* and *Monoculodes*. However, because (1) entrainment mortality of *Neomysis* is quite high, (2) *Neomysis* tends to be concentrated at the salt front and its reproductive activity may be relatively high at the salt front, and (3) when young-of-the-year striped bass or white perch and *Neomysis* occur together, *Neomysis* is an important component of the striped bass and white perch diet. The staff concludes that when the salt front is in the vicinity of Indian Point for much of June through October, entrainment of *Neomysis* at Indian Point, Lovett, and Bowline may well reduce the standing crop of this mysid crustacean and thus have an adverse effect on the growth and survival of striped bass and with perch young-of-the-year. With closed-cycle cooling as opposed to once-through cooling at Indian Point Unit No. 3, the staff's concern in this area is reduced in direct proportion to the reduction in the combined intake flow at Indian Point, Lovett, and Bowline.

Fish eggs and larvae. Forecasts of percent reduction in the number of young-of-the-year striped bass which survive to October 15 with a cooling tower at Indian Point Unit No. 3 are given in Section XI.C.3.c(4)(b)(iv) on short-term and long-term effects. The only topic addressed in the corresponding section of Chapter V on entrainment of fish eggs and larvae [Section V.D.2.b.(2)] that requires discussion here is that mortality is expected to be 100% for all fish eggs and larvae entrained at the intake of Unit No. 3 with a cooling tower.

(iii) Effects of Discharges

As in Sect. V.D.2.c(1), the staff concludes that the temperature of the Hudson River in the vicinity of Indian Point may be increased to levels detrimental to aquatic life. If the thermal discharges from Danskammer, Roseton, Lovett, and Bowline fossil-fueled plants are considered in addition to those from Indian Point Unit Nos. 1, 2, and 3, the staff studies indicate that the estimated cross-sectional average temperature rise, under certain conditions, will exceed the assumed ambient water temperature of 80°F by more than

4 F° between river miles 39 and 47 for Alternative A but not at all for Alternative B (see App. A, Table A-1 and Fig. A-2). Exposure temperature, duration of exposure, species, size of organism, and its thermal history will be important in determining the effects of thermal stress. Excess temperatures may attract fish to the intakes, which could cause additional impingement. However, since thermal effects on aquatic biota are directly a function of the amount of waste heat discharged into the aquatic environment, the staff feels that the detrimental thermal effects will be reduced in proportion to the reduction in waste heat discharged for each alternative.

As in Sect. V.D.2.c(2), the staff concludes that during conditions of low freshwater flow, high river temperatures, and high densities of plankton, the discharged thermal waste from the Indian Point Plant together with discharges from Lovett and Bowline may reduce the dissolved-oxygen concentration in the plume and in the vicinity of Indian Point to levels detrimental to aquatic life.[66] Mortality, reduced growth rates of larval and juvenile fish, and reduced production of phytoplankton and zooplankton may result. However, since decreased dissolved-oxygen levels are directly and indirectly (i.e., decreased solubility, increased metabolism, and increased stratification) a function of increase in waste heat, the staff feels that the detrimental effects resulting from decreased oxygen levels will be reduced in proportion to the reduction in waste heat for each alternative.

Chemical. Cooling towers normally require the use of chlorine to reduce the fouling of organisms in the closed-cycle cooling system. Thus, it probably would be used in Alternative A or B to reduce fouling of the closed circuit system. The subject of use of biocides in cooling towers is presented in Appendix XI-1 in the Final Environmental Statement for Indian Point Unit No. 2. It would be expected that more sodium hypochlorite would be required with any of the three alternatives than for the base design. Operating techniques and design and construction of the towers will influence the amount released to the blowdown. However, until a design of the towers has been finalized, it is difficult to make any quantitative evaluation of the detrimental effects on aquatic life resulting from chlorine and its products for Alternatives A and B as compared with the base design. Chlorination would contribute substantially to mortalities (up to 100%) in the closed-cycle cooling system, but chlorine releases could have little measurable effect on organisms in the vicinity of Indian Point if discharge concentrations are kept within the estimates given in Table XI-5.

Radiological. As in the case of the base design, there should be no discernible effects on aquatic organisms as a result of the low-level releases for Alternatives A and B. The dose levels should be identical to those shown in Tables C-2, C-3, C-4, and C-5, because the total radioactive materials released from the Units will be the same, regardless of which alternative is used for the cooling system or how much dilution water is available from the cooling tower blowdown. The modified radioactive waste system will, however, permit a decrease in radiological impacts to biota since the radioactive releases of steam generator blowdown will be reduced by a factor of about 4.5.

(iv) Short-Term and Long-Term Impacts

Percent reduction in number of young-of-the-year striped bass. As in Sect. V.D.2.d(3)(c)(iii), the staff has used its new striped bass young-of-the-year model to forecast percent reduction values, due to power plant operation, in the number of young-of-the-year striped bass in the Hudson River that survive to October 15 of each year. This model is described in App. B, Sect. B.4.b. Forecasts of percent reduction are given in Table XI-10 (identical to Table V-20) for:

(1) two baselines from which to calculate percent reduction,

(2) two values of the input f-factor (f_I),

(3) eleven configurations for power plants on the Hudson River.

As discussed in Sect. V.D.2.d(3)(c)(iii) under the heading of "Baselines for calculating percent reduction values," the staff's position is that the baseline of no plants operating on the river is the appropriate baseline for assessing the entrainment and impingement impact of Indian Point Unit No. 3 and of the other plants on the Hudson River spawned striped bass population. The reader is referred to this section of Chapter V for further discussion of the justification for and implications of this choice of a baseline.

A discussion of the model results with respect to the sensitivity of the forecasts to changes in the intake f-factor (f_I) and the convective transport defect factor (CTDF) are also given in Sect. V.D.2.d(3)(c)(iii), as is the discussion of the results for the base design and Alternative A. The results for Alternative B are discussed in this subsection, and results for the base design and both alternatives are conveniently summarized in Table XI-14. As pointed out in the corresponding Section of Chapter V, 100% mortality upon entrainment has been assumed at each unit with closed-cycle cooling.

As pointed out in Sect. V.D.2.d(3)(c)(iii), the staff's single best estimate for the convective transport defect factor (CTDF) is 0.8, whereas the staff's best estimate for the intake f-factor is the range 0.5 to 1.0. Consequently, in summarizing the forecasts of percent reduction with closed-cycle cooling at Indian Point Unit No. 3, the staff has not considered the results for CTDF = 0.4 in Table XI-10.

Table XI-10. Young-of-the-year model results

Numbers for the various cases indicate percent reduction in the young-of-the-year from the base populations as indicated for each set of results

Case	Other plants[b]	Cornwall	Method of cooling[a]			Percent reduction[d]	
						Intake f-factor (f_I)	
			IP-1	IP-2	IP-3	0.5	1.0
						Without plants on the river as the baseline (Case 1)	
1[c]	–	–	–	–	–	15.86	15.86
2	1973	–	–	–	–	14	23
3	+	–	–	–	–	21	34
4	+	–	OT	OT	–	29	45
5	+	–	OT	OT	OT	34	50
6	+	–	OT	CC	OT	30	46
7	+	–	OT	CC	CC	23	37
8	+	+	OT	OT	OT	47	64
9	+	+	OT	CC	OT	44	61
10	+	+	OT	CC	CC	38	55
11	–	–	OT	OT	OT	21	32
12	–	+	–	–	–	24	33
						All other plants except Cornwall as the baseline (Case 3)	
3[c]	+	–	–	–	–	12.50	10.42
4	+	–	OT	OT	–	10	16
5	+	–	OT	OT	OT	17	24
6	+	–	OT	CC	OT	11	17
7	+	–	OT	CC	CC	3	5
8	+	+	OT	OT	OT	33	46
9	+	+	OT	CC	OT	28	40
10	+	+	OT	CC	CC	22	32

[a]OT means once-through cooling; CC means closed-cycle cooling. See Sect. XI.C for further discussion of closed-cycle cooling alternatives.

[b]Other plants include four units at Albany, four units at Danskammer, two units at Roseton, five units at Lovett, two units at Bowline, and seven units at 59th Street. In 1973 (case 2), the two units at Roseton and the second unit at Bowline were not operating. + indicates plants included in the calculation, and – indicates plants not included in the calculation.

[c]Values in this row are millions of young-of-the-year striped bass in the Hudson River on October 15 of each year.

[d]Convective transport defect factor (CTDF) = 0.8.

With closed-cycle cooling at Indian Point Unit No. 3 as well as at Unit No. 2 (Alternative B), the percent reduction values range from 23 to 37% without Cornwall and from 38 to 55% with Cornwall. The significance of these results is considered in the next subsection.

Impact on the Hudson River spawned striped bass population

As in Sect. V.D.2.d(3)(c)(iv), the staff has used its striped bass life-cycle model to evaluate the long-term impact of entrainment and impingement mortality at the power plants on the striped bass population. The model is described in App. B, Sect. B.4.c. The staff refers the reader to Sect. V.D.2.d(3)(c)(iv) for consideration of caveats, model simplifications, and a modeling philosophy which must be kept in mind in interpreting the results of this simulation model.

As discussed in Chapter V, the primary output from the life-cycle model which the staff has relied on in assessing the impact of Indian Point on the striped bass population are curves of relative yield versus year (Fig. V-12d). Relative yield is defined as the ratio of the yield of striped bass to the fishery (in weight rather than numbers of fish) with a given level of power plant impact to the yield to the fishery with no power plant impact. The staff then has used two criteria to analyze the information in curves of the type given in Fig. XI-2a. First, the increase in cumulative yield over the duration of the model run (80 to 100 years) for an alternative is expressed as a percent of the cumulative yield for the base design. In other words, the shaded area in Fig. XI-2a is expressed as a percent of the area under the curve from year 0 through year 100 for the base design. Second, for the base design and each alternative the number of years for which the relative yield is less than 0.50 is calculated. For example, referring to the hypothetical curves in Fig. XI-2a, for the base design the relative yield is less than 0.50 for 29 years, while for the alternative the relative yield is never less than 0.50.

The staff considers the number of years the relative yield is less than 0.50 as an index of the risk of irreversible effects on the striped bass population. The longer the population is reduced below 0.50, the less likely it is that the recovery curve forecast by the simulation model will be an accurate reflection of reality. The topic of irreversible effects is discussed in Section V.D.2.d(3)(c)(iv). The staff considers the increase in cumulative yield to be an approximate estimate of the benefit to the striped bass population of installing closed-cycle cooling systems at Indian Point. A similar methodology provides a basis for a detailed assessment of the economic impact of the Indian Point Plant on the striped bass fisheries (Sect. XI.J.2.c).

The staff has used the percent reduction values for the young-of-the-year discussed in the preceding subsection as input to the life-cycle model by calculating the probability of surviving (or not being exposed to) entrainment or impingement through October 15 as:

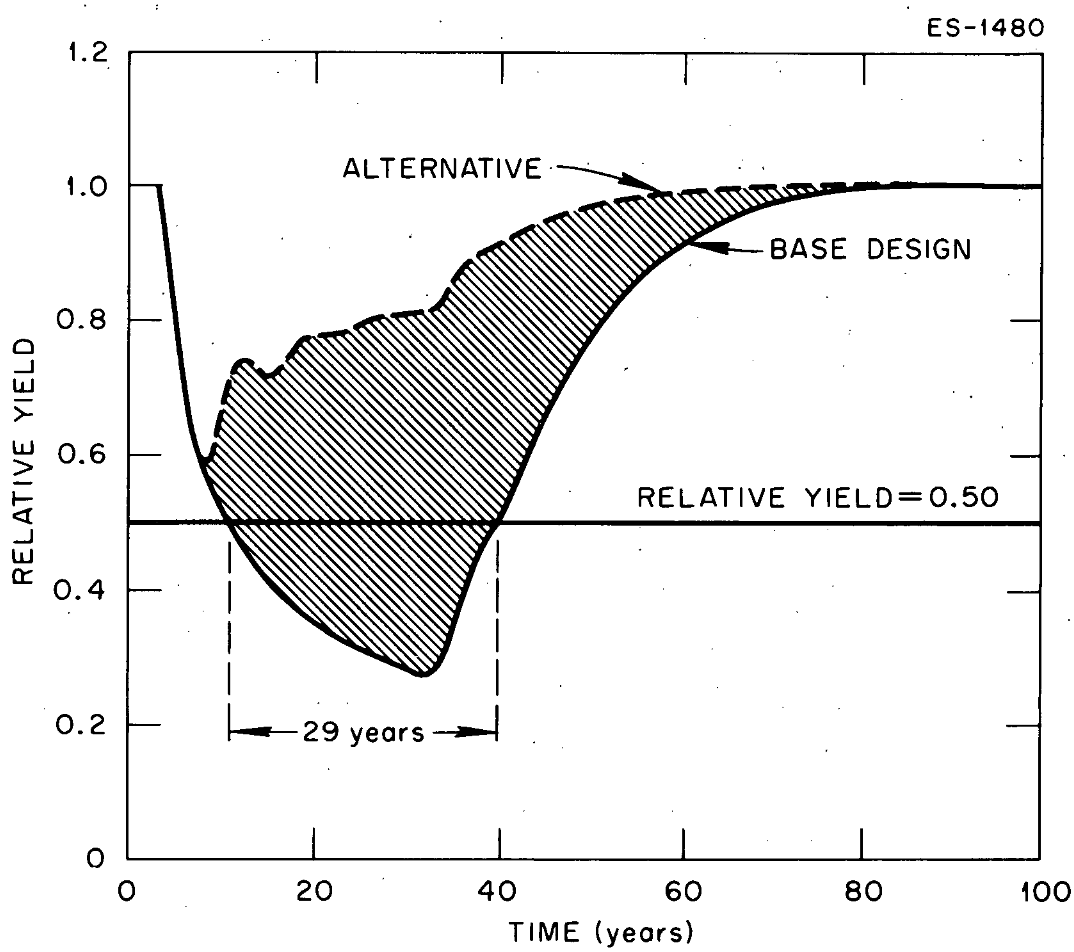

Fig. XI-2a. Two hypothetical curves of relative yield versus years to illustrate the two criteria used by the staff to further analyze results from the life-cycle model.

$$PPO = \frac{100 - \text{percent reduction}}{100}$$

As indicated in the previous subsection, the life-cycle model runs were based on percent reduction values calculated using a baseline of no plants operating on the river. Runs were done using the conditions described in detail in Sect. V.D.d(3)(c)(iv); the results for the base design and Alternative A are discussed in this section also. The results for Alternative B are discussed in this subsection, and results for the base design and both alternatives are conveniently summarized in Table XI-14.

As mentioned in the preceding subsection, the staff's single best estimate for the convective transport defect factor (CTDF) is 0.8, whereas the staff's best estimate for the intake f-factor is the range 0.5 to 1.0. Consequently, in summarizing the results from the life-cycle model with closed-cycle cooling at Indian Point Unit No. 3, the staff has not considered the results for CTDF = 0.4 in Table XI-11.

Table XI-11. Results of the sensitivity analysis using Parameter Set 1 (see Appendix B, Table B-43) for two values of the intake f-factor (f_I) for the base design, Alternative A, and Alternative B, without and with Cornwall, using the PPO values and durations given in Table V-21

f_I[c]	Alternative at Indian Point			Results[a,b]			
				Without Cornwall		With Cornwall	
	Alternative	IP-2	IP-3	A	B	A	B
0.5	Base design	OT[d]	OT	15	0	41	0
	A	CT[e]	OT	0	4	38	3
	B	CT	CT	0	9	28	7
1.0	Base design	OT	OT	36	0	55	0
	A	CT	OT	33	5	54	4
	B	CT	CT	28	14	53	10

[a]Number of years relative yield is less than 0.50 (Column A) and the increase in cumulative yield at year 80 as a percent of the cumulative yield for the base design (column B).
[b]Convective transport defect factor (CTDF) = 0.8.
[c]f_I = intake f factor.
[d]OT denotes once-through cooling.
[e]CT denotes cooling towers.

With a cooling tower at Unit No. 3 as well as at Unit No. 2 (Alternative B), but without Cornwall, (a) the number of years the relative yield is less than 0.50 ranges from 0 to 28 years, and (b) the increase in cumulative yield at year 80 relative to the base design ranges from 9 to 14%. With Cornwall, (a) the number of years the relative yield is less than 0.50 ranges from 28 to 53 years, and (b) the increase in cumulative yield at year 100 relative to the base design ranges from 7 to 10%. A detailed assessment of the economic benefit to the striped bass fisheries of installing cooling towers at Units Nos. 2 and 3 is given in Section XI.J.2.c.

In discussing the significance of the results of the life-cycle model in Sect. V.D.2.d(3)(c)(iv), the staff considered types of irreversible damage, types of impacts on a population, and the risk of irreversible damage to the Hudson River spawned striped bass population due to entrainment and impingement mortality of young-of-the-year striped bass at Indian Point and the other power plants on the Hudson River. In summary, it must be pointed out that the approach of treating each new plant on the Hudson River as a separate benefit-cost (or risk) exercise contains a bias against preserving the environment. This approach conceivably could result ultimately in the complete destruction of the Hudson River striped bass population. Nevertheless, for each new plant the benefits of cooling towers (or whatever measures were taken) would be calculated to be less than the costs (or risks) because the incremental (fractional) damage to the striped bass population would be less with each additional power plant. But, beyond some point, society is likely to conclude that further deterioration of the striped bass population is intolerable.

Furthermore, the possibility that the additional effect of once-through cooling at Indian Point Unit No. 3 (added to the effects of Indian Point Units Nos. 1 and 2 plus the other power plants on the river) will be the "straw that broke the camel's back" is a risk which cannot be lightly overlooked.

The adult model indicates full recovery of the fishery after cessation of the operation of the plants on the river. However, the model may not be an accurate representation of the dynamics of the striped bass population with respect to large perturbations [see App. B, Sect. B.4.C(7)(c)]. It is possible that if the insult of the power plants exceeds some maximum value for long enough the Hudson River spawned striped bass population will not fully recover. Rather, it may seek some new lower equilibrium value.

It is the staff's position that the number of years the relative yield is forecast to be less than 50% of its original size before the power plant impact is an index of the risk of irreversible damage to the population. This risk and the extent of irreversible damage cannot be more rigorously quantified. Furthermore, there are no generic guidelines as to what risk and extent of irreversible damage is acceptable or unacceptable to society. Such decisions are a matter of judgment. It is the staff's judgment that for the base design and Alternative A (with or without Cornwall), the risk of irreversible damage to the Hudson River spawned striped bass population is of sufficient concern that the long-term operation of Indian Point Unit No. 3 with once-through cooling is unacceptable. It is the staff's judgment that with closed-cycle cooling at Indian Point Unit No. 3 as well as at Unit No. 2 (Alternative B), the risk of irreversible damage to the striped bass population is still of substantial concern. However, the contribution of Unit No. 3 to this undesirable impact would be reduced to a practicable minimum.

(v) Applicant's Study of the Feasibility of Culturing and Stocking Hudson River Striped Bass

As pointed out by the applicant:[37]

"In recent years, the question of the feasibility of rearing striped bass to mitigate losses from power-plant operation has been a major concern in power-plant licensing. In 1970, the Federal Power Commission issued a license to Consolidated Edison Company of New York for construction and operation of a pumped-storage plant on the Hudson River at Cornwall, New York, with the condition that a study of the artificial propagation of striped bass be conducted, including implementation of a pilot hatchery. Primary emphasis involved the need for and feasibility of mitigation, as well as evaluation of the present state-of-the-art concerning artificial striped-bass propagation.

"In response to Article 36 of the Terms and Conditions of the Federal Power Commission license for the Cornwall pumped-storage hydroelectric project, Consolidated Edison Company of New York prepared a plan which included a study of the feasibility of artificial propagation of striped bass and contracted the study to Texas Instruments Incorporated, in April 1973 under Purchase Order 3-06119.

"The following were the major objectives of the study:

- Determine the feasibility of artificially rearing Hudson River striped bass

- Develop an ongoing program of stocking and monitoring to determine survivability of artificially reared striped bass

"Specific goals of the 1973 program were as follows:

(1) Determine whether Hudson River striped bass can be artificially spawned and hatched

(2) Obtain 20,000 cultured striped-bass fingerlings 2 to 5 in. in length from Hudson River stock

(3) Tag and release the fingerlings into the Hudson River

(4) Assess the survivorship of cultured striped bass after stocking in the Hudson River and develop an ongoing program to evaluate survival of fish stocked in 1973 and those to be stocked in the future

(5) Develop and evaluate techniques for striped-bass fingerling production

(6) Review literature on striped-bass culture

"It is important to note that it was not a goal of the 1973 program to achieve maximum efficiency in the over-all hatchery program. For example, distribution of larvae to inexperienced hatcheries for experimental purposes is inconsistent with such a goal. Accordingly, any attempt to use the overall results of the 1973 program to compute an estimated rate of efficiency for a hatchery program is unwarranted."

The accomplishments and results of the 1973 Hudson River striped-bass culturing and stocking feasibility study, according to the major objectives of the program as summarized by the applicant are:[37]

"Objective 1: Determine the Feasibility of Artificially Rearing Hudson River Striped Bass

- Of the 22 female Hudson River brood fish used for propagation at the Verplanck hatchery, 16 yielded viable eggs; however, only from the eggs of 12 fish (54.5%) were larvae successfully hatched.

- The amount of time that female brood fish are held prior to ovulation appears to be a critical factor in successful larvae production; i.e., the longer a fish is held, the lower the percentage of fertile eggs and hatched larvae. Estimated fertilization of all eggs per female ranged from 1% to 99%, with lowest fertilization occurring in females held for more than 50 hr prior to ovulation.

- An estimated 26,700,000 eggs were obtained from 16 females artificially spawned at Verplanck, the number of eggs per female ranging from 400,000 to 4,400,000. Of the total number of eggs produced, 10,640,000 (39.8%) hatched and produced larvae.

- Of the 4,800,000 larvae sent to Oklahoma for rearing to fingerling size, 1,950,626 (40.6%) survived shipping and holding and were stocked in earthen ponds; approximately 4 weeks later, 184,328 fingerlings, or 9.5% of those stocked, were harvested.

- Of the 40,232 fingerlings designated for stocking in the Hudson River but returned to ponds at the Durant, Oklahoma, hatchery to attain additional growth and await optimum stocking temperatures in the Hudson River, 10,730 fingerlings (40.6%) were eventually recovered.

- Of the 1,940,000 larvae held at Verplanck for intensive culture studies, 427, or 0.02%, were released into the Hudson River in the fall as 3- to 4-in. fingerlings; these fish were not included in the mark/recapture survival study. The lack of salinity or chlorides in the quarry water used for culturing purposes may have affected mortality, since fry transferred to water containing 2.0% salinity had a significantly lower mortality rate. Cannibalism was a definite cause of mortality among fry from 15 mm and larger.

- Of the 200,000 larvae shipped to Auburn University for intensive culture testing, 46 fingerlings (0.02%) were produced. Compiled from the Auburn University and Verplanck rearing experiments was a list of essential criteria for successful striped-bass intensive culture.

"Objective 2: Develop an Ongoing Program of Stocking and Monitoring To Determine Survivability of Artificially Reared Striped-Bass

- The 2-week survivorship tests on marked and unmarked hatchery-reared fingerlings resulted in higher survival (97%) for fish held in brackish river water than for those held in fresh quarry water (58%), thus suggesting a physiological requirement for salinity. No significant difference in mortalities between fin-clipped or tagged fish and unmarked control fish was found.

- A total of 28,674 striped-bass fingerlings, including 9,345 reared by the Oklahoma Department of Wildlife Conservation and 19,329 reared by Marine Protein Corporation of Florida, were stocked in the Hudson River between river miles (RM) 26 and 62 during the fall of 1973; all fish were marked with magnetic nose tags and fin-clipped as part of a mark/recapture program to assess survival.

- Recaptured as of 1 January 1974 were 46 hatchery fingerlings. Preliminary analysis of mark/recapture data indicated that the survival of hatchery-reared fingerlings stocked in the Hudson River was approximately the same or greater than the survival of wild fingerlings. Also, hatchery fingerlings were less susceptible to capture than were wild fingerlings, probably because they were larger than the wild fingerlings at the time of stocking.

- Appraisal of the results of the 1973 propagation and stocking program, although preliminary, indicates that Hudson River striped bass can be successfully cultured and stocked."

In 1974, Texas Instruments collected and spawned 30 female striped bass from the Hudson[37] to produce 30.1×10^6 eggs resulting in 15.5×10^6 fry for a 53% hatchability. Approximately 4×10^6 fry were sent to each of four Federal Hatcheries (Durant, Oklahoma; Edenton, North Carolina: Medicine Park, Oklahoma; and Welaka, Florida), from each of which they anticipate receiving 90,000 fingerlings as follows: 30,000 harvested in July, fin-clipped and stocked; 60,000 harvested in the fall, fin-clipped plus nose tag and stocked.

Several additional factors, which the applicant has not yet adequately evaluated, must be resolved in assessing the overall feasibility of stocking striped bass as a means of maintaining the Hudson River striped bass population:

(1) Size of the spawning population in the Hudson River (e.g., 2×10^3 or 2×10^5 spawners) and the fraction of this stock required for the hatchery operation.

(2) Number of fingerling striped bass in the Hudson River Estuary in the fall and/or the number of yearling striped bass in the spring required to maintain the Hudson River striped bass population at a yet-to-be-determined level (e.g., 1×10^6 or 30×10^6 fingerlings).

(3) Criteria to be used to monitor the performance of the stocking program. These criteria must involve evaluating the relative survival and success of the hatchery fish as compared to the wild fish at various points throughout the life cycle such as:

   (a) during the weeks immediately following stocking in the fall;

   (b) the following spring as yearlings;

   (c) at age 3–4 years when they are recruited to the fishery;

   (d) at age 5–7 years for the females and at age 3–4 years for the males when they are recruited to the reproductive stock.

The applicant had difficulty in the fall of 1973 evaluating item (a) because, at the time of stocking, the hatchery fish were appreciably larger than the wild fish (3.9 to 5.6 in. versus 3.3 in.) possibly resulting in different catchabilities (i.e., larger fingerlings better able to avoid the seines and trawls) and different distributions (i.e., larger fingerlings in deeper water).

The applicant is investing $280,000 in this aspect of their research program (i.e., artificial propagation of striped bass) for 1974 and is planning to invest $350,000 for 1975. The cost per fingerling harvested at the rearing facilities has been approximately $2.00, but undoubtedly it would be lower for a nonresearch program of larger scale. The total cost of stocking sufficient fingerlings to maintain the Hudson River striped bass population cannot be estimated on the basis of presently available information.

The program for evaluating the hatchery and stocking operations for salmon in the Northwest should provide valuable guidelines.[38,39]

The applicant has no plans to replace fish of other species killed by power plant operation, and, with the exception of shad, no mass culture techniques are presently available for these other species, such as white perch and tomcod.

The staff's position is that the burden of proof is on the applicant to demonstrate that the stocking of artificially reared striped bass fingerlings is a feasible method of maintaining the Hudson River striped bass population. To demonstrate such will require that this aspect of the research program be continued past 1975.

Thus, although the applicant's fish hatchery and replacement proposal might be a means to mitigate the damage done to the striped bass fishery during interim Plant operation, the staff concludes that the hatchery proposal cannot presently be accepted as a feasible method of replacing all of the striped bass and other fish the staff expects the Plant will kill during operation with once-through cooling over the lifetime of the three Units.

(vi) Summary and Conclusions of Biological Impacts

Environmental costs for the aquatic biota for the base design and the alternatives are compared in Table XI-14. See Section V.D.2.g for a summary and conclusion of the biological damage associated with the base design.

The following effects on aquatic biota resulting from operation of Indian Point Units Nos. 1 and 3 with once-through cooling and Unit No. 2 with a cooling tower (Alternative A) have been identified in the preceding sections and in Sections V.D.2.d(3)(c)(iii) and V.D.2.d(3)(c)(iv): (1) an estimated annual loss from impingement on the intake screens of 1.6 million fish; (2) the possibility of detrimental effects in the vicinity of Indian Point from waste heat, reduced dissolved-oxygen levels, and chlorine discharges; (3) an estimated reduction in the number of striped bass young-of-the-year surviving to October 15 of each year of 30 to 46%; (4) an estimated number of years the relative yield is less than 0.50 of 0 to 33 years; (5) an estimated increase in cumulative yield at year 80 as a percent of the cumulative yield for the base design of 4 to 5%; (6) the possibility that similar effects would decrease the populations of other fish species.

The following effects on aquatic biota resulting from operation of Indian Point Unit No. 1 with once-through cooling and Units Nos. 2 and 3 with a cooling tower (Alternatives B and C) have been identified in the preceding sections: (1) an estimated annual loss from impingement on the intake screens of 0.6 million fish; (2) the possibility of detrimental effects in the vicinity of Indian Point from waste heat, reduced dissolved-oxygen levels, and chlorine discharges; (3) an estimated reduction in the number of striped bass young-of-the-year surviving to October 15 of each year in the range of 23 to 37%; (4) an estimated number of years the relative yield is less than 0.50 in the range of 0 to 28 years; (5) an estimated increase in cumulative yield at year 80 as a percent of the cumulative yield for the base design of 9 to 14%; (6) the possibility that similar effects would decrease the populations of other fish species.

In reaching a final judgement concerning the biological damage resulting from the operation of Indian Point Unit No. 3 with once-through cooling (base design and Alternative A) and with closed-cycle cooling (Alternative B), the staff has relied heavily, although not exclusively, on its assessment of the potential impact on the Hudson River spawned striped bass population.

In summary, it must be pointed out that the approach of treating each new plant on the Hudson River as a separate benefit-cost (or risk) exercise contains a bias against preserving the environment. This approach conceivably could result ultimately in the complete destruction of the Hudson River striped bass population. Nevertheless, for each new plant the benefits of cooling towers (or whatever measures were taken) would be calculated to be less than the costs (or risks) because the incremental (fractional) damage to the striped bass population would be less with each additional power plant. But, beyond some point, society is likely to conclude that further deterioration of the striped bass population is intolerable.

Furthermore, the possibility that the additional effect of once-through cooling at Indian Point Unit No. 3 (added to the effects of Indian Point Units Nos. 1 and 2 plus the other power plants on the river) will be the "straw that broke the camel's back" is a risk which cannot be lightly overlooked. The adult model indicates full recovery of the fishery after cessation of the operation of the plants on the river. However, the model may not be an accurate representation of the dynamics of the striped bass population with respect to large perturbations [see App. B, Sect. B.4.c(7)(c)]. It is possible that if the insult of the power plants exceeds some maximum value for long enough the Hudson River spawned striped bass population will not fully recover. Rather it may seek some new lower equilibrium value.

It is the staff's position that the number of years the relative yield is forecast to be less than 50% of its original size before the power plant impact is an index of the risk of irreversible damage to the population. This risk and the extent of irreversible damage cannot be more rigorously quantified. Furthermore, there are no generic guidelines as to what risk and extent of irreversible damage is acceptable or unacceptable to society. Such decisions are a matter of judgment. It is the staff's judgment that for the base design and Alternative A (with or without Cornwall), the risk of irreversible damage to the Hudson River spawned striped bass population is of sufficient concern that the long-term operation of Indian Point Unit No. 3 with once-through cooling is unacceptable. It is the staff's judgment that with closed-cycle cooling at Indian Point Unit No. 3, as well as at Unit No. 2 (Alternative B), the risk of irreversible damage to the striped bass population is still of substantial concern. However, the contribution of Unit No. 3 to this undesirable impact would be reduced to a practicable minimum. During operation of Unit No. 3 with once-through cooling for any limited period of time, the staff analysis indicates that sizeable undesirable ecological damage of aquatic biota will result. Therefore, as outlined in the ecological monitoring program in the Environmental Technical Specifications, the applicant must develop and implement a plan of action including changes in operating procedures, design modifications of the intake system, and other fish protection methods to mitigate damage as discussed in Section XI.E that can aid in considerably reducing impacts prior to operation with a closed-cycle cooling system.

(5) Radiological Impact on Man

The radiological impacts described in Section V.E.2 were based on the conservative assumption that only the water flow of about 100,000 gpm was available for dilution in the discharge canal. Thus, the impacts described in Section V.E.1 are applicable to the three alternatives. The modified radioactive waste treatment system as described in Section V.E.1 will reduce the total liquid effluent from about 22 Ci/year to less than 5 Ci/year for each Unit. Thus, the radiological impacts on man will be reduced considerably through the control of liquid effluent releases. The radiological impact on a two-year-old child via the pasture-cow-milk pathway will be reduced 12.7 millirems/year to 7.9 millirems/year upon treatment of steam generator blowdown at the SBBPS at Unit No. 1. Although Alternative C will result in a fivefold decrease in water flow for dilution purposes, the radiological impact on man from the liquid radioactive effluents during operation with cooling towers should not change considerably since the impact will result from the total radioactivity released.

4. Summary of Staff's Evaluation of Alternative Heat Dissipation Systems

The staff concludes that of the possible alternatives to once-through cooling for condenser heat dissipation, wet natural-draft cooling towers appears to have the least amount of environmental impact. Dry towers were rejected on the basis of their resulting in higher condenser temperatures and concomitant electrical deratings, which in turn result in increased fuel consumption and associated environmental impacts. Land area requirements, in the case of a cooling pond, and potential for salt spray damage, along with fogging and icing from the operation of spray modules, resulted in the elimination of a pond or a spray canal from consideration as a viable alternative. Wet mechanical-draft towers are considered less desirable in view of their high potential for damage to vegetation due to deposition of drift salts, increased formation of ground-level fog, and high operating noise levels. Wet/dry cooling towers could be feasible, but only a very limited experience in their operation is available for cells of much smaller size than would be required for the Indian Point Plants.

Based upon criteria of minimal noise, fogging, and drift damage, wet natural-draft closed cycle cooling towers appear to be the preferred alternative to once-through cooling; however, adverse aesthetic impact of the height of natural-draft cooling towers also has to be considered. The Mayor of Buchanan[42] has expressed his concern about the height of such towers in terms of local zoning restrictions.

The applicant reported the breakdown of the cost estimates for the three cooling system alternatives in Table 17-3 of the Environmental Report. The total costs (with contingency and escalation) were $58.66 million for natural-draft cooling towers, $64.31 million for mechanical-draft cooling towers, and $75.06 million for spray ponds for a 1976 in-service date. Subsequently, the applicant conducted a conceptual design study to optimize the location for a single hyperbolic natural-draft cooling tower for Unit No. 2 with respect to engineering practicality and economic justification.[41] This single tower was 452 ft in diameter, 564 ft high with a total estimated cost of $70.6 million for an in-service date of January 1978. See Section 4 in Appendix G for additional information on this subject.

5. Recommended Environmental Monitoring for Cooling Tower Alternative

The applicant will be required to operate the three Units with appropriate Environmental Technical Specifications suitable for any cooling system used. Thus, a different set of specifications will have to be developed suitable for operation of an alternate closed-cycle cooling system compared with those for once-through cooling.

From the anlysis of alternative cooling systems, the staff believes that additional information of impacts of such systems should be obtained. As predictions of minimal vegetation damage were based upon calculated drift deposition rates, which have not been verified, the staff requires that upon completion of the construction of the cooling towers the applicant should establish a series of permanent plots at strategic locations (adjacent to towers, within predicted maximum deposition zones, outside areas of tower influence, etc.) within wooded areas surrounding the site. Soils and vegetation within these plots must be sampled and analyzed for leaf burn, discoloration, and tissue content of Na^+ and Cl^- at monthly intervals during the first year's operation, and thereafter at intervals corresponding with major phenological events. In the event that major vegetation damage is observed (e.g., extensive defoliation, dieback of trees and ornamentals on adjacent properties, decline of screening vegetation, etc.), it is recommended that appropriate steps be taken to minimize drift losses and subsequent salt deposition. However, proper engineering design of the cooling towers will assure drift elimination to reduce salt drift effects.

The applicant's current meteorological program is limited to monitoring wind speed and direction and vertical temperature gradients (dry bulb) (ER, IP-3, Section 4.4). This program is being modified to include continuous monitoring of dew point, air temperatures, and wind speeds at stations located along a 400-ft high meteorological tower (ER, IP-3, App. FF, p. II-26). The staff recommends that this revised monitoring scheme be implemented as early as possible and that measurements continue for one to two years after all units begin full-term operation with cooling towers. Such data will form a basis for evaluating potential climatic modifications resulting from Plant operation.

Further, the staff is of the opinion that avian collisions with large hyperbolic towers will not constitute a problem. Nonetheless, the applicant should monitor areas adjacent to these towers during periods of peak waterfowl migration for a period of several years after operation is begun, and, if warranted, installation of warning devices and netting may be appropriate.

D. ALTERNATIVE BIOCIDE SYSTEMS

The design of the once-through cooling of the Indian Point Units permits the release of residual chlorine to the effluent stream. The source of this release is the periodic biocide treatment of the circulating water system to control organic growth on condenser surfaces.

An alternative to biocide treatment is the use of a mechanical condenser-tube-cleaning system. "On-line" cleaning systems, such as the AMERTAP and MAN systems, have been successfully used at other power plants. While use of such systems would not entirely eliminate the need for biocide treatment in the Plant, the amount and duration of such treatment could be considerably reduced.

E. ALTERNATIVE FISH PROTECTION MEASURES

The alternative fish protection measures under consideration by the applicant (air bubble curtain, common intake structure, fish flume, horizontal traveling screens straight-line in the river, vertical traveling screens VV-shape with bypass in the river, relocation of vertical traveling screens at the front of the forebays at Units Nos. 1 and 2, and a vertical traveling fish basket) were discussed by the applicant (ER, IP-3, Section 17.2). At Unit No. 3, the channel walls of the intake do not extend beyond the traveling screens at the edge of the river, allowing lateral movement of fish and small crustaceans, thus reducing the possibility of their being impinged on the traveling screen. In addition, this modification will allow longitudinal washing of the face of the traveling screen by the river current. To evaluate the fish protection feature of this modification, the flow path from one circulating water pump to the condensers has been temporarily rerouted to the discharge canal. However, no results are available to the staff as to its effectiveness.

Another method being used at Unit No. 3 will be the incorporation of a recirculation loop which will allow operation at 100 and 60% of full flow to reduce the magnitude of the approach velocity in front of the traveling screens to approximately 0.5 fps. During operation at 60% flow, the ΔT across the condensers at Unit No. 3 will increase to 28 F°. Operation under such circumstances shall be carried out in the winter time (ER, IP-3, p. 9-6).

The applicant has also studied a modification to the intake structures at the Indian Point Plant that would reduce the velocity of the water at the intake screens and thereby mitigate the problem of fish impingement. The new arrangement would consist of a new and much larger intake screen structure, located just upstream of the Unit No. 2 intake screens, which would supply water to a common intake channel, or lagoon, which would feed cooling water to the existing intake structures for Units Nos. 1, 2, and 3. The new screened intake channel would be constructed by placing sheet piling 50 to 100 ft offshore from the existing river front structures (ER, IP-3, App. S, pp. 32-34).

The openings in the new common intake structure would be large enough to provide screen areas sufficient to permit face velocities of 0.5 fps in the summer and 0.3 fps in the winter. By being located nearer to the main longitudinal flow in the river, stronger river currents would sweep the face of the screens. The new arrangement would deny fish access to the unloading wharf (which may have been an attraction). In addition, the new intake channel would reduce the tendency for recirculation of discharged cooling water back into the intakes and would also alleviate the eddying conditions that have led to accumulation of river ice and debris at the individual intakes (ER, IP-3, Section 17.2, and App. S, pp. 33-34). The estimated cost of the new intake is $12 to $15 million. The staff agrees with the applicant that these are all worthwhile objectives.

As directed by the New York State Department of Environmental Conservation (NYSDEC) (ER, IP-3, App. FF, pp. 4-6), the applicant has completed hydraulic model studies of the new screened intake channel[43] (November 1972). If it is determined by the Commissioner of the NYSDEC that the screened intake channel would provide a significantly higher level of protection for fish than the air bubble curtains now being tested at Units Nos. 1 and 2, the applicant will be required to construct the new common intake facility as a condition for the State vacating its order to cease operation of the cooling water circulators for Indian Point Unit No. 2 (ER, IP-3, App. FF, pp. 4-6). The applicant estimates the total cost of the project to be about $18,000,000 (ER, IP-3, pp. 8-9).

Aside from some success with the air bubble curtain and operation at reduced flow, neither the effectiveness nor the practicability for Indian Point has been demonstrated for the protection measures proposed. In addition, even if proven, they would only be effective in reducing impingement, with little or no effect on entrainment. Furthermore, the estimated cost of the more elaborate protection measures would approach 42% or more of the $35,795,500 total direct cost estimated by the applicant[41] for installation of a natural-draft cooling tower for Unit No. 2. This recirculating cooling system would not only reduce impingement but also entrainment.

F. TRANSMISSION FACILITIES

All of the 2,100-ft right-of-way for the transmission facilities connecting Unit No. 3 to the Buchanan Substation is on the applicant's property (except for one public road), and the Hudson River Valley Commission and the Village of Buchanan have given their approval of the alignment, structure type, and design. Therefore, the staff concludes that the aesthetic benefits to be gained by the alternative of installing these and other existing overhead lines underground could not justify the higher capital costs for such an installation.

G. TRANSPORTATION

Alternatives such as special routing of shipments, providing escorts in separate vehicles, adding shielding to the containers, and constructing a fuel recovery and fabrication plant on the site, rather than shipping fuel to and from the Plant, have been examined by the staff for the general case. The impact on the environment of transportation under normal or postulated accident conditions is not considered to be sufficient to justify the additional effort required to implement any of these alternatives.

H. BENEFIT DESCRIPTION OF THE PROPOSED FACILITY

Both short-term and long-term benefits have been considered, as discussed below, and tabulated in Table XI-12.

1. Expected Average Annual Generation

The applicant has tabulated the results of its computations for capacity factor and average generation for the initial five years of operation (ER, IP-3, Section 22, p. B.1.1-1). An initial capability of 965 MW and the refueling schedule were used as the bases for the computations. Variations in capacity factor and energy production for the first three years were attributed to the varying periods between refueling until it is established on an annual basis to occur during the six-week scheduled maintenance period. Capacity unavailability was estimated to be a 15% annual forced outage rate with an additional 4% per year for miscellaneous partial deratings or limitations. The staff concurs that the outage rate is conservative, as the New York Power Pool's estimated upper range of forced outage rates, for a nuclear power plant in the capacity range of Unit No. 3, is 18% immature and 10% mature.[44]

Table XI-12. Benefits from the proposed facility

Direct benefits	
Expected average annual generation, kWhr	6,258 X 10^6
Capacity, kW	1.033 X 10^6
Proportional distribution of electrical energy expected (annual delivery), kWhr	
Industrial and commercial	3,630 X 10^6
Residential	1,752 X 10^6
Other (railroad and government)	876 X 10^6
Expected average annual Btu of steam sold from the facility	None
Expected average annual delivery of other beneficial products	None
Revenues from delivered benefits during 30-year life of plant	
Electrical energy generated (reported as kilowatt-hours)	187,740 X 10^6
Steam sold	None
Other products	None
Indirect benefits	
Taxes (real estate) per year	\$6,980,000
Research (5 years)	\$10,000,000
Regional product (would provide electrical energy requirements for)	\$8.8 billion
Environmental enhancement	
Recreation, acres	80
Navigation	0
Air quality (avoided with Unit No. 3 in service), tons/year	
SO_2	9,707
NO_X	11,811
Particulates	486
Employment	41
Education (visitors per year)	100,000

The staff agrees with the applicant's computational approach but does not agree with the inconsistencies between the data used and the data appearing elsewhere in the Environmental Report and its supplements. The proposed date of commercial operation is stated as November 1974 in the text and in the new-capacity addition table. However, the applicant used June 1974 in the computations for cost-benefit analysis. In addition, the initial capability of Unit No. 3 of 965 MW was used throughout, although the ten-year summer program plan calls for initial operation at 873 MW, followed by uprating to 965 MW in the spring of 1978, to 1,000 MW in the spring of 1979, and finally to 1,033 MW in the spring of 1980, at which capability it will operate for the remaining 24.5 years of the 30-year economic service life. Using these data, the staff calculated the average annual generation over the economic service life to be 6,258 x 10^6 kWhr. Expressed in terms of annual capacity factor, this is 69.2%, which is equivalent to 6,058 hr at 1,033 MW or to an outage rate of 19.3% in addition to the annual six-week maintenance period.

2. Proportional Distribution of Electrical Energy Expected

The staff's projection for consumption of electricity by user classification for 1980 is shown in Table X-6. Using this distribution, the annual delivery would be:

Commercial and industrial	$6,258 \times 10^6$ kWhr x 0.58 = $3,630 \times 10^6$ kWhr
Residential	$6,258 \times 10^6$ kWhr x 0.28 = $1,752 \times 10^6$ kWhr
Other (railroad and government)	$6,258 \times 10^6$ kWhr x 0.14 = 876×10^6 kWhr

3. Beneficial Products Sold from the Facility

The applicant does not plan to sell steam or other beneficial products from the facility. The turbine exhaust steam is not at a temperature or pressure suitable for commercial or domestic use, and there are no potential customers for such a large amount of waste heat.

4. Revenues from Delivered Benefits

The staff elected to report the total electric power produced over the 30-year life of Unit No. 3 because of the uncertainties in attempting to determine levelized annual revenues for that period.

5. Taxes

The applicant has estimated that annual real estate taxes will be about $6,980,000, based on current rates applied to the projected capital cost of Unit No. 3 (ER, IP-3, p. B.1.3-1).

6. Research

A total of approximately $10 million is being spent by the applicant on a five-year research program at Indian Point, directed primarily toward fish populations in the Hudson River. The program started in April 1972 and will be completed by the start of January 1977.

7. Regional Product

The U.S. Bureau of the Census reported the 1970 median income per family in the New York Standard Consolidated Area as being $11,169.[45] Using the 2.8% annual growth predicted by the Regional Plan Association,[46] the 1980 projection would be $14,721 per family (assumed equivalent to household). Information developed for use in assessing estimated summer peak loads indicated that the total number of households in the applicant's service area in 1980 would be 3,044,000, resulting in a total payroll of $44.8 billion for which the electrical energy requirements will be supplied through the applicant's system.

Indian Point Unit No. 3 will represent 11.6% of the applicant's projected annual energy requirements in 1980, and 72% of the average annual generation is expected to be consumed in commercial, industrial, and other classifications providing the bulk of employment. Therefore, the approximate portion of the service area gross income to which Unit No. 3 would supply electrical energy would be:

$$\$44.8 \text{ billion} \times 0.116 \times 0.72 = \$3.7 \text{ billion}.$$

The amount spent for goods and services is assumed to be 79% of the gross income. Upon applying an income multiplier of three, Unit No. 3, therefore, would contribute electrical energy in support of $8.8 billion of regional product during 1980.

8. Environmental Enhancement

a. Recreation

The applicant has a master plan to improve the appearance and usefulness of the site through development of recreational facilities for public use, including an 80-acre woodland park with a freshwater lake, gardens, nature trails, picnic tables, and parking facilities. The applicant has also transferred 14 acres at the northwest corner of the site to the Village of Buchanan, to be developed by the village as a public marina. Some of the area has already been converted to a ballfield. Development plans are still indefinite, but there is no doubt that the public marina, when completed, will enhance water-related activities of the area.

b. Navigation

No improvements to navigation on the Hudson River were planned in conjunction with the construction and operation of Unit No. 3.

c. Air Quality

The applicant projected the dispatch of power from its generating plants for the first full year of operation of Unit No. 3, with and without that Unit in service, and the emissions of pollutants were computed accordingly. The analysis was based on fossil-fueled units burning 0.3%-sulfur residual oil or gas when available, except that gas turbines would burn a mixture of 0.05%-sulfur kerosene and 0.2%-sulfur No. 2 oil. The atmospheric emissions avoided if Unit No. 3 is in service are 9,707 tons/year of SO_2, 11,811 tons/year of NO_x, and 486 tons/year of particulates (ER, IP-3, Section 22, p. B.1.3-1), which would otherwise be emitted inside the New York City limits.

The degree of environmental effects of atmospheric emissions from fossil-fueled electric generating plants is dependent upon a number of variable factors which preclude quantification. Table XI-13 indicates, however, that any reduction in atmospheric emissions inside New York City will definitely benefit the populace by improving the air quality.

Table XI-13. Effects of atmospheric emissions

Source: New York State Department of Public Service, *A Study of Electric Space Conditioning in New York State*, 1972, App. VIII.

	Particulate matter
Health	Temporary or permanent damage to the surfaces of the respiratory system. Transfer of particles from the respiratory tract to the lymph, blood, or gastrointestinal tract may exert effects elsewhere. Transient eye irritation from large dust particles
Climate near the ground	Particles absorb sunlight, reduce the amount of solar energy reaching the earth, produce hazes, reduce visibility, and play a significant role in bringing about precipitation
Materials	May chemically attack materials through its own intrinsic corrosivity or through the corrosivity of substances absorbed in or on it. Soiling action accelerates deterioration by requiring more frequent cleaning
	Sulfur dioxide (SO_2)
Health	Irritation to the respiratory system leading to temporary or permanent injury. A threefold to fourfold potentiation of the irritant response to sulfur dioxide is observed in the presence of particulate matter capable of oxidizing sulfur dioxide to sulfuric acid
Materials	Same as for particulate matter above. In addition, contributes to the damage of electrical equipment of all kinds. Attacks a wide variety of building materials, as well as statuary and other works of art, causing discoloration and deterioration. Certain textile fibers, such as cotton, rayon, and nylon, are harmed by atmospheric sulfur oxides
Vegetation	Acute leaf injury produced by high concentrations for relatively short periods. Chronic plant injury caused by gradual accumulation of excessive amounts of sulfate in leaf tissue which may result in leaf drop
	Oxides of nitrogen (NO_X)
Health	NO_2 has toxicological effects on the lungs. The oxidation process converting NO to NO_2 results in the net dissipation of existing ozone, a relatively rare gas which absorbs harmful ultraviolet rays
Materials	Significant effects of NO_X have been observed on textile dyes and additives, natural and synthetic textile fibers, and metals
Vegetation	The degree of injury to vegetation from NO_X is uncertain at this time

9. Employment

Unit No. 3 will require an operating staff of 41 permanent employees, creating an economic impact on the local community through an annual payroll of $700,000 (ER, IP-3, App. FF, pp. VIII-1 and VIII-2). This benefit may be partially offset by loss of employment resulting from retirement of older plants within the system.

On the same bases used to estimate the regional product in item 7 above, 72% of the electrical energy produced by Unit No. 3 in 1980 would be used to supply the energy requirements of about 395,000 employed people out of the total 1980 employment of 4,721,500 projected for the service area.

10. Education

Educational benefits will be provided by the new visitors' center to be constructed on the site. The new center will be considerably larger than the previously existing facility and will include more sophisticated exhibits focused on the peaceful uses of nuclear energy.

I. COST DESCRIPTION OF THE PROPOSED FACILITY

1. Generating Costs

The staff's method of computing generating costs is to include the capital cost of Unit No. 3 and the present worth of the annual costs of operation and maintenance, fuel consumption, and nuclear insurance, but not taxes.

The staff's current policy is to use a discount rate of 10% for environmental statements for investor-owned utilities, based on an average rate of return of new investments. About 65% of such investments consist of bonds and preferred stock with a rate of return taken as 9.5% per year. The other 35% of the investments consist of common equity (common stock and retained earnings) with a rate of return taken as 11% per year. The weighted average is then (0.65 x 9.5%) + (0.35 x 11%), or 10% per year. These figures vary from time to time and from utility to utility but are believed to provide a reasonable basis for calculations of present worth.

The staff used a 30-year operating period in calculating the present worth of annual costs, which is in accordance with the AEC benefit-cost guidelines issued in May 1972.

The monetized bases for generating costs are as follows:

C_I = Total outlay required to bring facility to operation

O_t = Annual operating cost including nuclear insurance

F_t = Annual fuel cost of Plant

P_t = Cost of makeup power purchased or supplied in year t

I_t = Annual fish impingement cost

V = Discount factor

i = Discount rate (10%)

GC_p = Total generating cost — present value

$$GC_p = C_I + \sum_{t=1}^{30} V^t(O_t + F_t) + \sum_{t=1}^{30} P_t V^t + \sum_{t=1}^{30} I_t V^t$$

GC_a = Total generating cost — present value annualized

$$GC_a = GC_p \times \frac{i(1 + i)^{30}}{[(1 + i)^{30} - 1]}$$

a. <u>Base Design for Indian Point Unit No. 3 (Plant as is)</u>

C_I = \$417,813,000 (November 1975)

O_t = 3,400,000 (levelized over 30-year life)

F_t = 13,682,000 (levelized over 30-year life)

P_t for periods when State thermal standards are exceeded with once-through cooling

Assumptions:

1. New York State thermal standards will be exceeded for 30 consecutive days in 60% of the years during the economic book life of the plant, or once every two years.

2. The applicant will have to operate Indian Point Unit No. 3 at 50% power level for 30 days for each occurrence.

3. The first violation of New York State's thermal standards will occur in 1976 and every second year thereafter up to and including the year 2004.

4. Planned rated capacities for Indian Point Unit No. 3 will be 873 MW in 1975, 965 MW beginning in 1978, 1,000 MW beginning in 1979, and 1,033 MW beginning in the spring of 1980.

5. Violations of the New York State thermal standards will occur in late summer after the striped bass spawning period has ended.

6. The cost of makeup power in 1975 dollars will be $0.0124/Whr.

P_t (1975 dollars)

1976: $\frac{436{,}500 \text{ kW} \times 720 \text{ hr} \times \$0.0124/\text{kWhr}}{(1.10)} = \$3{,}543{,}000$

1978: $\frac{482{,}500 \text{ kW} \times 720 \text{ hr} \times \$0.0124/\text{kWhr}}{(1.10)^3} = \$3{,}236{,}000$

1980: $\frac{516{,}500 \text{ kW} \times 720 \text{ hr} \times \$0.0124/\text{kWhr}}{(1.10)^5} = \$2{,}675{,}000$

1982: $\frac{516{,}500 \text{ kW} \times 720 \text{ hr} \times \$0.0124/\text{kWhr}}{(1.10)^7} = \$2{,}211{,}000$

1984: $\frac{516{,}500 \text{ kW} \times 720 \text{ hr} \times \$0.0124/\text{kWhr}}{(1.10)^9} = \$1{,}827{,}000$

1986: $\frac{516{,}500 \text{ kW} \times 720 \text{ hr} \times \$0.0124/\text{kWhr}}{(1.10)^{11}} = \$1{,}510{,}000$

1988: $\frac{516{,}500 \text{ kW} \times 720 \text{ hr} \times \$0.0124/\text{kWhr}}{(1.10)^{13}} = \$1{,}248{,}000$

1990: $\frac{516{,}500 \text{ kW} \times 720 \text{ hr} \times \$0.0124/\text{kWhr}}{(1.10)^{15}} = \$1{,}031{,}000$

1992: $\frac{516{,}500 \text{ kW} \times 720 \text{ hr} \times \$0.0124/\text{kWhr}}{(1.10)^{17}} = \$852{,}000$

1994: $\frac{516{,}500 \text{ kW} \times 720 \text{ hr} \times \$0.0124/\text{kWhr}}{(1.10)^{19}}$ = \$704,000

1996: $\frac{516{,}500 \text{ kW} \times 720 \text{ hr} \times \$0.0124/\text{kWhr}}{(1.10)^{21}}$ = \$582,000

1998: $\frac{516{,}500 \text{ kW} \times 720 \text{ hr} \times \$0.0124/\text{kWhr}}{(1.10)^{23}}$ = \$481,000

2000: $\frac{516{,}500 \text{ kW} \times 720 \text{ hr} \times \$0.0124/\text{kWhr}}{(1.10)^{25}}$ = \$398,000

2002: $\frac{516{,}500 \text{ kW} \times 720 \text{ hr} \times \$0.0124/\text{kWhr}}{(1.10)^{27}}$ = \$329,000

2004: $\frac{516{,}500 \text{ kW} \times 720 \text{ hr} \times \$0.0124/\text{kWhr}}{(1.10)^{29}}$ = \$272,000

Total \$20,899,000

I_t annual fish impingement mortality cost based on data furnished by the applicant (ER, IP-3, App. BB) and the staff (see Sect. V.D.2.a)

Average annual impingement costs

Base design

Species	Number of fish	Unit cost* (dollars)	Average annual cost (dollars)
White perch	1,845,298	0.15	276,795
Striped bass	80,911	0.75	60,683
Herrings	334,085	0.10	33,409
Bay anchovy	57,421	0.03	1,723
		Total	372,610

*Unit costs shown are for 3-in. fish as listed in the "1970 Monetary Values of Fish," prepared by The Pollution Committee, Southern Division, American Fisheries Society.

Alternative A

Species	Number of fish	Unit cost* (dollars)	Average annual cost (dollars)
White perch	1,117,060	0.15	167,559
Striped bass	48,980	0.75	36,735
Herrings	202,240	0.10	20,224
Bay anchovy	34,760	0.03	1,043
		Total	225,561

Alternatives B or C

Species	Number of fish	Unit cost* (dollars)	Average annual cost (dollars)
White perch	388,850	0.15	58,328
Striped bass	17,050	0.75	12,788
Herrings	70,400	0.10	7,040
Bay anchovy	12,100	0.03	363
		Total	78,519

Decrease in annual costs by installing cooling towers

Alternative A: $147,049
Alternatives B or C: $294,091

The value shown above for the total capital cost of the base design is based on the actual investment as of June 30, 1974, plus the applicant's estimated cost to complete Unit No. 3.[47] The applicant, however, incorrectly used the remaining capital expenditures as of August 1972 instead of the total capital outlay as of the date of commercial operation (ER, IP-3, Section 22, p. B.2.1-1). Computation of the annual fuel and operation and maintenance costs were based on its calculated annual energy outputs, thereby carrying forward the computational errors described in Sect. XI.H.1. The staff calculated the levelized costs shown above by determining the unit costs per kilowatt-hour from the applicant's figures, incorporating escalation where noted, and applying them to the

*Unit costs shown are for 3-in. fish as listed in the "1970 Monetary Values of Fish," prepared by The Pollution Committee, Southern Division, American Fisheries Society.

generation plan developed by the staff based on the applicant's ten-year plan.

$$GC_p = \$417{,}813{,}000 + 9.42691\ (\$3{,}400{,}000 + \$13{,}682{,}000 + \$372{,}610) + \$20{,}899{,}000$$

$$GC_p = \$603{,}255{,}000 \text{ (November 1975)}$$

$$GC_a = \$603{,}255{,}000 \times \frac{0.10(1.10)^{30}}{[(1.10)^{30} - 1]} = \$63{,}993{,}000$$

b. Alternative Cooling Systems

In order to properly assess the environmental impacts of Unit No. 3 in combination with Units Nos. 1 and 2, the staff has considered the base design (all three Units with once-through condenser cooling) and three alternatives involving cooling towers (Section XI.C.3.c above).

These alternatives assume that Unit No. 1 will remain as designed with once-through condenser cooling and that Units Nos. 2 and 3 will be backfitted with either natural-draft or mechanical-draft cooling towers. Only natural-draft and mechanical-draft cooling towers are considered in this cost analysis for Unit No. 3. A tentative schedule for the construction of a single cooling tower at Unit No. 3 is given in Appendix G. This tentative schedule shows that excavation could begin on June 1, 1977, and the outage of Unit No. 3 for cutover to the closed-cycle system could begin on September 15, 1980, resulting in cessation of once-through cooling on that date. It is assumed that, by utilizing the interim scheduled maintenance periods, as much installation as practicable can be accomplished so as to reduce the work required for cutover to the point where it can be completed within the final scheduled maintenance period plus five months. Therefore Unit No. 3 could resume operation on April 15, 1981. The cost of makeup power for the additional five months' downtime is included in the cost analysis. Capital costs used are as follows:

Natural-draft	\$70,600,000 (1978 dollars)
Mechanical-draft	\$67,551,000 (1978 dollars)

The estimate for the natural-draft tower is as submitted in the Unit No. 2 hearings,[41] with an in-service date of January 1978. The estimated capital cost for the mechanical-draft tower is based on the applicant's figures (ER, IP-3, Section 22, p. B.2.3-3). Since the vendor cost to furnish and erect a mechanical-draft tower is less than that for a natural-draft tower, and in the absence of a detailed cost estimate, the staff assumed this to be a reasonable cost estimate.

(1) Natural-Draft Tower Alternative

In-service date: April 15, 1981

Additional capital investment: \$93,969,000 (1981 dollars)

Average annual derating: 38 MW

Peak ambient temperature derating: 83 MW

Annual operating cost: \$261,000

Gas turbines for peak derating

83,000 kW x \$213/kW = \$17,679,000 (April 1981)

C_I = \$93,969,000 + \$17,679,000 = \$111,648,000 (April 1981)

P_t = \$0.0142/kWhr x 38,000 kW x 0.692 x 8,760 hr = \$3,271,000

Replacement power cost for cut-in work

Time period: from 11/15/80 to 4/15/81, or 3,624 hr

Unit No. 3 rated capacity: 1,033 MW

Downtime loss: 3,744 x 10^6 kWhr

Unit production costs (dollars per kilowatt-hour)

	Fuel	Operating and Maintenance	Total
Fossil	0.02259	0.00133	0.02392
IP-3	0.00219	0.00054	0.00273
		Difference	0.02119

3,744 x 10^6 kWhr x \$0.02119/kWhr = \$79,335,000

$$\sum_{t=5.5}^{30} (P_t + O_t)V^t = (\$3,271,000 + \$261,000)\frac{(1.10)^{24.5} - 1}{0.10\ (1.10)^{24.5}}$$

$$= \$31,901,000 \text{ (April 1981)}$$

$$\text{Incremental } GC_p = C_I + \left[\sum_{t=5.5}^{30} (P_t + O_t)V^t \right] + \text{replacement cut-in power cost} - \text{thermal standard } P_t \text{ saved} - I_t \text{ saved}^*$$

$$= \$111,648,000 + \$31,901,000 + \$79,335,000$$

$$- \$11,445,000 \text{ (1975 dollars)} - \$294,091$$

$$\times \frac{(1.10)^{24.5} - 1}{0.10\ (1.10)^{24.5}}$$

$$= \frac{\$225,540,000}{(1.10)^{5.5}} - \$11,445,000 = \$122,080,000 \text{ (Nov. 1975)}$$

$$\text{Incremental } GC_a = \$122,080,000 \times \frac{0.10(1.10)^{30}}{(1.1)^{30} - 1}$$

= $12,950,000 (2.1 mills/kWhr) IP-3 alone
(0.3 mills/kWhr) Total system

(2) Mechanical-Draft Tower Alternative

In-service date: April 15, 1981

Additional capital investment: $89,910,000 (1981 dollars)

Average annual derating: 37 MW

Peak ambient temperature derating: 64 MW

Annual operating cost: $886,000

Gas turbines for peak derating

64,000 kW x $213/kW = $13,632,000 (1981 dollars)

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*Thermal standard P_t saved is the cost saved due to not needing to reduce power to avoid exceeding New York State thermal criteria. I_t saved is the value of the decrease of impinged fish due to operation with cooling towers.

C_I = (\$89,910,000 + \$13,632,000) = \$103,542,000 (1981 dollars)

P_t = \$0.0142/kWhr x 37,000 kW x 0.692 x 8,760 hr

= \$3,185,000 (1981 dollars)

Replacement power cost for cut-in work same as for natural-draft tower alternative = \$79,335,000

$$\sum_{t=5.5}^{30} (P_t + O_t)V^t = (\$3,185,000 + \$886,000)\ \frac{(1.10)^{24.5} - 1}{0.10\ (1.10)^{24.5}}$$

$$= \$36,769,000$$

$$\text{Incremental } GC_p = C_I + \sum_{t=5.5}^{30} (P_t + O_t)V^t + \text{replacement cut-in power cost}$$

$$- \text{thermal standard } P_t \text{ saved} - I_t \text{ saved}$$

$$= \frac{\$103,542,000 + \$36,769,000 + \$79,335,000}{(1.10)^{5.5}}$$

$$- \$11,445,000 - \left[\$294,091 \times \frac{(1.10)^{24.5} - 1}{0.10\ (1.10)^{24.5}} \div (1.10)^{5.5} \right]$$

= \$117,018,000 (November 1975)

$$\text{Incremental } GC_a = \$117,018,000 \times \frac{0.10(1.10)^{30}}{(1.10)^{30} - 1}$$

= \$12,413,000 (2.0 mills/kWhr) IP-3 alone
(0.3 mills/kWhr) Total system

2. Environmental Costs

Table XI-14 tabulates the significant environmental effects as established by the staff review. All entries are referenced to subsections in the text that contain more complete discussions on the effects noted. The contribution of environmental effects associated with the uranium fuel cycle are sufficiently small as not to affect significantly the conclusion of the benefit-cost balance.

J. SUMMARY OF BENEFITS AND ENVIRONMENTAL COSTS

1. Benefits

The direct benefits from the operation of Indian Point Unit No. 3 will be derived from the electrical energy generated. This is expected to be about 187,740 x 10^6 kWhr for the 30-year service life of the plant. The facility will also enable the applicant to retire some of the existing fossil-fired units in New York City that are contributing to the air pollution problem. As these units have outlived their economic life and have high forced outage rates, the generating system will benefit by increased reliability.

Indirect benefits resulting from the electrical energy produced will be real estate taxes, research, regional product, environmental enhancement, employment, and education. All consumers of the power produced would share the cost of the estimated $6,980,000 annual real estate tax bill, but the taxes paid will result in a significant benefit to the local community. The five-year research program at Indian Point to study the fish populations in the Hudson River, if carried to a successful completion, will greatly benefit the New York State agencies responsible for power plant siting and fishery management. The staff estimates that Unit No. 3 will provide the electrical energy requirements for about $8.8 billion of regional product. Environmental enhancement will be increased through the public recreational facilities to be developed on the site, significant amounts of reduction of air pollutants through the retirement of oil-fired units, employment of 41 permanent employees at Unit No. 3, and provision of the job-related energy requirements of about 395,000 workers in 1980. The applicant's proposed visitors' center will serve as an educational facility for school groups and the general public. A minimum of 100,000 visitors per year are expected at the facility.

2. Costs

a. Generating Costs

Only the cooling towers associated with Unit No. 3 in the alternative cooling systems were considered in calculating generating costs. The total generating costs in present value and present value annualized for the base design and each of the three alternatives are tabulated in Table XI-14.

Table XI-14. Cost description of base design and proposed alternative cooling systems

All monetized costs expressed in terms of their present and annualized values

References are to subsections, tables, and figures in the text that contain more complete discussions of the effects noted

Base design: Units Nos. 1, 2, and 3 with once-through cooling

Alternative A: Units Nos. 1 and 3, once-through
Unit No. 2, natural-draft cooling tower

Alternative B: Unit No. 1, once-through
Units Nos. 2 and 3, natural-draft cooling towers

Alternative C: Unit No. 1, once-through
Unit Nos. 2 and 3, mechanical-draft cooling towers

	Base design	Alternative A	Alternative B	Alternative C
Generating cost (Unit No. 3 only)				
Present value	$603,255,000	$603,255,000	$725,335,000	$720,273,000
Annualized	$ 63,993,000	$ 63,993,000	$ 76,943,000	$76,406,000
Lost capacity, MWe				
Average annual derating	None	Unit No. 2, 37	Unit No. 2, 37 Unit No. 3, 38	Unit No. 2, 37 Unit No. 3, 37
Peak ambient temperature derating	None	Unit No. 2, 82	Unit No. 2, 82 Unit No. 3, 83	Unit No. 2, 64 Unit No. 3, 64

Population or resource affected	Units	Environmental costs				References	
		Base design	Alternative A	Alternative B	Alternative C	Base design	Alternatives
1. Natural surface water body							
1.1 Impingement or entrapment by cooling water intake structure							
1.1.1 Fish	10^3 lb/year	29	17	6	6	V.D.2.a	Table XI-6
1.2 Passage through or retention in cooling systems							
1.2.1 Primary producers and consumers	Qualified opinion	Potential effect	Probably small	Probably small	Probably small	V.D.2.b(1)	XI.C.3.c(4)(b)(ii)
1.2.2 Fish (striped bass only)	% reduction of juveniles	34–50	30–46	23–37	23–37	Table V-20	Table XI-10
	Number of years relative yield is less than 50%	15–36	0–33	0–28	0–28	Table V-22	Table XI-11

Table XI-14 (continued)

Population or resource affected	Units	Environmental costs				Reference	
		Base design	Alternative A	Alternative B	Alternative C	Base design	Alternatives
1.3 Discharge area and thermal plume							
1.3.1 Water quality, physical							
Heat to river	10^9 Btu/hr	15.8	9.6	2.3	2.3	Table V-2	Table V-2
Water volume inside 2° isotherm	10^3 ft^3	91	77	44	44	Table V-5	Table V-5
Water volume inside 4° isotherm	10^3 ft^3	67	52	18	18	Table V-5	Table V-5
Water volume inside 6° isotherm	10^3 ft^3	46	36	2	2	Table V-5	Table V-5
Distance $\Delta T > 4F^\circ$	Miles	15	8	0	0	V.D.2.c(1)	XI.C.3.c(4)(6)(iii)
1.3.2 Oxygen availability	Qualified opinion	Potential effect	Probably small	Probably small	Probably small	V.D.2.c(2)	XI.C.3.c(4)(b)(iii)
1.3.3 Nonmigratory fish	Relative scale	Unknown	Unknown	Unknown	Unknown	V.D.2.c(1)	V.D.2.c(1)
1.3.4 Wildlife (including birds, aquatic and amphibious mammals, and reptiles)	Qualified opinion	None	None	None	None		
1.4 Chemical effluents							
1.4.1 Water quality, chemical	Qualified opinion	Potential chlorine effect	Potential chlorine effect	Potential chlorine effect	Potential chlorine effect	V.C.2.a	XI.C.3.c(3)
1.4.2 Aquatic biota		Effects included in Items 1.2 and 1.3 above. See Sects. V.D.2.b(2) and V.D.2.c(3) for discussion					
1.4.3 Wildlife (including birds, aquatic and amphibious mammals, and reptiles)	Qualified opinion	None	None	None	None		
1.4.4 People (recreation)	Lost annual user days	0	0	0	0	V.C.4	V.C.4
1.5 Radionuclides discharged to water body							
1.5.1 Aquatic organisms (fin fish)	Rads/year	0.7	0.7	0.7	0.7	Table V-19	Table V-19
1.5.2 People, external (immersion)							
Individual	Millirems/year	<0.01	<0.01	<0.01	<0.01	Table V-37	Table V-37
Population	Man-rems/year	0.26	0.26	0.26	0.26	Table V-39	Table V-39
1.5.3 People, ingestion (drinking)		N.A.[a]	N.A.[a]	N.A.[a]	N.A.[a]		

Table XI-14 (continued)

Population or resource affected	Units	Environmental costs: Base design	Environmental costs: Alternative A	Environmental costs: Alternative B	Environmental costs: Alternative C	Reference: Base design	Reference: Alternatives
1.6 Consumptive use (evaporative losses)							
1.6.1 Evaporative losses	10^3 gpm	0	14	31	31	V.C.3	XI.C.3.c(3)
1.6.2 Property (water withdrawn from agricultural usage)	Acre-ft/year	N.A.[a]	N.A.[a]	N.A.[a]	N.A.[a]		
2. Groundwater							
2.1 Raising/lowering of groundwater levels	Qualified opinion	None	None	None	None	V.C.3	V.C.3
2.2 Chemical contamination of groundwater (excluding salt)	Qualified opinion	None	None	None	None	V.C.3	V.C.3
2.3 Radionuclide contamination of groundwater	Qualified opinion	None	None	None	None	V.C.3	V.C.3
3. Air							
3.1 Fogging and icing (caused by evaporation and drift)							
3.1.1 Ground transportation	hr/year	0	Negligible	Negligible	11	V.B.1	XI.C.3.c(2)(b)
3.1.2 Air transportation	hr/year	0	Negligible	Negligible	Small	V.B.1	XI.C.3.c(2)(b)
3.1.3 Water transporation affected	hr/year	0	~2	4	66	V.B.1	XI.C.3.c(2)(b)
3.1.4 Plants damaged	Qualified opinion	None	None	None	None		
3.2 Chemical discharge to ambient air							
3.2.1 Air quality, chemical	lb/yr	Negligible	Negligible	Negligible	Negligible	V.B.2	V.B.2
3.2.2 Air quality, odor	Qualified opinion	None	None	None	None		
3.3 Radionuclides discharged to ambient air							
3.3.1 People, external							
Individual (nearest residence)							
Total body	Millirems/year	0.43	0.43	0.43	0.43	Table V-37	Table V-37
Thyroid	Millirems/year	1.1	1.1	1.1	1.1	Table V-37	Table V-37
Population (50-mile radius)	Man-rems/year	21	21	21	21	Table V-38	Table V-38

Table XI-14 (continued)

Population or resource affected	Units	Environmental costs				Reference	
		Base design	Alternative A	Alternative B	Alternative C	Base design	Alternatives
3.3.2 People, ingestion							
Individual (terrestrial food chain, nearest cow)							
Total body	Millirems/year	<0.01	<0.01	<0.01	<0.01	Table V-37	Table V-37
Thyroid (child)	Millirems/year	7.6	7.6	7.6	7.6	Table V-37	Table V-37
3.3.3 Plants and animals		Sufficient information to allow determination of a meaningful number is not available					
4. Land							
4.1 Pre-emption of land							
4.1.1 Land, amount	Acres	35	45	55	95	V.A	XI.C.3.c(1)(a)
4.2 Plant construction and operation							
4.2.1 People (amenities)	Number of residents	Few	21	21	745	V.A.3	XI.C.3.c(1)(c)
4.2.2 People (aesthetics)	Qualified opinion	Minimal	Major	Major	Slight	V.A.1	XI.C.3.c(1)(b)
4.2.3 Wildlife (habitat affected by construction)	Acres	The site is not a major habitat for wildlife					
4.2.4 Land, flood control	Qualified opinion	None required	None required	None required	None required		
4.3 Salts discharged from cooling towers							
4.3.1 People	Qualified opinion	N.A.	None	None	Possible		XI.C.3.c(1)(d)
4.3.2 Plants and animals	Qualified opinion	N.A.	Minor	Minor	Major		XI.C.3.c(1)(d)
4.3.3 Property resources	Qualified opinion	N.A.	Minor	Minor	Major		XI.C.3.c(1)(d)

[a]Water in the estuary is not used for human consumption or agriculture.

The most economic generating cost for Unit No. 3 is achieved by employing either the base design or Alternative A, as they both specify a once-through cooling system for Unit No. 3 and have equal generating costs. The next to the lowest generating cost is for Alternative C (Unit No. 3 with mechanical-draft cooling towers), and the highest generating cost is for Alternative B (Unit No. 3 with a natural-draft cooling tower system). The incremental increase in present-value generating cost from the base design (or Alternative A) to Alternative C is $117,018,000, and the increase from Alternative C to Alternative B is $5,062,000. If these present-value costs are annualized, they become $12,413,000 and $537,000 respectively.

b. Environmental Costs

Both short-term and long-term environmental effects are considered.

(1) Natural surface Water Body

Available baseline data indicate that the effects of impingement on fish will be of the order of 28,600 lb/year for the base design, 17,300 lb/year for Alternative A, and 6,000 lb/year for either Alternative B or Alternative C. The corresponding numbers of fish are 2,600,000, 1,600,000, and 500,000 respectively. Entrainment costs for primary producers and consumers were expressed in terms of probability of entrainment rather than in pounds per year. Striped bass losses through entrainment are estimated to be a 34 to 50% reduction of juveniles for the base design as compared with a 30 to 46% reduction for Alternative A and a 23 to 37% reduction for either Alternative B or Alternative C.

Thermal discharges to the river for the base design are considered to be undesirable. Alternative A would have thermal effects slightly greater than Units Nos. 1 and 2 operating by themselves with once-through cooling, which may not meet the New York State thermal criteria. The heat rejection to the river for either Alternative B or Alternative C would be about 22% greater than for Unit No. 1 operating alone with once-through cooling and would therefore be acceptable. The effects on oxygen availability from the passage of cooling water through the condensers will probably be very small with once-through cooling. Aeration in the cooling towers may cause a desirable impact by increasing the dissolved-oxygen concentration. The staff was unable to quantify the effects of the thermal plume on nonmigratory fish except on a relative scale assigning a value of 1.0 to the base design and assuming that the effects are directly proportional to the volume of water within specified isotherms. Alternative A then has a relative value of 0.8, and Alternatives B and C each have relative values of 0.3.

The probable effects of the plume on migratory fish are unknown except that the thermal plume from the base design could possibly cause a thermal block in the river according to State thermal criteria.

The water quality of the Hudson River will not be significantly impaired by the discharge of chemicals or radionuclides from the Plant. No significant effects on wildlife habitats or recreational water uses are expected. Radiation doses to aquatic organisms and to people by immersion and ingestion are within acceptable levels. Consumptive use of water from the Hudson River will not affect supplies for drinking water or agricultural uses.

(2) Groundwater

No effects on people, plants, or animals are expected from raising or lowering of groundwater levels or from chemical or radionuclide contamination of the groundwater.

(3) Air

Fogging and icing caused by evaporation and drift from the natural-draft cooling towers in Alternative A or B are expected to affect ground and water transportation a maximum of 4 hr/year. Fogging and icing caused by the mechanical-draft towers in Alternative C are expected to affect ground and water transporation about 11 hr/year and 66 hr/year respectively. Neither type of cooling tower is expected to significantly affect air transportation in the area or damage any plants by fogging and icing.

The effect on air quality from chemical discharges to ambient air is expected to be very minor, and these discharges will not produce any perceptible offsite odors.

Calculated doses from radionuclides discharged to ambient air during normal operation of Unit No. 3, as well as Units Nos. 1 and 2, are within existing Federal regulations.

(4) Land

The land owned by the applicant at the Indian Point Plant (239 acres) is adequate to accommodate any of the three cooling tower alternatives. Estimated land requirements for the actual cooling devices (excluding pipe trenches, booster pump stations, etc.) are 10 acres for Alternative A, 20 acres for Alternative B, and 60 acres for Alternative C. The wildlife habitats affected by the construction of the towers would add additional acreage to the above land requirements. Noise from the natural-draft cooling towers would place an estimated 21 residents within range of unacceptable noise levels from these towers. Similarly, an estimated 745 residents would be affected by unacceptable levels of noise from the mechanical-draft cooling towers. The natural-draft cooling towers would be expected to have a greater visual impact than mechanical-draft cooling towers, as they would project several hundred feet above the local terrain. The magnitude of the visual impact, however, is a matter of personal judgment and cannot be assessed quantitatively.

Salt deposition rates from the natural-draft cooling tower alternatives would not cause serious contamination of well water in the vicinity of the Indian Point site and would have little, if any, effect on the plants, animals, and property resources. The higher and more localized salt deposition rates from the mechanical-draft cooling towers in Alternative C, however, could possibly contaminate groundwater supplies to levels approaching the upper limit of concentration for drinking water. Plants and property resources would definitely be subject to contact damage within a 1,000-ft radius of the mechanical-draft cooling tower complex, which would extend beyond the applicant's property line.

c. Economic Impact of the Indian Point Plant on the Hudson River Spawned Striped Bass Fisheries

In this analysis, the staff will evaluate the economic benefit to the Hudson River spawned striped bass fisheries which would result from the addition of natural-draft cooling towers to Indian Point Unit No. 2 or Units Nos. 2 and 3, as well as the incremental generating costs incurred by adding the cooling towers. A benefit-cost ratio will then be presented.

(1) Benefits to the Fisheries

The staff is concerned here with the striped bass fisheries which will be affected by losses of young-of-the-year striped bass at the Indian Point Plant. In Section V.D.2.d(3)(c)(v), the sport fishery and the commercial fishery have been discussed, and two geographical zones (an Inner Zone and an Outer Zone, which differ in the extent to which they rely on the Hudson River striped bass population) have been defined. This and other information will be used in quantifying the geographical range and size of the affected fishery. The staff's striped bass life-cycle population model and young-of-the-year model [Sections V.D.2.d(3)(c) and XI.C.3.c(4)(b)(iv) and App. B, Section B.4] have been used to predict the reduction in relative yield of striped bass to the combined sport and commercial fisheries for various cooling system configurations at Indian Point. The predicted increase in relative yield with cooling towers at Indian Point Unit No. 2 or at Units Nos. 2 and 3, as compared with once-through cooling, will be used as the measure of the benefit to the fisheries.

In Section (a) below, the overall methodology to be used is described. Section (b) considers the problem of quantifying the value of the sport fishery. In Section (c), the magnitude of the sport fishery which is supported by the Hudson River striped bass population is estimated. A similar estimate for the commercial fishery is derived in Section (d). In Section (e), the unit costs of the fisheries (values in terms of 1974 dollars) are calculated. The magnitude of benefits (increase in relative yield due to the use of cooling towers rather than once-through cooling) is shown in Section (f). Finally, the present value of benefits is calculated in Section (g).

(a) Methodology Used in the Analysis

In the sections which follow, quantitative measures of the size and the value of the striped bass sport and commercial fisheries which may be lost due to the operation of Indian Point are developed. The values are then expressed as unit costs in terms of 1974 dollars. The fraction of the unit cost (value) which is lost in each year by not installing cooling towers is assumed to equal the decrease in relative yield to the striped bass fishery for that year caused by using once-through cooling as opposed to cooling towers at Indian Point. Account is also taken of the zone and degree of influence of the Hudson River striped bass population.

All plants on the river are assumed to start operation in 1974 and cease operation on or before the year 2010. This is equivalent to assuming a 35- to 40-year operating lifetime and that replacement plants or additional plants will be equipped with cooling towers which will be assumed to cause negligible damage to the striped bass population. The staff's life-cycle population model is used to calculate incremental increased yield to the fishery for various cooling tower scenarios relative to the base design (once-through cooling at Indian Point Units 1, 2, and 3). Two sets of values for the fractional decrease in the probability of survival (PPO-1.0) for young-of-the-year striped bass are used in the life-cycle model, based on percent reduction values from the young-of-the-year model obtained using two values for the intake f factor (f_I).

It should be noted that the life-cycle model predicts that the recovery of the striped bass yield will be gradual after the cessation of power plant operation. In fact, full recovery is not predicted to occur until about 40 years thereafter. Obviously the total cost to the fishery of once-through cooling involves the integrated costs over the entire 80-year period; this period is used in the staff's analysis.

(b) A Method for Quantifying the Value of the Striped Bass Sport Fishery

In this section a model is formulated for estimating the economic benefits (dollars) of recreation opportunities (sport fishing) which would be preserved by the installation of cooling towers at Indian Point.

The heart of the problem is the need to measure the value of a recreation experience foregone. A recreation experience obviously has utility and thereby value to the recreator, but, for various reasons, recreation is not generally provided by the market at a price or fee. The absence of a price compels the investigator somehow to "estimate" the value of recreation benefits.

Briefly, the model developed here relies upon the costs which recreators are willing to incur to enjoy a recreational activity as a measure of the value of the experience. This model uses a variant of the technique of simulating demand curves for recreation by estimating the costs that recreators are willing to incur to enjoy a recreational experience. This technique, suggested by Hotelling[48] and employed by Knetsch[49] and others, has been used as a means of incorporating recreation benefits into the benefit-cost valuation of federal water resources projects. It is used here to estimate the recreation benefits which will be preserved by the installation of cooling towers.

The demand curve is simulated by taking the expenditures associated with a recreation experience as a proxy for the price the recreator would be willing to pay. It would appear that the greater the expenditure, the fewer the number of recreation occasions. Accordingly, the relationship between price (cost) and quantity demanded (number of trips per unit of time per unit of population) is inverse as expected,[50] and is illustrated in Fig. XI-3 by lines DD' (the hypothetical demand curve with cooling towers) and D_1D_1' (the demand curve with once-through cooling). The cost incurred should include only the costs associated with the particular activity in question — in this case, striped bass fishing. Expenditures which the individuals would incur, even in the absence of striped bass fishing, should not be included. It should be noted, however, that the use of this method is intended to provide a proxy for the value of the <u>entire</u> recreation experience. That is, it measures the value of any aesthetic pleasure derived by the angler from his entire recreation experience and not just the pleasure derived from the actual fishing component of the experience.

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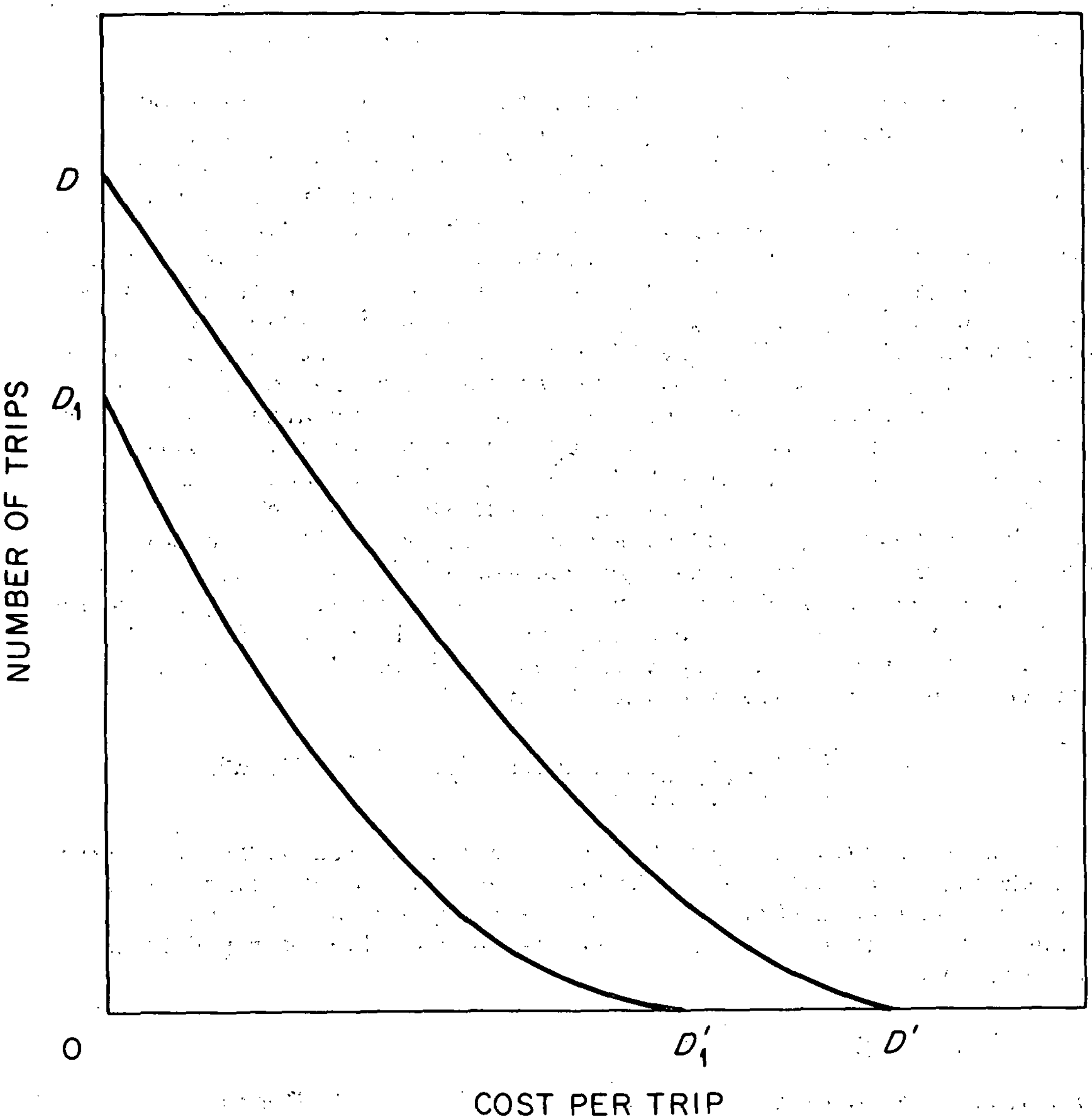

Fig. XI-3. Two hypothetical demand curves for recreation. DD' = demand curve with cooling towers; D_1D_1' = demand curve with once-through cooling.

Under certain conditions* the demand curve may be considered the marginal utility function of the recreation user, and the gross value of recreation may be considered the integral of the function; (i.e., the area ODD' or OD_1D_1') under the demand curves.

In terms of Fig. XI-3, consider the simulated demand curve DD' as measuring expenditures for equipment, travel, and all other costs associated with the striped bass fishing experience if cooling towers were installed. In this case, total benefits to recreators would be area ODD'. Thus, as Wennergren[52] has pointed out, the true value of the recreation experiences is the amount of consumer's surplus they generate, that is, the amount which the striped bass fishermen would be willing to pay rather than do without the recreation experience. The area ODD' may also, of course, be considered a calculation of the maximum recreation damage which could occur if the fishery were destroyed, that is, the area ODD' may be considered as a measure of consumer's surplus which is available to be sacrificed. The line D_1D_1' on Fig. XI-3 is lower than line DD' because once-through cooling reduces the fishable population, and the recreator (striped bass angler) is not willing to pay as much per trip because of the reduced reward (lower catch of fish). The area bounded by $DD'D_1'D_1$ represents the recreation damages which would occur if cooling towers were not installed at Indian Point. In the present case the staff does not have the data necessary to construct demand curves such as DD' or D_1D_1'.

(c) Estimate of Hudson River Striped Bass Angler-Days

The sample calculations in the first five numbered paragraphs below are shown to indicate the methodology used in determining the minimum and maximum number of striped bass angler-days in the two zones assumed to be influenced by the Hudson River striped bass population.

(i) Zone Factor

The staff has subdivided the zone of influence of Hudson River striped bass into an Inner Zone (Hudson River, western half of Long Island Sound, and the New York Bight) and an Outer Zone (Atlantic coastline from Maine to Cape May County, N.J., inclusive, less the Inner Zone). See Section V.D.2.d(3)(c)(v) for further details.

*Briefly, the condition is that the marginal utility of money is constant. See Vickrey,[51] p. 66.

The zone factor (Table XI-16) was selected to represent approximately that fraction of the state's coastline that is within the Inner and Outer Zone. This factor is applied in the calculations described in (v) below.

(ii) Proportion of the Population Twelve Years and Older (1970) (Angler-Age Factor)[53,54a]

New England (Me., N.H., Vt., Mass., Conn., and R.I.)	0.730
Middle Atlantic (N.Y., N.J., and Pa.)	0.760
U.S. Total	0.762

(iii) Proportion of Population Twelve Years and Older Who Fished in Salt Water (Salt Water Factor)[54a]

New England (Me., N.H., Vt., Mass., Conn., and R.I.)	0.80
Middle Atlantic (N.Y., N.J., and Pa.)	0.69

(iv) Proportion of Salt Water Anglers Catching Striped Bass (Striped Bass Factor)[55]

North Atlantic (Me., N.H., Vt., Mass., Conn., R.I., and N.Y.) $\frac{368,000}{1,666,000} = 0.221$

Middle Atlantic (N.J., Del., Md., Va., and N.C.) $\frac{415,000}{1,767,000} = 0.235$

(v) Number of Striped Bass Anglers

The staff assumes that the Inner and Outer Zones include all of the region to which the Hudson River striped bass population makes a significant contribution.

The staff has estimated previously [Sect. V.D.2.d(3)(c)(v)] the percent contribution of the Hudson River striped bass population to the total striped bass population in the Inner Zone as 90% and in the Outer Zone as 10% or 50%.

The number of striped bass anglers in each zone is calculated on the bases of the population projections shown in Table XI-15 and the factors described above. A sample calculation for the year 1970 is shown in Table XI-16. As opposed to the angler-age factor, the saltwater factor, and the striped bass factor, which are based on data, the staff's use of the zone factor in these calculations is based on an assumption that the fishing effort along the coastlines of Connecticut, New York, and New Jersey is uniformly distributed within each state.

Table XI-15. State population projections Series D (in thousands)

Year	State							
	New York	New Jersey	Massachusetts	Connecticut	Rhode Island	New Hampshire	Maine	Vermont
1970	18,191	7,168	5,689	3,032	950	738	994	445
1971	18,514	7,302	5,689	3,082	931	745	1,014	455
1972	18,837	7,435	5,680	3,133	940	752	1,002	439
1973	19,144	7,548	5,693	3,163	928	759	1,012	443
1974	19,491	7,690	5,688	3,217	937	767	1,001	426
1975	19,853	7,838	5,685	3,273	926	775	1,012	431
1976	20,034	7,948	5,727	3,332	936	784	1,023	436
1977	20,225	8,042	5,794	3,371	947	793	1,035	441
1978	20,427	8,162	5,843	3,412	937	803	1,026	446
1979	20,637	8,264	5,916	3,455	948	813	1,039	452
1980	20,855	8,392	5,968	3,499	960	823	1,052	457
1981	21,057	8,502	6,023	3,544	973	834	1,066	463
1982	21,286	8,636	6,102	3,591	986	845	1,080	469
1983	21,518	8,750	6,158	3,638	975	856	1,070	476
1984	21,749	8,888	6,238	3,709	988	867	1,084	482
1985	21,979	9,001	6,294	3,757	1,000	878	1,098	488
1986	22,244	9,110	6,370	3,802	1,012	889	1,111	494
1987	22,510	9,219	6,446	3,848	1,024	899	1,124	500
1988	22,776	9,328	6,522	3,893	1,036	910	1,138	506
1989	23,042	9,437	6,598	3,938	1,049	921	1,151	511
1990	23,308	9,546	6,674	3,984	1,061	931	1,164	517
1991	23,552	9,646	6,744	4,025	1,072	941	1,176	523
1992	23,795	9,745	6,814	4,067	1,083	951	1,188	528
1993	24,039	9,845	6,884	4,109	1,094	960	1,201	534
1994	24,283	9,945	6,953	4,150	1,105	970	1,213	539
1995	24,526	10,045	7,023	4,192	1,116	980	1,225	544
1996	24,774	10,146	7,094	4,234	1,127	990	1,237	550
1997	25,022	10,248	7,165	4,277	1,139	1,000	1,250	555
1998	25,270	10,349	7,236	4,319	1,150	1,010	1,262	561
1999	25,518	10,451	7,307	4,362	1,161	1,020	1,274	566
2000	25,766	10,552	7,378	4,404	1,172	1,029	1,287	572
2001	26,044	10,666	7,458	4,451	1,185	1,041	1,301	578
2002	26,322	10,780	7,537	4,499	1,198	1,052	1,315	584
2003	26,600	10,894	7,617	4,546	1,210	1,063	1,329	590
2004	26,878	11,008	7,696	4,594	1,223	1,074	1,342	597
2005	27,156	11,122	7,776	4,642	1,236	1,085	1,356	603
2006	27,458	11,245	7,863	4,693	1,249	1,097	1,371	609
2007	27,760	11,369	7,949	4,745	1,263	1,109	1,386	616
2008	28,062	11,493	8,035	4,796	1,277	1,121	1,402	623
2009	28,364	11,616	8,122	4,848	1,291	1,133	1,417	630
2010	28,666	11,740	8,208	4,900	1,304	1,145	1,432	636
2011	28,970	11,864	8,295	4,952	1,318	1,158	1,447	643
2012	29,274	11,989	8,383	5,004	1,332	1,170	1,462	650
2013	29,578	12,113	8,470	5,055	1,346	1,182	1,477	657
2014	29,882	12,238	8,557	5,107	1,360	1,194	1,492	663
2015	30,186	12,363	8,644	5,159	1,374	1,206	1,508	670
2016	30,480	12,483	8,728	5,210	1,387	1,218	1,522	677
2017	30,775	12,604	8,812	5,260	1,400	1,230	1,537	683
2018	31,069	12,724	8,897	5,310	1,414	1,241	1,522	690
2019	31,364	12,845	8,981	5,361	1,427	1,253	1,566	696
2020	31,658	12,965	9,065	5,411	1,441	1,265	1,581	703

Source: Department of Commerce, Bureau of the Census; Current Population Reports, Series P-25, No. 493.

Table XI-16. Number of striped bass anglers in inner and outer zones (1970)

State	Population	Zone factor	Angler-age factor	Saltwater factor	Striped bass factor	Striped bass anglers
Inner zone						
Connecticut	3,032,217	0.25	0.730	0.080	0.221	9,783
New York	18,190,740	0.5	0.760	0.069	0.221	105,408
New Jersey	7,168,164	0.5	0.760	0.069	0.235	44,168
Total						159,359
Outer zone						
New York	18,190,740	0.5	0.760	0.069	0.221	105,408
New Jersey	7,168,164	0.5	0.760	0.069	0.235	44,168
Massachusetts	5,689,170	1.0	0.730	0.080	0.221	73,427
Connecticut	3,032,217	0.75	0.730	0.080	0.221	29,351
Rhode Island	949,723	1.0	0.730	0.080	0.221	12,258
New Hampshire	737,681	1.0	0.730	0.080	0.221	9,521
Maine	993,663	1.0	0.730	0.080	0.221	12,825
Vermont	444,732	1.0	0.730	0.080	0.221	5,740
Total						292,698

(vi) Number of Hudson River Striped Bass Angler-Days

The Hudson River striped bass population contributes only part of the recruitment to each of the two zones that are under consideration. In reality, most of the striped bass anglers whose numbers are estimated in (iv) above are likely to catch a mixture of striped bass originating in the Hudson and those originating elsewhere. For convenience, however, the staff defines the term "Hudson River striped bass anglers" as being the total number of striped bass anglers in a given zone multiplied by the fractional contribution of the Hudson River to the total fishable striped bass population in that zone. This number represents, in one sense, the number of anglers in the zone whose catch of striped bass would be supplied entirely by the Hudson River if each angler caught the same number of striped bass, and if each angler caught bass which were either all of Hudson River origin or else all originated elsewhere.

The staff assumes that the Hudson River striped bass population contributes 90% of the striped bass in the Inner Zone and either 10% or 50% in the Outer Zone [see Section V.D.2.d(3)(c)(v)]. Therefore, the minimum and maximum number of Hudson River striped bass anglers in the combined zones in 1970 would be:

$$(159{,}359)\ (0.90) + (292{,}698)\ (0.10) = 172{,}693$$
$$(159{,}359)\ (0.90) + (292{,}698)\ (0.50) = 289{,}772$$

The average number of days fished per angler on the Atlantic coast in 1970 was 12.2.[54] Therefore, the number of angler-days expended on Hudson River striped bass during 1970 ("Hudson River striped bass angler-days") was:

$$(172,693)\ (12.2) = 2,107,000 \text{ minimum}$$
$$(289,772)\ (12.2) = 3,535,000 \text{ maximum}$$

The estimated numbers of Hudson River striped bass angler-days for the years 1970 through 2020 are tabulated in Table XI-17. The population of the states in the Inner and Outer Zones is assumed to attain zero growth by the year 2020 and the number of striped bass angler-days would then remain constant from that point on into the future.

(d) Commercial Catch of Striped Bass in the Hudson River Zone

The values shown below are the average annual commercial catch of striped bass for the years 1961-1969 (see Table V-24). See Fig. V-15 for geographical location of areas 1 through 12.

Inner zone	Average annual commercial catch (lb)
New York	
Area 1	12,700
Area 2	16,400
Area 3	70,900
Area 4	1,200
Area 9 (41,660) 1/2	20,800
Area 12	
Hudson River	52,100
New Jersey	
Monmouth County	44,300
Ocean County (99,533) 1/2	49,800
Total	268,200

The staff assumes that 90% of this total landings was from the Hudson River striped bass population, that is, (268,200)(0.90) = 241,400 lb.

Table XI-17. Hudson River striped bass angler days

Year	Striped bass anglers		Striped bass anglers catching Hudson River striped bass		Hudson River striped bass angler days	
	Inner zone	Outer zone	Minimum	Maximum	Minimum	Maximum
1970	159,359	292,698	172,693	289,772	2,107,000	3,535,000
1971	162,230	296,130	175,620	294,072	2,143,000	3,588,000
1972	165,084	299,942	178,480	298,097	2,177,000	3,637,000
1973	167,657	302,093	181,100	301,938	2,209,000	3,684,000
1974	170,717	305,295	184,175	306,293	2,247,000	3,737,000
1975	173,908	308,976	187,415	311,005	2,286,000	3,794,000
1976	175,825	312,268	189,470	314,377	2,312,000	3,835,000
1977	177,637	315,673	191,440	317,710	2,336,000	3,876,000
1978	179,679	318,560	193,567	320,991	2,362,000	3,916,000
1979	181,663	322,280	195,725	324,637	2,388,000	3,961,000
1980	183,858	325,947	198,067	328,446	2,416,000	4,007,000
1981	185,850	329,507	200,216	332,019	2,443,000	4,051,000
1982	188,155	333,703	202,710	336,191	2,473,000	4,102,000
1983	190,355	336,890	205,009	339,765	2,501,000	4,145,000
1984	192,772	341,365	207,632	344,177	2,533,000	4,199,000
1985	194,956	345,137	209,974	348,029	2,562,000	4,246,000
1986	197,309	349,303	212,508	352,230	2,593,000	4,297,000
1987	198,999	352,800	214,379	355,499	2,615,000	4,337,000
1988	202,029	357,655	217,592	360,654	2,655,000	4,400,000
1989	204,387	361,827	220,131	364,862	2,686,000	4,451,000
1990	206,749	365,995	222,674	369,072	2,717,000	4,503,000
1991	208,912	369,830	225,004	372,936	2,745,000	4,550,000
1992	211,065	373,649	227,324	376,783	2,773,000	4,597,000
1993	213,231	377,492	229,657	380,654	2,802,000	4,644,000
1994	215,393	381,300	231,984	384,504	2,830,000	4,691,000
1995	217,553	385,125	234,311	388,360	2,859,000	4,738,000
1996	219,748	389,010	236,674	392,278	2,887,000	4,786,000
1997	221,952	392,924	239,049	396,219	2,916,000	4,834,000
1998	224,148	396,811	241,414	400,139	2,945,000	4,882,000
1999	226,352	400,699	243,787	404,066	2,974,000	4,930,000
2000	228,547	404,585	246,151	407,985	3,003,000	4,977,000
2001	231,012	408,967	248,808	412,394	3,035,000	5,031,000
2002	233,480	413,332	251,465	416,789	3,068,000	5,085,000
2003	235,946	417,688	254,120	421,195	3,100,000	5,139,000
2004	238,414	422,053	256,778	425,599	3,133,000	5,192,000
2005	240,883	426,433	259,438	430,011	3,165,000	5,246,000
2006	243,555	431,150	262,315	434,775	3,200,000	5,304,000
2007	246,237	435,898	265,203	439,562	3,235,000	5,363,000
2008	248,916	440,647	268,089	444,348	3,271,000	5,421,000
2009	251,592	445,401	270,973	449,133	3,306,000	5,479,000
2010	254,273	450,122	273,858	453,907	3,341,000	5,538,000
2011	256,967	454,906	276,761	458,723	3,376,000	5,596,000
2012	259,667	459,697	279,670	463,549	3,412,000	5,655,000
2013	262,357	464,459	282,567	468,351	3,447,000	5,714,000
2014	265,057	469,224	285,473	473,163	3,483,000	5,773,000
2015	267,756	474,014	288,381	477,987	3,518,000	5,831,000
2016	270,365	478,629	291,192	482,643	3,553,000	5,888,000
2017	272,981	483,246	294,008	487,306	3,587,000	5,945,000
2018	274,846	487,137	296,075	490,930	3,612,000	5,989,000
2019	278,205	492,489	299,634	496,629	3,656,000	6,059,000
2020	280,809	497,120	302,440	501,288	3,690,000	6,116,000

Outer zone	Average annual commercial catch (lb)
New York	
Area 5	171,100
Area 6	6,500
Area 7	654,900
Area 8	54,500
Area 9 (41,660) 1/2	20,800
Area 10	300
Area 11	900
New Jersey	
Ocean County (99,533) 1/2	49,800
Atlantic County	221,700
Cape May County	51,000
New England	737,500
Total	1,969,000

The staff assumes that either 10 or 50% of this total landings was from the Hudson River striped bass population, that is,

(1,969,000) (0.10) = 196,900 lb minimum
(1,969,000) (0.50) = 984,500 lb maximum

The annual totals for the commercial fishery in both zones, based on the staff's assumptions are a minimum of 438,300 lb and a maximum of 1,225,900 lb. In contrast to the method of estimating the number of striped bass sport anglers, the staff has assumed a constant (although unquantified) commercial striped bass fishing effort. This assumption is based on the fact that there has not been a major or systematic change in the total commercial striped bass fishing effort in the recent past.[56] This assumption, in combination with the staff's simplifying assumption in its life-cycle model of an equilibrium or constant-sized striped bass population in the absence of power plant impacts, implies a constant yield to the commercial fishery in the absence of power plant impacts. As pointed out in Sect. V.D.2.d(3)(c)(iv), this approach is based on the fact that there has not been an escalation of commercial striped bass fishing effort.[56] However, this assumption does not take into account that the approximate ninefold increase in commercial striped bass landings from the early 1930's to the present may continue.[56]

(e) Unit Costs

The staff elected to use the \$10.43 per angler-day for the Atlantic coast as reported on page 10 of ref. 54a and the 1971 weighted average retail price of \$0.48 per pound[57] for the commercial catch. These values were then converted to 1974 dollars (in-service date for Indian Point Unit No. 2) by multiplying by the ratio of the 1974 consumer price index (144.9) to the 1970 index (116.3) and 1971 index (121.3) respectively.

$$\$10.43 \times \frac{144.9}{116.3} = \$12.99 \text{ per angler-day (1974)}$$

$$\$0.48 \times \frac{144.9}{121.3} = \$0.57 \text{ per pound (1974)}$$

These unit costs were used throughout the period under consideration.

(f) Relative Yield Factors

The relative yield factors are defined as the relative yield to the fisheries for the case when one or more generating units are backfitted with natural-draft cooling towers operating in the closed-cycle mode minus the relative yield for the case when all units are operating with once-through cooling.

Runs of the striped-bass life-cycle population model were made using the conditions shown in Table XI-18. The parameters used in the model correspond to the staff's best estimates (Parameter Set 1, Table B-43, App. B).

For Alternative A, Alternative B, and for base design, the PPO values were calculated from percent reduction values obtained from the young-of-the-year model. For Set 1.1 the intake f factor (f_I) had a value of 0.5 and the convective transport defect factor (CTDF) had a value of 0.8. For Set 1.0, f_I had a value of 1.0 and CTDF had a value of 0.8.

Curves of relative yield versus year for Alternatives A, B, and the base design are given in Fig. XI-4 for Set 1.0 and in Fig. XI-5 for Set 1.1.

The yearly values of the relative yield factors (the difference in yield between Alternatives A or B and the base design) for Set 1.1 and Set 1.0 are given in Tables XI-19 to XI-22 respectively.

Table XI-18. Summary of conditions used in the staff's striped bass life cycle model for obtaining the relative yield factors

Alternative at Indian Point[a]					Set 1.1[b]		Set 1.0[c]	
	IP-2	IP-3	Period	Number of years	Percent reduction[d]	PPO[e]	Percent reduction	PPO
Alternative B	OT		1974–75	2	29	0.71	45	0.55
	OT	OT	1976–78	3	34	0.66	50	0.50
	CT	OT	1979–81	3	30	0.70	46	0.54
	CT	CT	1982–2008	27	23	0.77	37	0.63
		CT	2009–10	2	22	0.78	36	0.64
			2011–53	43	0	1.00	0	1.00
Alternative A	OT		1974–75	2	29	0.71	45	0.55
	OT	OT	1976–78	3	34	0.66	50	0.50
	CT	OT	1979–2008	30	30	0.70	46	0.54
		OT	2009–10	2	29	0.71	45	0.55
			2011–53	43	0	1.00	0	1.00
Base design	OT		1974–75	2	29	0.71	45	0.55
	OT	OT	1976–2008	33	34	0.66	50	0.50
		OT	2009–10	2	29	0.71	45	0.55
			2011–53	43	0	1.00	0	1.00

[a]OT = once-through cooling; CT = cooling tower.

[b]Intake f factor (f_I) = 0.5 and convective transport defect factor CTDF = 0.8 in runs with the staff's young-of-the-year model used to obtain the percent reduction values given for set 1.1.

[c]f_I = 1.0 and CTDF = 0.8 in runs with the young-of-the-year model used to obtain the percent reduction values given for set 1.0.

[d]Percent reductions calculated by the staff's young-of-the-year model for the indicated alternative at Indian Point with all other plants on the river assumed to be operating at design capacity. Cornwall was not included.

[e]$PPO = \frac{100 - \%\ \text{reduction}}{100}$; input to the staff's life cycle model.

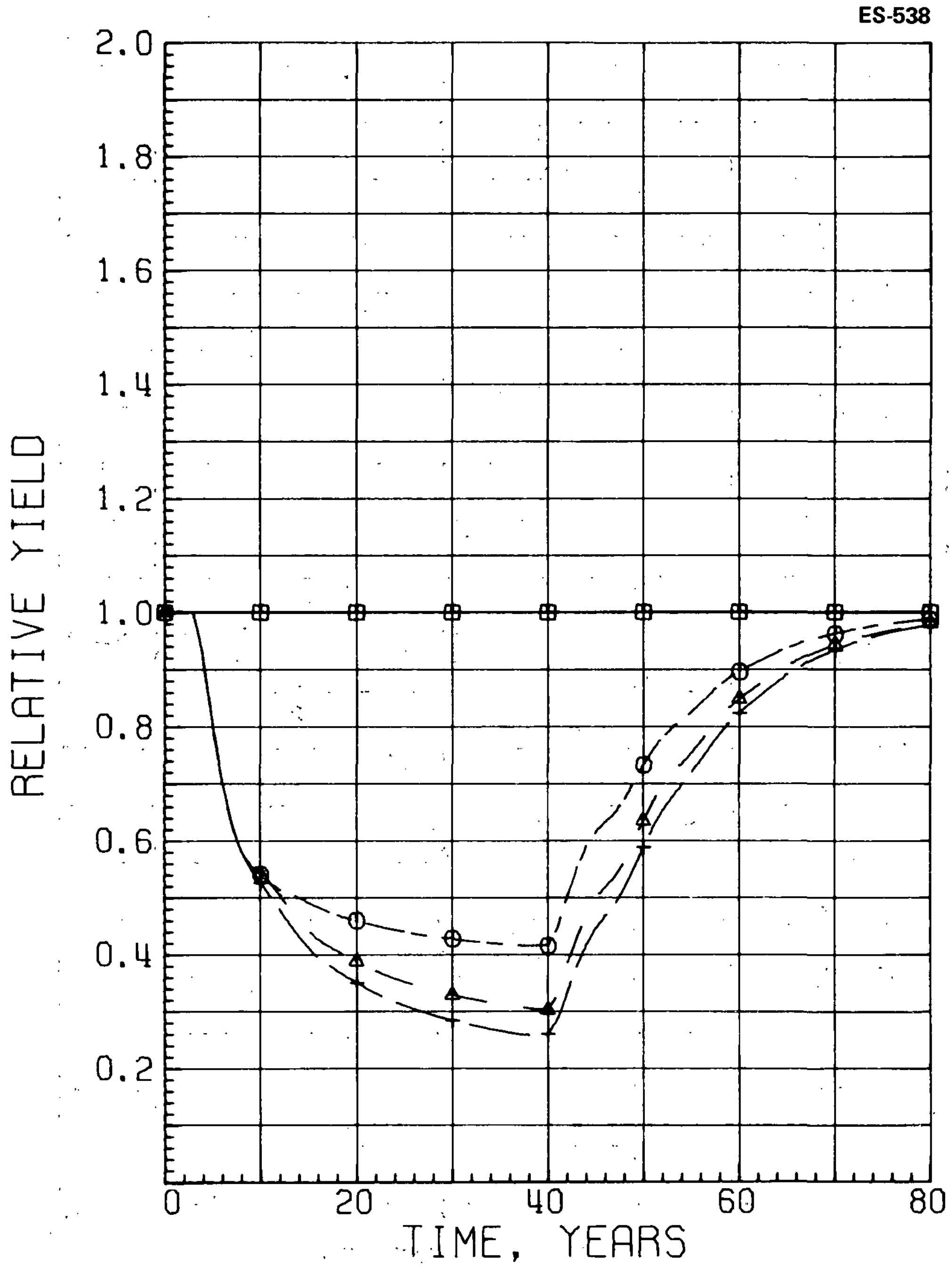

Fig. XI-4. Curves of relative yield vs time for Set 1.0; the +'s are for base design, the Δ's are for Alternative A, and the o's are for Alternative B.

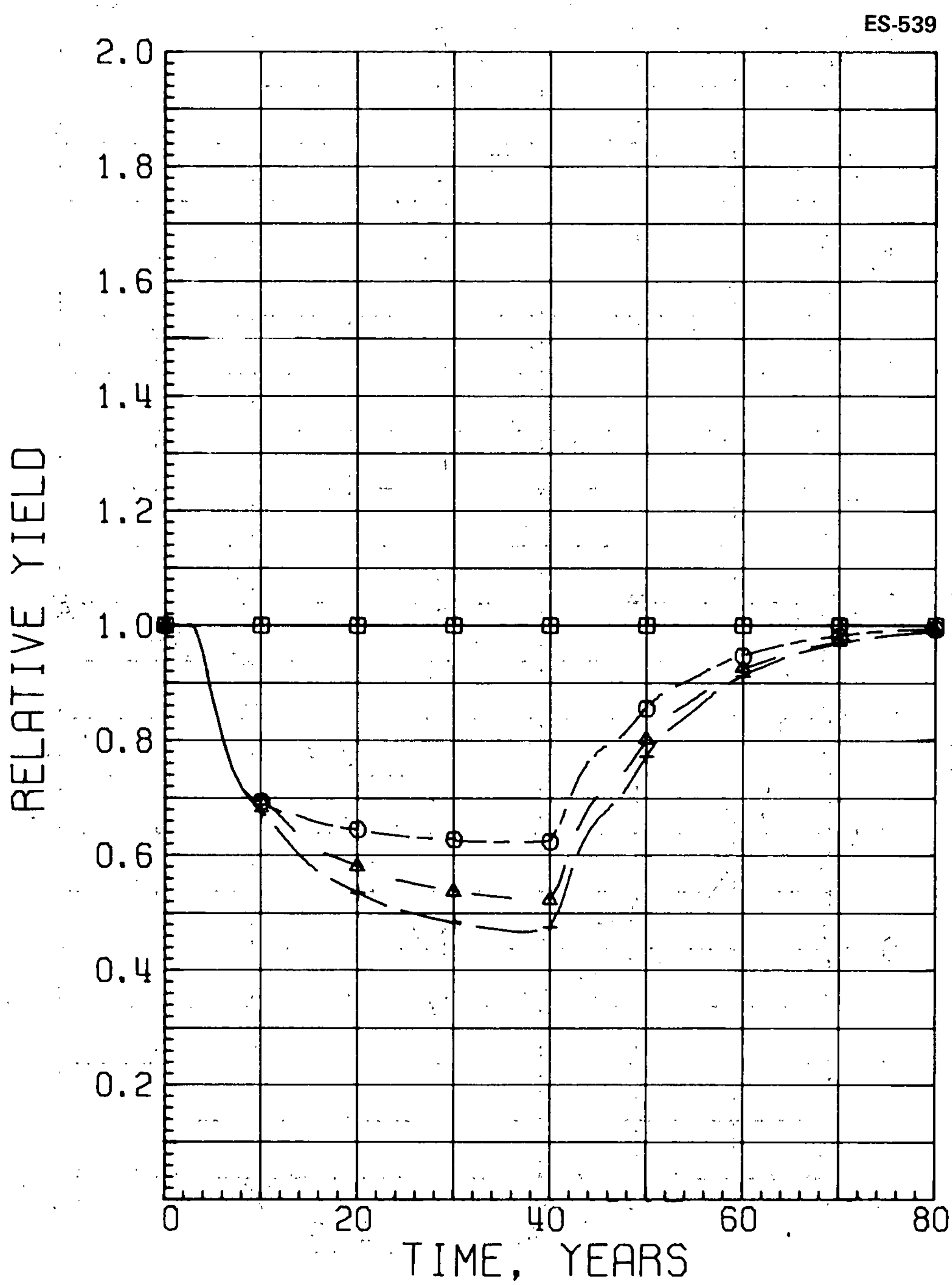

Fig. XI-5. Curves of relative yield vs time for set 1.1; the +'s are for base design, the Δ's are for Alternative A, and the o's are for Alternative B.

Table XI-19. Set 1.1 sport fishery

Present value = (angler days) × (cost per angler day) × (relative yield factor)/$(1 + I)^N$

cost per angler day = $12.99

discount rate (I) = 10%

Year (N)	Hudson River striped bass angler days		Relative yield factors		Present value (1974 dollars) Alternative B		Present value (1974 dollars) Alternative A	
	Minimum	Maximum	Alternative B	Alternative A	Minimum	Maximum	Minimum	Maximum
1974	2247000.	3737000.	0.00	0.00	0.	0.	0.	0.
1975	2286000.	3794000.	0.00	0.00	0.	0.	0.	0.
1976	2312000.	3835000.	0.00	0.00	0.	0.	0.	0.
1977	2336000.	3876000.	0.00	0.00	0.	0.	0.	0.
1978	2362000.	3916000.	0.00	0.00	0.	0.	0.	0.
1979	2388000.	3961000.	0.00	0.00	0.	0.	0.	0.
1980	2416000.	4007000.	0.00	0.00	0.	0.	0.	0.
1981	2443000.	4051000.	0.00	0.00	0.	0.	0.	0.
1982	2473000.	4102000.	0.00	0.00	0.	0.	0.	0.
1983	2501000.	4145000.	0.01	0.01	138000.	228000.	138000.	228000.
1984	2533000.	4199000.	0.02	0.02	254000.	421000.	254000.	421000.
1985	2562000.	4246000.	0.02	0.02	233000.	387000.	233000.	387000.
1986	2593000.	4297000.	0.04	0.03	429000.	711000.	322000.	534000.
1987	2615000.	4337000.	0.06	0.03	590000.	979000.	295000.	490000.
1988	2655000.	4400000.	0.07	0.03	636000.	1054000.	272000.	452000.
1989	2686000.	4451000.	0.08	0.03	668000.	1107000.	251000.	415000.
1990	2717000.	4503000.	0.09	0.04	691000.	1146000.	307000.	509000.
1991	2745000.	4550000.	0.09	0.04	635000.	1052000.	282000.	468000.
1992	2773000.	4597000.	0.10	0.04	648000.	1074000.	259000.	430000.
1993	2802000.	4644000.	0.10	0.04	595000.	986000.	238000.	395000.
1994	2830000.	4691000.	0.11	0.04	601000.	996000.	219000.	362000.
1995	2859000.	4738000.	0.12	0.05	602000.	998000.	251000.	416000.
1996	2887000.	4786000.	0.12	0.05	553000.	916000.	230000.	382000.
1997	2916000.	4834000.	0.12	0.05	508000.	842000.	212000.	351000.
1998	2945000.	4882000.	0.13	0.05	505000.	837000.	194000.	322000.
1999	2974000.	4930000.	0.13	0.05	464000.	768000.	178000.	296000.
2000	3003000.	4977000.	0.13	0.05	425000.	705000.	164000.	271000.
2001	3035000.	5031000.	0.14	0.05	421000.	698000.	150000.	249000.
2002	3068000.	5085000.	0.14	0.05	387000.	641000.	138000.	229000.
2003	3100000.	5139000.	0.14	0.05	355000.	589000.	127000.	210000.
2004	3113000.	5192000.	0.14	0.05	324000.	541000.	116000.	193000.
2005	3165000.	5246000.	0.15	0.05	321000.	533000.	107000.	178000.
2006	3200000.	5304000.	0.15	0.05	295000.	489000.	98000.	163000.
2007	3235000.	5363000.	0.15	0.05	271000.	450000.	90000.	150000.
2008	3271000.	5421000.	0.15	0.05	249000.	413000.	83000.	138000.
2009	3306000.	5479000.	0.15	0.05	229000.	380000.	76000.	127000.
2010	3341000.	5538000.	0.15	0.06	211000.	349000.	84000.	140000.
2011	3376000.	5596000.	0.15	0.06	193000.	321000.	77000.	128000.
2012	3412000.	5655000.	0.16	0.06	190000.	314000.	71000.	118000.
2013	3447000.	5714000.	0.15	0.05	163000.	271000.	54000.	90000.
2014	3483000.	5773000.	0.15	0.05	150000.	249000.	50000.	83000.
2015	3518000.	5831000.	0.14	0.04	129000.	213000.	37000.	61000.
2016	3553000.	5888000.	0.14	0.04	118000.	196000.	34000.	56000.
2017	3587000.	5945000.	0.13	0.04	101000.	167000.	31000.	51000.
2018	3612000.	5989000.	0.12	0.04	85000.	141000.	28000.	47000.
2019	3656000.	6059000.	0.12	0.04	78000.	130000.	26000.	43000.
2020	3690000.	6116000.	0.11	0.04	66000.	109000.	24000.	40000.
2021	3690000.	6116000.	0.11	0.04	60000.	99000.	22000.	36000.
2022	3690000.	6116000.	0.10	0.03	49000.	82000.	15000.	25000.
2023	3690000.	6116000.	0.09	0.03	40000.	67000.	13000.	22000.
2024	3690000.	6116000.	0.08	0.03	33000.	54000.	12000.	20000.
2025	3690000.	6116000.	0.08	0.03	30000.	49000.	11000.	18000.
2026	3690000.	6116000.	0.07	0.03	24000.	39000.	10000.	17000.
2027	3690000.	6116000.	0.07	0.02	21000.	36000.	6000.	10000.
2028	3690000.	6116000.	0.06	0.02	17000.	28000.	6000.	9000.
2029	3690000.	6116000.	0.06	0.02	15000.	25000.	5000.	8000.

Table XI-19 (continued)

Year (N)	Hudson River striped bass angler days: Minimum	Hudson River striped bass angler days: Maximum	Relative yield factors: Alternative B	Relative yield factors: Alternative A	Present value (1974 dollars) Alternative B: Minimum	Present value (1974 dollars) Alternative B: Maximum	Present value (1974 dollars) Alternative A: Minimum	Present value (1974 dollars) Alternative A: Maximum
2030	3690000.	6116000.	0.05	0.02	12000.	19000.	5000.	8000.
2031	3690000.	6116000.	0.05	0.02	10000.	17000.	4000.	7000.
2032	3690000.	6116000.	0.04	0.02	8000.	13000.	4000.	6000.
2033	3690000.	6116000.	0.04	0.01	7000.	11000.	2000.	3000.
2034	3690000.	6116000.	0.03	0.01	5000.	8000.	2000.	3000.
2035	3690000.	6116000.	0.03	0.01	4000.	7000.	1000.	2000.
2036	3690000.	6116000.	0.03	0.01	4000.	6000.	1000.	2000.
2037	3690000.	6116000.	0.03	0.01	4000.	6000.	1000.	2000.
2038	3690000.	6116000.	0.02	0.01	2000.	4000.	1000.	2000.
2039	3690000.	6116000.	0.02	0.01	2000.	3000.	1000.	2000.
2040	3690000.	6116000.	0.02	0.01	2000.	3000.	1000.	1000.
2041	3690000.	6116000.	0.02	0.01	2000.	3000.	1000.	1000.
2042	3690000.	6116000.	0.02	0.01	1000.	2000.	1000.	1000.
2043	3690000.	6116000.	0.01	0.01	1000.	1000.	1000.	1000.
2044	3690000.	6116000.	0.01	0.00	1000.	1000.	0.	0.
2045	3690000.	6116000.	0.01	0.00	1000.	1000.	0.	0.
2046	3690000.	6116000.	0.01	0.00	1000.	1000.	0.	0.
2047	3690000.	6116000.	0.01	0.00	0.	1000.	0.	0.
2048	3690000.	6116000.	0.01	0.00	0.	1000.	0.	0.
2049	3690000.	6116000.	0.01	0.00	0.	1000.	0.	0.
2050	3690000.	6116000.	0.01	0.00	0.	1000.	0.	0.
2051	3690000.	6116000.	0.01	0.00	0.	1000.	0.	0.
2052	3690000.	6116000.	0.01	0.00	0.	0.	0.	0.
2053	3690000.	6116000.	0.01	0.00	0.	0.	0.	0.
2054	3690000.	6116000.	0.00	0.00	0.	0.	0.	0.
***** TOTALS:					13867000.	22991000.	5926000.	9829000.

Table XI-20. Set 1.1 commercial fishery

Present value = (catch in pounds) × (cost per pound) × (relative yield factor)/$(1 + I)^N$
maximum catch = 1,225,900 lb
minimum catch = 438,300 lb
cost per pound = $0.57
discount rate (I) = 10%

Year (N)	Relative yield factors		Present value (1974 dollars) Alternative B		Present value (1974 dollars) Alternative A	
	Alternative B	Alternative A	Minimum	Maximum	Minimum	Maximum
1974	0.00	0.00	0.	0.	0.	0.
1975	0.00	0.00	C.	0.	0.	0.
1976	0.00	0.00	0.	0.	0.	0.
1977	0.00	0.00	0.	0.	0.	0.
1978	0.00	0.00	0.	0.	0.	C.
1979	0.00	0.00	C.	0.	0.	0.
1980	0.00	0.00	0.	0.	0.	0.
1981	0.00	0.00	0.	0.	0.	0.
1982	0.00	0.00	0.	0.	0.	0.
1983	0.01	0.01	1000.	3000.	1000.	3000.
1984	0.02	0.02	2000.	50C0.	2CC0.	5CCC.
1985	0.02	0.02	20CC.	5000.	2000.	5000.
1986	0.04	0.03	3000.	9000.	2CC0.	7CC0.
1987	0.06	0.03	40CC.	12000.	2000.	60C0.
1988	0.07	0.03	5000.	130C0.	2CC0.	60CC.
1989	0.08	0.03	500C.	130C0.	2000.	5000.
1990	0.09	0.04	5000.	140C0.	2CC0.	60CC.
1991	0.09	0.04	40CC.	12000.	2000.	6000.
1992	0.10	0.04	4000.	130C0.	20C0.	50C0.
1993	0.10	0.04	40C0.	110C0.	2000.	5000.
1994	0.11	0.04	40C0.	110C0.	10C0.	4CCC.
1995	0.12	0.05	40C0.	110C0.	2000.	5000.
1996	0.12	0.05	4000.	100C0.	2CC0.	40CC.
1997	0.12	0.05	3000.	90C0.	1000.	4000.
1998	0.13	0.05	30C0.	9000.	1CC0.	40C0.
1999	0.13	0.05	30CC.	80C0.	1000.	3000.
2000	0.13	0.05	3000.	80C0.	10C0.	3C00.
2001	0.14	0.05	3000.	7000.	10C0.	3000.
2002	0.14	0.05	2000.	70C0.	10C0.	2CCC.
2003	0.14	0.05	20CC.	60C0.	1000.	2000.
2004	0.14	0.05	2000.	60C0.	1CC0.	2CC0.
2005	0.15	C.05	2000.	5000.	10C0.	2000.
2006	0.15	0.05	2000.	5000.	1CC0.	20CC.
2007	0.15	0.05	20CC.	5000.	1000.	2000.
2008	0.15	0.05	1000.	40C0.	0.	10C0.
2009	0.15	0.C5	10CC.	4000.	0.	1000.
2010	0.15	0.06	1000.	30C0.	0.	10CC.
2011	C.15	0.06	10CC.	3000.	0.	1000.
2012	0.16	0.06	1000.	30C0.	0.	1000.
2013	0.15	0.05	10C0.	3000.	0.	1000.
2014	0.15	0.05	1000.	2000.	0.	1CC0.
2015	0.14	0.04	10CC.	20C0.	0.	1000.
2016	0.14	0.04	1000.	20C0.	0.	10C0.
2017	0.13	0.04	10CC.	20C0.	0.	0.
2018	0.12	0.04	0.	1000.	0.	C.
2019	C.12	0.04	C.	10C0.	0.	0.
2020	0.11	0.04	0.	10C0.	0.	C.
2021	0.11	0.04	0.	10C0.	0.	0.
2022	0.10	0.03	0.	10C0.	0.	0.
2023	C.09	0.03	C.	1000.	0.	0.
2024	0.08	0.03	0.	0.	0.	0.
2025	0.08	0.03	C.	0.	0.	0.

Table XI-20 (continued)

Year (N)	Relative yield factors		Present value (1974 dollars) Alternative B		Present value (1974 dollars) Alternative A	
	Alternative B	Alternative A	Minimum	Maximum	Minimum	Maximum
2026	0.07	0.03	0.	0.	0.	0.
2027	0.07	0.02	0.	0.	0.	0.
2028	0.06	0.02	0.	0.	0.	0.
2029	0.06	0.02	0.	0.	0.	0.
2030	0.05	0.02	0.	0.	0.	0.
2031	0.05	0.02	0.	0.	0.	0.
2032	0.04	0.02	0.	0.	0.	0.
2033	0.04	0.01	0.	0.	0.	0.
2034	0.03	0.01	0.	0.	0.	0.
2035	0.03	0.01	0.	0.	0.	0.
2036	0.03	0.01	0.	0.	0.	0.
2037	0.03	0.01	0.	0.	0.	0.
2038	0.02	0.01	0.	0.	0.	0.
2039	0.02	0.01	0.	0.	0.	0.
2040	0.02	0.01	0.	0.	0.	0.
2041	0.02	0.01	0.	0.	0.	0.
2042	0.02	0.01	0.	0.	0.	0.
2043	0.01	0.01	0.	0.	0.	0.
2044	0.01	0.00	0.	0.	0.	0.
2045	0.01	0.00	0.	0.	0.	0.
2046	0.01	0.00	0.	0.	0.	0.
2047	0.01	0.00	0.	0.	0.	0.
2048	0.01	0.00	0.	0.	0.	0.
2049	0.01	0.00	0.	0.	0.	0.
2050	0.01	0.00	0.	0.	0.	0.
2051	0.01	0.00	0.	0.	0.	0.
2052	0.01	0.00	0.	0.	0.	0.
2053	0.01	0.00	0.	0.	0.	0.
2054	0.00	0.00	0.	0.	0.	0.
***** TOTALS:			88000.	251000.	37000.	110000.

Table XI-21. Set 1.0 sport fishery

Present value = (angler days) × (cost per angler day) ×
(relative yield factor)/$(1 + I)^N$
cost per angler day = $12.99
discount rate (I) = 10%

Year (N)	Hudson River striped bass angler days		Relative yield factors		Present value (1974 dollars) Alternative B		Present value (1974 dollars) Alternative A	
	Minimum	Maximum	Alternative B	Alternative A	Minimum	Maximum	Minimum	Maximum
1974	2247000.	3737000.	0.00	0.00	0.	0.	0.	0.
1975	2286000.	3794000.	0.00	0.00	0.	0.	0.	0.
1976	2312000.	3835000.	0.00	0.00	0.	0.	0.	0.
1977	2336000.	3876000.	0.00	0.00	0.	0.	0.	0.
1978	2362000.	3916000.	0.00	0.00	0.	0.	0.	0.
1979	2388000.	3961000.	0.00	0.00	0.	0.	0.	0.
1980	2416000.	4007000.	0.00	0.00	0.	0.	0.	0.
1981	2443000.	4051000.	0.00	0.00	0.	0.	0.	0.
1982	2473000.	4102000.	0.00	0.00	0.	0.	0.	0.
1983	2501000.	4145000.	0.01	0.01	138000.	228000.	138000.	228000.
1984	2533000.	4199000.	0.02	0.02	254000.	421000.	254000.	421000.
1985	2562000.	4246000.	0.02	0.02	233000.	387000.	233000.	387000.
1986	2593000.	4297000.	0.04	0.03	429000.	711000.	322000.	534000.
1987	2615000.	4337000.	0.06	0.03	590000.	979000.	295000.	490000.
1988	2655000.	4400000.	0.07	0.03	636000.	1054000.	272000.	452000.
1989	2686000.	4451000.	0.08	0.03	668000.	1107000.	251000.	415000.
1990	2717000.	4503000.	0.09	0.03	691000.	1146000.	230000.	382000.
1991	2745000.	4550000.	0.09	0.03	635000.	1052000.	212000.	351000.
1992	2773000.	4597000.	0.10	0.04	648000.	1074000.	259000.	430000.
1993	2802000.	4644000.	0.10	0.04	595000.	986000.	239000.	395000.
1994	2830000.	4691000.	0.11	0.04	601000.	996000.	219000.	362000.
1995	2859000.	4738000.	0.12	0.04	602000.	998000.	201000.	333000.
1996	2887000.	4786000.	0.12	0.04	553000.	916000.	184000.	305000.
1997	2916000.	4834000.	0.12	0.04	508000.	842000.	169000.	281000.
1998	2945000.	4882000.	0.13	0.04	505000.	837000.	155000.	258000.
1999	2974000.	4930000.	0.13	0.04	464000.	768000.	143000.	236000.
2000	3003000.	4977000.	0.13	0.04	425000.	705000.	131000.	217000.
2001	3035000.	5031000.	0.14	0.04	421000.	698000.	120000.	199000.
2002	3068000.	5085000.	0.14	0.04	387000.	641000.	111000.	183000.
2003	3100000.	5139000.	0.14	0.04	355000.	589000.	102000.	168000.
2004	3113000.	5192000.	0.14	0.04	324000.	541000.	93000.	155000.
2005	3165000.	5246000.	0.15	0.04	321000.	533000.	86000.	142000.
2006	3200000.	5304000.	0.15	0.04	295000.	489000.	79000.	131000.
2007	3235000.	5363000.	0.15	0.04	271000.	450000.	72000.	120000.
2008	3271000.	5421000.	0.15	0.05	249000.	413000.	83000.	138000.
2009	3306000.	5479000.	0.15	0.05	229000.	380000.	76000.	127000.
2010	3341000.	5538000.	0.15	0.05	211000.	349000.	70000.	116000.
2011	3376000.	5596000.	0.16	0.05	206000.	342000.	64000.	107000.
2012	3412000.	5655000.	0.16	0.05	190000.	314000.	59000.	98000.
2013	3447000.	5714000.	0.16	0.04	174000.	289000.	44000.	72000.
2014	3483000.	5773000.	0.16	0.04	160000.	265000.	40000.	66000.
2015	3518000.	5831000.	0.16	0.04	147000.	243000.	37000.	61000.
2016	3553000.	5888000.	0.17	0.05	143000.	237000.	42000.	70000.
2017	3587000.	5945000.	0.17	0.05	131000.	218000.	39000.	64000.
2018	3612000.	5989000.	0.17	0.05	120000.	200000.	35000.	59000.
2019	3656000.	6059000.	0.17	0.05	111000.	184000.	33000.	54000.
2020	3690000.	6116000.	0.17	0.05	102000.	168000.	30000.	50000.
2021	3690000.	6116000.	0.16	0.05	87000.	144000.	27000.	45000.
2022	3690000.	6116000.	0.16	0.05	79000.	131000.	25000.	41000.
2023	3690000.	6116000.	0.15	0.05	67000.	112000.	22000.	37000.
2024	3690000.	6116000.	0.14	0.05	57000.	95000.	20000.	34000.
2025	3690000.	6116000.	0.14	0.04	52000.	86000.	15000.	25000.
2026	3690000.	6116000.	0.13	0.04	44000.	73000.	13000.	22000.
2027	3690000.	6116000.	0.12	0.04	37000.	61000.	12000.	20000.
2028	3690000.	6116000.	0.11	0.04	31000.	51000.	11000.	18000.

Table XI-21 (continued)

Year (N)	Hudson River striped bass angler days		Relative yield factors		Present value (1974 dollars) Alternative B		Present value (1974 dollars) Alternative A	
	Minimum	Maximum	Alternative B	Alternative A	Minimum	Maximum	Minimum	Maximum
2029	3690000.	6116000.	0.11	0.04	28000.	46000.	10000.	17000.
2030	3690000.	6116000.	0.10	0.03	23000.	38000.	7000.	11000.
2031	3690000.	6116000.	0.09	0.03	19000.	31000.	6000.	10000.
2032	3690000.	6116000.	0.08	0.03	15000.	25000.	6000.	9000.
2033	3690000.	6116000.	0.08	0.03	14000.	23000.	5000.	9000.
2034	3690000.	6116000.	0.07	0.02	11000.	18000.	3000.	5000.
2035	3690000.	6116000.	0.07	0.02	10000.	17000.	3000.	5000.
2036	3690000.	6116000.	0.06	0.02	8000.	13000.	3000.	4000.
2037	3690000.	6116000.	0.06	0.02	7000.	12000.	2000.	4000.
2038	3690000.	6116000.	0.05	0.02	5000.	9000.	2000.	4000.
2039	3690000.	6116000.	0.05	0.02	5000.	8000.	2000.	3000.
2040	3690000.	6116000.	0.04	0.01	4000.	6000.	1000.	1000.
2041	3690000.	6116000.	0.04	0.01	3000.	5000.	1000.	1000.
2042	3690000.	6116000.	0.03	0.01	2000.	4000.	1000.	1000.
2043	3690000.	6116000.	0.03	0.01	2000.	3000.	1000.	1000.
2044	3690000.	6116000.	0.03	0.01	2000.	3000.	1000.	1000.
2045	3690000.	6116000.	0.03	0.01	2000.	3000.	1000.	1000.
2046	3690000.	6116000.	0.02	0.01	1000.	2000.	1000.	1000.
2047	3690000.	6116000.	0.02	0.01	1000.	2000.	0.	1000.
2048	3690000.	6116000.	0.02	0.01	1000.	1000.	0.	1000.
2049	3690000.	6116000.	0.02	0.01	1000.	1000.	0.	1000.
2050	3690000.	6116000.	0.02	0.01	1000.	1000.	0.	1000.
2051	3690000.	6116000.	0.01	0.01	0.	1000.	0.	1000.
2052	3690000.	6116000.	0.01	0.00	0.	0.	0.	0.
2053	3690000.	6116000.	0.01	0.00	0.	0.	0.	0.
2054	3690000.	6116000.	0.01	0.00	0.	0.	0.	0.
*****	TOTALS:				14341000.	23775000.	5422000.	8992000.

Table XI-22. Set 1.0 commercial fishery

Present value = (catch in pounds) × (cost per pound) ×
(relative yield factor)/$(1 + I)^N$
maximum catch = 1,225,900 lb
minimum catch = 438,300 lb
cost per pound = $0.57
discount rate (I) = 10%

Year (N)	Relative yield factors		Present value (1974 dollars) Alternative B		Present value (1974 dollars) Alternative A	
	Alternative B	Alternative A	Minimum	Maximum	Minimum	Maximum
1974	0.00	0.00	0.	0.	0.	0.
1975	0.00	0.00	0.	0.	0.	0.
1976	0.00	0.00	0.	0.	0.	0.
1977	0.00	0.00	0.	0.	0.	0.
1978	0.00	0.00	0.	0.	0.	0.
1979	0.00	0.00	0.	0.	0.	0.
1980	0.00	0.00	0.	0.	0.	0.
1981	0.00	0.00	0.	0.	0.	0.
1982	0.00	0.00	0.	0.	0.	0.
1983	0.01	0.01	1000.	3000.	1000.	3000.
1984	0.02	0.02	2000.	5000.	2000.	5000.
1985	0.02	0.02	2000.	5000.	2000.	5000.
1986	0.04	0.03	3000.	9000.	2000.	7000.
1987	0.06	0.03	4000.	12000.	2000.	6000.
1988	0.07	0.03	5000.	13000.	2000.	6000.
1989	0.08	0.03	5000.	13000.	2000.	5000.
1990	0.09	0.03	5000.	14000.	2000.	5000.
1991	0.09	0.03	4000.	12000.	1000.	4000.
1992	0.10	0.04	4000.	13000.	2000.	5000.
1993	0.10	0.04	4000.	11000.	2000.	5000.
1994	0.11	0.04	4000.	11000.	1000.	4000.
1995	0.12	0.04	4000.	11000.	1000.	4000.
1996	0.12	0.04	4000.	10000.	1000.	3000.
1997	0.12	0.04	3000.	9000.	1000.	3000.
1998	0.13	0.04	3000.	9000.	1000.	3000.
1999	0.13	0.04	3000.	8000.	1000.	3000.
2000	0.13	0.04	3000.	8000.	1000.	2000.
2001	0.14	0.04	3000.	7000.	1000.	2000.
2002	0.14	0.04	2000.	7000.	1000.	2000.
2003	0.14	0.04	2000.	6000.	1000.	2000.
2004	0.14	0.04	2000.	6000.	1000.	2000.
2005	0.15	0.04	2000.	5000.	1000.	1000.
2006	0.15	0.04	2000.	5000.	0.	1000.
2007	0.15	0.04	2000.	5000.	0.	1000.
2008	0.15	0.05	1000.	4000.	0.	1000.
2009	0.15	0.05	1000.	4000.	0.	1000.
2010	0.15	0.05	1000.	3000.	0.	1000.
2011	0.16	0.05	1000.	3000.	0.	1000.
2012	0.16	0.05	1000.	3000.	0.	1000.
2013	0.16	0.04	1000.	3000.	0.	1000.
2014	0.16	0.04	1000.	2000.	0.	1000.
2015	0.16	0.04	1000.	2000.	0.	1000.
2016	0.17	0.05	1000.	2000.	0.	1000.
2017	0.17	0.05	1000.	2000.	0.	1000.
2018	0.17	0.05	1000.	2000.	0.	1000.
2019	0.17	0.05	1000.	2000.	0.	0.
2020	0.17	0.05	1000.	1000.	0.	0.
2021	0.16	0.05	0.	1000.	0.	0.
2022	0.16	0.05	0.	1000.	0.	0.
2023	0.15	0.05	0.	1000.	0.	0.
2024	0.14	0.05	0.	1000.	0.	0.
2025	0.14	0.04	0.	1000.	0.	0.
2026	0.13	0.04	0.	1000.	0.	0.

Table XI-22 (continued)

Year (N)	Relative yield factors Alternative B	Relative yield factors Alternative A	Present value (1974 dollars) Alternative B Minimum	Present value (1974 dollars) Alternative B Maximum	Present value (1974 dollars) Alternative A Minimum	Present value (1974 dollars) Alternative A Maximum
2027	0.12	0.04	C.	1000.	0.	0.
2028	0.11	0.04	0.	0.	0.	C.
2029	C.11	0.04	0.	0.	0.	0.
2030	0.10	0.03	C.	0.	0.	C.
2031	C.09	0.03	C.	0.	0.	0.
2032	C.08	0.03	0.	0.	0.	0.
2033	0.08	0.03	0.	0.	0.	0.
2034	0.07	0.02	0.	0.	0.	C.
2035	C.07	0.02	C.	0.	0.	0.
2036	C.06	0.02	0.	0.	0.	C.
2037	C.06	0.02	C.	0.	0.	0.
2038	0.05	0.02	0.	0.	0.	C.
2039	0.05	0.02	C.	0.	0.	0.
2040	0.04	0.01	0.	0.	0.	C.
2041	0.04	0.01	C.	0.	0.	0.
2042	0.03	0.01	0.	0.	0.	C.
2043	0.03	0.01	C.	0.	0.	0.
2044	0.03	0.01	0.	0.	0.	0.
2045	0.03	0.01	0.	0.	0.	0.
2046	0.02	0.01	C.	0.	0.	0.
2047	0.02	0.01	C.	0.	0.	0.
2048	0.02	0.01	0.	0.	0.	0.
2049	0.02	0.01	C.	0.	0.	0.
2050	0.02	0.01	0.	0.	0.	C.
2051	0.01	0.01	C.	0.	0.	0.
2052	0.01	0.00	0.	0.	0.	C.
2053	0.01	0.00	C.	0.	0.	0.
2054	0.01	0.00	C.	0.	0.	C.
***** TOTALS:			91000.	257000.	32000.	100000.

(g) Present Value (1974) of Benefits to the Fisheries

The minimum and maximum present values (1974) of benefits to the sports fishery were calculated by taking, for each year, the product of the minimum or maximum number of Hudson River striped bass angler-days, \$12.99 per angler day, and the relative yield factor for the year and case being computed divided by $(1 + I)^N$, where I = 10% and N = the number of years from year 0 (1974). The summation of present values from year 0 (1974) through year 80 (2054) gave the total present value of benefits to the sports fishery in 1974 dollars for the specific cases being computed.

The staff recognizes that use of this procedure to calculate the present value of benefits to the sport fishery contains the implicit assumption that for all saltwater anglers twelve years and older who catch striped bass, the value of angling is directly proportional to the rate of catch of striped bass. Since other aspects of the saltwater angling experience are also clearly of value (e.g., the catch of other species of fish and the contact with nature), this assumption tends to overestimate the benefit of cooling towers to the sport fishery. Still, this tendency to overestimate will tend to be offset by the facts that (a) the analysis does not incorporate certain aesthetic or ecological values associated with the maintenance of a large striped bass population and (b) the analysis does not consider the effects of Indian Point on other species.

Present values for the commercial fishery were calculated in the same manner except the minimum or maximum catch in pounds was substituted for the number of angler-days and a cost of \$0.57 per pound was substituted for the cost per angler-day.

The results of these calculations are shown in Tables XI-19 to XI-22 and summarized in Table XI-23. These benefits to the striped bass fisheries if cooling towers are installed represent a decrease that would not occur in (a) sport fishermen angler days, (b) sport fishermen catch per unit effort, and (c) yield to the commercial fishery.

The interfacing in this subsection of the staff's life-cycle model, from which the staff has obtained the relative yield factors [Sect. XI.J.2.c(1)(f); also see Sect. V.D.2.d(3)(c)(iv)], with the staff's methodologies involved in estimating the magnitude of the sport fishing effort and the commercial fishing yield [Sects. XI.J.2.c(1)(c) and XI.J.2.c(1)(d), respectively], are preliminary. Further calculations are planned involving (1) computation of relative effort factors and relative catch per unit effort factors in addition to relative yield factors for the sport fishery, and (2) incorporation of options in the life-cycle model itself for a changing (e.g., increasing) fishing effort independent of the size of the striped bass population and for a changing (e.g., increasing) size of the striped bass population independent of fishing effort.

Table XI-23. Benefit to striped bass fisheries if cooling towers are installed on Indian Point Units Nos. 2 and 3 (present value – 1974 dollars)

Fishery	Alternative B		Alternative A	
	Minimum	Maximum	Minimum	Maximum
		Set 1.1		
Sport	13,867,000	22,991,000	5,926,000	9,829,000
Commercial	88,000	251,000	37,000	110,000
Total	13,955,000	23,242,000	5,963,000	9,939,000
		Set 1.0		
Sport	14,341,000	23,775,000	5,422,000	8,992,000
Commercial	91,000	257,000	32,000	100,000
Total	14,432,000	24,032,000	5,454,000	9,092,000

(2) Cooling Tower Cost for the Natural-Draft Tower Alternative for Indian Point Unit No. 3

In-service date: April 15, 1981
Additional capital investment: $93,969,000 (1981 dollars)
Average annual derating: 38 MW
Peak ambient temperature derating: 83 MW
Annual operating cost: $261,000

From Section XI.I.1, the incremental generating cost-present value is $122,080,000 for November 1, 1975. The 1974 present value would then be:

$$\frac{\$122,080,000}{1.10} = \$110,982,000$$

The staff realizes that using the same cooling tower base cost (1978 dollars) as applicable to either Units Nos. 2 or 3 may not be entirely correct as excavation and piping costs, etc., may not be equal. However, as both units have the same rated capacity and in the absence of detailed engineering studies for both units the staff feels that this is a reasonable assumption for comparing benefits with cost.

(3) Benefit-Cost Ratios

Since the purpose of this analysis is to compare the benefits to the Hudson River striped bass fisheries with the incremental generating costs incurred by installing a cooling tower at Unit No. 3, all of the above benefits and costs were calculated as present value — 1974 dollars. To obtain the benefit-cost ratios for a cooling tower at Unit No. 3, the values of the benefits for Alternative A (Unit No. 2 only with cooling tower) must be subtracted from the values of the benefits for Alternative B (Units Nos. 2 and 3 with cooling towers). Referring to Table XI-23, the resultir benefit-cost ratios would be as follows:

Set 1.1

$$\text{Minimum} = \frac{\$13,955,000 - \$5,963,000}{\$110,982,000} = 0.07$$

$$\text{Maximum} = \frac{\$23,242,000 - \$9,939,000}{\$110,982,000} = 0.12$$

Set 1.0

$$\text{Minimum} = \frac{\$14,432,000 - \$5,454,000}{\$110,982,000} = 0.08$$

$$\text{Maximum} = \frac{\$24,032,000 - \$9,092,000}{\$110,982,000} = 0.13$$

The above benefit-cost ratios were calculated in accordance with Senate Document 97 which states that both benefits and costs must be discounted to the present value. In effect, this means that if the applicant would invest some $860,000 to $1,441,000 annually at 10% interest, then funds would be available in future years to pay the fishermen for the fishing experience foregone as a result of the operation of Indian Point Unit No. 3. The monumental task of determining which fishermen should be paid and how much each should receive makes this alternative impractical.

On the other hand, as a matter of comparison it is interesting to note the total dollar benefit compared to the total dollar cost of the tower over the plant lifetime. The total benefits (in constant 1974 dollars) are given in Table XI-24.

Table XI-24. Benefit to striped bass fisheries if cooling towers are installed on Indian Point Units Nos. 2 and 3 (constant 1974 dollars)

Fishery	Alternative B		Alternative A	
	Minimum	Maximum	Minimum	Maximum
		Set 1.1		
Sport	238,553,000	395,463,000	86,649,000	143,642,000
Commercial	1,380,000	3,920,000	496,000	1,442,000
Total	239,933,000	399,383,000	87,145,000	145,084,000
		Set 1.0		
Sport	301,505,000	499,800,000	97,244,000	161,191,000
Commercial	1,712,000	4,844,000	544,000	1,575,000
Total	303,217,000	504,644,000	97,788,000	162,766,000

The Unit No. 3 cooling tower costs in 1974 dollars would be:

$$C_I = \frac{\$111,648,000}{(1.10)^{5.5}} = \$66,098,000$$

$$O_t = \frac{\$261,000}{(1.10)^{5.5}} \times 24.5 = \$3,786,000$$

$$P_t = \frac{\$3,271,000}{(1.10)^{5.5}} \times 24.5 = \$47,445,000$$

$$\text{Replacement power for cut-in work} = \frac{\$79,335,000}{(1.10)^{5.5}} = \$46,968,000$$

$$\text{Less thermal standard } P_t \text{ saved}^* = \frac{\$4,309,000 \times 13}{1.10} = -\$50,925,000$$

$$\text{Less impingement costs} = (\$294,091 - \$147,049)\ 24.5 = -\$3,603,000$$

Total = $109,769,000 (1974 dollars)

*Thermal standard P_t saved is the cost saved due to not needing to reduce power to avoid exceeding New York State thermal criteria.

Benefit-Cost Ratios

Set 1.1

$$\text{Minimum} = \frac{\$239,933,000 - \$87,145,000}{\$109,769,000} = 1.39$$

$$\text{Maximum} = \frac{\$399,383,000 - \$145,084,000}{\$109,769,000} = 2.32$$

Set 1.0

$$\text{Minimum} = \frac{\$303,217,000 - \$97,788,000}{\$109,769,000} = 1.87$$

$$\text{Maximum} = \frac{\$504,644,000 - \$162,766,000}{\$109,769,000} = 3.11$$

On total cost basis this comparison produces benefit-cost ratios greater than unity and would justify the installation of a cooling tower at Unit No. 3. However, this is not the generally accepted discounting method.

In presenting a benefit-cost analysis for a project such as the one examined here, it should be made clear that the individuals who would receive the benefits are not necessarily the same as those who would pay the costs. In the present case, the benefits of installing cooling towers would accrue to striped bass fishermen while the costs would be borne by the applicant's electric power customers, or, putting it another way, the benefits of once-through cooling will accrue to the applicant's customers and the costs to the fishery will be paid by the striped bass fishermen. The use of the benefit-cost technique assumes that a project is economically justified if the benefits, to whomsoever they may accrue, exceed the costs, where both benefits and costs are of course discounted to the present value.

Further, it should be pointed out that the present approach of treating each new plant on the Hudson River as a separate benefit-cost or risk-cost exercise contains a bias against preserving the environment. This approach conceivably could result ultimately in the virtually complete destruction of the Hudson River striped bass population; still, for each new plant the benefits of cooling towers (or whatever measures were taken) would be calculated to be less than the costs (or risks) because the incremental (fractional) damage to the striped bass population would be less with each additional power plant. But, beyond some point, society is likely to conclude that further deterioration of the striped bass population is intolerable.

The staff feels that the classical benefit-cost analysis presented above gives ratios that are low because of three reasons:

a. It does not include benefits to other fish species except those impinged species that can be quantified.

b. The cost per angler day of $12.99 used for the sport fishery may be low by a factor of 4.6.

c. It does not include the intangible value of the nonconsumptive enjoyment of fish.

Other species were not included, as estimates of entrainment mortality would require the development of young-of-the-year and life-cycle models which time and funding will not permit. Species other than striped bass will certainly be affected and those spared by the installation of a cooling tower would have a monetary value that would increase the benefit-cost ratios.

As a result of general dissatisfaction with the arbitrary values assigned to fish and wildlife in Senate Document 97, Supplement No. 1, the Southeastern Association of Game and Fish Commissioners, backed by the U.S. Fish and Wildlife Service, the U.S. Forest Service, and the Tennessee Valley Authority, determined in 1968 to underwrite a study to reconsider these values.[60] This study,[61] completed in March 1974, found that saltwater fishing was valued higher per day (an average of $59.80) by participants than any other type of fishing. Had this value been used in the staff's analysis, the benefit to the sport fishery and the benefit-cost ratios would have more than quadrupled.

This same study found the intangible benefits of fish and wildlife resources in the southeast — the nonconsumptive enjoyment of fish, animals, and birds — to be greater in value than that of fishing and hunting combined. Had the intangible benefits to the fish been included in the analysis, they too would have increased the benefit-cost ratios.

The one factor that contributes the most to an unfavorable benefit-cost ratio for the fisheries is the capital outlay required to bring the cooling tower to operation. The fish have no offsetting capital outlay unless the administrative expenditures for fish management by federal and state agencies are considered. Also, monies spent by private industry to reduce the pollution in the Hudson River and enhance aquatic life would be negated in part by the operation of Unit No. 3 with a once-through condenser cooling system. Another way of putting it would be that the fish would continue to benefit from management, conservation, and pollution abatement funds already expended if a cooling tower is installed at Unit No. 3.

A very important consideration in weighing the various benefit-cost ratios calculated above is the possibility that the additional effect of once-through cooling at Indian Point Unit No. 3 (added to the effects of Indian Point Units Nos. 1 and 2 plus the other power plants on the river) will be the "straw that broke the camel's back" is a risk which cannot be lightly overlooked. The adult model indicates full recovery of the fishery after cessation of the operation of the plants on the river. However, the model may not be an accurate representation of the dynamics of the striped bass population with respect to large perturbations [see App. B, Sect. B.4.c.(7)(c)]. It is possible that if the insult of the power plants exceeds some maximum value for long enough, the Hudson River spawned striped bass population will not fully recover. Rather, it may seek some new lower equilibrium value.

It is the staff's position that the number of years the striped bass population is forecast to be less than 50% of its original size before the power plant impact is an index of the risk of irreversible damage to the population. This risk and the extent of irreversible damage cannot be more rigorously quantified. Furthermore, there are no generic guidelines as to what risk and extent of irreversible damage is acceptable or unacceptable to society. Such decisions are a matter of judgment. It is the staff's judgment that for the base design and Alternative A (with or without Cornwall), the risk of irreversible damage to the Hudson River spawned striped bass population is of sufficient concern that the long-term operation of Indian Point Unit No. 3 with once-through cooling is unacceptable.

(4) Summary and Conclusions of the Economic Impact of the Indian Point Plant on the Hudson River Spawned Striped Bass Fisheries

The methodology used to determine the benefits to the fisheries is comprised of a combination of staff model results, assumptions regarding the zones of influence of the Hudson River spawned striped bass, population projections, and statistics on salt-water fishermen published by the Department of the Interior and the 1970 Salt-Water Angling Survey. Therefore, the results should not be misconstrued as being absolute values but understood that they are subject to the same sampling variability as the original statistical data and confidence limits on the model output. The staff, however, feels that the benefit values obtained are a fair representation for the purposes of this economic impact analysis.

Two sets of benefit-cost ratios were computed. The first set discounted both benefits and costs to 1974 and the second set used constant 1974 dollars summed without discounting. Only the first set, which is the accepted method, had ratios less than one. This set then indicates that, as far as the striped bass population is concerned, a cooling tower for Unit No. 3 cannot be economically justified. However, there are other factors that must be considered in the decision-making process. They are:

a. The benefits to other species are not included in the analysis.

b. The cost per angler day used in the analysis is an estimate of actual expenditures. A recently published study conducted in the southeast gives an estimate of what the saltwater fisherman would be willing to pay rather than forego the fishing experience.[60] This per day value is 4.6 times the cost per angler day used in the striped bass analysis.

c. This same study in the southeast found the intangible value of nonconsumptive enjoyment of fish to be greater than the tangible value of fishing.

d. Once-through cooling would negate a portion of the benefits gained from conservation funds already expended in the development of fish populations.

e. The risk involved in assuming that the staff's model gives an accurate representation of the river ecology with respect to large perturbations.

It is the judgment of the staff that the additional benefits from the above factors would be sufficient to increase the benefit-cost ratios to unity or above and that a cooling tower for Unit No. 3 is economically justified. The previously estimated average cost to the consumer of 0.3 mill/kWhr would increase the average monthly electric bills of consumers as follows:

Classification	Average Monthly Increase
(Based on 1973 average consumption and declining block rates)	
Residential	$0.11
Commercial and Industrial	$1.28
Other	$33.18

These increases amount to less than 1% in each of the three classifications and would provide $12,950,000 of additional annual revenue. This amount seems almost insignificant when compared to the applicant's 1974 request for an increase of $422,600,000 which resulted in two increases totaling about $338,700,000 of additional annual revenue.[62] Furthermore, commercial operation of Unit No. 3 will permit the applicant to retire some fossil units and reduce the output of others. The resulting savings in unit production costs would more than offset the 0.3 mill/kWhr required to amortize the incremental increase in generating cost for the cooling tower.

d. Interim Biological Damage

The date of January 1, 1978, for installation of a cooling tower at Unit No. 2 was recommended by the staff in the FES for Indian Point Unit No. 2 based on: (1) a judgment that the potential impact on the Hudson River spawned striped bass population due to the operation of Indian Point Units Nos. 1 and 2 with once-through cooling required that the duration of the interim period prior to installation of a cooling tower at Unit No. 2 be minimized and (2) estimates of time required to design and build a cooling tower. The Licensing Board modified the date to May 1, 1978, and the Appeal Board later modified the date to May 1, 1979. It is the staff's opinion that operation of Units Nos. 1 and 2 with once-through cooling for six striped bass entrainment seasons (1973-1978), while undesirable, is necessary in view of the need for power, and it is not likely to have any permanent effect on the striped bass population or fishery. [In the staff's judgment the 1973 entrainment season (May 15 to July 31) must be counted as a year that both Indian Point Units Nos. 1 and 2 were in operation with respect to impact on the striped bass population.] Entrainment mortality is primarily due to the mechanical stress associated with passage through the plant and secondarily due to thermal stress [see Section V.D.2.b.(2)(d)]. Thus, impact on the striped bass population is primarily a function of the volume of water passing through the plant and secondarily a function of the ΔT. Unit No. 1 averaged 24% and Unit No. 2 averaged 39% of full flow during the entrainment season (May 15 to July 31).[57a]

The staff expects that Unit No. 3 will be in full power operation before the 1975 spawning and entrainment periods. The date of September 15, 1980 is proposed by the staff for the cessation of once-through cooling for this unit based on estimates of time required to design and build a closed-cycle cooling system. Although the operation with once-through cooling for this five-year period will result in damage to the striped bass and other fish species, the staff believes that this environmental cost is warranted on the basis of the need for power. That is, the staff believes that the additional cost of obtaining replacement power during this interim period outweighs the societal value of the cumulative damage which will be done to the striped bass or other fisheries because of the operation with once-through cooling during five entrainment seasons. For example, Carter[58] estimates the incremental cost of obtaining replacement power for Unit No. 2 (via fossil-fuel generation through delay of retirement of old units) for the period 1972-1977 to be about $\$87 \times 10^6$ (1973 dollars). This calculation assumes operating Unit No. 2 for about six months each year. In the preceding section (Table XI-23), it was shown that the total integrated value of the increased yield of the striped bass fishery due to installation of cooling towers at Units Nos. 2 and 3 ranged from $\$6$ to $\$26 \times 10^6$ (1974 dollars). Thus, considering that only a small fraction of the total integrated damage will occur during the interim period, in a strict benefit-to-cost sense, the added costs of alternative power are considerably greater than the benefits to the fishery even if the value of the fishery is considerably underestimated.

Of course, the real question is whether once-through operation during the interim period will cause irreversible damage to the striped bass fishery. If the striped bass population were to be reduced to a low value for a sufficient period of time, there is a possibility that the population would not fully recover following removal of the stress. Such apparently irreversible changes have been observed in fish populations in Lake Erie, as was pointed out in Sect. V.D.2.d(3)(c)(iv).

However, the staff believes that it is very unlikely that the effect of Units Nos. 2 and 3 operating with once-through cooling during the interim period, in addition to Unit No. 1 and the Bowline, Lovett, Roseton and Danskammer Plants, will cause such an irreversible change. Thus, the staff believes that the risk involved with interim operation is acceptable.

This interim period is sufficiently long to permit the applicant time to complete its ecological research program. The results of this research, which should be available before breaking ground for a cooling tower for Unit No. 3, may help better quantify the impact of Indian Point and other power plants on the young-of-the-year striped bass and on other fish species.

However, the staff believes that this interim operating regime is ecologically undesirable and that the applicant must develop and implement, prior to commercial operation of Indian Point Unit No. 3, a Plan of Action. This Plan of Action should include operating procedures and design modifications to the once-through cooling system that will substantially reduce immediate and observable adverse effects, particularly entrainment and impingement, to a practicable minimum during the interim period prior to installation of a closed-cycle cooling system. The plan shall include means of minimizing: (1) entrainment of phytoplankton, zooplankton, and fish eggs, larvae, and juveniles; (2) impingement of fish on the intake structure; (3) thermal shock; (4) thermal discharges; (5) chemical discharges; (6) decreases of dissolved oxygen below 4.5 ppm; and (7) radioactive discharges in accordance with 10 CFR 50. The plan will complement the Environmental Technical Specifications which set forth a number of specifications to assure protection of the environment during the interim period and compliance with applicable water quality standards. The specifications are designed to limit and monitor nonradiological and radiological effluent releases and provide for a surveillance study to determine short-term effects, including any observable changes in aquatic life in the Hudson River that may be due to operation of the three Units with the once-through cooling system.

K. CONCLUSIONS

From review and evaluation of the applicant's Environmental Report and supplements thereto, and from independent observations and analyses discussed in this Statement, the Regulatory staff has reached the following conclusions concerning the need for power and the environmental impacts of operation of Unit No. 3 simultaneously with Units Nos. 1 and 2:

1. Unit No. 3 is needed for the additional base-load capacity required to generate annually 6.26×10^9 kWhr electrical energy on the average out of a total of 48.5×10^9 kWhr required of the applicant's service system in 1980.

2. There are no viable alternatives capable of economically producing electrical energy equivalent to the capability of Unit No. 3 other than the creation of new base-load generating capacity.

3. Under certain conditions outlined in Section V.C, Units Nos. 1, 2, and 3, operating simultaneously with once-through condenser cooling systems, will probably exceed the New York State thermal criteria for discharge of heated effluent to the Hudson River; the staff's best estimate is that these conditions will occur for 30 consecutive days in at least nine years out of every ten; however, the staff's most optimistic estimate of one year out of every two years was used in the benefit-cost analysis (see Section V.C.1.b(3)).

4. The staff's evaluation remains in disagreement with the applicant's assessment on the key issue of the extent of damage from once-through cooling to the young-of-the-year striped bass population and, subsequently, to the adult striped bass population. The primary reasons for the difference in model predictions of the impact on the striped bass population are the values selected for the intake f factor f_I and for compensation.

   (a) The staff's analysis of field data supports a f_I value of less than 1.0 but not less than 0.5 for striped bass eggs, larvae and nonscreenable juveniles at Indian Point, Bowline, Lovett, Roseton, and Danskammer. These values were used in sensitivity runs of the staff's young-of-the-year striped bass model. Upon careful examination of all available data, the staff cannot agree with the applicant's very low values for the intake f factor.

   (b) From the staff's point of view, the major issue in controversy on the topic of natural compensation is not the concept of natural compensation nor whether it is occurring and will continue to occur to some degree. Rather, the major issue is the extent to which the parties rely on compensatory decreases in natural mortality to offset the increased mortality due to Plant operation. Given that applicant has not and will not be able to quantify the degree of natural compensation, the staff has assumed that natural compensation of early life stages and older age classes is not likely to be of major importance in offsetting the increased mortality due to the power plants. However, the staff has included a compensation function in its young-of-the-year model in order to determine the effects of changes in the compensation parameters on the results of the model used to assess the impact of Plant operation on the striped bass young-of-the-year population. On the other hand, considering that: (1) fishing mortality appears to be a more important source of mortality than natural causes for adult striped bass once they enter the fishery; (2) the striped bass sport catch substantially exceeds the commercial catch; and (3) the fishing effort, particularly the sport fishing effort, is dependent in part on the size of the striped bass population, the staff assumed that the combined fishery will respond in a compensatory manner, with or without new fishing regulations, so as to partially offset the increased mortality due to the power plants. On the basis of this assumption, the staff has included a density dependent, fishing-mortality function in its life-cycle model.

5. Based on the staff's thorough analysis of the results of the applicant's research program, on the results of the analysis of impacts from the staff's young-of-the-year striped bass model and the new life-cycle model, the staff concludes that a significant yearly reduction in the striped bass young-of-the-year is likely to occur from operation with once-through cooling. The predicted effects of Indian Point alone are appreciable, and the combined effects of Indian Point, Roseton, Bowline, Lovett and Danskammer power plants are very extensive. The staff, however, believes that during the short term (less than five years) the risk of doing irreversible damage to the Hudson River spawned striped bass population because of operation with once-through cooling is sufficiently small to be acceptable, provided appropriate environmental monitoring and mitigating measures are taken by the applicant to minimize the biological damage.

6. The results of the staff's striped bass life-cycle model indicate that the impacts from operation with once-through cooling each year during the spawning season will likely be reflected in comparable long-term significant reductions in the yields in the Hudson River spawned striped bass population. The cumulative effects of operation of Indian Point and the other power plants on the Hudson River can decrease the striped bass population yield substantially and for long periods of time. Although the probability that irreversible damage to the striped bass population will occur cannot be estimated with certainty, the risk increases with the magnitude of reduction of the striped bass population and with increases in the length of the time that the population will be substantially reduced. Therefore, the staff has concluded that the risk of causing severe and permanent ecological damage to the Hudson River spawned striped bass population in the Hudson River, western half of Long Island Sound, New Jersey Coast, New York

Bight, and New England regions, by long-term (beyond five years) operation of Units Nos. 2 and 3 with once-through cooling, in concert with Unit No. 1 and the other power plants on the river, is unacceptable. This is particularly true because the fish population present in the Hudson River, such as the striped bass, are resources valuable to the present and future generations of our country.

7. The applicant's ecological studies, designed to provide only two years of postoperational data from Units Nos. 2 and 3, cannot demonstrate long-term impacts. Long-term field studies would have to last through several generations (i.e., years) of fish species of importance in order to predict accurately long-term impacts of once-through cooling, but by that time unacceptable damage may have occurred. However, the applicant's studies have the potential for determining short-term effects of the once-through cooling system and for assuring that the short-term impacts will be kept to an acceptable limit. Furthermore, these studies may be of value in further quantifying the intake factor f_I and in providing data for validating ecological models that are useful in predicting long-term, as well as short-term, impacts on the striped bass population. The applicant will be able to complete its ecological studies prior to commencement of construction of alternate cooling system.

8. Based on information presently available from the applicant and other sources, replacement of striped bass by stocking the Hudson River from fish hatcheries cannot be accepted as a feasible method of replacing all of the striped bass the staff expects the Plants will kill during operation with once-through cooling over the lifetime of Units Nos. 1, 2, and 3.

9. Alternatives to the applicant's proposed method of once-through cooling operation are available which would result in a sizeable reduction of long-term aquatic environmental impacts, primarily on the Hudson River spawned striped bass population, without jeopardizing the needed base-load capacity and reliability of the applicant's service system in the New York area. A balancing of generating costs and environmental costs and risks indicates that operation of Units Nos. 2 and 3 with closed-cycle cooling (i.e., costing the consumer in the applicant's service system about 0.3 mills per kWhr based on natural-draft cooling towers), is preferred over the once-through cooling system over the long term. The staff evaluation indicates that this alternative mode of cooling operation will significantly reduce the

biological damage, including the number of fish impinged and ichthyoplankton entrained, and will significantly reduce thermal discharges to the river.

10. In the short term (e.g., the next five years, which is the staff's estimate of the time required to design and install an alternative cooling system), the benefits of meeting an urgent need for power in the New York area outweigh the estimated corresponding environmental costs incurred over this short time period. The need for power for the metropolitan New York area has been demonstrated in terms of the decreasing reserve margins and increasing frequency of brownouts during peak load periods of the past several summers. Indian Point Unit No. 3 will add needed new baseload capacity to the applicant's system and improve the reliability of service in the metropolitan New York area.

11. The aesthetic benefits from installing Unit No. 3 transmission lines and other existing transmission lines underground from the Plant to Buchanan substation are insufficient to justify the higher capital costs required.

12. Installation of modified radioactive waste treatment facilities will be needed by May 1, 1975, or by initial criticality, whichever occurs later, to assure that radioactive releases will be kept "as low as practicable" and that adequate process monitoring of all principal release points will be required in accordance with criterion 64 of Appendix A of 10 CFR 50 and Regulatory Guide 1.21.

13. The impact of fuel transportation on the environment under normal or postulated accident conditions is not considered to be sufficient to justify the additional cost of alternatives.

14. The environmental effects associated with the uranium fuel cycle are sufficiently small so as not to affect the cost-benefit balance of operation of Unit No. 3.

L. RECOMMENDATIONS

On the basis of the evaluation and analysis set forth in this Statement and after weighing the environmental, economic, technical, and other benefits against environmental costs and risks and considering available alternatives, the staff concludes that the action called for under the National Environmental Policy Act of 1969 (NEPA) and the former Appendix D to 10 CFR 50, is the issuance of an operating license for Indian Point Unit No. 3, subject to the following conditions for the protection of the environment:

1. <u>License Conditions</u>

(a) Operation of Indian Point Unit No. 3 with the once-through cooling system will be permitted until September 15, 1980, subject to the terms and conditions of the stipulation reached by the parties, and, thereafter, a closed-cycle cooling system will be required.

(b) Evaluation of the economic and environmental impacts of alternative closed-cycle cooling systems shall be made by the applicant in order to determine a preferred system for installation. This evaluation shall be submitted to the U.S. Nuclear Regulatory Commission for approval in accordance with the conditions of the stipulation reached among the parties.

(c) Installation of modified radioactive waste treatment facilities will be needed by May 1, 1975, or by initial criticality, whichever occurs later. Radiological process monitoring of all principal release points will be required in accordance with Criterion 64 of Appendix A of 10 CFR 50, by May 1, 1975, or by initial criticality, whichever occurs later.

(d) The applicant shall operate Indian Point Unit No. 3 within applicable Federal and State air and water quality standards and the Environmental Technical Specifications which will include nonradiological and radiological monitoring programs, limits on effluent releases, an appropriate comprehensive ecological surveillance study, and reporting requirements.

(e) The applicant shall develop a Plan of Action of operating procedures and design modifications of the once-through cooling system for Indian Point Unit No. 3 in order to take corrective actions to minimize detrimental effects on aquatic biota in the Hudson River to a practicable minimum during the interim period prior to installation of a closed-cycle cooling system. The Plan shall include means of reducing thermal shock; impingement on the intake structure; entrainment of fish eggs, larvae, and plankton; chemical and thermal discharges; and loss of dissolved oxygen below 4.5 ppm; and shall include other mitigating measures available. The Plan shall be submitted to the U.S. Nuclear Regulatory Commission one month after receipt of the operating license, and upon approval by the Commission, the Plan shall be implemented so as to eliminate or substantially reduce such adverse effects as are revealed by the monitoring and ecological surveillance study program presented in the Environmental Technical Specifications for once-through cooling.

2. Significant Environmental Technical Specification Requirements

The Technical Specifications will include the following:

(a) Measurement of entrainment mortality of aquatic organisms after passage through the condenser by using sampling procedures which will permit statistically valid estimates of that mortality during the first year of Plant operation; and measurement of eggs and larvae concentration in the vicinity of the Indian Point intakes of the river to determine statistically valid values for the intake f_I factor during two spawning seasons.

(b) Throughout the period of once-through cooling, determination of the number, species, and sizes of fish collected on the screens and trash racks of the intake structures by using sampling procedures which will permit statistically valid estimates of that mortality, and estimation of the number of fish killed on the screens but are forced off into the river by backflushing the screens and are not collected.

(c) Based on the foregoing determinations, an analysis of the biological significance of impingement and entrainment mortality in relation to fish population in the river; to be reported annually and then revised each year depending on new data obtained during once-through cooling operation.

(d) Measurement of concentrations of total residual chlorine, free and combined, at the point of discharge into the river during each chlorination period during the first year of Plant operation; thereafter, the amount used will be controlled to assure concentrations of total residual chlorine released will not exceed 0.5 ppm. The study to evaluate effects of chlorine residuals and chlorinated compounds on aquatic biota in the vicinity of Indian Point shall be continued for one year after Plant operation begins.

(e) Measurement of concentration of dissolved oxygen in the vicinity of Indian Point and determination of the significance of effects of any low concentration levels during two years of once-through cooling operation.

(f) Measurement of concentrations of heavy metals, especially copper and chromium (VI), at the point of discharge into the river during the first year of Plant operation.

(g) Measurement of radiation levels of radioactive releases and radionuclide content of samples exposed to radioactive releases from the reactors through a radiological environmental monitoring program during the lifetime of Plant operation.

(h) Measurement of concentrations of radioiodine in fresh milk obtained from cows pastured on nearby dairy farms as part of the radiological environmental monitoring program during the lifetime of Plant operation.

(i) Measurement of temperature of thermal discharges at the outfall during the summer months and determination during the first three years of Plant operation of the size, shape, and location of isotherms of the thermal plume with different freshwater flows over complete tidal cycles during different seasons of the year to demonstrate compliance with the New York State thermal criteria at all times of the year, particularly during periods of anticipated potential violations of the State's limits, and to verify thermal models to predict future plume behavior under different seasonal and tidal influences.

(j) Determination of the effects of thermal discharges on biota during different life stages during Plant operation with once-through cooling.

(k) Determination of any changes in aquatic life in the Hudson River during operation of the Plant with once-through cooling.

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54b. Deuel, D. G. 1973. 1970 Salt-Water Angling Survey. U.S. Dept. of Commerce, NOAA, National Marine Fisheries Service, Current Fishery Statistics No. 6200.

55. U.S. Department of Commerce, National Oceanic and Atmospheric Administration and National Marine Fisheries Service, "1970 Salt-Water Angling Survey," pp. 9, 16, April 1973.

56. Koo, T. S. Y., "The Striped Bass Fishery in the Atlantic States," *Chesapeake Science* 11(2): 73-93 (1970).

57. Lawler, J. P., "Economic Evaluation of the Impact of Indian Point Unit 2 Operation on the Middle Atlantic Fishery" (before the USAEC on February 20, 1973), Docket No. 50-247, p.26.

57a. Texas Instruments, Inc., "Indian Point Impingement Study Report for the Period June 15, 1972 through December 31, 1973," draft copy, prepared for Consolidated Edison, July 1974.

58. Testimony of C. M. Carter, "Indian Point Unit No. 2, Benefit-Cost Analysis of Alternate Operating Modes for the Period 1973 through 1977," Docket No. 50-247, Feb. 9, 1973.

59. *Peekskill Evening Star*, "Few Sparks Light Hearing on New Consolidated Edison Lines," May 23, 1973, p. 35.

60. Sport Fishing Institute, Washington, D.C., "SPI Bulletin No. 258," September 1974.

61. Environmental Research Group, Georgia State University, Atlanta, Georgia, "Southeastern Economic Survey of Wildlife Recreation," March 1974.

62. Consolidated Edison Company of New York, "Report to Stockholders," December 15, 1974.

XII. RESPONSES TO COMMENTS ON THE DRAFT ENVIRONMENTAL STATEMENT FOR INDIAN POINT UNIT NO. 3

A. INTRODUCTION

Pursuant to paragraphs A.6 and C.1 of the former Appendix D to 10 CFR 50, the Draft Environmental Statement for Indian Point Unit No. 3 was transmitted with a request for comment by December 10, 1973, to:

- Advisory Council on Historic Preservation
- Department of Agriculture
- Department of the Army, Corps of Engineers
- Department of Commerce
- Department of Health, Education, and Welfare
- Department of Housing and Urban Development
- Department of the Interior
- Department of Transportation
- Environmental Protection Agency
- Federal Power Commission
- Governor of the State of New York
- New York State Agencies
  - Atomic Energy Council
  - Department of Commerce
  - Department of Environmental Conservation
  - Department of Public Service
- Westchester County Department of Planning
- Mayor of the Village of Buchanan

In addition, the AEC solicited comments due by December 10, 1973, on the Draft Environmental Statement from interested persons by a notice published in the *Federal Register*.[1]

Comments in response to the requests to the above were received from:

- Department of Agriculture (AGR)
- Department of Commerce (COM)
- Department of Health, Education, and Welfare (HEW)
- Department of the Interior (DOI)
- Department of Transportation (DOT)
- Environmental Protection Agency (EPA)
- Federal Power Commission (FPC)
- New York State Department of Environmental Conservation (DEC)
- New State Attorney General's Office (AGO)
- Hudson River Fishermen's Association (HRFA)
- Save Our Stripers (SOS)

Consolidated Edison Company of New York, Inc. (ConEd)
Federated Conservation of Westchester County, Inc. (FCWC)
Rockland Conservation Association, Inc. (RCA)
Environmental Defense Fund (EDF)
North Brookhaven Sport Fishermen's Club, Inc. (NBSFC)
Great South Beach Mobile Sportfishermen (GSBMS)
West Branch Conservation Association (WBCA)
Connecticut Coastal Anglers Association (CCAA)
Mr. Kenneth E. Bay
Mrs. Harold Cooper
Mr. Don McLean
Mr. John Nicholas, Jr.
Mr. Robert J. Rance
Mr. Dennis Zaccardi

The staff consideration of comments received and the disposition of the issues involved are reflected in part by revised text in other sections of this Final Environmental Statement and in part by the following discussion. The comments below are exact quotations excerpted from the full comments which are included in this Statement as Appendix I.

B. <u>DEPARTMENT OF AGRICULTURE (AGR) (1/4/74)</u>

1. <u>Comment</u>: (Forest Service)

Little adverse effect on vegetation is anticipated from construction and use of Plant No. 3. If once-through cooling does not meet thermal criteria (V-7-17), however, cooling towers (Alternate B) may be used (XI-14). Salt drift from tower plumes (Appendix G 12-15) will probably affect nearby vegetation. We trust that vegetation will be included in the studies mentioned on Page G-14, par. 7.

<u>Response</u>:

Phases 2 and 3 of the program to study the effects of salt drift from the cooling tower at Chalk Point Unit 3 will consist of field measurements on the land environments. Field studies on the assessment of possible air pollution injury and sodium and chloride ion concentrations in leaves of tree species near the Chalk Point area are being carried out. Effects of salt sprays on the yield and nutrient balance in corn and soybeans are under investigation.

In addition, the applicant has been supporting a research program at the Boyce Thompson Institute on the effects of salt spray deposition on vegetation indigenous to the Hudson

River Valley. The Environmental Technical Specifications support the applicant's efforts to determine threshold values for physiological damage to the most susceptible species of vegetation in the site and surrounding areas of Indian Point.

2. Comment: (Forest Service)

As an indirect effect of running the plant, there will be a large amount of uranium ore (116000KG) (P.IX-4) processed. What is the effect on vegetation of the air pollution resulting from ore enrichment?

Response:

The Commission has addressed this problem as indicated in the document[2] "Environmental Survey of the Nuclear Fuel Cycle." The primary source of environmental impacts associated with the enrichment of uranium is related to the generation of the required electric power. At present, the supply of electricity comes from coal-fired stations. This report discusses the emission rates of effluents from a typical 1000-MWe coal-fired power station and the quantities of effluents emitted by the power plant in support of the production of an annual uranium fuel requirement for a model light water reactor.

3. Comment: (Soil Conservation Service)

Page IV-1 - A. SUMMARY OF CONSTRUCTION STATUS - 4th line

It says, "after which this plant went critical on May 22, 1973." The word critical can be read to imply an unintended meaning. For the ordinary reviewer, clarification of the word critical is needed.

Response:

The text has been revised. The word critical as used in the nuclear energy field refers to the condition when the fissioning of uranium-235 or other fissionable isotope becomes a self-sustaining chain reaction.

4. Comment: (Soil Conservation Service)

Page IV-1 - A

We note that Unit No. 3 is presently under construction and is 80% completed. Completion is expected in 1974.

Response:

Construction of Indian Point Unit No. 3 should be completed in the early part of 1975. The expected fuel loading date is April 1, 1975.

5. Comment: (Soil Conservation Service)

Page IV-1 - B. IMPACTS ON LAND USE I. Onsite Construction

4th paragraph and the three following paragraphs on page IV-2 seem to say landscaping and vegetative measures are delayed because of construction. In this situation, temporary use of vegetative measures such as grasses and legumes would be appropriate. This might be discussed.

Response:

Between one-third to one-half of the site has not been disrupted by construction activities. Most of the areas cleared for construction use will continue to be in use until construction is completed. Temporary measures such as planting of grasses and legumes might be appropriate after sections of the site become cleared of debris. Once construction has been finished, the entire site will be landscaped, and construction equipment and debris will be removed and disposed of by the contractors.

C. DEPARTMENT OF COMMERCE (DOC)(11/26/73, 12/10/73)

1. Comment (11/26/73):

With regard to the release of routine radioactive wastes to the atmosphere, it is not clear whether the major portion of the releases are sporadic or continuous. In the case of sporadic releases, the application of an annual average atmospheric dilution factor is inappropriate. For example, the gaseous processing system, which is the primary source of radioactivity, involves a minimum gaseous holdup time of 45 days in decay tanks. If this is followed by release to the atmosphere in a few hours, we would consider the source to be sporadic.

Response:

The release rate of radioactive gaseous waste to the atmosphere will be governed by the limits specified in the Technical Specifications for Unit No. 3 as well as for Units Nos. 1 and 2. The staff assumes the release will occur over a period of days and, therefore, the annual average dispersion factor is used.

On May 31, 1973, the Commission held a meeting with the National Oceanic and Atmospheric Administration of the Department of Commerce to discuss (1) the frequency and period of release of so-called routine gaseous effluents from hold-up tanks and containment purge and (2) the applicability of annual average relative concentration values to sporadic releases. For controlled batch releases, the use of annual average concentration values will be acceptable to the Department of Commerce since the applicant will be required through the Technical Specifications to release the gases, on the average, under favorable meteorological conditions (i.e., equal to or better than the annual average) under normal operation. In addition, for uncontrolled but expected releases, the meteorological assumption as stated in the proposed Annex to the former Appendix D of 10 CFR 50 would apply instead of the annual average. The assumption is that the χ/Q value should be one-tenth of the value using the graph in Regulatory Guide 1.4. This value is routinely determined by the staff. At the 350-meter site boundary, the χ/Q value is 3.8×10^{-4} sec/m^3.

2. Comment (12/10/73):

The radiological monitoring program, which is described in condensed form, does not include the analysis of benthic animals (page V-138 to V-139). In the subject report, reference is made to the applicant's Environmental Report, which also does not include benthic animals. The program will be modified in the Technical Specifications, but these modifications are not described.

The environmental monitoring section of the subject report should include a summary table giving monitoring details and a location map.

Response:

The Environmental Technical Specification Requirements for Units Nos. 1 and 2 (Appendix B to Facility Operating License DPR-26 for Unit No. 2) require seasonal sampling of macrobenthos and measurement of gross beta-gamma activity. These requirements will also be applied to Unit No. 3. Details of the radiological environmental surveillance program, including a map of the sampling locations, are presented in Table V-40 of Section V.E.2.e of this Statement.

D. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE (HEW) (11/30/73)

1. Comment:

Indian Point Nuclear Generating Plant, Unit 3 is the third of three reactor plant installations to be constructed and operated on the same site. Units 1 and 2 are already constructed and in operation. The draft statement includes consideration of the cumulative effect of all three reactors in operation.

Response:

This Statement includes an environmental assessment of the benefits and costs of Indian Point Unit No. 3 in conjunction with those for Units Nos. 1 and 2 and thus includes the cumulative effects of all three reactors in operation. In addition, the cumulative effects of existing fossil power plants on the Hudson River along with those from the Indian Point Plants are considered in this Statement.

2. Comment:

From information contained in this draft statement, it appears that this third unit can be constructed and operated without undue health impact on the population as a result of radiation exposures or discharges of radioactivity to the environment. The report notes that in order to meet the AEC "as low as practicable" criteria, it will be necessary to modify the radioactive waste treatment facilities. The report prescribes a date of spring 1975 to accomplish completion of this modified radioactive waste treatment facility. This is an appropriate recommendation.

Response:

The applicant has described in its Environmental Report the modifications to its radioactive waste system and these modifications have been further described in this Statement in Section V.E.1.

On November 6, 1973, the staff informed the applicant that the modifications of its radioactive waste system would have to be installed and ready for operation by May 1, 1975. The staff's assessment indicates that with these modifications, the radioactive waste system will meet the Commission's "as low as practicable" guidelines.

3. Comment:

The report discusses doses to the population which might reasonably be expected from an incident occurring at the reactor site. The derivation of these doses and the postulation of the types and frequency of incidents which might occur appear reasonable. The projected doses are not excessive; in fact, based on the estimates and calculations in the report, doses to individuals at the site boundary would be well below the maximum permissible doses derived from 10 CFR Part 20 of the AEC Regulations for normal operations. The estimated dose to populations within a 50-mile radius of the site would be a small fraction of the population dose from natural background, as expressed in man-rems.

Response:

In Chapter VI of this Statement, the staff has pointed out the radiation doses to the population living within 50 miles if an incident should occur at the reactor site. The conclusions reached agree with those reached by HEW in which the realistically estimated radiological consequences of the postulated accidents would result in exposure of an assumed individual at the site boundary to concentrations of radioactive materials that are comparable to or within the Maximum Permissible Concentrations of 10 CFR 20. The Table VI-2 also shows the estimated integrated exposure of the population within 50 miles of the Plant from each postulated accident. Any of these integrated exposures would be much smaller than that from naturally occurring radioactivity.

4. Comment:

Section V.E.1.d states that the solid wastes will eventually be shipped to a licensed burial facility. The specific burial site may not yet have been identified and such burial sites may be covered by other impact statements, but it is suggested that a discussion of the capacity of burial sites to handle the material from this plant, perhaps as a percentage of existing burial site capacity, be included in this statement.

Response:

The subject of the disposal of solid wastes containing either high or low level of radioactivity, is addressed in the Commission's publication,[2] "Environmental Survey of the Nuclear Fuel Cycle." The applicant can ship its solid radioactive wastes to Allied Gulf Nuclear Services in Barnwell, South Carolina. See Section V.F for further details on the transportation of these wastes to this facility. The Commission also licenses such facilities and will license burial facilities. At the present time there are six commercial land burial sites in operation in the United States. The total area of these sites is approximately 600 acres. However, not all of this land is available for actual burial of wastes since some of the land area is needed for support facilities, pre-burial storage, etc. The land available for burial of wastes at existing sites is adequate for the current generation of radioactive waste by the fuel cycle industry. The current requirement for the storage of both high-level and other than high-level wastes generated in the fuel cycle is about 1.0-1.5 acres annually for a model 1000-MWe LWR. At the present time, there is no requirement for a Federal storage facility for long-term storage of solidified high-level wastes generated as a result of fuel reprocessing operations. However, by 1980, it is expected that a retrievable surface storage facility will be under construction for storage of solidified high-level wastes. Meanwhile, the high-level wastes in a combination of liquid and solid forms, would be stored at the fuel reprocessing facilities without significant environmental effects until the Federal repository is completed and available for storage of wastes during the next decade. Management of commercial high-level radioactive wastes is discussed in the AEC statement "Management of Commercial High-Level and Transuranium-Contaminated Radioactive Waste."[3]

5. Comment:

Exposures from transportation of radioactive materials to and from the plants is discussed. These are very small exposures and are based on realistic assumptions. The question of transportation accidents is discussed, but in very general terms. However, the discussion is adequate and as concise as is possible based on the current information from the history of transportation accidents.

Response:

The subject of transportation accidents and the exposure doses the population would receive in the unlikely event of transportation accidents is presented in Section VI.B of this Statement. Many more details of this subject are described in the Commission's publication,[4] "Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants."

6. Comment:

Considering the protection of fish, fish food at the plant site, it is recommended that the applicant study alternatives to the presently designed once-through cooling system for the plant—namely, the use of cooling towers in order to reduce the volumes of water pumped from the river and entraining fish. The applicant is told to design and install an alternate cooling system within the next four years to remedy this situation. This appears to be a sound recommendation.

Response:

This comment concurs with the staff's recommendation that the applicant install an alternative closed-cycle cooling system to reduce the volume of water withdrawn to remedy significant long-term impacts of once-through cooling. The details of the impacts are presented in Chapter V and the benefit-cost analysis of the once-through cooling system versus closed-cycle cooling systems is presented in Chapter XI and Appendix G. The timing of the installation of the alternative cooling system is also discussed in Appendix G.

E. DEPARTMENT OF THE INTERIOR (DOI)(12/13/73)

1. Comment:

Timing of the Closed-Cycle Cooling System - The regeneration cycle of many fish species of importance to sport and commercial fishing interests is long; for example, the striped bass require about 6 years. If the closed-cycle cooling system for Units 2 and 3 are not operating prior to May 1, 1978, the effects of once-through cooling would be experienced by striped bass and other aquatic organisms in the Hudson River through 1984. These effects could be devastating. We strongly recommend that AEC reconsider this deadline of May 1, 1978.

The applicant has been fully aware for years of the general concerns for adverse impacts on aquatic life, including those of the Atomic Energy Commission. It does not appear to be in the public interest to delay the closed-cycle operation of Units 2 and 3 until 1978 if there is a reasonable possibility that such a system could be operating prior to this date.

Our letter of December 4, 1972,* to you recommended the installation of closed-cycle cooling for Unit 2 by July 1, 1975. It appears to us that if appropriate action had been undertaken at that time Unit 3 could have begun its closed-cycle operation by the summer of 1976 rather than two years later.

Every effort should be made to minimize unnecessary further damage to the fishery resources of the Hudson River. Consideration should be given to requiring interim operation standards to be implemented at Indian Point. Criteria have been developed for the operation of the Bowline Point Generating Station downstream and across the river from Indian Point, which are designed to reduce the mortalities associated with impingement and entrainment during peak periods of fish activity in the area. Bowline Point criteria could be used as a model for criteria to be applied at Indian Point.

Response:

The staff has responded in part to this comment in Chapter XI and Appendix G. The acceptability of the operation of Units Nos. 1, 2, and 3 with once-through cooling for an interim period has been evaluated (Section XI.J.2.d). The staff balanced the need for power against the intensity and duration of the impact on the aquatic biota and concluded that an operating license should be granted to the applicant for operating Unit No. 3 with once-through cooling up to September 15, 1980, provided certain conditions and precautions be taken into account during the interim period of operation to limit the impact to a practicable minimum for protection of the environment. In Chapter X in this Statement, the staff assessed the need for power generated from Unit No. 3 along with Units Nos. 1 and 2 in order to maintain the health and welfare of the present and future populations in the New York area. Unit No. 3 is expected to generate commercial power by 1975. However, the applicant will operate the once-through cooling system of Unit No. 3 through six entrainment periods (May 15 through July 31, 1975–1980), and operation shall stop after completion of the summer power peak demand period in 1980. During the

*This date should be June 29, 1972.

interim period, any immediate and short-term impacts will be limited by the Environmental Technical Specification and a Plan of Action. The Environmental Technical Specifications, which will be appended to the Facility Operating License, will define the limits on effluent releases to assure protection of the environment. The releases will be monitored and ecological surveillance studies will also be carried out to observe any immediate effects of once-through cooling operation. The applicant will also be required to implement a Plan of Action for reducing detrimental effects on aquatic biota during the interim period before the installation of a closed cycle cooling system. For example, the applicant is considering a common intake structure for all three Units which would reduce the velocity at the intake screens and thereby mitigate the problem of fish impingement (see Sect. XI.E).

In addition, the subject of restricted operation for certain time periods depending on impingement and entrainment effects during the interim period was under consideration in the hearing for Unit No. 2. After a cost-benefit analysis was carried out for the 1973-1977 interim period, the staff concluded that the costs of restricting operation during this period would not be warranted, and thus no specific time period was set aside for restricted operation beyond that already required by the New York State Department of Environmental Conservation and the Environmental Technical Specifications (60% flow when river temperatures are 40°F).

In reference to the criteria for operation of the Bowline Point Generating Station during peak periods of fish activity in the area, a consent decree was entered into to settle an action brought by the Hudson River Fishermen's Association against Orange and Rockland Utilities and Consolidated Edison Company. However, the applicant has reported that it is effective only through 1974 in which the two Bowline units will operate one-third cooling water flow during the striped bass spawning period (May 20–July 31).

As the Department of the Interior points out, because of the long generation time of six years for striped bass, the impacts of once-through cooling will begin to show up six years later. The staff has taken this effect into account in its life-cycle model discussed in Section V.D.2.d(3)(c)(iv) and Appendix B, Section B.4.c(7). The ecological study program as required by the Environmental Technical Specifications will serve to study the short-term impacts and will assure that the environment will be protected as much as practicable during once-through cooling operation of Unit No. 3 up to September 15, 1980.

Although the Department of the Interior did recommend an earlier date of July 1, 1975, for installation of a closed-cycle cooling system for Unit No. 2 and points out that such a system could be operational at Unit No. 3 by the summer of 1976 if appropriate action had been undertaken, the staff believes meeting these earlier suggested dates is impractical. For one thing, the Atomic Safety and Licensing Board issued its Initial Decision[5] relative to Indian Point Unit No. 2 on September 25, 1973, and specified the date of May 1, 1978, for termination of the once-through cooling system. This date was based on the schedule for design and construction of the closed-cycle cooling systems which is summarized in the Initial Decision.

The applicant took exception to the Initial Decision before the Appeal Board. On April 4, 1974, the Appeal Board ordered the schedule for termination of once-through cooling of Unit No. 2 be delayed until May 1, 1979. This was based on the applicant's construction schedule. See Appendix G for further details of the construction schedule for cooling towers at Units Nos. 2 and 3. This schedule permitted a year or more of environmental studies, including meteorological tests and studies involving the effects of the plume and salt drift from a closed-cycle cooling system. An environmental report on alternative cooling systems was submitted to the AEC on December 1, 1974, as ordered through the Appeal Board's decision[6] for the purpose of selecting the preferred alternative cooling system.

2. Comment:

The Site - this section should be expanded to include a description of the existing and future proposed steam electric generating facilities which will be constructed by the utilities including the proposed pump storage project at Storm King. Other agencies such as the New York City Transit Authority have proposed development of additional steam electric power plants. The City of New York is considering diversions of water for municipal and industrial purposes. Descriptions of these existing and future proposed projects are necessary to adequately describe the cumulative impacts of man's use of the Hudson River estuary.

Response:

Other major steam-electric generating facilities on the Hudson River have been considered in evaluating the effects of thermal discharges (App. A) and the effects of impingement and entrainment (Chapters V and XI and Appendix B). The staff has also evaluated the potential effects of the Cornwall (Storm King) pumped storage plant. This evaluation is complicated by the intermittent nature of the Cornwall plant operation. See response to comment No. 10 by the New York State Department of Environmental Conservation for further details on the impacts of the Cornwall Project. Detailed information on other proposed generating facilities on the Hudson River, such as that proposed by the New York City MTA, is not available for any assessment of environmental impacts at this time.

3. Comment:

Geology and Geography - the brief description of geology and geography, presented on pages II-15 and II-16, is inadequate for evaluating whether the geologic and seismic conditions and the physical properties of the natural materials on which the plant is founded have been investigated in sufficient detail. The history of earthquakes in the region has been briefly summarized by the seismic-design criteria for plant construction and the methods of their derivation are not included. This inadequacy could be alleviated if the geology and seismology have been taken into account according to AEC's "Seismic and Geologic Siting Criteria for Nuclear Power Plants" (10 CFR 100, Appendix A, *Federal Register*, Vol. 36, No. 228, Nov. 25, 1971). If this has been done we suggest that it be indicated along with a reference to the AEC Criteria.

Response:

The subjects of geology and seismology of the site are treated in depth as safety items and presented in Section 2 of the Safety Evaluation Report for Indian Point Unit No. 3, dated September 21, 1973, and the Supplement 1 to the Safety Evaluation Report as well as the Final Facility Design and Safety Analysis Report. The AEC's seismic and geological siting criteria for nuclear power plants were used to evaluate the adequacy of the geological and seismological aspects of the site. The U.S. Coast and Geodetic Survey (now NOAA) and U.S. Geological Survey have used the siting criteria to evaluate the applicant's design bases for protecting against any earthquake disturbances. See response to comments Nos. 16–18 by the New York State Department of Environmental Conservation on this same subject.

4. Comment:

Macroinvertebrates – Compared with extensive detail found in sections dealing with fish species, plankton, etc., the benthic section on macroinvertebrates and benthic organisms appears to be deficient. We suggest that this section recognize that due to pollution control programs, the quality of the water has improved in recent years. This is evident by the reappearance of blue crabs in the lower Hudson River in the vicinity of Indian Point.

Response:

An appropriate addition has been made in Sect. V.D.2.d.

5. Comment:

Impacts of Station Operation on Land Use – We have been aware of the applicant's intentions of providing recreation opportunities on its site for some time. It is indicated on page V-2 that a Master Land Use plan has been developed for the plant site and that the 80-acre woodland recreational facility will be available for public use. We are pleased with this planning and suggest that a description of these plans, including a timetable for implementation should be included in the final statement.

Response:

The plan has been described by the applicant (ER, IP-2, Sect. 7). The plan was originally scheduled for completion in 1973. Recent information from the applicant indicates that "while site restoration, construction of the training facility, and construction of the simulator and the Visitors Center are underway, complete implementation of this plan will be contingent on the completion of construction of Unit No. 3" (ER, IP-1, Sect. 16). Construction of the visitors' center should be completed by the latter half of 1974.

6. Comment:

Effects on Historical Landmarks – No existing or proposed units of the National Park System will be adversely affected by the proposal. It does not appear that any site registered as a National Historic Natural, or Environmental Education Landmark or any site listed as eligible for such registration will be adversely affected. We are pleased that evidence exists of consultation with both the Advisory Council on Historic Preservation and the State Historic Preservation Officer both of which reveal an effort to comply with Section 106 of the National Historic Preservation Act of 1966 and Executive Order 11593.

Response:

The Advisory Council, the State Historic Preservation Officer, the applicant, and the staff have been in contact with each other regarding any impacts affecting present and future historical sites and landmarks caused by the Indian Point Plants in compliance with Section 106 of the National Historical Preservation Act of 1966 and pursuant to Executive Order 11593 of May 31, 1971. With the Indian Point Plants operating with once-through cooling, no impacts on historical sites should occur. No access routes to the historical sites use any portion of the Indian Point site. Power transmission lines associated with Indian Point Plants do not interfere with public land and cross only one public road (Broadway) immediately east of the Plant. Construction activity at the Indian Point site has revealed no evidence of items having archaeological value. However, the State Museum and Science Service, State Education Department, has noted archaeological sites at Montrose Point (shell middens), Georges Island, Oscawana Island, Croton Neck, and Kettle Rock Points. None of these sites are impacted by the facilities at Indian Point.

As stated in Chapters V and XI of this Statement, the requirement for operation with an alternative closed-cycle cooling system could have an adverse impact on the local national historical landmarks. An adverse visual impact could result on historical sites if natural-draft cooling towers were to be the alternative closed-cycle cooling system required for Unit No. 2 after May 1, 1979, and for Unit No. 3 after September 15, 1980. However, it is doubtful that the existing plant structure can be seen from the Stony Point Battlefield located 2 to 3 miles from Indian Point on the west bank of the Hudson. Thus, it is expected that the existing structure will have very little, if any, additional impact on visitations to this historical site or to others farther away.

7. Comment:

Thermal Effects on Water Uses — Anticipated impacts of thermal effluents on aquatic biota in the Hudson River appear to have been exhaustively analyzed. However, little or no information is included in the effect of the raised water temperature on other uses of the river water upstream and downstream from Indian Point, particularly at points between 90 and 120 miles downstream of Troy, New York. It is recognized that the effects will be partially inseparable from those of other power plants such as the Lovett and Bowline fossil-fuel plants, and that the effects would presumably not be significant after May 1, 1978, when a closed-cycle cooling system would become operational. However, it is suggested that assurances be given that thermal effects evaluated in the statement include effects on other industrial uses of the water, particularly the important use of the water as a coolant.

Response:

When all three Units at Indian Point are operating with once-through cooling and the effects of other power plants are considered, the average temperature of the Hudson River in about a 10-mile reach at Indian Point may at times be increased up to 4 F° over what it would have been without operation of the Indian Point Plant (see Chapter V). Industries and other users of process water will be adversely affected due to either slightly higher process temperatures or increased water circulation requirements. The effect will be most pronounced during July and August when river freshwater flow rates are low and the ambient river temperatures are highest. The staff believes it reasonable to assume that most users have processes that are sufficiently insensitive, or have sufficient cooling capacity margin, to accommodate this change with little inconvenience or cost. However, a complete survey and analysis of all process water uses in the affected reach of the river is not readily available and without such information the hardships, if any, as a result of raising the river temperature cannot be accurately estimated. Once closed-cycle cooling systems are in operation, thermal effects from the Indian Point Plants should be minimal.

8. Comment:

Cumulative Impacts — We believe it imperative, when considering impacts on fish and wildlife resources, that all units operating or planned on the Hudson River estuary be considered. The fishery loss associated with steam-electric power plants withdrawing water from the river should be discussed more thoroughly. Such an overall analysis of impacts would be more informative than a discussion of only the Indian Point Nuclear Generating Station's impacts.

The principal emphasis of the biological impacts have related to the effects on striped bass resources. Many pages of testimony have been presented, both pro and con, as to the significance of thermal pollution, chemical impacts, entrainment, and impingement on the resources of the Hudson River. Much of this testimony is centered on whether or not installation of a closed-cycle cooling system is necessary to prevent unacceptable adverse effects on the striped bass population. The AEC has recognized and we concur that the effects on other species are equally as important although not as much information has been presented.

Response:

The effects of the other major steam-electric power plants are considered in the analysis of the effects of entrainment of fish eggs and larvae. The discussion of impingement effects has been expanded to include the effects of these other plants. Furthermore, the Corps of Engineers is sponsoring a study to investigate the cumulative effects of the various power plants and other facilities on the Hudson River. See Comment DOI-2. Additional discussion of effects on other species has been added to Chapter V.

9. Comment:

Transmission Facilities — It is stated on page V-4 that chemical treatment shall be used only after consultation with recognized experts in this type of work. Since no specific chemicals are mentioned, it must be emphasized that the applicant should consult the Environmental Protection Agency, the New York Department of Environmental Conservation and the Bureau of Sport Fisheries and Wildlife of this Department when chemical control of vegetation or pests is contemplated.

Response:

The staff agrees that the applicant should consult the appropriate State and Federal agencies prior to chemical treatment to control vegetation or pests in transmission corridors.

10. Comment:

Sampling Methods — Three important considerations which tend to reduce the reliability of the fish count studies of impinged fish are discussed on page V-36. We suggest that a fourth factor be considered. The data collected in substantiation of air curtain use are suspect because, as pointed out by HRPC in their letter of July 16, 1973, to Consolidated Edison, the air curtain creates a positive outflow away from the screen. Fish which have already been damaged or killed by impingement are thus moved out into the river rather than onto the traveling screens to be enumerated. We understand that the applicant has designed studies to determine the extent of this problem.

Response:

An appropriate addition has been made in Section V.D.2.a. The applicant's impingement projections are based on collection data for Unit No. 1 from December 1970 to March 1972. The air curtains were extended across all four bays of Unit No. 1 and have been available for operation since December 1, 1972 (ER, IP-3, App. BB, p. 41). However, Unit No. 1 was shut down from December 31, 1972, to January 18, 1974, and the air curtains have been operated only intermittently during 1973. The projections were thus, presumably, not biased by air curtain effects.

11. Comment:

It appears that the AEC staff has evaluated extensively the studies and study techniques accomplished at Indian Point. However, it appears that the efficiency of gear used in capturing various species of larvae, juvenile and adult fishes by various consultants who have worked on the river should receive additional consideration. Certain types of gear such as beach seines to enumerate striped bass may be found to be inappropriate.

Response:

The staff agrees with this comment, and a section on ichthyoplankton sampling has been added to Chapter V (Section V.D.2.e).

12. Comment:

Due to the recognized detrimental environmental impacts of chlorine on the aquatic environment, consideration should be given to the elimination of this element from power plant effluents. Although an alternative biocide system is discussed on page XI-50, the feasibility of this alternative at Indian Point 3 is not given. We are aware that the discharge of chlorine after the closed-cycle cooling system is in operation will be greatly reduced.

Response:

The applicant will be required to monitor the concentration of residual chlorine at the point of discharge and determine the effects on aquatic biota. The applicant is investigating ways and means to reduce concentrations and frequencies of use of chlorine. Present estimates of this effect are not sufficiently serious to warrant requiring the backfitting of an alternate biocide system. As yet, the applicant has not firmed up the selection or need for a biocide for a closed-cycle cooling system. However, any residual chlorine discharged in the blowdown will be monitored and diluted with the circulating water from the Unit No. 1 condenser system. The applicant will be required to meet the water quality standards for residual chlorine.

13. Comment:

Solid Radioactive Wastes — The solid radioactive wastes are described as evaporator concentrates from the liquid waste processing system along with spent resins, filter sludges, air filters, miscellaneous paper and rags. It is estimated that about 1,000 drums, having an estimated total activity of approximately 4,900 curies, will be shipped offsite annually to a licensed burial facility at Morehead, Kentucky. We think that the impact evaluation would be greatly improved if it specified the kinds of radionuclides, their physical states, their concentrations in wastes, and the estimated total volume of wastes for the expected operating life of the plant.

We also suggest that the statement include an evaluation of the ultimate disposal sites for all radioactive wastes generated by Unit 3. The statement should also include Federal and State Licensing provisions, criteria, and responsibilities for the site in regard to: (1) determination of the hydrogeologic suitability of the site to isolate the wastes of the Indian Point Station from the biosphere; (2) surveillance and monitoring of the site; and (3) any remedial or regulatory actions that might be necessary during the period in which the wastes will be hazardous.

Response:

Based on our evaluation of similar type of reactors and data from operating reactors, we estimate that approximately 4900 Ci/year will be shipped from the site in drums. Greater than 90% of the radioactivity associated with the wastes will be long-lived fission and corrosion products, principally Cs-134, Cs-137, Co-58, Co-60, and Fe-55.

The concerns expressed in this comment are appropriately addressed in the AEC document "Environmental Survey of the Nuclear Fuel Cycle."[2] As noted in that document, the environmental effects of the entire uranium fuel cycle with regard to an individual reactor are small. Further, the potential for any significant effect from the disposal of solid radioactive wastes from a reactor is extremely limited due to (1) the small quantity of radioactive material contained in the wastes and (2) the care taken in establishing and monitoring commercial land burial facilities. Commercial land burial facilities must be located on land which is owned by a state or the Federal government, and after radioactive wastes are buried at a site the land must not be used for any other purpose. Authorization to operate a commercial land burial facility is based on an analysis of nature and location of potentially affected facilities and of the site topographic, geographic, meteorological, and hydrological characteristics which must demonstrate that buried radioactive waste will not migrate from the site. Environmental monitoring includes sampling of air, water, and vegetation to determine migration, if any, of radioactive material from the actual location of burial. To date, there have been no reports of migration of radioactive material from commercial burial sites. In the event that migration were to occur, plans for arresting any detected migration have been developed. On the basis of the general environmental considerations of burial sites now developed, the wide range of wastes that can be buried, and the observation that an applicant is not restricted to a specific burial site, the staff believes that a detailed discussion of solid radioactive waste disposal sites is inappropriate to an environmental statement for any one nuclear power plant facility. See Comment HEW-4.

14. Comment:

Major Accidents — The environmental effects of Class 9 accidents which would result in both air and water releases of radioactive materials should be described along with the potential impacts on human life and the remaining environment as long as there is any possibility of occurrence. The consequences of an accident of this severity could have far-reaching effects on land and in the Hudson River estuary which could persist for centuries affecting millions of people.

The recent bulging of the steel liner for the containment used at Indian Point Unit No. 2 dramatically displays the significant problems associated with nuclear plants and also the very real potential for major accidents.

Response:

The initial results of such an accident have been presented in the Rasmussen Reactor Safety Study.[7]

In regard to the bulging of the steel liner of the containment building at Indian Point Unit No. 2, the problem has been resolved and it does not appear to present a significant safety question as the leak integrity of the barrier (which is not a structural member) was maintained. The bulging of the liner resulted after the failure of a main feedwater pipe to the steam generator occurred on November 13, 1973, primarily because of a water hammer. Analysis indicates that the feedwater piping failed during unrestrained rebound from a fixed restraint located at an elbow near the containment. A report analyzing the problems at Indian Point Unit No. 2 has been prepared. The incident did not pose a threat to public health and safety. Several tests were performed to ensure containment integrity after the incident. The tests included a special leakage test of the containment liner integrity at full postulated accident pressure and magnetic particle examination of the entire bulge area prior to, during, and subsequent to the pressure leak test. Other measurements were also made, including those during the leak test. All tests demonstrated that the liner, including the bulge section, performed as analyzed and that at no time prior to, during, or after the test was the integrity of the liner violated and that the liner is well within its original design capabilities to withstand the effects of a design basis LOCA and to contain the radioactive material which might be released to containment from such an accident. This occurrence is not related to a Class 9 accident.

15. Comment:

The second sentence, paragraph 2, page XI-51 should read 0.5 fps rather than 0.5 ppm.

Response:

This error has been corrected.

16. Comment:

Environmental Costs — The Pollution Committee of the American Fishery Society, Southern Division, in 1970 published a report entitled, "Monetary Values of Fish," which described cost of fish replacement. Although these values do not reflect the true environmental costs, they may be useful in arriving at a minimal dollar value of fish resources impacted by power plants. As an example, replacement costs for white perch range from 5 cents per fish, 1 inch long up to 60 cents per fish, 12 inches long. These values are more appropriate to use than values of adult fish to the sport and commercial harvest because of problems relating to estimating the survival of fishes through various life history stages and the value of fish which have been incorporated into food webs. They would be of much more value than those values included in Table XI-15 which places a relative value on the magnitude of resource losses.

Response:

The staff agrees with this comment. An estimate of the monetary loss to the striped bass fishery has been added to Chapter XI (see Sections XI.I.1 and XI.J.2.c).

17. Comment:

Footnote a. [Table A-6] indicates that the river temperature at the mouth is 70°F. Data compiled by NOAA in National Ocean Survey publication 31-1, "Surface Water Temperature and Density for North and South America" indicates that the mean monthly-temperature near the Battery for the months of July and August have been 71.4°F and 73.2°F, respectively.

Response:

Although the calculated temperatures at Indian Point are not very sensitive to the temperature of the river at the Battery, the staff agrees that the input data for the far-field analysis should have been as representative as possible and that 73 to 74°F would have been a better assumption than 70°F. The results presented in Chapter V and Appendix A have been revised using a temperature of 74°F at the mouth of the river. For Case 1-a, this change raised the maximum and average calculated tidal temperatures at Indian Point by about 0.1 F°.

F. DEPARTMENT OF TRANSPORTATION (DOT)(12/3/73)

Comment:

The Department of Transportation has reviewed the material submitted. We have no comments to offer nor do we have any objection to the project.

Response:

No response is necessary.

G. ENVIRONMENTAL PROTECTION AGENCY (EPA)(12/10/73)

1. Comment: RADIOLOGICAL ASPECTS

Radioactive Waste Management Systems - The radioactive waste treatment systems for all three units at the Indian Point site are to be intertied with the planned modifications to the Unit 1 liquid waste management system. Therefore, it has been necessary for us to include consideration of all three units in our review. The existing liquid and gaseous waste treatment systems for Indian Point Units 1, 2, and 3 are not capable of limiting radioactive discharges to levels that are consistent with the provisions of 10 CFR Part 50 and Regulatory Guide 1.42, since there is no provision for treating effluents from the steam generator blowdown from all three units and no current capability to control gaseous iodine from the Unit 3 auxiliary building and containment. However, in an effort to comply with the AEC's 10 CFR Part 50 regulations, the applicant is modifying the waste treatment systems to provide treatment for these effluents. In general, the proposed modified systems are expected to limit radionuclide releases and, subsequently, offsite doses to levels within those proposed in Appendix I to 10 CFR Part 50, with the exception of the potential doses to a child via the cow-milk and inhalation exposure pathways at or near the site boundary.

Response:

During the interim period before the modifications to the steam generator blowdown treatment system and installation of charcoal absorbers in the auxiliary and containment building are completed by May 1, 1975, the radioactive releases will be limited by the Technical Specifications to assure releases will be kept "as low as practicable." Since the nuclear fuel in Unit No. 3 will not be loaded until the early part of 1975, there will be insufficient time to build up much fission-product inventory in the core by May 1, 1975, and there should be minimal releases from the fuel to the primary system and minimal leakage to the secondary system. It is expected that during the first few months of operation, the plant will be undergoing a series of tests and thus will not be operating at full power for any extended time period up to May 1, 1975. The radioactive waste treatment system will limit the releases in accordance with the Commission's regulations in 10 CFR 20. Modifications, however, are necessary to assure that the releases and the related offsite doses will be kept "as low as practicable" in accordance with 10 CFR 50 over the lifetime of the Plant. See the staff response to the comment below regarding the thyroid doses from radioiodine releases via the grass-cow-milk and inhalation exposure pathways at or near the site boundary.

2. Comment:

Operating experience at other reactors which employ a 2 gallon per minute (gpm) waste evaporator (Ginna, H. B. Robinson), has shown that it is not possible to attain the design decontamination factor and/or flow rates assumed for this size evaporator. Although the operational problem may be characteristic of specific types of evaporators, there is insufficient information to make this determination. The final statement should provide a discussion of its characteristics compared to those in operating plants which have experienced evaporator problems. Sufficient detail should be provided to assure that the Indian Point Unit 3 evaporator will perform up to its design characteristics, so that the liquid radioactive effluent can be considered to be "as low as practicable" using "state-of-the-art" technology.

Response:

The staff evaluation indicates that the 2-gpm evaporator was of adequate capacity to treat the liquid waste for which it was intended. The radioactive waste system has the capacity to reduce effluents to less than 5 Ci/year per Unit and has the capability to keep the doses resulting from liquid radioactive materials to less than 5 mrem/year, which meets the staff's acceptance criteria.

3. Comment:

In view of the liquid radioactivity actually released during normal operation of Unit 1 and the near-term (to 1975) effluent projections for Units 2 and 3, it is possible that applicable regulatory guidelines may be exceeded by the individual units. We stress the importance of the utility's full utilization of the available waste treatment capabilities until the modifications are completed.

Response:

See the staff's response in EPA-1 above regarding the releases from Unit Nos. 1, 2, or 3 up to May 1, 1975. According to the Commission's regulation 10 CFR 50.36a, the applicant shall be required to maintain and utilize the radioactive waste equipment to control the releases of radioactive effluents as defined by the Technical Specifications.

4. Comment:

According to the draft statement, the liquid effluents from steam generator blowdown will be released directly into the environment without treatment, if the blowdown contains activity below a predetermined value. The final statement should provide the criteria for such untreated discharges and should indicate if such untreated releases are taken into account in Table V-6 of the draft statement.

Response:

The criteria for release of liquid effluents will be contained in the Technical Specifications, which will ensure that releases from the site are "as low as practicable." The Technical Specifications will be based on design objectives that limit the releases of radioactivity in liquid effluents to unrestricted areas to 5 Ci/year per Unit, and the dose or dose commitment to the total body or any organ of an individual in an unrestricted area to 5 mrem/year from the site.

5. Comment:

Ventilation air from the turbine building, Unit 1 flash tank vapor (via Unit 1 roof vent) and Unit 3 flash tank vapor (via Unit 3 roof vent) will not be monitored. Also, it is not clear from the draft statement whether turbine building drains will be monitored. The final statement should discuss how AEC Safety Guide 21 criteria can be met without monitoring. If monitoring or sampling provisions are not to be included, the AEC should discuss in the final statement exactly how the radioactivity in the discharges will be quantitated, so that environmental dose assessments and station release records will reflect the total station impact on the environment. It appears that the Unit 3 flash tank vapor via the Unit 3 roof top vent is not accounted for in the list of radioiodine source terms in Table V-9. This source term should be given in the final statement, and the dose evaluations correspondingly modified.

Response:

In a letter dated November 6, 1973, from G. W. Knighton, Chief, Environmental Projects Branch No. 1, Directorate of Licensing, AEC, to Mr. William J. Cahill, Jr., Vice President, Consolidated Edison Company of New York, Inc., the staff informed the applicant that the proposed effluent monitoring systems do not meet the requirements of Regulatory Guide 1.21 and General Design Criteria 64 of Appendix A of 10 CFR 50. The staff will require that all principal release points be identified and be monitored prior to startup of Indian Point Unit No. 3. On July 29, 1974, in Amendment No. 11 to the FFDSAR, the applicant responded by stating that the monitors will be installed by May 1, 1975.

The staff evaluation of the proposed secondary boiler blowdown purification system (SBBPS) considered that a 20-gpd primary to secondary leak was present continuously and that the blowdown from Unit No. 3 was diverted to the Unit No. 1 blowdown flash tank (BFT). The staff also considered that Unit No. 1 would not be operating 33% of the time; that the Unit No. 3 blowdown would be diverted to the SBBPS; and that, the Unit No. 1 main condenser would be available for venting the BFT. As a result, the staff calculated iodine-131 release of 0.16 Ci/year from the BFT vent. The staff considers this mode of operation to be limiting. The staff also calculated the release of 0.48 Ci/year of iodine-131 from the Unit No. 1 BFT when Unit No. 1 is not in operation.

6. Comment:

On Page V-121 in the draft statement, the AEC states that the ventilation air from the fuel storage buildings will be treated by a charcoal adsorber only if the radioactivity in the air is above a present value. The specific criteria for utilizing the charcoal adsorber should be given in the final statement.

Response:

The criteria for utilizing the charcoal adsorber in the fuel storage building ventilation system and all other effluent treatment systems will be contained in the Technical Specifications and will ensure that releases from the Plant are "as low as practicable." The Technical Specifications will be based on design objectives that limit the quantity of iodine-131 to be released in gaseous effluents so that the dose to the whole body or critical organ of an individual in an unrestricted area from all pathways of exposure will not exceed 15 mrem/year.

7. Comment:

Dose Assessment - Based on EPA's independent analysis, the thyroid doses from radioiodine via both the cow-milk child and inhalation pathways at or near the site boundary exceed the guides in the proposed Appendix I and the interim Regulatory Guide 1.42. Thus, the applicant should develop a program to identify the location of milk cows and monitor the critical dose pathways in order to assure that the real doses are maintained within the provisions of applicable regulatory limits and guides throughout the lifetime of the Plant.

Response:

The nearest potential pasture is at the same location as the nearest cow; consequently, the child's thyroid dose will be the same as that shown in Table V-37 in this Statement. Therefore, the thyroid doses from radioiodine at or near the site boundary and a child's thyroid dose via the milk pathway will be within applicable Regulatory guides and limits throughout the lifetime of the Plants. The thyroid doses have been calculated based on the assumptions in Regulatory Guide 1.42 and are less than 15 mrem/year.

The identification of actual pastures within 16 sectors of the compass has been presented in Supplement No. 8 to the Environmental Report, April 30, 1973, p. IV-11, and is presented below.

Sector	Distance to Nearest Milk Cow (miles)	Distance to Nearest Point of Site Boundary (meters)	Distance to Nearest Residence (meters)
N	16	River	1950
NNW	10	River	1740
NW	13	River	1830
WNW	7	River	1830
W	7	River	1890
WSW	7	River	2135
SW	None Detected	350	2745
SSW	7	380	1525
S	7	580	1280
SSE	None Detected	595	1220
SE	7	580	1100
ESE	7	580	1070
E	7	625	730
ENE	10	760	1370
NE	7	790	1525
NNE	7	River	3050

All cow pastures are located seven or more miles away. It is very unlikely that additional land will be converted to dairy pasture use in the Westchester County. This highly populated area is being developed for industrial, commercial, and residential use. The pressures of land availability, the trend of converting rural land to suburban land usage, the high taxable land, and the high economic value of the land will prevent development of remaining land areas into pasture land.

In the environmental radiological monitoring survey, the applicant is carrying out a milk sampling program and is collecting fresh milk once a month from cows located at the nearest actual pasture in the most critical wind direction. The applicant will be required to meet the analytical sensitivity of its milk monitoring program in Regulatory Guide 1.42. These requirements are spelled out in the Environmental Technical Specifications.

Since the area surrounding the site is zoned for industrial use, there will be no potential cows nor children located at the site boundary. The distance to the nearest residence located east of the Unit No. 3 containment building is 730 meters. The thyroid dose via inhalation as shown in Table

V-37 is expected to be 0.80 mrem/year at the nearest residence. The gaseous radioiodine releases from the modified radioactive waste treatment system for all three Units will result in thyroid dose levels to a 2-year old child of less than the 15 mrem/year guidelines in Regulatory Guide 1.42. All critical dose pathways will also be monitored during the lifetime of the Plants, as required in the Technical Specifications.

8. Comment:

Furthermore, in order to assure that employees at the visitors' center do not receive doses in excess of those suggested by the proposed Appendix I to 10 CFR Part 50 and Regulatory Guide 1.42 appropriate monitoring systems should be provided in the visitors' center. This is particularly important in relation to potentially excessive thyroid exposures.

Response:

Employees at the visitors' center are not subject to the dose limits of proposed Appendix I to 10 CFR 50 and of Regulatory Guide 1.42 but are subject to 10 CFR 20. Also, although Table V-37 indicates that the thyroid dose at the proposed visitors' center is 15 mrem/year, this dose rate is conservative since it is based on 168 hr/wk occupancy. The actual dose rate should be about 4 mrem/year.

Based on the above, the staff does not feel that a monitoring system at the visitors' center is appropriate.

9. Comment: Transportation of Radioactive Wastes

The generic approach has reached the point where on February 5, 1973, the AEC published for comment in the *Federal Register* a rulemaking proposal concerning the "Environmental Effects of Transportation of Fuel and Waste from Nuclear Power Reactors." EPA commented on the proposed rulemaking by a letter to the AEC, dated March 22, 1973, and by an appearance at the public hearing on April 2, 1973.

Until such time as a generic rule is established, EPA is continuing to assess the adequacy of the quantitative estimates of environmental radiation impact resulting from transportation of radioactive materials provided in environmental statements. The estimates provided for this station are deemed adequate based on currently available information.

Response:

Estimates of radiation doses that employees and the public would receive from the transportation of radioactive materials from the Plant during normal operation are shown in Section V.F and during accidental situations in Section VI.B. See Comment HEW-5.

10. Comment — Reactor Accidents

EPA has examined the AEC analysis of accidents and their potential risks which the AEC has developed in the course of its engineering evaluation of reactor safety in the design of nuclear plants. Since these accident issues are common to all nuclear power plants of a given type, EPA concurs with the AEC's approach to evaluate the environmental risk for each accident class on a generic basis. The AEC has in the past and still continues to devote extensive efforts to assure safety through plant design and accident analyses in the licensing process on a case-by-case basis. EPA, however, favors the additional step now being undertaken by the AEC of a thorough analysis on a more quantitative basis of the risk of potential accidents in all ranges. We continue to encourage this effort and urge the AEC to press forward to its timely completion and publication. EPA believes that this will result in a better understanding of the possible risks to the environment.

We are pleased to note in the draft statement the discussion of the Reactor Safety Study and the commitment for timely public presentation of its results. If the AEC's efforts indicate that unwarranted risks are being taken at the Indian Point Plant, we are confident that the AEC will assure appropriate corrective action. Similarly, if EPA efforts related to the accident area uncover any environmentally unacceptable conditions related to the safety of the Indian Point Plant, we will make our views known. Furthermore, the discussion of the potential consequences of the failure of radioactive waste systems is recognized as a significant improvement which is responsive to EPA's request that plant specific consideration be amplified in individual draft statements.

Response:

In Section VI.A, the staff discusses the consequences of reactor accidents and the expected radiological doses to the public living within 50 miles of the Indian Point and the results of the realistic analysis indicate that the environmental risks due to postulated radiological accidents based on gaseous releases are exceedingly small. See Comments HEW-3 and DOI-14.

11. Comment — NON-RADIOLOGICAL ASPECTS

New York State Water Quality Standards

The thermal discharges from Indian Point Units 1, 2, and 3, using once-through cooling, will result in violation of applicable New York State water quality standards for the Hudson River. Specifically, surface width and cross-sectional temperature rise criteria will be exceeded and the maximum surface temperature criteria of 90°F (32.2°C) may also be exceeded. Dissolved oxygen concentrations in the Hudson River are already, at times, below New York State standards. The addition of a thermal discharge from Unit 3 to the River will likely cause a further deterioration in this water quality parameter. These factors underscore the need for thermal pollution control measures at Indian Point.... To better evaluate this situation it would be helpful if the AEC included actual operating data in the final statement with respect to the thermal plume resulting from operation of Units 1 and 2.

Response:

The applicant shall be required to operate the Plants so as to meet all applicable water quality standards and in accordance with the limits and monitoring and surveillance requirements in the Technical Specifications. By such operation, the environmental impacts will be limited and will permit the applicant to operate Units Nos. 2 and 3 with once-through cooling up to May 1, 1979 and September 15, 1980, respectively.

The requirement to operate Units Nos. 2 and 3 with a closed-cycle cooling system after these dates will further assure that the NYS thermal criteria will be met under all conditions for all seasons when thermal discharges from all three Plants are taken into consideration.

During the operation of Unit No. 2 in 1974, measurements of thermal discharges and the plume characteristics have been carried out by the applicant both on the water and through infrared aerial overflights. The measurements will be used to: (1) determine the extent and intensity of the thermal plume as a function of time for comparing the results with the applicable NYS thermal criteria; (2) supplement previous studies and provide information to verify the mathematical and physical hydrothermal models; (3) compare the model analyses with the measured response of the river to the heat load from the Indian Point Plants; and (4) enable the applicant to improve the models for predicting the intensity and extent of the thermal plume under varying hydraulic and seasonal characteristics and during the addition of Unit No. 3 heat load. The applicant will have to demonstrate that the Unit No. 3 heat load will meet the NYS thermal criteria. The plant will be restricted in operation in accordance with the Technical Specifications if the thermal criteria should be exceeded. The Plan of Action will spell out specific details as to operating procedures of restricted operation in order to minimize detrimental effects on aquatic biota during the interim period before operation with the closed-cycle cooling system.

In terms of available thermal plume measurements, since the spring of 1974, Units Nos. 1 and 2 have operated up to 100% power for an extended period of time since the operating license for Unit No. 2 was granted on September 28, 1973. Unit No. 1 was shut down from December 31, 1972, to January 18, 1974. Unit No. 2 was operational during the summer of 1974; however the applicant has supplied very little practical information on thermal plume surveys to the staff at this time. As soon as such information becomes available, the staff will evaluate the information so that steps can be taken, if required, to assure that the NYS thermal criteria are met and that the operation of the Plants will provide protection to the aquatic biota.

12. <u>Comment</u>:

In addition to the above, the once-through design will probably not be in conformance with certain provisions of the Federal Water Pollution Control Act Amendments of 1972 (FWPCA). Specifically, Section 301 of this Act requires that cooling systems of steam electric plants employ the "Best Practicable Control Technology Currently Available" by July 1, 1977, and the "Best Available Technology Economically Achievable" by

July 1, 1983. Although a description of these terms (embodied in effluent limitations for this type of facility) has just been promulgated by EPA, it is likely that some form of closed-cycle cooling will be required, particularly in those situations where such a system is obviously the best alternative environmentally. All jurisdictional and environmental factors will be considered when EPA evaluates the application for a permit under the National Pollutant Discharge Elimination System (NPDES) instituted by Section 402 of the FWPCA. In particular, impacts from thermal discharges, impingement, and entrainment will be used to develop special conditions which will be imposed by EPA in issuing a permit for Unit 3.

It should be noted that a reconsideration of the requirements of the FWPCA, as they apply to the thermal component of a discharge, may be allowed by the Administrator of EPA (or if appropriate the State) under Section 316(a) of the Act, if it can be demonstrated by the applicant that less stringent requirements will "...assure the protection and propagation of a balanced, indigenous population of shell-fish, fish, wildlife in and on the body of water into which the discharge is made."

This possibility notwithstanding and without prejudging the permit application, we concur with the AEC recommendation that cooling towers be installed on Indian Point Unit 3. The May 1, 1978, date specified in the draft statement for completion of this system, however, may not be acceptable from the standpoint of adequate protection of aquatic biota since, considering electrical energy demands in the region, the plant will be permitted to operate with once-through cooling during the interim period. Nor will the date be consistent with the July 1, 1977, compliance date specified in the FWPCA. Therefore, we suggest that consideration be given to expediting the construction schedule where possible to meet the 1977 date or earlier and that the final statement detail those procedures that will be taken during the interim operation to minimize the impacts on the Hudson River fishery. If it is not feasible to reduce power at Unit 3 during critical periods to protect aquatic biota, some structural and operational mitigating measures may be possible.

In this regard, it should be noted that the importance of reducing environmental damage of this nature is addressed in the FWPCA. Section 316(b) of the Act provides that the "... location, design, construction, and capacity of cooling water intake structures reflect the best technology available for minimizing adverse environmental impacts."

Response:

In reference to the provisions of the FWPCAA of 1972, EPA has established a description of the terms "best practicable control technology currently available" required by July 1, 1977, and the "best available technology economically achievable" required by July 1, 1983. EPA has embodied such terms by way of setting effluent limitations for different types of facilities[8,9] [Thermal Discharges and Effluent Guidelines and Standards, *Federal Register* 39: 36176, 36186 (Oct. 4, 1974)]. As of September 1, 1973, the New York Environmental Conservation Law was amended to eliminate the requirement for an operating permit and to substitute a requirement for an "SPDES" permit. It was intended to have this amendment make the New York law compatible with the Federal system adopted under FWPCAA of 1972. The applicant has written that until December 31, 1974, an application for a permit (under the NPDES instituted by Section 402 of this FWPCAA) is deemed a permit and thus such permits are not required for Units Nos. 1 and 2 until December 31, 1974. On June 28, 1974, the applicant obtained a draft permit under Section 402 for Units Nos. 1 and 2 requiring a closed-cycle cooling system at Unit No. 1 by July 1983 and at Unit No. 2 by July 1978. A Section 401 water quality certification has been issued for Unit No. 2 on September 24, 1973, and an application for Unit No. 3 was first filed by the applicant on October 4, 1973. On October 4, 1974, the applicant withdrew the Section 401 application and reapplied for a new Section 401 water quality certificate. Prior to the AEC granting an operating license for Unit No. 3, the applicant shall be required to obtain a Section 401 water quality certification from New York State. The conditions of the Section 401 water quality certification will become part of the operating license. Any discharge limits through the Section 402 permit will also have to be met.

In regards to the timing of the operation of a closed-cycle cooling system, the staff agrees that if it is at all feasible, the applicant should attempt to expedite the schedule of work so as to install the preferred closed-cycle cooling system as soon as practicable but certainly no later than December 1, 1979, at Unit No. 2 and after September 15, 1980, at Unit No. 3. If the applicant can meet the July 1, 1977, date, there will be greater assurance that the Hudson River ecosystem will be protected and that damage to the aquatic biota will be kept to a minimum. See the staff response to Comment No. 1 from the

Department of the Interior regarding the time it will take to install a closed-cycle cooling system and the bases for selecting the September 15, 1980, date for termination of once-through cooling at Unit No. 3. See Appendix G for a construction schedule for the alternative cooling system at Units Nos. 2 and 3.

In setting up a schedule to have a specific closed-cycle cooling system ready for operation by 1979 and 1980 for Units Nos. 2 and 3, respectively, the staff took several of the following considerations into account. As a result of the Unit No. 2 proceeding, the applicant is carrying out meteorological, noise, and salt drift studies to add to the information already available to the applicant through its Supplement No. 3 to the Environmental Report for Unit No. 2, Supplement No. 2 to the Environmental Report for Unit No. 3, the Burns and Roe Report (HRFA Exhibit V in the Unit No. 2 proceeding), and other information presented by the applicant in the Unit No. 2 hearing to determine the environmental effects of cooling towers specific to the Indian Point site. The studies should be completed by September 1, 1974. If there is serious doubt concerning the impact of salt deposition, the applicant can use a freshwater tower with water from below Chelsea, which is 22 miles north of the site and is used as the location for the New York City drinking water pumping station. The applicant already investigated the technical feasibility of importing fresh water via a 40-mile-long 36-in.-diam pipeline or via barge shipment in connection with a study made in 1971 and found, for the case then under consideration, that the costs of both methods were comparable and estimated to be about $60 million (Unit No. 2 proceeding, Tr. 7675—7677). However, the staff evaluation of the salt impacts in Section XI.C and Appendix G in this Statement indicates that there should be no serious adverse impacts from salt drift from natural-draft cooling towers. Based on the above information, the applicant has submitted an environmental report on alternative cooling systems to the Atomic Energy Commission by December 1, 1974 for the purpose of selecting the preferred closed-cycle cooling system. It is anticipated that the staff will review the environmental report and approve the conversion from the once-through cooling to closed-cycle cooling system within six months to a year. At the same time it is anticipated that it will take about six months to a year to obtain approvals from other Federal and State agencies. The applicant has had sufficient time since the granting of the operating license for Unit No. 2 in September 28, 1973, to initiate contacts with the appropriate agencies and to prepare the necessary papers for submission to the appropriate Federal and State agencies and to obtain approval by December 1975 for the closed-cycle cooling system at Unit No. 2.

Approvals anticipated to be required will be obtained from the Atomic Energy Commission, New York State (Department of Environmental Conservation, Public Service Commission), U.S. Corps of Engineers, Environmental Protection Agency, Federal Aviation Administration, Advisory Council of Historic Preservation, Federal Power Commission and the Village of Buchanan.

Since the applicant has received the operating license for Unit No. 2 on September 28, 1973, the applicant should have had sufficient time to incorporate information from the environmental report on closed-cycle cooling systems submitted on December 1, 1974, and to complete the design by March 1, 1976. Based on the time to excavate, to procure and install equipment, to complete the construction of the preferred system, and to cut the system into the Plant, Unit No. 2 should be ready to operate with a closed-cycle cooling system by December 1, 1979 and Unit No. 3 after September 15, 1980. At that time the effluents should be within limits set in the Section 401 and 402 permits. Thus operation with an open-cycle system at Unit No. 2 will not occur after May 1, 1979, and at Unit No. 3, after September 15, 1980.

The applicant is carrying out a number of procedures to keep the biological impacts from once-through cooling to a minimum, as discussed in Section V.D.2. See Section XI.E for alternative fish protection measures regarding construction of a common intake system to reduce impingement effects. The Plan of Action will also provide a number of mitigating measures to minimize damage to the aquatic biota. If the monitoring or surveillance studies, including the ecological surveys, indicate excessive damage, the Plan will be implemented. Depending on the particular situation involved when an occurrence of excessive damage results, restricted operation in which the circulating cooling water would be reduced might be required. In the Unit No. 2 proceeding, the staff carried out a benefit-cost analysis[10] which indicated that curtailed operation of Unit No. 2 to minimize impingement and entrainment of striped bass young-of-the-year was probably not warranted. This judgment was based on an estimate of the additional cost which would be required to supply needed electrical energy (1973-1977) through alternative sources as weighed against the damage to the Hudson River biota which might occur during this interim period of operation with once-through cooling. The staff has reassessed this position in the case of Units Nos. 2 and 3 together and finds no compelling reason to change its position. Thus any restricted operation required would be limited to apply to a specific situation such as a large fish kill rather than throughout the interim period prior to installation of the closed-cycle cooling system.

13. Comment:

In an earlier AEC impact statement issued on Indian Point Unit 2, it was recognized that fish impingement rates are a function of both flow and velocity through the intake structure. Figure V-4 in the present draft statement (which was also presented in a previous statement for Unit 2), illustrates this point. It can be seen that the impingement rate increases drastically at the plant site for velocities greater than 0.9 fps (0.28 mps). The intake velocity across the screens at Unit 3 will be 1.5-2.0 fps (0.46-0.61 mps) under full flow conditions. The question then arises as to why the applicant did not utilize such information in the final design of the intake structure. A better design could have resulted in an intake configuration with a lower intake velocity and consequently a reduced impingement rate.

Response:

As directed by the New York State Department of Environmental Conservation (NYSDEC), the applicant is studying a modified intake structure for all three units which would reduce the intake velocity to 0.3 to 0.5 fps. Based on rescinding the State order to shut down the circulating pumps at Units Nos. 1 and 2 after an extensive fish kill on February 24-28, 1972, the NYSDEC will require construction of the new intake facility if it is determined at public hearings that it will provide a significantly higher level of protection than the air bubble curtains now being tested at Units Nos. 1 and 2. (See Sects. I.B and XI.E.)

14. Comment:

Although the applicant estimates that the total annual kill from impingement at all three Units will be 2.6×10^6 fish per year, the AEC staff estimates that this figure may be low for a number of reasons, among which is the fact that the figure does not include peaks resulting from large-scale periodic kills. EPA believes, however, that from previous data submitted, the above estimate may be very low. To this point, in the final statement for Indian Point Unit 2, it was estimated that the winter kill at Unit 2 alone would be about 30,000 per day, which translates to 5.5×10^6 over the 6-month winter period. It would probably not be too unreasonable to estimate a total annual kill of 8×10^6 at Unit 2. This would be equivalent to about 20×10^6 at all three units, a figure 7 times higher than that given in this draft statement. This point is reinforced by Raytheon data which show about 1.3×10^6

fish killed in only 2 months of data collection. The AEC should attempt to clarify this discrepancy in fish kill estimates in the final statement. In addition, considering the magnitude of the impingement problems likely to be experienced at Unit 3 during the interim period, the final statement should indicate the means by which intake design changes and plant operations will be utilized to reduce excessive impingment rates

Response:

The number of fish that will be killed by impingement at Indian Point Units Nos. 1, 2, and 3 at full flow has been estimated in a variety of ways. The staff does not place great confidence in any of these estimates because none of them is based on the biological and physical factors that underlie the impingement problem. Although there are important considerations not factored into the applicant's method of projection (see Sect. V.D.2.a), the method is not unreasonable. The 5.5×10^6 fish killed over a 6-month period was based on a reduced flow of 105,000 gpm of one of the circulating pumps and on preliminary data presented by the applicant as to the anticipated weight of fish killed at the intake structure during the testing of the pumps at Unit No. 2. The applicant also reports that the Raytheon data, in which 1.3×10^6 fish were killed in only two months of data collection, were obtained by extrapolating from data collected on only eight days during the two-month period. At that time, an unusual incident was occurring. As reported by the applicant, during the period of incidence, the fixed screens were out of service much of the time and full flow through the intake structure was maintained rather than reduced flow. Since that incident, the applicant has been counting fish impinged on a regular basis. Daily counts have been reported to the NYSDEC since December 1970.

The applicant's projections of 2.6×10^6 fish killed are based on collection data from December 1970 to March 1972. The reasons for selecting this two-year period have been given by the applicant (ER, IP-3, App. BB), and the choice seems justified. The estimates referred to in the above comment are based on earlier impingement data, in particular, data collected before the applicant started to operate the condenser cooling water pumps at 60% flow in the winter. The applicant's present operating procedure is to operate the condenser cooling water systems for all three Units at 60% of full intake flow during October through March of each year (see Section V.C.2.a).

Since Unit No. 2 has yet to operate at full power and at full or reduced flow during the wintertime, very little practical information on operating at reduced flow and with the air bubble curtains has been gathered to date. The impingement rate has been limited in the Environmental Technical Specifications for Units Nos. 1 and 2 up to 5,000 fish killed per day three days in a row or 15,000 fish over a three-day period. If these limits are exceeded, the applicant has to report the event to the AEC within 24 hr and take appropriate action, including shutting down the circulating pumps. Meanwhile, the applicant is required to keep a daily count of the number, size, and type of species collected on the traveling screens. The results are reported monthly to the AEC. After one year of operation, the staff and applicant will examine the results to determine if the upper limit is appropriately set. The applicant is also conducting ecological studies on the effects of impingement on the fish populations to determine the significance of impingement and how impingement can be reduced.

Furthermore, the intake structure at Unit No. 3 is different from that at Units Nos. 1 and 2. See Fig. III-2. At Unit No. 3, the traveling screens are flush with the river's edge and no fixed outer screens are used as at Units Nos. 1 and 2. The river current should aid to flush impinged fish back to the river before they are mortally injured.

15. Comment:

The AEC staff proposes that the applicant be required to monitor impingement and indicates that the "Environmental Technical Specifications will place a maximum number on daily fish kill in order to limit kills." In other words, the applicant will be expected to monitor impingement kill rates and to reduce flow when a given number is reached. We are skeptical that this procedure will be effective considering that this unit will supply base load capacity to a system that is purported to be, during some periods of the year, already overtaxed in terms of electrical demands. Thus, the final statement should only indicate those realistic measures that will be taken to assure that impacts due to impingement kills will be minimized.

Response:

The applicant is required to reduce flow when temperature of the Hudson River is 40°F. Impingement effects are more severe in the winter because of the behavior of white perch and other fishes at the lower temperatures. The applicant will be required to comply with the Environmental Technical Specifications. In addition the applicant will be required to implement a Plan of Action for minimizing impingement effects (see Summary and Conclusions.

16. Comment:

It should be noted that the applicant, in an effort to reduce kills on the traveling screens, has installed fixed screens in the front portion of the intake structure of Unit 1. This has reduced the impingement problems on the traveling screens, but it would seem, though, that the problem has been transferred to the fixed screens. Documents reviewed by EPA to date appear to indicate that little is known about the effectiveness of the fixed screens in prevention of impingement mortalities. If this is not the case and data exist to show that fixed screens are truly effective in reducing such mortalities, it should be presented in the final statement and a reason given for not installing this device on Unit 3 during its interim period of operation with once-through cooling.

Response:

The original intake structures at Units Nos. 1 and 2 had open intake forebays leading to the traveling screens. Subsequent installation of the fixed fine screens at the entrance to the forebays, flush with the river, did simply shift the impingement problem from the traveling screens to the fine screens. However, the applicant claims that this change did reduce the average size of the fish captured, perhaps by eliminating the recessed intake forebays as preparation chambers for impingement. With the fixed screens installed at the entrance, large fish cannot enter the forebay. Fish can avoid impingement on the fixed screens at the entrance by swimming laterally. The applicant claims that it is the position rather than the type of screen that is important. The reason for not installing fixed screens on Unit No. 3 is that the traveling screens for Unit No. 3, which have the same 3/8-in. mesh as the fixed screens, are located at the entrances of the six intake forebays, flush with the river. Thus the fish cannot enter the bay behind the screens and fish in front of the screen can swim laterally to avoid impingement. The traveling screens can be cleaned regularly and automatically while in place, unlike the fixed screens which must be removed for cleaning.

17. Comment:

Entrainment is and will continue to be a major problem at Indian Point, particularly during the interim period. The draft statement addresses this problem, but the AEC staff's approach is limited and may well be underestimating the overall picture by concentrating too extensively on the effects on the striped bass. For example, the draft statement does not adequately cover a significant decline in the white perch that has occurred since the early 1960's. If, as seems likely, a major contributing factor in this decline was the operation of Unit 1, then combined operations of all three units promise to accelerate this trend. Since the same problem exists for yet other species (e.g., tomcod, shad, and alewife), it is important that decisions concerning the schedule and manner of replacing the present once-through cooling systems be based on analyses that include species in addition to the striped bass.

Response:

The staff feels that the draft statement does adequately cover the New York University 1965-1969 catch per effort beach seine data and the Raytheon 1969-1970 catch per effort bottom trawl data, which suggest a decline in the Hudson River white perch population during that period.

Texas Instruments' analysis of the yearly fluctuations in mean catch per effort for abundant species in bottom trawls and in beach seine hauls for the Lower Hudson Estuary for the period 1965-1972[11] suggest that the yearly densities of these species appear to be fluctuating in unison and that there has not been a continuing decline in the white perch population [see Section V.D.2.d(3)(c)(vi)].

In reference to EPA's comment on species in addition to the striped bass, there has been an intensive effort by the applicant to collect data on all aspects of the life cycle of white perch. Since white perch is the dominant large fish species in the area, the applicant should present an evaluation for the Hudson River population of white perch of the combined impact of entrainment and impingement at Indian Point in combination with the Danskammer, Roseton, Lovett, and Bowline plants. This evaluation should be organized around a white-perch, life-cycle model. Since white perch, unlike striped bass, are nonmigratory and are not subjected to a strong white-perch-directed fishing effort, the evaluation should be much easier. The ecological studies in the Environmental Technical Specifications have as one objective a determination of the effect of impingement on the fish populations, including white perch as well as other species. See Response to Comment No. 1 from DOI regarding the decision to schedule the replacement of the present once-through cooling system by a closed-cycle cooling system after May 1, 1979, at Unit No. 2 and September 15, 1980, at Unit No. 3. Impingement effects on not only striped bass but also white perch plus other species were only one of several factors influencing the schedule of the alternative system.

18. Comment:

With respect to the analysis of the impacts on the striped bass population, the AEC staff estimates that reductions of eggs and larvae moving past the plant will range from 43 to 72%, if the combined effects of all plants in the area are considered, including those caused by Indian Point operating at full capacity. Although the draft statement does indicate that such losses could result in the bass population deteriorating"... beyond the point of rehabilitation," we are concerned that it has been assumed that irreversible conditions will arise only if operation of the three units with once-through cooling were to persist well beyond the period allotted for installation of closed-cycle cooling on Units 2 and 3. It is possible that the irreversible point could be reached before 1978 or even July 1, 1977. Thus we concur in the recommendation of the AEC staff that the applicant develop a "plan-of-action of operating procedures and design of the once-through cooling system ... to minimize detrimental effects on aquatic biota in the Hudson River to a practicable minimum during the interim period ..." We suggest, however that the details of this plan be submitted to EPA for review as soon as they are available and, in any case, prior to EPA's action on an NPDES permit application for Unit 3.

Response:

The staff has not made the assumption mentioned in the above comment that the irreversible point could not be reached before 1978 or even July 1, 1977. Concern for damage to biota during the interim period before installation of a closed-cycle cooling system was the main reason for requiring the Environmental Technical Specifications and Plan of Action (see Summary and Conclusions and Chapter XI). The Plan of Action, once approved by the AEC, will be made available to EPA and to the public.

19. Comment:

If the effects of impingement and entrainment are great and if there is a short time lag between hatching and recruitment of the adult population, then population effects in these other species may be even more significant than those exhibited by the striped bass population. Thus we question the argument that a 5 year "test" period before installation of a closed-cycle system(s) is warranted because there is a 4- to 6-year lag before egg and larval destruction will result in a decline in adult bass population. In our opinion, any such test period should be predicated on one of the other important species, for example the white perch discussed previously. The final statement should discuss this point.

Response:

As discussed in Chapter XI, there would be a six-year "test" period (1975–1980) involving Unit No. 3. The duration of this interim period is predicated on concern not only for striped bass but for other components of the Hudson River ecosystem (such as white perch) as well. A benefit-cost analysis indicated that the need for power from Unit No. 3 outweighed the damage to the aquatic biota, provided due caution is taken through the limits in the Environmental Technical Specifications and the provisions for corrective actions in the Plan of Action during once-through cooling operation. See also response to comment DOI-1.

20. Comment:

In the draft statement it is stated that: "The Hudson River near Indian Point has a relatively low load of decomposing matter." This would seem to be contradicted by the range of ambient summertime dissolved oxygen levels in the receiving water (3-11 mg/l). An ambient D.O. of 3.0 mg/l would indicate a very high loading of the water with putrescible organics. No B.O.D. data were reported in the statement; if this were included in the final statement, we would be better able to judge the possible severity of the thermal enhancement of biochemical oxygen demand.

Response:

More recent measurements by the applicant indicate that the lowest mean monthly dissolved oxygen concentration in the Indian Point region is 4.65 ppm.[11] The biochemical oxygen demand for the Hudson River ranges from 1.4 ppm to 4.6 ppm with the average at 2.7 ppm as measured from the intake at the IBM facility at MP 71.6.

21. Comment:

The waters into which the Indian Point plant discharges are classified as "SB" under the New York State regulations. The present regulations for this class specify a minimum of 5.0 ppm (mg/l) of dissolved oxygen. Since combined discharges of all three units at Indian Point will further lower D.O. values, which are already in violation of regulations during certain seasons of the year, plant operations will further contravene the New York regulations for dissolved oxygen. The final statement should discuss this problem.

Response:

The applicant will be required to monitor dissolved oxygen concentrations as specified in the Environmental Technical Specifications (see Summary and Conclusions). In addition, the plan of action to be implemented by the applicant (see Summary and Conclusions) includes concern for dissolved oxygen levels. (See also response to previous comment.)

22. Comment:

According to the statement, "Chlorination of the once-through cooling system for either Unit 2 or Units 1 and 3 may result in discharging cooling water containing up to 0.5 ppm (mg/l) of residual chlorine." It is also stated that, "The (AEC) staff will require that the total residual chlorine concentration at the point of discharge into the Hudson River shall not exceed 0.1 ppm (mg/l)." As was the case with fish kills on the intake screens, the applicant will also be required to monitor chlorine residual. The final statement should contain actual operating data from Units 1 and 2 in this regard. From previous documents it seems that the chlorine residual from Unit 1 alone has at times exceeded 0.5 mg/l (ppm). In light of this fact, further evaluation is needed that combined operations at Units 1-3 will yield no more than 0.1 mg/l (ppm).

Response:

On February 16, 1972, the applicant provided calculated chlorine residual concentrations for Indian Point Units Nos. 1 and 2 for the period of November 1968 through November 1971. However, Unit No. 2 did not start full flow operation for any period of time until May 1973. For example, during December 1973, the residual chlorine at the discharge canal ranged from 0.1 to 0.3 ppm concentration.

23. Comment:

We agree with the AEC staff that chlorination should be performed during peak tidal flows and daylight hours. We also feel, however, that due to uncertainty as to actual chlorine residuals which might result from combined operations, alternate means of condenser cleaning should be reevaluated and the results discussed in the final statement.

Response:

See response to Comment DOI-12. The applicant chlorinates during the daytime. As the study results become available from the applicant's attempts to reduce the concentration levels of chlorine residuals to less than 0.5 ppm, it will be possible to assess if the chlorine residuals can be reduced. The draft Section 402 permit issued by EPA on June 28, 1974, for Units Nos. 1 and 2 places a maximum limit on free residual chlorine concentration at 0.5 ppm. Mechanical cleaning using Amertap or cleaning using air-water guns to propel brushes are alternative ways to consider to reduce the need for chlorination. The applicant does not chlorinate during the colder months of the year, i.e., when the river water temperature becomes 45°F or colder.

24. Comment:

EPA believes that there is significant potential at the site for recirculation of the heated effluent. The combined discharge is located only 152 m (500 ft) downstream of the intake openings for Unit 3. The final statement should discuss the potential for recirculation of heated effluent during incoming and slack tidal cycles and the effect of this recirculation on the ability of the plant to meet thermal standards.

Response:

The staff recognizes the potential for recirculation. Since specific information was not available, the staff took the effect into account by investigating whether the 90°F surface temperature limitation of the New York State criteria would be exceeded by assuming in some cases that the intake water temperature was 81°F rather than the 79°F used by the applicant as the highest ambient water temperature on record. (In the near field, if the intake water temperature is increased by

1 F°, the estimated river surface temperature at the discharge will also be raised about 1 F°.) Even with this assumption, the surface temperature criteria would not be exceeded as long as the 10-fps discharge port velocity is maintained. (See Chapter V and Appendix A.) In the intermediate and far fields, the temperature rise of the river and the extent of the 4 F° isotherm is not strongly dependent upon the intake temperature and the amount of recirculation.

25. Comment:

In order to reduce impingement, during the time when ambient water temperature is 4.4°C (40°F) or less, 60% recirculation of flow will take place in accordance with a directive from the State of New York. Given that this procedure will reduce impingement, it may also, however, aggravate the already unacceptable thermal discharge effects. The statement contains information indicating that the cross-section requirement of the New York regulations will be violated. They stipulate that no greater than 50% of the cross-section of the river shall be impacted by the 4°F (2.2°C) isotherm. The thermal plume will exceed this limitation most of the time. Thus, it appears that the only way New York State criteria will be met is by conversion of Unit 2 to closed cycle cooling.

Response:

Reducing the rate of once-through cooling water circulation increases the temperature rise through the condensers but does not alter the total amount of heat discharged into the river for operation at the same power level. The higher temperature of the discharged water would affect the surface temperature of the river in the near field, but since the reduced circulation flow is used when the river intake water temperature is at 40°F or below, it is not likely even with low discharge port velocities that the 90°F surface temperature limitation in the New York State criteria would be exceeded. The intermediate and far-field isotherms are primarily affected by the total amount of heat discharged into the river and thus would not be appreciably altered by the reduced circulating water flow condition.

26. Comment:

The final statement should specify the estimated percent of operating time that plant load will exceed the percolation capacity of the sand filter beds. This excess would be bypassed directly to the river. If the bypass time is significant, consideration should be given to enlarging the capacity of the beds.

Response:

The most recent information from the applicant indicates that it does not intend to discharge any effluents from the sewage treatment facilities into the river (ER, IP-3, App. FF, p. III-25). The applicant indicates that the possibility does exist that an overload of the filter beds may eventually occur during the operation of Unit No. 3. Therefore, readings to determine the excess of effluent and appropriate action to increase the filter bed capacity will be taken ahead of time. The applicant is looking into the possibility of expanding the facility to accommodate a larger population in the future.

27. Comment:

With respect to the total Indian Point station, the AEC favors the alternative that calls for cooling towers for Units 1 and 2 and continuance of operation of Unit 1 with once-through cooling. Regarding Unit No. 1, however, EPA will be evaluating its impact, based on the requirements of the NPDES permit program to determine what actions may be necessary to protect aquatic biota.

Response:

The impact of operation with and without a closed-cycle cooling system for Unit No. 1 will be addressed in a separate environmental impact statement. On June 28, 1974, the EPA issued a draft Section 402 permit requiring closed-cycle cooling at Unit No. 1 by July 1, 1983, and at Unit No. 2 by July 1, 1978. The applicant submitted an application for a Section 402 NPDES permit for Unit No. 3 on October 4, 1974.

H. THE FEDERAL POWER COMMISSION (FPC) (12/13/73)

1. Comment:

The Federal Power Commission discusses the long-term considerations for the need for the baseload bulk power generated from Indian Point Unit No. 3 as well as the need for the power plant during peak load periods not only for the applicant's service system but also as a part of the New York Power Pool. The applicant is also a member of the Northeast Power Coordinating Council (NPCC), which coordinates the planning of members' bulk power generating capacity and transmission facilities and the Canadian provinces of New Brunswick and Ontario. The FPC in its review of the DES concurs with the conclusion in the AEC staff's Statement that new capacity such as the 965 MWe Indian

Point Unit No. 3 is needed to meet the projected load requirements and provide reliability of bulk power supply in the areas involved. This is particularly true because of the lack of availability of coal to replace the needed oil during the current oil shortage.

Response:

The staff notes that the FPC supports the need for Indian Point Unit No. 3 which "will make a significant contribution to the reliability and adequacy of the electric power supply in the applicant's service area."

The FPC also agreed with the staff's original data on the capacity, load, and reserve margins presented in this Statement. The staff recognizes the difficulties the applicant faces in meeting the demand of its customers in view of the extreme oil shortage. The applicant is attempting to convert some of its oil-fired plants to coal-fired. The lack of availability of coal, particularly of low sulfur content, and the handling and transportation problems, with the added air pollution problems associated with the burning of coal, compound severely the applicant's difficulties.

I. THE NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION (DEC) (12/17/73)

Due to the extensive nature of these comments, the comments themselves will not be repeated here. The responses are identified by numbers corresponding to the numbered comments on the DES in the letter from the Department of Environmental Conservation dated December 17, 1973 (see Appendix I).

1. In reference to the subject of conservation of energy, there is one important difference between the Nine Mile Point Unit No. 2 (AEC Docket No. 50-410) proceedings and those pending for Indian Point Unit No. 3 (AEC Docket No. 50-286) in that the proposed action for Nine Mile Point is the issuance of a construction permit, whereas the proposed action for Indian Point Unit No. 3 is the issuance of an operating license. Energy conservation alternatives, to be effective in reducing or eliminating the need for construction of new generating capacity, must be put into effect before the need for new capacity becomes a fact. If it could be demonstrated beyond a reasonable shadow of doubt that energy conservation alternatives could maintain or reduce the present peak loads in the Niagara Mohawk system, then construction of Nine Mile Point Unit No. 2 could be deferred until needed for replacement of

obsolete units. On the other hand, Indian Point Unit No. 3 is nearing completion with significant sunk costs and, even if the need for its capacity were suddenly eliminated, the more logical action in the interest of the State and the nation would be to shut down existing oil-fired units. This action would effect reductions in generating costs, air and thermal pollution, and the major concern of the present energy crisis — oil consumption.

The staff agrees that viable energy conservation measures are of the utmost importance to our nation but feels that they are secondary to the proposed action of the Indian Point Unit No. 3 proceedings for the reasons stated above. The staff, however, feels that it is appropriate to include a limited discussion of the conservation of energy in the Final Environmental Statement for Indian Point Unit No. 3, and to refer the reader to the testimony of the staff[12] and the FPC[13] in the matter of Nine Mile Point Unit No. 2 which is available to the public. The staff does feel it is appropriate for the New York State Department of Environmental Conservation, other interested State agencies, intervenor groups, etc., to formally present their suggestions for energy conservation to State and local governments that have the statutory authority to act on such matters.

2. In reference to the alternate use of the rejected heat from Plant operation, the staff considered use of the heat available in the turbine exhaust for low-grade thermal requirements such as domestic and process uses during its assessment of Indian Point Unit No. 2 (FES, IP-2, Section XI.A.2.e, p. XI-14). These uses require temperature levels generally corresponding to condenser pressures and temperatures not compatible with the design of the existing Indian Point Units Nos. 2 and 3 turbine generator systems. In addition, there are no potential users of waste heat in the quantity available within reasonable proximity to the Indian Point Plant.[5]

Interest in utilization of waste heat from thermal power stations has prompted many studies and investigations, but the low level of the waste heat (usually only about 10 F° to 20 F° above ambient temperatures) has discouraged its use because the cost of the piping systems and other capital equipment is high compared with the value of the salvaged heat. Modification of the thermal power cycles to reject the heat at a higher temperature has had some limited application, but this lowers the thermal efficiency of the cycle and there is an economic tradeoff between the value of the generated electricity and the recovered heat. The staff believes it reasonable to assume that recovery of any significant portion of the waste heat from the Indian Point Plants would not be economical at the present time.

3. The applicant is carrying out, in accordance with the Environmental Technical Specifications, collection of meteorological data, particularly wind speed, wind direction, and temperature differentials at 33 ft and at 100 ft above ground level in accordance with Regulatory Guide 1.23, to satisfy the requirements of the Contingency Plan for the Indian Point site. Because of numerous equipment failures, the applicant's meteorological data recovery rate during the 1970-1972 years was often below 90%, as utilized in staff practice for offsite dose calculations, so that the staff has had to compile meteorological data for a composite year consisting of January-July 1970, August 1971, September-October 1972, and November-December 1970 which is required for the staff to carry out its accident analysis for Unit No. 3. The staff concluded that the data provided a reasonable basis for estimating atmospheric conditions for accidental and routine gas effluent releases from the Plants. Furthermore, the applicant is collecting information on wind, temperature, dew point, visibility, and solar radiation at a 400-ft meteorological tower and with balloons to determine the baseline information for the impacts from cooling tower plumes.

4. It is expected that the impact of the thermal plume from once-through cooling on the local climate will be minimal with some wispy fog formation occurring, depending on meteorological conditions. The impact on air quality from emissions from the package boilers as well as the superheater at Unit No. 1 has been reevaluated and the text modified accordingly. It was found that although the Ambient Air Quality Standards are not applicable to the Indian Point Plants because they are not new plants, the emissions from the superheater at Unit No. 1 and the package boilers for all three Units will comply with Federal and State regulations. For further details on these emissions, see the Indian Point Unit No. 1 Environmental Report and Benefit-Cost Analysis and Suppl. 1, August 15, 1973.

5. In regard to DEC's comment concerning thermal shock following shutdown of a Unit in the winter, several points should be made. First, the applicant claims that during the years of operation of Indian Point Unit No. 1, thermal shock has never resulted in any discernible fishkill. The applicant recognizes that this has been a problem at other plants with other

outfall designs, but apparently it has not been a problem with Indian Point Unit No. 1 in operation. Second, once all three Plants are operating, the potential for thermal shock will be minimized because severe thermal shock could only occur if all three Plants shut down simultaneously which is unlikely to occur very often.

Third, the high-velocity submerged-discharge assures rapid dilution so the applicant does not anticipate that large areas of the river will be heated to a degree that could cause thermal shock. Finally, the Environmental Technical Specifications limit the rate of temperature change for planned shutdowns, and the planned rate is 7 F° per hour in the discharge canal which will result in a rate of change in the river of less than 1 F° per hour. An unplanned shutdown might stress the fish within the discharge canal, but these populations are not significant in size relative to populations in the river.

6. In Chapter XI and in Appendix G, the staff has independently evaluated in detail the various impacts from alternative cooling systems, primarily mechanical-draft and natural-draft cooling towers. The supporting information includes a wide variety of references based on actual practical experience at other sites which have been presented in the staff's responses to the applicant's interrogatories of December 28, 1973. The staff also has independently assessed the information reported by the applicant pertaining to the Indian Point site. Both onsite and offsite effects have been presented in Chapter XI.

The AEC is also supporting research work at the Chalk Point site on the Chesapeake Bay where the environmental effects from natural-draft cooling towers will be investigated. Salt drift effects on the vegetation are included. The AEC supported the study on the state-of-the-art of saltwater cooling towers.[14] A conference on the environmental effects of cooling towers held at the University of Maryland on March 4-6, 1974, was cosponsored by the AEC. Extensive information on the subject of cooling tower effects has been presented at other conferences such as the Cooling Tower Institute Annual Conference and in the literature.

Actual measurements of plume size, fogging, drift and other parameters are being carried out in this country as well as in Europe. Recent results of salt drift measurements at a full scale natural-draft cooling tower using sea water in Le Havre, France, indicate that improved drift eliminators can be used to reduce drift to 0.00041%. From the staff analysis, wet natural-draft cooling towers have little potential for vegetation damage assuming drift losses of 0.005% of circulating water flow and two cycles of concentration. Impacts from cooling towers can be held to a minimum by initially utilizing the proper engineering design of cooling towers by incorporating improved drift eliminators. Impacts can be reduced through pretreatment of the makeup water, selection of newer construction materials (corrosion resistant) and design characteristics to avoid galvanic corrosion, controlling the number of recirculations and concentration of TDS in the cooling water circuit, and selection of amount and types of chemicals needed for biocide control.

With natural-draft towers fitted with improved drift eliminators and operated in a manner consistent with these assumptions, the staff does not anticipate drift damage from natural-draft towers installed at Indian Point.

The applicant also is carrying out a study to determine the relative effects of various alternative closed-cycle cooling systems and submitted an environmental report on December 1, 1974, to the Commission for the purpose of selecting a preferred closed-cycle cooling system for Unit No. 2. The report will also be used for the same purpose for Unit No. 3. After such systems are constructed and ready for operation, the Environmental Technical Specifications for once-through cooling will need to be modified to take into account the changed mode of cooling.

7. The section on noise (Section V.A.3) has been expanded. The subject of predicted noise levels from proposed alternative cooling methods is discussed in Section XI.C.3.c(1)(e).

   In terms of human response to noise, at present insufficient data have been supplied by the applicant to determine HUD-type contours delineating the areas which are unacceptable, normally acceptable, and acceptable. However, the applicant's cooling tower study due by December 1, 1974, should provide such information.

8. The proposed action to be taken by the Atomic Energy Commission will be one of several actions to be taken by Federal agencies, including the Environmental Protection Agency and the Department of Defense, Army Corps of Engineers, in regard to operation of the Indian Point Plants. The EPA and the New York State DEC are involved in establishing water quality standards. The State will be issuing a Section 401 water quality certification for operation of Indian Point Unit No. 3.

On September 24, 1973, the applicant received a certification for Units Nos. 1 and 2, and on October 4, 1974, the applicant reapplied to NYSDEC for certification for all three Units. The applicant also has to receive a Section 402 permit under the National Pollutant Discharge Elimination System (NPDES) through EPA and a State Pollutant Discharge Elimination System (SPDES) permit instituted by the FWPCA of 1972. A draft permit for Units Nos. 1 and 2 was issued on June 28, 1974, by EPA. The applicant also applied for a Section 402 permit for Unit No. 3 on October 4, 1974. Effective September 1, 1973, the New York Environmental Conservation Law was amended to take into account the requirements under the FWPCA of 1972 so that the State and Federal Laws are compatible with each other. Until December 31, 1974, an application for a permit is deemed a permit. Accordingly, SPDES permits for Units Nos. 1 and 2 will be required after this date. Thus several Federal agencies will be involved in affecting the operation of the Indian Point Plants.

9. The applicant states that construction of the visitors' center should be completed by August 1974. The 80-acre area is primarily covered with second generation forest and is available and unused. However, construction of the alternative closed-cycle cooling systems may affect the availability of parts of the 80-acre forest up to 1979. The 14 acres have already been transferred to the Village of Buchanan and part of the land has been converted to a ballpark, which was officially dedicated on September 11, 1973, with a benefit fast-pitch softball game. Additional playground facilities and parking lot are planned to be built by the Village of Buchanan and the Village is planning to build a marina. It is uncertain when the marina will be built.

10. The Federal Power Commission has legal jurisdiction over the licensing action of the Cornwall pumped-storage facility and has included in its licensing action discussion of the environmental impacts of that facility.

a. Impingement

The additional impingement impact due to the Cornwall (Storm King) Plant can be estimated by using the same methodology as outlined in Section V.D.2.a; the staff emphasizes that there are several untested assumptions underlying this methodology. Assuming that (1) the number of fish impinged is proportional to intake flow, (2) the average intake flow over each 24 hr at Cornwall is 4000 cfs, and (3) the ratio of number (or weight) of fish impinged at Indian Point Unit

No. 1 to intake flow at Indian Point Unit No. 1 is representative of what can be expected at Cornwall, it is estimated that 2.1×10^6 fish per year and 23×10^3 lb of fish per year would be lost due to impingement at Cornwall. However, if Cornwall operates only 25% of the time (e.g., mid-June through mid-September), these values would be reduced, by a factor of approximately 4, to 0.5×10^6 fish per year and 6×10^3 lb per year. In addition, since impingement at Indian Point is relatively low during the summer, expected impingement losses at Cornwall might be even less than the above values. On the other hand, shoal areas where juvenile fish tend to concentrate are more extensive at Cornwall than at Indian Point.

b. Entrainment

In response to a request from Senator Ribicoff,[15] the staff evaluated the bases of the conclusions expressed in the document entitled "Hudson River Fisheries Investigations, 1965-1968"[16] (hereafter termed HRFI). This evaluation is summarized below.[17]

> "In brief, it was determined that the numerical values relied upon by Consolidated Edison as estimates of the annual losses of striped bass at Storm King were, in fact, estimates of the proportion of eggs and larvae which would be withdrawn daily during the two to three month period that these vulnerable developmental stages would be present. No analysis of the annual impact of Storm King was developed in the HRFI report. Thus, any assertion by Consolidated Edison that this study shows that the Storm King plant would remove only an insignificant 3% of the yearly striped bass catch, as stated in your September 10 letter, should be considered unfounded.
>
> "The HRFI report resulted from a relatively intensive study of the distribution of larval and juvenile stages of fishes in the Hudson River and was supported by Consolidated Edison. An impressive amount of information was obtained during this study, particularly in relation to the life history of striped bass. In applying their findings, however, the authors of the HRFI report erred in their method of computing the percentage of eggs and larvae withdrawn at Storm King

by omitting consideration of the bi-directional nature of the tidal flow, which leads to an underestimate of the daily proportion of larvae and eggs entrained. This error in formulation has served as the basis for much of the criticism of the conclusions expressed in the HRFI report.

"A second and compensating error resulted, however, when the volume of the Cornwall sector was equated with the volume assumed to have flowed past Storm King each day. The numerical effect of this error would be exactly compensated for by assuming an 8-hour daily mean pumping rate of 19,900 cfs, a value well below the maximum (21,600 cfs) of the proposed facility. Because of these factors, the estimates derived in the HRFI report are not obviously in error, when applied on a daily basis.

"The real problem results from the integrated exposure of larvae and eggs over the entire period during which they are present. The importance of this fact is related to the magnitude of cumulative losses which would occur because the larval bass remain vulnerable to withdrawal over an extended period of time. The importance of this factor is illustrated in [Fig. XII-1] which shows how the predicted daily withdrawal of 2.8% would accumulate during successive days of vulnerability. The period over which the 2.8% daily removal estimate should be applied is uncertain because it presumes that plant operation would not alter the larval distribution in a manner that would change the daily rate of removal. If the duration of this period is as short as 10 days, nearly 25% of the larval population would be withdrawn. If, on the other hand, the daily removal estimate is applicable over the entire seven week period that the young bass remain pelagic, then approximately 75% of the annual hatch might be destroyed.

"Such losses would cause proportionately similar reduction in recruitment to striped bass stocks supported by Hudson reproduction. The numbers of bass available to fishermen along the Atlantic Coast from New Jersey northward would thereby be reduced, although the effects

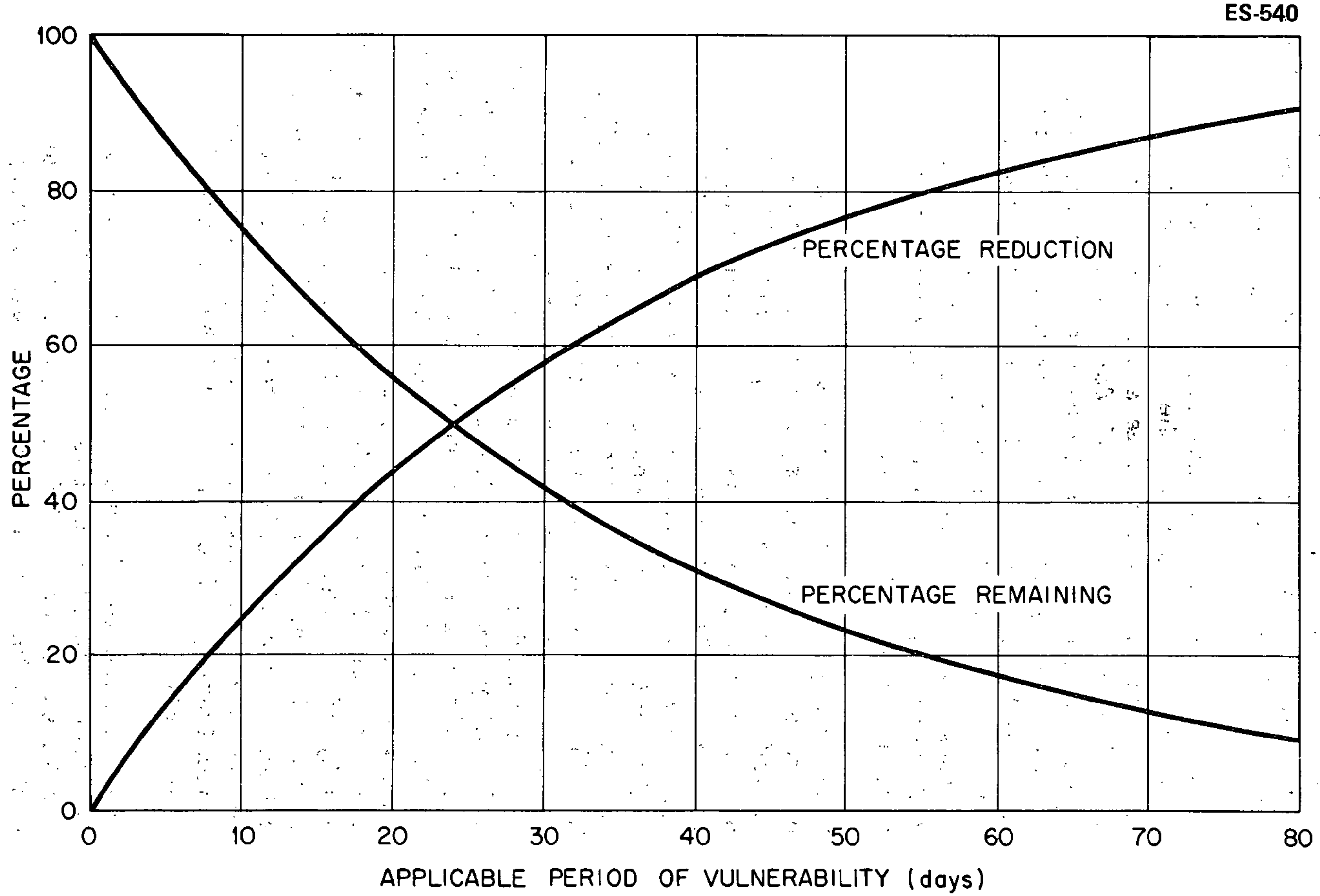

Fig. XII-1. Cumulative reductions in striped bass young-of-the-year resulting from daily removals of 2.8% of the total larval population by operation of the Cornwall Plant.

> would be most strongly felt in the New York Bight and Long Island Sound which depend almost entirely on the Hudson."

The staff also has estimated the impact of Cornwall on the young-of-the-year striped bass population by using the staff's new young-of-the-year transport model (Appendix B, Section B.3.b). The results of this model for various combinations of plants, including Cornwall, are given in Chapters V and XI. These results indicate a significant impact, as does the above analysis.

c. <u>Thermal</u>

In its far-field studies of the thermal impacts of the Danskammer, Roseton, Indian Point, Lovett, and Bowline Stations on the Hudson River, the staff made an additional case study in which the thermal discharge from the Cornwall Pumped Storage Plant was also included. The staff estimated the thermal discharge from Cornwall to be about 15×10^9 Btu/day; if it is assumed that the several tidal cycle reversals experienced by a batch of water discharged from Cornwall Plant before reaching Indian Point would evenly distribute the heat, then this amounts to about 0.6×10^9 Btu/hr on a continuous basis. The staff studies indicated that the thermal discharge from Cornwall, under the most adverse conditions that it seemed reasonable to assume, would contribute a calculated increase in the cross-sectional average river temperature at Indian Point of about 0.1 F° over what it would have been without Cornwall in operation. (Since it might be possible, although not necessarily probable, that the heat discharged from Cornwall could be phased with a particular tidal cycle in such a manner that a heated volume of water reached Indian Point in a discrete batch, an additional case was run in which the heat discharge from Cornwall was arbitrarily doubled. The calculated effect was to raise the average river temperature at Indian Point by about 0.2 F°.) Because of the several uncertainties involved in the input values used in the far-field thermal calculations, however, the staff does not wish to imply that the average river temperature is precisely known to within 0.1 F°, but does draw the conclusion from the special case study that the thermal effect of the Cornwall Plant is small and would not alter the general conclusions reached by the staff regarding the thermal effects of the Indian Point Plant on the near, intermediate, and far fields of the river.

The pumping rate at the Cornwall Plant varies with the level of the water in the upper reservoir but is approximately 20,000 cfs. This is on the order of 15% of the tidal average flow in one direction. It is, however, a substantially greater amount than the freshwater flow rate at certain times of the year. Cornwall will thus have some effect on the hydrology of the Hudson, but the staff lacks definitive data and information in this regard. However, it seems reasonable to assume that the effect on hydrology at Indian Point is not a major one because the water discharged at Cornwall will experience several tidal reversals in moving 13 miles downstream to Peekskill. For lack of better information, the staff does not include the effects of the Cornwall Plant on river water movements in the vicinity of Indian Point when making its mathematical analyses of the thermal discharges into the river.

In light of the above analysis, operation of the Cornwall Plant is not expected to significantly modify the thermal effects on aquatic biota at Indian Point.

11. In accordance with the Commission regulations 10 CFR 50.57, the Commission may issue a provisional operating license pursuant to the Commission's regulations in this Part in effect on March 30, 1970, for any facility for which a notice for hearing on an application for a provisional operating license or a notice of proposed issuance of a provisional operating license has been published on or before that date. However, the notice for a hearing for a full-term license for Indian Point Unit No. 3 was published on October 25, 1972, in the *Federal Register*[18] which was after the March 1970 date and thus the Commission will not issue a provisional operating license for Unit No. 3. The proposed action in this hearing is the granting, denial, or conditioning of a full-term operating license for Unit No. 3 in accordance with 10 CFR 50.51, 50.54, and 50.55.

12. On October 4, 1973, the applicant applied to the NYS Department of Environmental Conservation for a Section 401 water quality certification for all three Units. On October 4, 1974, the applicant withdrew its application and filed a new application for a Section 401 water quality certificate. The applicant received a Section 401 certification for Units Nos. 1 and 2 on September 24, 1973, for full power operation of Unit No. 2. The text has been modified accordingly.

13. The staff has modified the text in accordance with discussions with the Department of Interior (DOI) on the role it plays as a member of the Hudson River Policy and Technical Committee. The Committee provides mainly review and advice to the applicant on the ecological studies on the river but the DOI has no authority to direct the work. The representative of the DOI on site acted as an observer and participated in the bimonthly meetings of the Technical Committee by preparing minutes of the meetings. However, he had no authority to direct how the work should be done. He has since been transferred to another position, and there is no replacement for his position. The HRPC has recently been reorganized into the Hudson River Fish and Wildlife Cooperative.

14. See response to comment No. 9.

15. This change has been made in the text.

16. The New York State Atomic Energy Council and the State Geological Survey have expressed concern about the adequacy of the seismic design of the Indian Point plants with respect to potential earthquakes on the Ramapo fault, which passes less than one mile from the plant site. The fault is a well-known, major structural feature of the region that is postulated on geologic evidence to have been recurrently active throughout the recognizable tectonic development of the area during the last 700 to 800 million years. Two published reports[19,20] propose that historical earthquake activity (both early macroquakes and recent instrumentally recorded microquakes) may be associated with this fault zone. Another report[21] discusses a swarm of microearthquakes that was centered about 12 miles north of the Ramapo fault and was found to result in a focal mechanism consistent with a northeast trending fault parallel to the trend of the Ramapo fault. One recent[22] study has shown many offsets of glacial striations up to 1 in. in magnitude along the Hudson River. None of these displacements is associated with the Ramapo fault.

    This information is cited by the New York State Geological Survey as a basis for asserting that the Ramapo fault is a "capable" fault within the definition of 10 CFR 100, Appendix A, and could cause an earthquake to be localized in the vicinity of the Indian Point site resulting in an acceleration higher than the safe shutdown earthquake (SSE) acceleration for which the Indian Point Units are designed. On the latter point, they cite certain recordings of very high accelerations in the source areas of several recent earthquakes in California.

The staff has reviewed the information that the State of New York has brought to the staff's attention. With respect to the central issue, the staff does not consider that the studies cited above show that the Ramapo fault is "capable." The staff views the significance of the offsets of glacial striations as unclear. They could be associated with tectonic stresses but can be equally well explained by glacial unloading, thermal or chemical processes, or frost heaving of the rocks. Moreover, the staff does not view the quakes in question to be sufficiently well located to show that the Ramapo fault is "capable."

Members of the staff visited the fault area on May 21, 1974, and found that there is a lack of definitive geologic mapping. The staff also found that, beginning in 1962, several pipe breaks occurred in the vicinity of Mahwah, N.J., near the fault and coincident with an increase in the rate of subsidence along the Atlantic seacoast. The sense of the subsidence is consistent with movement on the Ramapo fault. However, the subsiding area is of much greater extent than the Ramapo fault. Thus, the subsidence cannot be reasonably associated with that fault. With respect to the pipe breaks, although they could be indicative of movement in the fault zone, the lack of significant concurrent earthquake activity suggests that an alternative explanation such as landsliding is more likely.

At present there appears to be no clear evidence of activity on the Ramapo fault. Each single observation presented as evidence is both tenuous and equally well or better explained by other causes. The staff believes that inactivity of the fault can be conclusively demonstrated and the question raised by New York State resolved with additional high-quality seismic and geologic data on the region.

The applicant plans to implement both a microearthquake network and a program of geologic mapping to confirm that the fault is not "capable." The network will be operated for about a year, after which the staff will review the information developed by the applicant's investigations. The staff is confident that the new data will support the earlier conclusions drawn by the staff and its USGS advisors of lack of earthquake activity on the faults in the vicinity of the Indian Point site.

17. The text has been modified to account for the fact that the three reactor containment buildings are built on hard grey limestone but the waste holdup tank pit and the east side of the Primary Auxiliary Building are built on caissons. The applicant's consultants, Fluhr and Paige, reported that the rock is capable of supporting foundation loads of 50 tons/sq ft

and the design loading used by the applicant's engineering firm, United Engineers and Constructors, was 25 tons/sq ft.

Further information on the capacity of the foundation bedrock is found in the answer to Question No. 2.6 in Supplements 10 and 18 of the Indian Point No. 3 PSAR which states "the compressive stress of 118 test cylinders taken from the bedrock on site resulted in an average of 5250 psi with approximately 90% of the tests falling in the range 2100 to 9900 psi."

18. See response to comment no. 16.

19. In the staff's opinion, the section describing the ecology of the site and the environs is adequate; references are given for more detail if needed. Ecological parameters such as diversity indices, biomass, productivity and indices of stability are estimated and discussed in publications of the applicant's consultants.[23,24] The staff has used this information where appropriate in assessing the environmental impacts. The ecological survey as presented in the Environmental Technical Specifications includes these parameters for investigation.

20. An appropriate addition has been made to Section II.F.1.

21. The text on radiological background in Section II.G was modified accordingly. A radiological survey of the area surrounding the Indian Point Plant was taken in August 1969. The Aerial Radiological Measuring System (ARMS) was used to obtain the survey which measured terrestrial background gamma radiation and included an attempt to detect stack release gases. A map of a 625-square-mile area showing isoexposure contours three feet above the ground was obtained. Exposure rates and isotopes identified in the area survey are generally consistent with normal terrestrial background. A single point source of low energy photons, possibly an x-ray machine, was observed near the western edge of the area. This resulted in an abnormally high exposure rate of 30 μR/hr which was observed 1.5 miles west of Southfield, New York. Additional spectral data accumulated over the anomalous point indicate that the increased exposure rate was due to a low energy photon source. Southfield is about 10 miles southwest of Indian Point and point source is located in an industrial complex. The plume assay revealed no radioactivity other than normal background.

22. An appropriate change has been made in the text.

23. The specific dates for environmental radiological monitoring data from representative samples are reported in Semi-Annual Operating Report No. 20 for the period from April-September 1972. Earlier Semi-Annual Operating Reports discuss the effect of fallout in samples collected.

24. There are six main cooling water pumps of 140,000-gpm capacity each and six service water pumps of about 5,000-gpm capacity each serving Unit No. 3 (see Fig. III-2). The main cooling water pumps are of the single-speed type. A by-pass arrangement permits up to 40% of the discharged water to be returned to the intake side of the pumps to achieve capacity control and to reduce the flow through the intake screens.

25. The transmission facilities between the turbine building and the Buchanan substation are described in Section III.C. Except for the crossing of Broadway, the lines are over the applicant's property. Such lines associated with Unit No. 3 represent a minimal additional visual intrusion on the neighboring communities.

26. Because of lack of space on the drawing for Figure III-2, it is judged sufficient to label the effluent from the service water pumps as "service."

27. Line 3 of the second paragraph on page III-6 of the DES states that there is one intake service water structure for Unit No. 3. This structure is provided with six service water pumps and thus several service pumps are available for washing the traveling screens if one or two service pumps are out of commission.

28. The traveling screens will be operated intermittently as required and, according to the applicant, at least once per day. The flow of water from the de-icing pumps, which introduces warmed water from the discharge canal back into the intake structure upstream of the screens for Units Nos. 2 and 3, is expected to keep the screens sufficiently free of ice to permit all-weather operation. The de-icing flow for Unit No. 1 is not achieved via a pumped return flow from the discharge canal but via a direct flow from the condenser outlet. The applicant states that no delay time is expected in starting operation after the screens have been idle during severe cold weather.[25]

29. The velocity of the water leaving a port will be a function of the effective head of water across the port and the discharge coefficient, as explained in the second paragraph on page

III-13 of the DES. The applicant states that the discharge coefficient for the ports will be verified during operating of Indian Point Unit No. 2.[25] The applicant also cites the existence of level indicators on the outfall structure so that "the gates can be adjusted to attain the requisite height [head] for the desired discharge velocity." Although the staff is not in the position of specifying the equipment used to maintain the requisite port exit velocity, the applicant will be required to determine the actual current flow in accordance with the Environmental Technical Specifications to verify the gate adjustments. The staff has previously noted (2nd par., p. III-13, DES) the inconvenience of manual adjustment of the gates. The applicant[26] has stated its intention to install electric motors "to enable raising and lowering the gates remotely from the control room of Unit No. 2 rather than manually as is presently done. The new system is expected to be operational late in 1974." The staff believes that the water level in the discharge canal should be measured to indicate the difference in head across the ports, that this signal should be sent to the control rooms, and that control of the motor-operated gates should be possible from the Unit No. 3 control room. As previously stated (DES, 2nd par., p. III-13), "the Environmental Technical Specifications will require the applicant to adjust the gates to obtain the desired water velocity with changing Plant operating modes within a specified time period." The Unit No. 3 Environmental Technical Specifications will require that the gate adjustment be made within 4 hr after a change in condensing cooling water flow rate.

30. The section in question has been expanded. The applicant will install an air bubbler system in front of the Unit No. 3 intakes. The effectiveness of the air bubbler systems at Units Nos. 1 and 2 is still being evaluated. In a letter of July 16, 1973, to the applicant, the Chairman of the Hudson River Policy Committee has reported the questionable validity of the impingement data collected at the intake screens because the air bubbler curtains create a positive outward flow away from the screens so that fish already killed or damaged by impingement are moved out into the water rather than onto the traveling screens for subsequent enumeration. Because of the unknown variability in fish counts, the Policy Committee as of July 16, 1973, withdrew its endorsement of the impingement studies until they have been redesigned to account for this variability.

31. The aesthetic impacts of alternate cooling systems are discussed in Section XI.C.3.c(1)(b).

32. See staff reference to DEC Comment No. 7. Once construction is completed, the use of the outdoor loudspeaker system should be minimized.

33. Potential impacts from ozone are discussed in Section V.B.2. The staff does not have information concerning ground clearances, conductor diameters, etc., required for adequate assessment of possible problems associated with induced charges. The applicant states that the transmission line rights-of-way are designed with this problem (induced charges) in mind and sufficient distances are maintained so that this problem does not occur.[25]

34. Refer to staff response to DEC comment No. 4.

35. Refer to staff response to DEC comment No. 4.

36. The wording in this footnote of Table V-3 has been changed to indicate that NYS Department of Environmental Conservation is requiring the collection of all chromium discharges. This is so indicated in the Environmental Technical Specifications.

37. The section has been modified to reflect this comment.

38. At the front of the intake structure of Unit No. 3, unlike Unit No. 2, there are traveling screens constructed of the same size fine mesh (3/8 inch) as the fixed screens at the Units Nos. 1 and 2 intakes (see ER, IP-3, p. 9-2). Traveling screens provide additional flexibility beyond fixed screens in terms of screen cleaning capability and represent an improvement over the earlier Unit No. 2 design. This flexibility is an advantage for such a system and eliminates the need for the fixed screens.

    An appropriate addition, summarizing the above information, has been made to Section V.D.2.a.

39. The paragraph in question in Section V.D.2.a has been modified.

    The applicant agrees that further studies of impingement should be carried out. The applicant is planning a flume study in which fish will be exposed to controlled conditions of water velocity to study their behavior in relation to fish protection devices. The relationship of impingement to ambient temperature, recirculation temperatures, if any, salinity, dissolved oxygen, pH, intake volumes and velocities, and the presence of air curtains is also being studied. A Fish Impingement Study Report by Texas Instruments, describing results of fish impingement studies conducted during 1972-1973 at Indian Point, although scheduled for March 1974,[17] has not yet been finalized or received.

40. The staff's elaboration on the relation between temperature, spawning and discharge of heated water by the Indian Point Plant is given in Section V.D.2.c(1).

41. Section V.D.2.c has been modified to include discussion of DO content in the vicinity of Indian Point and not just in the thermal plume. The staff has requested a copy of the data referred to by the NYS DEC in comment 41. The staff further notes that DO measurements taken at Verplanck are lower than 4.5 ppm and values of less than 4.0 ppm have been recorded at Lovett. During the summer time, the higher temperatures of the water and higher chloride content will undoubtedly influence the DO content, particularly in the plume. The monitoring station at Verplanck should measure if such changes in DO content occur during full power operation of all three Units.

42 The chromium concentration is given in the modified Table V-7. This concentration is not expected to be harmful to biota in the Hudson River. The applicant has under study the use of a biodegradable corrosion inhibitor, Drewgard-100, as a replacement for potassium chromate.[26]

43. The text has been modified to show that, if the level of radioactivity in the steam generator blowdown approaches a predetermined value of 3.5×10^{-5} µCi/cc, a signal will actuate an audible alarm and close the isolation valves. The blowdown will be manually diverted to the Unit No. 1 SBBPS for further treatment.

44. The paragraph in question has been modified. The staff's criticism of the Indian Point Ecological Study is that some of the objectives may not be achievable within the proposed time frame. This study will, however, provide information useful in assessing the impacts which may occur prior to the installation of a closed cycle cooling system and is, therefore, an appropriate part of the Environmental Technical Specification.

45. The Figure V-19 has been modified. The liquid radioactive waste from the waste condensate tank flows directly into the discharge canal after being continuously monitored, sampled and analyzed. If the radioactivity exceeds a predetermined value, the discharge from the condensate tanks will be automatically stopped by a valve on the discharge line and recycled through the waste disposal system.

At the bottom of each steam generator are two lines, the blowdown and the sampling lines. The blowdown line will pass directly into the Unit No. 3 blowdown flash tank (BFT) if the radioactivity is less than 3.5×10^{-5} μCi/cc. Some of the blowdown is discharged through a sampling line from each of the four steam generators into a common header from which samples are continuously monitored by gamma scintillation counting.

The condensate from the BFT and the liquid waste from the waste condensate tank are mixed and diluted with service water in the service water return line prior to flowing into the discharge canal. See Figure No. Q11.13-1 in Supplement 10 (January 1973) to the FFDSAR for a schematic of possible radioactive releases from the steam and power conversion system.

46. The text has been modified. Liquid leaks from the steam and power conversion system from Unit No. 3 will be discharged into the river. The applicant has to control the inadvertent releases of oil, grease, and other nonradioactive wastes before entry into the river in accordance with the Environmental Technical Specifications. An oil slick boom located in the discharge canal helps to remove any oil before the discharge reaches the confluence with the river.

47. Table V-41 has been modified to include the 50 truckloads of waste shipped from Units Nos. 1, 2, and 3 each year.

48. Although the applicant has used cask designs in which only one PWR spent fuel element is shipped by truck, the applicant has received proposals to furnish casks designed for three spent fuel assemblies from PWRs of the current generation. Thus there will be 57 truckloads per year from all three Units based on three fuel assemblies per cask and one cask per truckload.

49. In the case of accidents, the DOT regulations provide specific instructions to deal with emergency situations involving leaking packages or damaged packages of radioactive material, which include measures to control the exposure of the worker and the general public and to require reporting of such incidents to the shipper and to DOT (49 CFR 171.15, 175.655, 177.861). The text also has been modified accordingly.

50. The text has been corrected.

51. The training of emergency personnel and other aspects of emergency situations are a part of the applicant's responsibilities under Section 12, Conduct of Operation, of the FFDSAR. The

New York State has an emergency plan for major radiation accidents involving nuclear facilities. See Appendix C in Section 12 of Supplement 17 (April 1973) to the FFDSAR which includes the availability of the support activities by the State Education Department under the direction of the State Commissioner of Health.

52. Alternative biocide systems are discussed in Section XI.D; see also responses to Department of the Interior (DOI) Comment No. 12 and EPA Comments Nos. 22 and 23.

53. The visual impacts of cooling towers are discussed under alternative heat dissipation systems in Chapter XI.

54. The sentence in question has been modified.

55. The staff notes the concurrence with its position.

56. The staff's assessment of predicted demand was based upon sound economic parameters commonly used by utilities throughout the country. The present energy crisis and concerted public appeals for energy conservation came after the staff assessment was prepared.

History attests to the fact that the American people will respond to appeals made during national crisis but only for the duration of the crisis. Customers in the applicant's service area are responding to energy conservation appeals, and electrical "sendout" has decreased from that of the corresponding period of the previous year. A part of this reduction was attributed to statewide voltage reductions mandated by the New York State Public Service Commission. Such voltage reductions are emergency measures to reduce oil consumption and are not in keeping with Federal and State regulatory agency requirements to adequately serve the applicant's customers. As the oil supply crisis subsided, the mandate was lifted, and the temporary load reduction returned to normal. Public response to energy conservation appeals could diminish with increasing fuel supplies except during periods of ambient temperature extremes when adequate generating capacity is not available.

Any attempt to predict a reduction in residential, commercial, or industrial demand in the applicant's service area resulting from an effective national energy conservation program which has not been legislated would be pure conjecture on the part of the staff. The same would be true for projections pertaining to electric-powered modes of transportation. If both conservation program and electric power transportation should come into being concurrently, they would tend to offset each other with respect to electrical demand.

57. The staff received a copy of the "1973 Report of Member Electric Corporations of the New York Power Pool and the Empire State Electric Energy Research Corporation Pursuant to Article VIII, Section 149-B of the Public Service Law" subsequent to the issue of the Indian Point Unit No. 3 DES. Information contained in this report did not conflict with data listed in the DES. However, Volume 1 has been included as a source reference for Table X-8.

58. The text has been revised to reflect this updated information.

59. The action under consideration here pertains only to Unit No. 3. Restrictions on Units Nos. 1 and 2 are, therefore, not appropriate.

60. The staff agrees that the Verplanck site is a possible location for the disposal of overburden and spoil.

61. The effects of salt deposition from both natural- and mechanical-draft cooling towers are discussed in Chapter XI, which has been revised. Salt deposition diagrams (Appendix G, Figs. G-3 and G-5) indicate larger deposition rates south of the Plant. The staff has recommended additional monitoring to assure minimal damage from cooling tower drift in Section XI.C.5.

62. This effect is discussed further in Chapter XI. (See also Section II.E.2.)

63. The staff notes the concurrence with its position.

64. This error has been corrected.

65. The basis of comparison was the New York Power Pool's estimated upper range of forced outage rates for a nuclear power plant in the capacity range of Indian Point Unit No. 3. Indian Point Unit No. 1 was a very early design, being the fourth U.S. power reactor to begin commercial operation, is a combination nuclear and fossil unit, and is not in the same capacity range as Unit No. 3. Indian Point Unit No. 2 has been in service only for a limited length of time and has yet to establish a meaningful forced outage rate.

66. The staff has made considerable use of the 1973 ichthyoplankton data collected by Texas Instruments.[28,29,30] (See Sections V.D.2.d(3)(c) and V.D.2.e and Appendix B, Section B.4.b)

67. The radionuclide concentrations given in Appendix C were calculated on the conservative assumption that only the service water flow (about 100,000 gpm) was available for dilution. This is still a conservative assumption even with the reduced cooling flow rates associated with closed-cycle systems.

J. ATTORNEY GENERAL OF THE STATE OF NEW YORK (AGO) (12/17/73)

Due to the extensive nature of these comments, the comments themselves will not be repeated here. The responses are identified in a manner consistent with the comments of the Attorney General (see Appendix I).

I. General comments

A. The staff concurs with the supporting statements of the New York State Attorney General. The staff further adds that the National Environmental Policy Act (NEPA) requires a Federal Agency such as the Atomic Energy Commission to utilize a systematic interdisciplinary approach that will ensure the integrated use of the natural and social sciences and the environmental design arts in planning and in decision-making which may have an impact on man's environment; to identify and develop methods and procedures that will ensure that currently unquantified environmental amenities and values may be given appropriate consideration in decision-making along with economic and technical considerations; and to include in every recommendation a report on proposals for major Federal actions significantly affecting the quality of the human environment, a detailed statement of the five items presented in the Foreword of this Statement. Furthermore, NEPA requires the Commission to study, develop, and describe appropriate alternatives; to recommend courses of action in any proposal which involves unresolved conflicts concerning alternative uses of available resources; and to recognize the world wide and long-range character of environmental problems. Thus NEPA requires the AEC to make decisions (before the fact rather than after the fact) based on assessments of potential impacts which can occur in the future and, after review of alternatives to resolve conflicts, to decide on a cost-benefit basis which system is the preferable one to mitigate impacts. The staff did so in the Indian Point Unit No. 2 and Unit No. 3 cases. The ASLB in its Initial Decision for Unit No. 2 supported the same position as that of the staff, namely, that to continue operation of Indian Point Unit No. 2, an alternative cooling system would be needed based on the ASLB's benefit-cost analysis of the two modes of cooling operation. The ASLAB in its decision modified the date from May 1, 1978, to May 1, 1979, for termination of once-through cooling operation at Unit No. 2.

B. The staff recognizes the values and limitations of modeling. The staff has not relied on model estimates to predict the totality of environmental damage. The staff agrees with the Attorney General that (a) indirect effects are important, although difficult to quantify; (b) very little data exist on the indirect effects, and because of the necessity for measuring the nature of these effects over the long-term, it would be impossible to calculate them in the time available; and (c) if long-term studies (e.g., 10 years and more) were undertaken, there would still be unpredictable effects due to the limitations of man's present knowledge.

II. Comments on AEC Staff Analysis of Multi-Plant Impact

A. The staff has carried out an assessment of the various plants which currently exist on the Hudson River, namely, the three Indian Point Plants, Lovett, Danskammer, Bowline, and Roseton power plants, as reflected in Chapters V and XI of this Statement for Unit No. 3. The subject of multiplant analysis was brought into the Indian Point Unit No. 2 proceeding before the ASLB in the March and April 1973 hearing sessions. The staff submitted testimony on the subjects of thermal effects and biological damage from operation of the above mentioned power plants (follows Tr 10,021-Docket No. 50-247). The staff does recognize the existence of many other sources of discharges, both industrial and municipal, resulting primarily in sewage and sanitary discharges along the entire length of the river. All such sources are under State and local jurisdiction, not the AEC's jurisdiction. Under the FWPCA of 1972, industrial concerns will be required to obtain SPDES permits under Section 402 through the New York State Department of Environmental Conservation. Thus, when the discharges from industrial concerns are limited in accordance with the Section 402 permits, any total environmental assessment of all existing and future resources on the Hudson River done today will be different from that made later on.

In comparison with the environmental assessment of industrial and municipal discharges, the staff believes it has far more adequate information pertaining to the operation of power plants on the river, and in addition, most of the impacts on the river would probably result from power plants rather than from other facilities on the river because of the large volumes of water withdrawn through the power plant condensers for once-through cooling. Thus with the limitations on discharges, the impacts would primarily be from entrainment and impingement.

The staff further notes the New York State Attorney General's remarks regarding Dr. J. Lawler's testimony on potential impacts. The intent of the hydraulic and mathematic hydrological models for thermal discharges and the striped bass young-of-the-year and life cycle models for biological damage developed by the applicant as well as the staff was to estimate and predict the potential impacts of future operation so as to take appropriate corrective measures to minimize impacts before they actually happened. This is what NEPA intended that the AEC or other Federal agencies should do in preparing environmental impact statements. As required in the safety analysis of the radiological aspects of the nuclear plant, the applicant has to rely on different models to predict future fuel element behavior, core performance, and operational safety and to determine whether the Plant could be built to meet the design criteria for plant accidents outlined in Chapter VI. Thus mathematical and computer models of all types have been used throughout the entire field of technology for predictive purposes with the intent to simulate reality as closely as possible.

In regard to the Cornwall pumped storage facility, the staff has evaluated the potential effects of this proposed facility relative to Indian Point in Chapters V and XI. Discussion of this subject is also found in staff's response to New York State Department of Environmental Conservation comment No. 10. Furthermore, the impacts of operation of the Cornwall facility in itself have been dealt with in a separate hearing before the Federal Power Commission.

C. The staff's evaluation of impingement effects is given in the response to comment No. 10 of the New York State Department of Environmental Conservation.

D. The staff's evaluation of entrainment effects is given in the response to comment No. 10 of the New York State Department of Environmental Conservation.

The staff's evaluation of mortality on passage through the Plant is discussed in Section V.D.2.b(2)(d).

E. The staff has made a study of the thermal effects of the Cornwall Pumped-Storage Plant (see reply to New York State Department of Environmental Conservation comment No. 10). The staff's estimates, based on the best information available to it at this time, confirm that about 3.4×10^9 ft^3 of water may be pumped per week, but that the heat release to the river may be more in the order of 15×10^9 Btu/day rather than 24×10^9 Btu/day. The staff's analysis was made on the basis of 15×10^9 Btu/day.

III. Thermal Effects

B. Federal and State Criteria. The staff concurs that its mathematical analyses have indicated that under certain assumed conditions the thermal discharges from Unit No. 3 have potential for contravening the New York State water quality criteria.

As indicated in both the Hirst and Koh and Fan analyses by the staff (DES, pp. A-6 through A-9), there is essentially a direct relationship between the ambient river temperature and the calculated temperature where the heated water plume surfaces, i.e., raising the river ambient temperature by 1 F° raises the calculated temperature by 1 F°. The staff's analyses indicated that if the port velocities were 10 fps and the ambient river temperature were 79°F, the near-surface temperature would be about 84°F. It follows that, if the temperature of the river at the Indian Point intake and discharge structures were 85°F or over, the 90°F maximum allowable surface temperature will likely be exceeded.

The staff's intermediate and far-field analyses gave results that indicated that with many of the cases studied the State criteria with regard to the extent of the 4 F° isotherms would not be met and that the temperature of the passageway would also be marginal if the local ambient temperature were 79°F. Again, it would follow that if other effects raised the local receiving water temperature by 1 F° or 2 F°, or more, the temperature of the passageway would be more unacceptable from a biological standpoint.

The effect of the ocean temperature is discussed below.

C. With the exception of the Albany Steam Station and the 59th Street Station, the major thermal power plants listed in the Quirk, Lawler and Matusky reference were included in the staff's far-field study of thermal effects on the river of the Indian Point Plant. The Albany and 59th Street Stations were judged to be so distant from the reach of the river under study that their influence would not be significant. In addition to the five major thermal power stations included, the staff also studied a special case which included the thermal effects of the Cornwall Plant at Storm King Mountain. (See NYSDEC Comment No. 10.) The staff believes that this accounts for the major heat releases affecting the Indian Point waters, but it does not have the manpower available to survey the Hudson River for all industrial or municipal thermal discharges.

D. Although the assumed temperature of the mouth of the Hudson River has only a small effect on the calculated temperatures at Indian Point, the staff agrees that the assumed temperature should be as representative as possible and has revised the calculations to be on the basis of a 74°F rather than a 70°F temperature at the Battery.

A curve has been added to Figure V-4 showing the calculated river temperature if the upper reaches are at 80°F, the Battery temperature is 74°F, the fresh-water flow rate is 4,000 cfs, and there are no heat discharges into the river from the power stations. This curve may be used for reference in examining the calculated temperatures along the river when the power stations are rejecting heat, because all of these studies were based on 80°F upper reach and 74°F Battery temperatures. However, the staff does not intend that this curve represents the true or "legal" ambient temperature to be used to monitor enforcement of the NYS water quality criteria. It may be noted, for example, that whereas the 80°F and 74°F temperatures may occur simultaneously with a 4,000-cfs freshwater flow rate, this represents a severe condition that does not always exist.

The curve shown in Figure V-4 was not originally included by the staff because, as can be noted in the figure, the calculated effect of the assumed temperature at the Battery does not extend upstream far enough to appreciably influence the "ambient" temperature at Indian Point, and for purposes of evaluation of the temperature rises at Indian Point, the calculated temperatures can be compared to 80°F as a base.

E. As stated above, the staff does not consider the calculated curve connecting the assumed 80°F and 74°F reaches of the river when no heat is discharged as necessarily the true "ambient" temperature. The staff recognized the difficulties of enforcement of regulations based on establishment of ambient temperatures as defined in the NYS criteria. This is indeed an important issue to which state authorities should direct their attention.

F. Present indications[23] are that, because of the nature of the discharge, the benthic community will not be exposed to an appreciable thermal stress.

Pertinent information from the Gift-Westman Study[31] on responses of striped bass and white perch to increasing thermal gradients is quoted below. These are the only two species covered in the Gift-Westman Study that are also abundant in the vicinity of Indian Point.[11]

<u>Striped Bass, *Morone saxatilis*</u>

"Examination of the three thermal studies with striped bass shows appreciable differences in the thermal responses. The bass examined in experiment thirty-four were four-year-old fish with a mean length of 51.6 cm. These fish were collected in mid-April at a water temperature of 53.0°F. The ambient water temperature was adjusted to 68°F over a four-day period and then the stripers were held for at least a week at the 68°F acclimation temperature. Acclimation to 68°F should have been complete in this time period. The striped bass in this experiment actively avoided a water temperature of 80°F and had an avoidance breakdown temperature of 86.0°F. A second experiment (27) was conducted approximately one month later with a single four-year-old bass, 49.7 cm in length. This fish was collected in 60.5°F water and was acclimated for a similar one-week period. An avoidance temperature of 84.0°F and an avoidance breakdown temperature of 90.0°F were determined for this striper. In both of these studies, it was difficult to observe the actual avoidance temperatures since the fish were quite large and confinement in the cool end of the gradient was severe. It is possible that in a less confined natural habitat, these large fish would have avoided lower temperatures.

"A third experiment with one-year-old bass (mean length 17.2 cm) was conducted during the summer. In this study (32) an avoidance temperature of 85.0°F and an upper avoidance breakdown temperature of 93.6°F were determined. An upper thermal tolerance limit of 94.4°F has been reported for young-of-the-year striped bass (Talbot, 1966). Both season of the year and fish size play major roles in influencing the thermal requirements of striped bass. The water temperatures tolerated by young-of-the-year or yearling stripers are appreciably higher than those tolerated by larger individuals of this species."

White Perch, *Morone americana*

"A mean avoidance temperature of 89.6°F was determined in replicate studies with white perch (mean lengths 12.2 and 16.9 cm). A mean avoidance breakdown temperature of 96.5°F was determined in the same experiments. In both experiments a direct relationship between size and thermal tolerance was noted. The mean sizes of the first halves of the populations to die were slightly smaller than the mean sizes of the second halves. No experiments were conducted with small, young-of-the-year white perch, consequently it is not

> known whether this relationship holds true for all size white perch."

The three temperature criteria mentioned above are defined below.

> "The upper avoidance temperature is here defined as the temperature that causes a fish's ability to discriminate slight temperature differences to be a meaningful activity, i.e., the temperature which creates sufficient stress to cause temperature to be a directive factor. Areas with temperatures above the upper avoidance temperature are an unacceptable environment."

The upper avoidance breakdown temperature is

> "the temperature that caused a breakdown in avoidance behavior. This temperature has been defined by other researches as the Critical Thermal Maximum (C.T.M.). The C.T.M. is the thermal point at which the locomotory activity becomes disorganized and the animal loses its ability to escape from conditions that will soon cause its death (Mihursky and Kennedy, 1967). The C.T.M. has been determined for some reptiles and amphibians (Hutchinson, 1961; Lowe and Vance, 1955). At this temperature, ecologically the organism is dead: even if this temperature is not lethal to the organism, it still would cause the organism to be very vulnerable to predation by another more temperature tolerant species."

The upper thermal tolerance limit,

> "a third temperature response recorded in this study, was the temperature that caused death. This was determined experimentally by recording the temperature in the gradient that caused the death of each individual and then calculating the lethal dose that caused the death of 50% of the experimental population (the LD_{50}) by probit analysis (Finney, 1952). This is not to imply that this temperature represents the actual, ultimate upper thermal tolerance limit for the species. The effect of time of exposure to a given lethal temperature cannot be completely evaluated in a system with

> a changing temperature. Rate of temperature increase affects both the time fish have for acclimation and the time they are exposed to lethal temperatures. The death temperature will depend on the interaction between the length of exposure at lethal temperatures and the change to acclimatize at a given rate of temperature change (Cocking, 1959b). The upper thermal tolerance limit determined in the present study, then, does not necessarily represent the ultimate upper thermal tolerance limit (Fry, 1964), but rather a relative measure of the thermal tolerance of the different species examined under the present experimental conditions."

The paragraph on p. V-52 of the DES regarding thermal pollution has been modified. In the staff's opinion present data are not adequate to quantify in biological terms the effects of thermal pollution in the vicinity of Indian Point. See also App. V-1 in FES, IP-2 on the subject of effects of temperature increases on the environment.

K. HUDSON RIVER FISHERMEN'S ASSOCIATION (HRFA) AND SAVE-OUR-STRIPERS (SOS) (12/14/73)

Due to the extensive nature of these comments, the comments themselves will not be repeated here. The responses are identified in a manner consistent with the comments of HRFA-SOS (see Appendix I).

I. Impingement Damage Must Be Curbed

The short-term environmental impact from impingement for white perch, striped bass, and other fish species has already been estimated in terms of number and weight of fish lost per year (Chapters V and XI).

The long-term environmental impact on the river population of white perch has been estimated in terms of percentage of the young-of-the-year that may be impinged (see Section V.D.2.a). Comparable estimates for striped bass and other fish species cannot be made with comparable reliability because of the lack of estimates for population sizes of impingement-length fish for any year up through 1973.[32]

The staff has discussed and evaluated in Sect. XI.E the various means of reducing impingement that are being studied by the applicant. Details of the Environmental Surveillance Program for Impingement of Organisms, including the setting of a limit on the number of fish killed on the fixed and/or traveling screens, are given in the Environmental Technical Specifications for Indian Point Units Nos. 1 and 2; similar requirements are proposed for Units Nos. 1, 2, and 3.

Means of reducing impingement presently planned for the Indian Point Plants include the following:

1. Air bubbler curtains at the Units Nos. 1 and 2 intakes. Depending on results of present experiments, air bubbler curtains may be installed at the Unit No. 3 intake.

2. Reduction of flow from 100% to 60% of circulating water, thereby resulting in reduction of intake velocity to 0.5 fps through the fixed screens at Units Nos. 1 and 2.

3. Location of the Unit No. 3 traveling screens located at the river's edge.

4. Setting an upper limit on the impingement count taken daily on three consecutive days as discussed in 4.1.2 a(VI) of the Environmental Technical Specifications for all three Units.

5. Implementation of the Plan of Action to minimize impingement.

6. Operation with closed-cycle cooling after May, 1979 for Unit No. 2 and September 15, 1980, for Unit No. 3.

Additional means of reducing impingement effects include the following methods under consideration by the applicant:

1. Reduction of flow using a common intake (LaSalle Hydraulic Study) and incorporating horizontal traveling screens.

2. Relocation of traveling screens of Units Nos. 1 and 2 to river's edge.

3. Modifications of existing traveling screens to operate continuously and the installation of low pressure spray wash, as a means of increasing the survival of impinged fish.

4. Avoidance devices such as light, sound, and electricity.

5. Guidance devices such as louvers, magnetic fields, fish pumps, fish flume, lift baskets, odor, pipes, fish locks, fishways, intake dam, and orifices.

6. Pervious rock dike.

7. Sand filter.

8. Underwater wall.

The material in Sect. V.D.2.a relating to Fig. V-8 and Fig. V-8 itself have been modified.

The claim stated in the HRFA-SOS comment that air-bubble screens have not proven effective is not supported by the references they cite. Clark and Brownell[33] state that bubblers have not proved effective for fish protection in estuarine water, and they refer to Maxwell.[34] The following quotation from Maxwell[34] gives an overview of the use of bubblers to reduce impingement.

"An air bubble screen has been in operation since 1967 at the Pulliam Plant of Wisconsin Public Service. ...Water is taken from two intakes, one from a rather wide inlet to the north of the plant, and one from a 150-foot-wide canal at the opposite end of the property. The air bubble screens extend across both inlets, well in front of the intake structures.

"The principal problem fish is the alewife, a variety of herring which made its appearance in Lake Michigan in the middle 1960's, having come up through the St. Lawrence Seaway. It is a heavily schooling fish — schools of at least a half mile in diameter have been observed from the air. These fish are usually between 6 and 8 inches long. ...Prior to the installation of the air bubble screen, there had been several shutdowns caused by schools of alewives jamming the screens and shutting off the flow of cooling water. Since installation of the screens, there have been only one or two shutdowns of this type during more than four years of operation. The air bubble screen is not expected to be an impervious barrier. Casual fish penetrate it, and fish are removed daily from the traveling screens, but in quite limited quantities. The major purpose of the air bubble screen is to divert schools of fish, rather than to stop all individuals. For this purpose it is considered to be quite successful.

"The air bubble screen has been satisfactory in diverting alewives at the Pulliam location. However, air bubble curtains installed at Indian Point Unit 1 on the Hudson River were "completely ineffective as fish barriers." The fish at Indian Point are white perch, tomcod and striped bass, and there are many other differences between the Pulliam and Indian Point installation.

"Work reported at the Johns Hopkins Workshop found that small striped bass in an experimental apparatus would, under certain conditions, refuse to cross an air bubble curtain. The response of fish to the air bubble curtain varies considerably from species to species as it does with other stimuli.

"Despite its failure in certain instances, the air bubble screen is of considerable interest. From the theoretical aspect, it might be of value to know by what sensory mechanism the screen works to divert fish. If these mechanisms were known, ways might be found to employ them more effectively. From the practical standpoint, the air bubble screen is low in capital cost as the installation consists of a few hundred feet of line and an air compressor. Operating costs are also low so that an operator faced with serious fish problems (not, probably, involved with perch or bass) could afford to experiment with the method, even if success with fish dissimilar to the alewife is uncertain."

The staff wants to emphasize its agreement with the second and third sentence in the preceding paragraph.

The material in Appendix S, ER, IP-3 relating to air bubblers is cited below.

"Subsequent to the formation of Indian Point Fish Advisory Board in April, 1970 Bechtel Associates was retained by the Company to conduct a survey of fish screening systems. This study reviewed both the biological and engineering aspects of screening fish from water flows.

"Results of the Bechtel study indicate that non-physical barriers to fish such as electrical screens, air bubble curtains, and light arrays are considered impractical because of their proven inefficiency at deflecting fish under all environmental conditions."

Although the applicant has not made available the results of the Bechtel study, the results were not based on studies at Indian Point. More recent data from the applicant (ER, IP-3, Appendix BB, pp. 40-42) indicate that air curtains may reduce fish impingement at Indian Point. The staff is reserving judgment on the effectiveness of air curtains at Indian Point until adequate data are available on which to base such a judgment; the applicant indicates that such data will be available shortly (ER, IP-3, Appendix BB, p. 42).

II. Cooling Towers are Needed at Unit No. 3

A. The staff notes the statements made by HRFA and SOS and agrees that based on a benefit-cost analysis the long-term incremental impacts from once-through cooling of Indian Point Unit No. 3 over that of Units Nos. 1 and 2 are of such magnitude to require closed-cycle cooling for Unit No. 3 to mitigate the environmental impacts in order to protect the aquatic resources of the Hudson River. Operation with a closed-cycle cooling system would reduce impacts from impingement and entrainment, thermal discharges, and reduced dissolved-oxygen levels. NEPA requires the AEC to assess the action under consideration for cumulative and long-term effects from the perspective that each generation is trustee of the environment for succeeding generations and to assure for all Americans productive surroundings and to attain the widest range of beneficial uses of the environment without degradation, risk to health or safety, or other undesirable and unintended consequences. Thus, by altering the cooling system before the biological damage becomes unacceptable, the benefits of Indian Point Unit No. 3 in terms of producing electrical power can be realized while minimizing the impact on the aquatic system by means of a closed-cycle cooling system.

B. The staff's evaluation of the environmental effects (impingement, entrainment, and thermal) on the Hudson River ecosystem with the addition of Cornwall is given in response to the New York State Department of Environmental Conservation comment No. 10.

III. Construction Time for Cooling Towers Must be Advanced

The subject of the scheduling for construction of the cooling towers has been addressed in the responses to Department of the Interior comment No. 1 and Environmental Protection Agency comment No. 12 as well as Appendix G. The schedule for excavation at the two locations on site is staggered so that no simultaneous excavation will occur. In this manner, no blasting at two locations on site will occur at the same time to affect operation of any of the Units.

IV. Reduced Operation is Necessary Each Spring at Unit No. 3

The staff agrees that damage to the Hudson River striped bass population would be minimized during the entrainment season if the cooling water withdrawal rate for Unit No. 3 were reduced to zero or limited to a practical minimum until a closed-cycle cooling system is operational. The staff does not, however, agree with the critical period specified above. Examination of 1955,[36] 1966-68,[16] and 1973[28,30] data on temporal and spatial distribution of striped bass eggs, yolk-sac larvae, and post yolk-sac larvae indicates that the critical period is from May 15 through July 31, a 10- to 11-week period.

Possibly, planned retirements of 292 MW in 1975 and 402 MW in 1976 could be deferred until the fall of 1977 and Indian Point Unit No. 3 could be placed in cold standby during the period May 15 to July 31 for the years 1975 through 1979. The steps outlined below represent a possible operating plan that would reduce the effects of entrainment during a critical period.

1. Purchase power. A concerted effort could be made to execute additional contracts for firm purchases of as much bulk capacity as the applicant's summer import capability will permit. Bulk capacity obtained in this manner will supplement the applicant's base load capacity when it is especially needed during the peak load period from June 15 to September 15. Summer peaks generally occur in mid-afternoon, but the system is at 90% of daily peak or above from 9:30 a.m. until after 6:00 p.m., and firm bulk power purchases would be available throughout the critical daily peak period.

2. Peaking units. When peak loads exceed available purchased and base load capacity, the more economical steam peaking units should be brought on line first followed by gas turbines as required. Concurrently, appeals for voluntary load reduction by all customers should be made through every means available to the applicant.

3. Voltage reduction. Before the available peaking capacity is exhausted, voltage reduction for the system could be initiated. If the Public Service Commission mandated 3% voltage reduction is still in effect, it could be increased to 5% or the 8% maximum allowable as required.

4. Emergency purchases. If steps 1 through 3 above are not adequate to meet daily peak loads, then emergency purchases (transfer limits 2 hr or less) should be employed. The first attempt to make emergency purchases should be through the New York Power Pool. These purchases would, by necessity, come from Upstate as Long Island Lighting Company is not expected to have significant summer reserves during the period under consideration. The next probable source would be PJM with which the applicant has interconnections capable of transmitting 400 to 700 MW depending upon operating conditions at the time. Projected surplus reserves upstate for the years 1975, 1976 and 1977 are 1,367, 574 and 1,095 MW respectively.[56] The applicant's unused transfer capacity, particularly with Indian Point Unit No. 3 in cold standby, is more than adequate for these projected reserves.

5. Operation Indian Point Unit No. 3 at 50% of rated capacity. In the event of an emergency (such as the unscheduled outage of a large unit or a heat wave affecting the entire northeast as experienced in August of 1973), the applicant would be permitted to operate Unit No. 3 at 50% of rated capacity. Operation at less than 50% pumping capacity (3 pumps) is not possible[37] and therefore no additional reduction of intake flow is achieved by operation at less than 50% power. Once in operation, Unit No. 3 would operate at a steady-state power level around the clock until the end of the emergency or the cold standby period, whichever comes first. Should the emergency end prior to the end of the cold standby period, a judgment decision as to whether or not Unit No. 3 should return to cold standby status would be based on the time remaining in the cold standby period.

Replacement power would likely be obtained from fossil-fueled units which would represent an increase in the discharge of air pollutants and also the consumption of fuel oil. Rapidly changing fuel costs makes it difficult to estimate exactly the incremental generating costs of the above plan. The staff did present a benefit-cost assessment of curtailed operation of Indian Point Unit No. 2 in the Unit No. 2 proceedings.[10] The staff's judgment was that the additional cost of alternative power would outweigh the environmental damage that might occur during the interim period if once-through cooling is allowed. The increased cost of fossil fuels leads the staff to conclude that this judgment is still correct for the case of both Units Nos. 2 and 3.

V. Cost/Benefit Evaluation Must be Scrutinized

The staff has included an analysis of the economic impact of the Indian Point Plants on the Hudson River spawned striped bass fisheries in this Final Statement (Section XI.J.2.c). In this analysis, the economic benefit to the Hudson River spawned striped bass fisheries that would result from the addition of natural-draft cooling towers at Units Nos. 2 and 3 are compared with the incremental generating costs incurred by adding the cooling towers. In this analysis, the staff has used figures for the number of striped bass anglers in New York and neighboring states, the average amount spent per day per angler, and the number of fishing days per year per angler comparable to those given in the HRFA-SOS comment.

The staff's conclusion is that the risk of causing severe and permanent ecological damage to the striped bass fisheries by the long-term operation of Units Nos. 2 and 3 with once-through cooling systems, in concert with Unit No. 1 and other power plants on the river, overrides the additional cost that will result from the installation of cooling towers at Units Nos. 2 and 3.

The staff's conclusion regarding interim operation of Units Nos. 2 and 3 with once-through cooling is that it is unlikely that this operation will cause irreversible damage to the striped bass fisheries and that the risk involved with such interim operation is acceptable in light of the applicant's need to install additional generating capacity.

L. CONSOLIDATED EDISON COMPANY OF NEW YORK, INC. (Con Ed) (12/24/74)

The applicant made three general comments about the conclusions reached in the DES and about the objectivity of the staff. In addition, the applicant appended a long list of detailed comments. Due to the extensive nature of these comments, the comments themselves will not be repeated here. The responses are identified in a manner consistent with the comments of the applicant (see Appendix I).

General Comments

1. The first general comment (by the applicant) was that the DES fails to analyze whether there is time to complete the applicant's ecological research program prior to a final decision concerning the need for closed-cycle cooling. This comment has been addressed in the Final Environmental Statement by

allowing the applicant to complete the presently planned ecological studies by the end of 1975 and to start excavation and construction of the cooling tower for Unit No. 3 by June 1977. Appendix G discusses the schedule for preliminary studies, planning, designing, excavating, and building of the cooling towers at Units Nos. 2 and 3. The schedule calls for complete installation of cooling towers at Unit No. 2 by December 1979 as discussed in the Atomic Safety and Licensing Appeal Board's Decision[38] (ALAB-188) of April 4, 1974. The once-through cooling at Unit No. 2 would terminate by May 1, 1979, and the cutover to the cooling towers would be completed by December 1979. The staff has recommended that, at Unit No. 3, once-through cooling be terminated by September 15, 1980, and the cutover to cooling towers would be completed by April 1981.

The applicant's research program has been discussed at length in Chapter V. The applicant's collection of data will be completed by the end of 1975, and during 1976 the applicant will prepare a final report. The final report is due by January 1, 1977. Therefore, the applicant can complete its ecological studies and the staff can review the final report before the start of excavation in June 1977 for the Unit No. 3 cooling towers.

The applicant urges postponement of the decision on the alternative cooling system until direct empirical evidence of the impact of plant operation is obtained. The applicant states that by this means, "we will know impacts instead of assuming them." In Comment No. 88, the applicant contends that the traditional scientific empirical approach of making measurements before and after plant startup should be followed, while maintaining detailed data on plant operation and all other river variables, is the only scientifically responsible approach. The applicant places little confidence in the ability of "early developmental mathematical models to predict biological effects" and quotes the statement made by the Department of the Interior in its letter to the AEC staff dated May 10, 1973, presented in Chapter XI.

The applicant's standard that a decision requiring cooling towers be based on empirical field evidence and that the decision must await the collection of the empirical evidence has specifically been rejected by the courts in decisions applying NEPA. In the Scientists Institute for Public Information, Inc. vs Atomic Energy Commission,[39] 481F.2d.1079 (1973) p. 1092:

"... one of the functions of a NEPA statement is to indicate the extent to which environmental effects are essentially unknown. It must be remembered that the basic thrust of an agency's responsibilities under NEPA is to predict the environmental effects of proposed action before the action is taken and those effects fully known. Reasonable forecasting and speculation is thus implicit in NEPA, and we must reject any attempt by agencies to shirk their responsibilities under NEPA by labeling any and all discussion of future environmental effects as 'crystal ball inquiry.' 'The statute must be construed in the light of reason if it is to demand what is, fairly speaking, not meaningfully possible.*** 'But implicit in this rule of reason is the overriding statement procedures to 'the fullest extent possible.'"

(citing Calvert Cliffs and NRDC vs Morton) (See also Environmental Defense Fund vs Frochlla, 473F.2d., 346, 1972), and Natural Resources Defense Council vs Morton 458F.2d.827, 1972.)

The applicant has carried out intensive studies starting in 1965 on the Hudson River ecosystem. The staff has reviewed the extensive reports from this work, including the reports from Texas Instruments, Inc., Quirk, Lawler, and Matusky, and New York University Institute of Environmental Medicine, particularly those reports containing 1971-74 data. The Final Environmental Statement includes detailed assessment of the empirical evidence in these reports. Semiannual operating reports involving actual operating experience of Units Nos. 1 and 2 also have also been reviewed.

In the Final Environmental Statement, the staff has made extensive use of the Texas Instruments, Quirk, Lawler and Matusky, and New York University 1973 data both in parameterizing and validating the staff's new young-of-the-year striped bass model. The young-of-the-year model and the staff's life-cycle model are used to forecast the short-term and long-term effects on the Hudson River spawned striped bass population that may occur due to plant operation. The forecasts from these models, as presented in Chapters. V and XI and Appendix B, have been instrumental in the staff's overall environmental assessment, leading to the decision that once-through cooling operation of the Indian Point Plants will result in unacceptable damage to the Hudson River striped bass fishery, thereby requiring an alternative closed-cycle cooling system at Units Nos. 2 and 3.

The staff does not agree with the applicant concerning postponement of the decision to require cooling towers until the applicant can provide only empirical field evidence after plant startup. The response time of the striped bass population is such that the impact on the adult population and fishery would not become evident until after several years of continuous impact on the young-of-the-year.

2. The second general comment by the applicant was that the staff showed bias in the analysis of biological impact. For example, the applicant states: "Con Edison is deeply distressed at the obvious bias that permeates the estimate of biological impact of plant operations. In this respect the DES can hardly be considered a realistic assessment of environmental impacts as specified by the National Environmental Policy Act (NEPA). Rather the staff has strained to find indications of damage or potential damage from plant operations and has systematically rejected all evidence, no matter how clear the data may be, that the plant will not damage the aquatic environment."

   The staff does not agree with this indictment. However, in response to the Atomic Safety and Licensing Appeal Board decision on Indian Point Unit No. 2 (ALAB-188)[38] the staff completely re-evaluated the Indian Point Unit No. 3 assessment during the summer and fall of 1974. In the process of this reassessment, a number of meetings were held between staff scientists and the scientific staff of the applicant, the applicant's contractors, the State of New York, intervenors, and other interested parties. Every attempt was made both to obtain the most recent data and to obtain information about various interpretations of those data. This document reflects this re-evaluation or "fresh look," and change is evident in the major revision of key sections of the DES to reflect new data, new thinking, and the many excellent comments received not only from the applicant but also from various government agencies, conservation groups, and interested citizens.

   The applicant complains of the reliance of the staff on mathematical simulation models in preference to empirical data in making the assessment. The fact is that adequate data that are directly relevent to assessing the effects of power plant operation on the Hudson River ecosystem are still very sparse. However, the staff still insists that models are essential to forecast the future impact of power plants, including the impact of those facilities not yet operating. Models are also necessary to unify, interpret, and extrapolate field and laboratory data and to help guide the experimental program.

Of course, the simulation of a system as complicated as the Hudson River estuary or the simulation of the effect of entrainment and impingement on the Hudson River spawned striped bass population is a very difficult undertaking. It can only be done properly when the models are based on parameters derived from careful observation. Thus, the staff believes that a better understanding of the Hudson and the effect of power plants on the river biota will be achieved through research that involves an integrated effort of experimental measurement and modeling. The staff believes that the applicant is conducting such an integrated research effort and that the results of this effort may greatly improve our understanding of the effects of power plant operation on various fish species.

During its re-evaluation the staff has greatly improved its models both conceptually and with respect to using available data to parameterize and validate the simulations. The young-of-the-year striped bass model has been completely revised to account more rigorously for the hydraulic behavior of the Hudson, the effect of various power plants, and possible compensation mechanisms. A life-cycle population model has been developed to simulate the long-term effect on the striped bass fishery of power plant impacts on the young-of-the-year.

The range of results that the staff has obtained with the new young-of-the-year model does not differ appreciably from that reported in the DES using the old model. However, this range of results depends strongly on the parameters chosen, especially on the values of the f factors. Values of f_c, the plant mortality factor, for various life stages of striped bass were estimated not only from the applicant's data but also from other research results (see Chapter V). Two values of the intake f factor (f_I), 1.0 and 0.5, were used. These two values were used partly because the staff has not received any data from the applicant relative to 1973 measurements of f_I at Indian Point by New York University and partly because data taken by QLM at other power plants indicated f_I values considerably lower (e.g., 0.1 to 0.2, according to the QLM analysis). The staff has carefully analyzed these data and has evaluated the experimental methods used to obtain the measurements (see Chapter V). It has also compared data obtained by QLM with Texas Instruments' river segment data taken at approximately the same time and locations. This evaluation leads the staff to believe that the f_I values of QLM are probably lower than the "true" values; thus the staff's use of 0.5 and 1.0.

The staff believes that future results from the applicant's research program will better define the f factors. The date of September 15, 1980, after which Unit No. 3 must have closed-cycle cooling, allows time for the completion of the research program (sampling through the summer of 1975) and for reevaluation of the impact of once-through cooling before groundbreaking for closed-cycle cooling (June 1977). (See Appendix G.) The staff will continue to evaluate the results from the research program.

Also, the results from the striped bass life-cycle model indicate that the incremental damage to the striped bass fishery (over and above that due to the other power plants already operating on the river) caused by operation of Units Nos. 2 and 3 with once-through cooling during the interim period until 1979 and 1980, respectively, will not be so significant that earlier installation of cooling towers is warranted.

3. The third general comment by the applicant was that the staff made a wrong decision (re closed-cycle cooling) by using the wrong procedures. Specifically, the applicant contends that the staff did not properly evaluate the chances that the applicant's research program could measure the magnitude of the impact of the Indian Point Plant on the striped bass fishery supported by the Hudson River. The applicant cites a statement on p. V-97 of the DES relative to the staff claim that the applicant must "conclusively demonstrate" that there is no unacceptable adverse impact of the Plant. However, the staff did not state on p. V-97 of the DES that the applicant must "conclusively demonstrate" that operation of the Indian Point Plant will not have an unacceptable adverse impact on the fisheries supported by the Hudson River. Rather, the staff cited its rebuttal testimony and proposed findings of fact in the Indian Point Unit No. 2 proceedings to the effect that it is unlikely that applicant's research program will be capable of conclusively demonstrating that there will be no such adverse impact.

The staff's skepticism concerning the applicant's research program is related to the nine criteria adopted by the applicant to judge the success of that program in measuring the impact of the power plant. These reservations are discussed in Chapter V of this document in great length. This is not to say that the staff believes the applicant's research program to be without value. As already mentioned above, the staff thinks the research may lead to the measurement of important simulation modeling parameters (e.g., f factors) and to the collection of data useful for the verification and further improvement of models, so that the models can be used to predict with greater certainty the future effects of Indian Point and of other power plants on the striped bass fishery of the Hudson River.

The applicant also argues that the staff used different standards when comparing the relative importance of the environmental impacts of cooling towers with once-through cooling. To this comment the staff response is that the potential adverse environmental impacts of natural-draft cooling towers (i.e., increased fogging, icing, and salt deposition), even for the worst conditions, appear to be small. (See Chapter XI and Appendix G.) This is not at all the case with respect to the potential effects of once-through cooling on the Hudson River striped bass population. The staff recognizes that there is one impact of cooling towers that is not negligible; this is the visual insult of the towers themselves and, under certain meteorological conditions, the plumes from the towers. In the judgment of the staff, this impact is acceptable, whereas the likely damage to the striped bass is not.

The staff recognizes that such a judgement is subjective. The applicant is correct in saying that, in principle, comparisons between alternatives should be made on a cost-benefit basis. The staff has included in the Final Environmental Statement a revised analysis that includes an estimate of the commercial and sport value of the striped bass fishery due to the Hudson River spawning (see Section XI.J.2.c). The incremental damage to the fishery in proportion to the cost of a cooling tower at Indian Point Unit No. 3 is about 0.1. In this analysis, the ecological value of striped bass in the Hudson River, or the aesthetic cost of cooling towers could not be accounted for. However, the staff's analysis results in the conclusion that the cumulative impact of all the power plants on the Hudson River (including the three units at Indian Point) operating with once-through cooling, will be substantial, (i.e., resulting in a reduction to the Hudson River supported fishery by 40% or more for 20-25 years). The question is whether such a large impact continued over many years will cause a significant irreversible decrease of the striped bass fishery. The staff's judgement is that the risk of such a consequence increases with the magnitude and duration of the impact, and the incremental effects of operating with once-through cooling at Indian Point Unit No. 3 increases the risk. This increased risk is considered unacceptable by the staff — thus, the recommended requirement of a cooling tower at Unit No. 3.

Detailed Comments

The following detailed comments have been responded to by appropriate modification of the text and in some cases modification of figures and tables:

4	5	7	10	12	18	19	20	21	23
25	27	29	31	32	36	39	40	41	42
43	44	46	50	51	54	55	56	57	58
59	60	61	62	63	64	65	66	67	68
69	71	72	73	74	75	76	77	78	79
80	81	82	83	84	85	92	96	98	99
101	102	103	104	105	106	108	109	110	111
112	113	114	115	116	117	118	119	121	122
123	124	126	127	128	129	131	132	134	136
137	138	140	141	142a	142b	143b	150	151	158
159	160	161	167	168	169	170	171	172	173
174	175	177	178	179	180	181	182	183	184
185	187	190	193	194	195	196	197	198	199
201	203	207	210	211	212	214	215	219	226
229	230	231	232	233	234	235	238	239	241
245	253	254	255	256	257	258	267	B(2)	B(3)
B(4)									

Following are those comments submitted by the applicant which have not been dealt with within the text, figures, or tables of this Final Environmental Statement:

1. Calculations for both the radioactive releases and the thermal discharges were based on a power level of 3,216 MWt and 1,033 MWe in anticipation of the fission product inventory and the

heat output for most of the plant lifetime (see Table X-7). The applicant provided such information in the Final Facility Description and Safety Analysis Report (FFDSAR). The staff carried out its analysis of radioactive releases based on 3,216 MWt in accordance with Sections 9 and 11 of the FFDSAR, and the thermal discharges were similarly based on a core thermal output of 3,216 MWt.

2. By its nature a summary must be confined to the most salient points. The staff agrees that the qualifications applying to the thermal analyses are important, but in summarizing the conclusions, the staff felt that the significant aspect was that combined operation of Units Nos. 1, 2, and 3 at Indian Point presents a situation in which, according to analyses, there is a strong possibility that the NYS water quality criteria might not be met. However, during these specific occasions, the applicant will have to reduce power sufficiently to assure that the criteria are met. Operation with closed-cycle cooling will assure that the discharges from the three Units will meet the criteria at all times.

3. As in comment No. 2 above, it is a matter of judgment as to what material should and can be included in a summary. In the staff's view, the main thrust of the applicant's arguments and conclusions regarding its mathematical studies was that the combined discharges from Units Nos. 1, 2, and 3 at Indian Point would meet the NYS water quality criteria. However, the summary has been revised.

6. Alternate methods, currently in operation or under consideration, for fish protection are presented under Item 5 of the Summary and Conclusions. Additional information on fish protection is discussed in Section XI.E and also in the response to the Hudson River Fishermen's Association and Save-Our-Stripers comment K.I.

8. The applicant is confusing the ecological program it is carrying out with that the staff feels should be carried out to determine accurately and precisely the long-term impact of Plant operation. The applicant's ecological program can provide at best information about short-term impacts, because only two years of post-operational data will be collected when Units Nos. 2 and 3 are in operation. The applicant's ecological program of data collection ends by the Fall of 1975. Because of the relatively long life cycle of the striped bass, the staff's recommended ecological studies would involve five to ten years of post-operational data collection to determine long-term impacts.

The ecological surveillance programs in the Environmental Technical Specifications are designed to observe only short-term impacts. The long-term significance of entrainment impacts will not be measured directly in the surveillance program, but they can be inferred by the use of ecological models. The staff believes that, during the five to ten years it takes to collect accurate data, the Plant operation could cause irreparable harm to the biota. The mitigating means to assure that damage does not become irreparable is to require the applicant to install closed-cycle cooling as soon as practicable and no later than April 1981.

9. The staff believes that the word severe is appropriate.

11. The basis for this statement is found in Section XI.C.3.c(4)(b)(v).

13. The Plan-of-Action of operating procedures and design of the once-through cooling system for Indian Point Unit No. 3 serves to complement the Environmental Technical Specifications by providing for implementation of alternate mitigating measures, as discussed in Section XI.E and HRFA-SOS Comment I, to prevent the environmental effects observed in the ETS. The environmental effects observed in the environmental surveillance programs outlined in the ETS will be short-term in nature. By use of ecological and thermal models, long-term impacts can be predicted. The output of the models can serve to indicate the urgency with which different mitigating measures should be instigated to reduce the ecological damage to acceptable levels prior to operation of a closed-cycle cooling system. (See staff response to the applicant's Comment 8.)

14. As stated above, in staff's responses to Comments 8 and 13, the need for detailed studies, as required in the Environmental Technical Specifications, is to assure the short-term effects observed in the surveillance program will be kept to a minimum by implementing the Plan-of-Action prior to operation of closed-cycle cooling system.

15. The staff is concerned about potential harmful discharges of copper from condenser tube corrosion and feels that copper concentrations at the point of discharge should be monitored.

16. As stated in the staff's responses to Comments 8, 13, and 14, the ecological surveillance program presented in the Environmental Technical Specifications is designed to observe changes in aquatic life during operation of the plants. If unforeseen damage occurs, the applicant will be required to take action to determine the cause of the damage and then to find means to prevent circumstances that might cause future damage to the fishery.

17. (A) The range, as stated in this table, was intended to indicate the disagreement regarding the maximum ambient temperature. Further discussion on the subject of ambient temperature has been added to Chapter II.

(B) The text has been changed to reflect this comment.

22. (1) The visual impact of natural-draft cooling towers at Units Nos. 2 and 3 has been considered in Section XI.C. Because of the topography of the Hudson Valley surrounding the Indian Point site and in consideration of the height of the cooling towers relative to the height of the hills and mountains surrounding the Indian Point site, the cooling towers at Indian Point cannot be seen from Bear Mountain Bridge or the Park Lodge. The Dunderberg Mountains, at 600- to 900-ft elevation, will obscure the view of any towers from the Bridge or the Lodge. The plume from the towers, however, may be seen from the Bridge or Lodge, depending on light and meteorological conditions.

Depending on distance, the sight of cooling towers at an effective elevation of about 550 ft will be obscured by Prickly Pear Hill (536 ft) and Hessian Hill (450 ft), two miles southeast of the site, if one is at Croton-on-Hudson. The Blue Mountain Reservation, 1.5 miles east of the site, will obscure the view of the towers from towns east of the reservation. The towers will be seen in Peekskill and Haverstraw and probably from Tappan Zee Bridge, depending on the meteorological conditions.

This section is intended as a brief overview of pertinent site features. Additional details are included in later sections.

(2) The text has been changed to reflect this comment.

24. The text has been changed to reflect this comment. See also the staff response to Department of the Interior comment No. 6.

26. See response to comment 17 above.

28. The meteorological models referred to in the DES, page II-18 at line 15, are the same as those referred to in the Safety Evaluation Report, September 21, 1973, on page 2-13.

30. The point the staff is making in the first paragraph of Section II.F.2.c(2) of the DES is that frequency of reproduction will tend to be positively correlated with ability to recover from

a kill, and that macrobenthic forms tend to have a lower frequency of reproduction than microbenthic forms.

33. A minimum velocity of 10 fps is required to ensure proper mixing of the discharge jet and the receiving water to assure that the State thermal criteria regarding surface temperature will be met.

34. A more recent photograph has been used in Chapter III.

35. (A) The figure has been changed to reflect this comment.
(B) The figure has been changed to reflect this comment.
(C) See staff response to comment no. 1 above.

37. See staff response to comment No. 1 above.

38. The staff elected to use the residence times as given in ER, IP-3, Appendix FF rather than other conflicting information supplied by the applicant.

45. See staff response to comment no. 1 above.

47. Additional discussion of the staff's reasons for selecting the parameters used and estimates of their frequency of occurrence have been added to Chapters II and V.

48. The text has been revised to reflect this comment. The basis for the staff's reservations is covered in the response to New York State Department of Environmental Conservation comment No. 29. The applicant will be required by the Environmental Technical Specifications to verify that a 10 fps discharge velocity will be maintained with all possible combinations of port openings and gate adjustments.

49. Although the staff's position with regard to recirculation is admittedly conservative, one can correctly assume that the cross-sectional temperature distribution in the river at the Indian Point discharge falls somewhere between near-field and far-field behavior, and that, as such, this intermediate field could be influenced to some extent by the recirculation of water to the Plant intake. This issue has been discussed by Siman-Tov[35] in the Unit No. 2 ASLB hearings. Note, however, that the point is somewhat academic, because the staff's conclusions are valid even when based entirely on the cases that assume zero recirculation.

52. Table V-7 has been modified to reflect the new information supplied by the applicant.

53. The staff feels that Table V-8 serves the purpose of clearly identifying intermittent chemical discharges.

70. The applicant has suggested that mortality does not properly constitute an environmental cost unless there is an established impact on total populations in the river, which, according to the applicant, has not yet been established and cannot be properly assumed. The applicant further expresses its concern of the application of the "as low as practicable" philosophy, which has not been made applicable to environmental matters by any law. However, the purpose of NEPA is to "encourage productive and enjoyable harmony between man and his environment; to promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man; to enrich the understanding of the ecological systems and natural resources important to the nation." Thus the staff believes that any plant-induced mortality resulting from impingement is one of many environmental costs, the magnitude and significance of which are matters of controversy between the parties in this proceeding. Given the history of impingement problems over 10 years of operation of Indian Point Unit No. 1, the staff has a vital concern to preserve and to protect the Hudson River ecosystem for the present and future generations. Although the applicant has made valid attempts to solve the problems of fish damage from operation of the Indian Point Plants and has modified the design of the once-through cooling system to minimize ecological problems from operation of Units Nos. 2 and 3, it does not appear that one can predict that the efforts planned by the applicant promise adequate protection against impingement. Therefore, the biological damage from impingement and entrainment estimated by the staff over the long term is of sufficient magnitude to justify considering an alternative cooling system design as the best corrective measure for continuing operation of Unit No. 3.

86. Animal predators also return much of what they eat to the system, where it is available for recycling through the food chain. Perhaps the most important weakness in the analogy between a power plant and an animal predator is that the latter can be satiated.

Reference to volume of river flow in 2.1 days has been deleted.

87. Post-yolk sac striped bass larvae do gradually develop swimming ability, and the applicant's consultant has collected 13- to 16-mm larvae in beach and shoal areas. What is very much in contention is the significance of collecting 13- to 16-mm striped bass larvae in beach and shoal areas. The applicant has not yet presented data or analyses indicating what percentage of larvae of given lengths are in beach areas, shoal areas and deep-water areas and to what extent their location influences their downstream movement.

88. See staff response to General Comment No. 1.

89. In light of the Appeal Board Decision for Unit No. 2 (ALAB-188),[38] the staff has developed a new young-of-the-year population model (see Appendix B, Section B.4.b). This model has been applied to a variety of plant configurations by using a range of input parameters.

90. The staff's detailed response to the applicant's detailed criticism (FES, IP-2, Vol. II, pp. 239-263) of the use of Eqs. (1) and (2) to approximate the probability of entrainment for primary producers and consumers has already been presented (FES, IP-2, Vol. 1, pp. XII-24 to XII-26).

91. See staff response to comment no. 90 above.

93. See staff response to comment no. 90 above.

94. After examining the NYU Progress Report for 1971 and 1972,[24] the staff agrees with the applicant that the American eel is not one of the species most likely to be affected by entrainment; this species has been deleted from the list in the paragraph in question.

Since shad do spawn far up river of Indian Point, entrainment of shad eggs is not expected to occur at Indian Point. The larvae, however, tend to disperse from the upstream spawning grounds down into the lower brackish parts of the river, during which time entrainment at Indian Point can occur.

95. The staff has examined the information contained in: Vol. I, "1973 Hudson River Program Fisheries Data Summary, May-July;"[28] Vol. II, "1973 Hudson River Program Fisheries Data Summary, July-November;"[29] and Vol. III, "Fisheries Survey of the Hudson River, March-July 1973."[30] Although these reports contain data from a more complete and intensive sampling program than represented by the Rathjen and Miller study (1955)[36] or the Hudson River Policy Committee study (1968),[16] the Texas Instruments study, as it relates to longitudinal

distribution of eggs, larvae, and juveniles, provides estimates of these distributions for 1973 only. It does not replace or negate the information relating to longitudinal distributions for 1955, 1966, and 1967.

97. See staff response to comment no. 89 above.

100. The phrase "thermal range of metabolic insensitivity" has been replaced by the phrase "thermal optimum."

The paragraph referred to by the applicant has been modified to indicate that changes in the biotic community, such as in the distribution of a single species or in species composition, might not be readily apparent unless an adequate biological sampling program were designed and executed to test this hypothesis.

107. If recirculation causes an increase in temperature at the intake of 1 to 2 F° and the discharge produces an increase in temperature of 15 F°, fish will be attracted in the winter to the discharge area to a greater extent than to the intake area. The staff's point is that because of an increase in temperature at the intake of 1 to 2 F°, there will probably be more fish in the intake area than if there were no temperature increase at the intake. Consequently, impingement will tend to increase.

120. The staff stated in the last paragraph of Section V.D.2.c(3) that the detrimental effects of reduced dissolved-oxygen concentration may be manifested by mortality, by reduced growth rates of larval and juvenile fish, and by reduced production of phytoplankton and zooplankton. The applicant's comment is that the evidence is all to the contrary with respect to growth rates and DO (i.e., all evidence indicates that growth rates of larval and juvenile fish are not reduced at low levels of DO).

The following material summarizes as of 1970 the state of knowledge concerning the dependence of larval and juvenile fish growth on dissolved oxygen levels.[40]

Larval growth

"Great depression of the growth rates of salmonid alevins by reduction of O_2 concentrations to about 5 or 7 mg/l has been reported, but results of recent, thorough investigations indicate that this is not a normal response. Under otherwise favorable conditions, reduction of dissolved O_2 to these levels apparently has little or no effect on growth rates of those salmonid alevins whose responses have been carefully studied and described, and on the efficiency of their utilization of yolk for growth. Moderately wide diurnal fluctuation of O_2 concentration about these levels also has little effect on growth. Even at constant concentrations as low as 3 mg/l, the rate of growth is reduced only moderately, and the size of the fry at the time when absorption of yolk is complete is reduced by no more than 25%, except at very low water velocities (e.g., 10 cm/hr) and perhaps at unfavorable, high temperatures. When embryonic and larval development both occur at a moderately reduced O_2 concentration, the consequent delay of completion of yolk absorption is ascribable in much larger degree to retardation of embryonic growth than to the retardation of larval growth.

"Detailed information of the influence of O_2 concentration on larval growth of fish other than salmonids is lacking. In view of the relatively short duration of the larval life of most fishes, moderate retardation of larval growth at reduced O_2 concentrations probably is not usually as important as in similar retardation of postlarval (juvenile) growth. However, O_2 concentrations in water percolating through streambed gravels in which salmonid alevins remain for a considerable period of time before emergence are often much lower than concentrations in the water above the gravels. The ecological significance of effects on growth of the alevins is uncertain."

Juvenile growth

"Food consumption and growth rates of juvenile fishes receiving unrestricted or abundant food rations and growing rapidly at favorable temperatures in laboratory aquaria can be limited by the O_2 concentration at levels near the air-saturation level. They are then depressed by any considerable reduction of O_2 from saturation levels. Lack of dependence of growth rates of abundantly fed fish on O_2 levels well below saturation levels has been observed but perhaps is always associated with relatively slow growth, for which a low temperature or nutritionally deficient or unattractive food may be responsible. The maximum limiting O_2 concentration apparently can increase sharply from a very low level to near the saturation level with a small increase of temperature beyond a critical point, which is between 15° and 20°C in the case of the largemouth bass, *Micropterus salmoides*, a warmwater species. Appetite and growth rates are depressed, but only moderately, at very high O_2 concentrations up to three times the air-saturation levels; they may be increased or depressed slightly by O_2 supersaturation that is not so great.

"The gross efficiency of conversion of food to body tissue as a rule is not markedly impaired at a reduced O_2 level if food consumption is not depressed greatly at that O_2 level and the O_2 level is not very low. Therefore, considerable impairment of gross food conversion efficiency of fish kept on unrestricted or abundant food rations in aquaria generally does not occur at reduced O_2 levels much above 4 mg/1, even when temperatures are moderately high. When food rations are restricted so that equal amounts of food are consumed at all tested O_2 levels, reduction of the O_2 concentration even to much lower levels (3 mg/1 or less) apparently has little or no effect on food conversion and growth. Observations conflicting with these findings have been reported but are deemed unreliable or inconclusive.

"When food rations are unrestricted, growth of juvenile fish in laboratory aquaria is impaired by large diurnal fluctations of O_2, as compared with growth at constant O_2 concentrations equal to the mean levels (arithmetic or geometric means) in the aquaria with fluctuating concentrations. Such diurnal fluctuations of O_2 between very high and low O_2 levels sometimes can impair the appetite and growth of fish at moderately high temperatures almost as much as does continuous exposure to the low O_2 levels.

"Under natural conditions, food intake is not rigidly fixed or restricted, but growth apparently is usually limited by the availability of food; increased exploitation of available food resources may require excessive energy expenditures. Neither in ordinary laboratory (aquarium) experiments in which rations are unrestricted nor in similar experiments with restricted rations are conditions that are natural from a bioenergetic standpoint approached. Limiting O_2 levels at which food consumption and growth become O_2-dependent under natural conditions therefore cannot be established through such simple laboratory experiments alone. They may, however, prove not very different from those concentrations at which growth begins to be restricted in laboratory tests with unrestricted rations."

125. The chlorine-tolerance data presently available from the applicant are not adequate to substantiate the applicant's claim that the concentrations of residual chlorine found to result in mortality of test organisms was sufficiently high that the less sensitive ortho-toluidine or Black-Whittle methods of analysis were sufficiently precise. Chlorination tests to evaluate the practicability of reducing the frequency and concentration level are being carried out by the applicant in accordance with the requirements of the Environmental Technical Specifications. The applicant also is not chlorinating when the river temperature is 45°F or lower. Only in the late spring, summer, and early fall will the applicant have to chlorinate.

130. The staff agrees that there is a potential for extended growing periods of certain organisms (e.g., blue-green algae), and, in fact, the staff explicitly states in the paragraph referred to by the applicant that "when ambient river temperatures are below optimum for algal growth, productivity would be significantly increased in the larger plume" [(fourth par., Section V.D.2.d(2)]. Whether annual growth rates of fish will change remains to be demonstrated.

133. The calculations in Table V-7 were made using the same assumptions regarding dilution flows as used by the applicant. The statement quoted in this comment recognizes that there will be some additional dispersion due to tidal action.

135. The paragraph in question has been modified. However, the reference mentioned in the comment contains no data or suggestion that detritus is an important source of food for zooplankters in the vicinity of Indian Point.

139. The applicant claims in this comment that "dominance by blue-green algae in discharge canals occurs at temperatures near 90°F and above." The staff claims in the paragraph in

question that "reports of field studies of the biota associated with discharge canals of power plants, ..., have noted dominance of the periphyton community by heat-tolerant blue-green algae when water temperatures exceed about 86°F." The data available at present support both claims, which do not differ significantly.

143. (A) Although choice of the word conflict was originally the applicant's, the staff agrees that a word such as contrast is more appropriate; this change has been made in Section V.D.2.d.

144. What should be noted here is that the applicant is overlooking other data (collected by consultants for the applicant) relating to the importance of *Neomysis*.

Texas Instruments[11] found during 1972 that:

a) *Neomysis* contributed little to the diet of young striped bass examined in their study area (p. V-163);

b) *Neomysis* was of minor importance in the diet of white perch during 1972 in their study area (p. V-160);

c) White perch and young striped bass were found to be very opportunistic in their food habits (p. V-170);

d) 1972 salinity levels were revealed to be less than average, with 1972 being a year of record rainfalls and increased freshwater runoff, which tended to limit migration of the salt wedge and thus reduce expected salinity levels.

Zooplankton population studies in the river are being conducted by New York University, and they have found the following:

a) The 1972 macrozooplankton data have not yet been analyzed and no comment will be made about them at this time;[24]

b) The most abundant organisms occurring in the 1971 macrozooplankton were *Gammarus tigrinus*, *Monoculodes edwardsi*, and *Neomysis americana* comprising, respectively, 54%, 21%, and 11% of the total number of organisms caught during the collection period in the vicinity of Indian Point.[24]

c) The occurrence of *Neomysis* in the vicinity of the Indian Point plant is related to the presence of the salt front in that part of the river. According to the data for 1971, *Neomysis* was present in significant numbers in the vicinity of the Indian Point plant only when the salinity exceeded about 0.5 ppt. Due to the very heavy rains experienced in this area in 1972, the movement of *Neomysis* into the vicinity of the Indian Point plant did not occur until approximately one month later (i.e., August instead of July) than in 1971.[41]

Raytheon[42] reported for 1970 that:

> Salinity and season appeared to have strong influence on the distribution of *Neomysis americana* (opossum shrimp), one of the most abundant organisms present in plankton collections. Maximum concentrations occurred during June, July, and August, resulting primarily from the presence of free-swimming juveniles. The seasonal and north-south distribution among transects clearly indicated a close relationship to salinity concentrations until early June. During the latter part of June and early July, *Neomysis* was more concentrated upstream where salinity values were lower. Since this period coincided with the presence of maximum numbers of juveniles, these data may indicate that sensitivity to salinity is not as important a factor [for juveniles] as it appeared to be for adults (pp. 6-6 to 6-7).

These results indicate to the staff that the importance of *Neomysis* in aquatic community dynamics near Indian Point will vary from year to year depending upon the salinity distribution. During years when the salt front is in the vicinity of Indian Point for much of June through October, the importance of *Neomysis* may be comparable to that of *Gammarus*.

These results also indicate to the staff that the research programs of Texas Instruments and New York University are not adequately integrated to evaluate the importance of *Neomysis*, *Gammarus*, or other zooplankton species in aquatic community dynamics near Indian Point. Population dynamics studies in the river of the major macrozooplankton species must be integrated with studies of the distribution and food habits of white perch and young striped bass.

145. The material on *Neomysis* in the paragraph in question has been moved to the paragraph following it in this Statement.

146. The last paragraph of Section V.D.2.d(3)(b) has been modified. The staff did not say that *Neomysis* move to Indian Point from downstream and then stay there. The staff said "as the salt front moves north of Indian Point these animals move upstream into the plant vicinity." See response to comment no. 144 above.

147. See staff response to comment no. 144 above.

148. The phrase "in zone of preferred salinity" has been replaced with the phrase "at or below the salt front." See staff response to comment no. 144 above.

149. The staff has not seen the unpublished 1972 NYU data indicating that juvenile *Neomysis* are distributed throughout the saltwater portion of the estuary; such data are not contained in NYU's Progress Report for 1971 and 1972,[24] received by the staff in March 1974. However, with reference to the question of the distribution of juvenile *Neomysis*, the staff points out again (see staff response to comment no. 144 above) that Raytheon[42] found that: "during the latter part of June and early July [of 1970], *Neomysis* was more concentrated upstream where salinity values were lower. Since this period coincided with the presence of maximum numbers of juveniles, these data may indicate that sensitivity to salinity is not as important a factor [for juveniles] as it appeared to be for adults." The staff's opinion is that present data concerning the frequency and location of reproduction by *Neomysis* in relation to the corresponding longitudinal salinity profile are not adequate to dismiss the possibility that reproductive activity is relatively high at the salt front.

152. This comment is addressed in the staff's elaboration of the relationship between temperature, spawning, and the possible effects of thermal discharges [Section V.D.2.c(1)].

153. The paragraph in question has been modified. Also, see the staff response to comment no. 87 above.

154. The sentence in question has been modified.

Although data are lacking on the longitudinal spawning distribution for 1968, the spawning distributions for 1955, 1966, and 1967 (Fig. B-6) and for 1973[30] indicate that the great majority of spawning occurs above Indian Point. Thus, the great majority of juvenile striped bass found below

Indian Point probably moved past Indian Point at an earlier stage of development. The applicant's present hypothesis (see staff response to comment no. 87 above) is that the post yolk-sac, striped bass larvae gradually develop swimming ability and at 13 to 16 mm (approximately 4 weeks old) move to the shoals, thus terminating their planktonic downstream movement.

The longitudinal distribution of eggs in the spring and of juvenile striped bass in late summer and early fall, together with the above hypothesis of the applicant, further supports the staff's hypothesis that the great majority of zero-year-old striped bass move past Indian Point at an entrainable stage of development.

155. The staff's analysis of 1955, 1966, 1967, and 1973 data shows that all spawning has not taken place above the vicinity of Indian Point in any of these four years. The table below gives the percentage of eggs estimated to be spawned above the vicinity of Indian Point and in the vicinity of Indian Point for each of these four years. "In the vicinity of Indian Point" includes between river miles 35 and 50. These percentages were calculated in the same manner and using the same figures as described in Section V.D.c(1).

	Percentage of Eggs	
Year	Above the vicinity of Indian Point	In the vicinity of Indian Point
1955	94	30
1966	90	23
1967	97	10
1973		
Epibenthic Sled	76	30
Tucker Trawl	87	13

156. The staff adamantly disagrees with the applicant that the data generated by Rathjen and Miller[36] in 1955 and by HRFI[16] in 1966-1968 are of very poor scientific quality compared to data now available from the applicant's ecological study. See staff's response to the applicant's comment 95. Also, see Section V.D.2.f, where the staff provides a preliminary evaluation of the ichthyoplankton data the staff has received from the applicant as of September 1974. Specifically, the staff's preliminary analysis of the new information contained in Refs.

10, 15, 17, and 19 indicates that previously held notions about striped bass abundance, spawning areas, movement of young, and distribution of nursery areas are not seriously in error.

157. The results available to the staff as of September 1, 1974, from the 1973 Texas Instruments' riverwide ichthyoplankton and beach seining programs[28,29,30] have been used where appropriate in preparing the Final Statement for Indian Point Unit No. 3 (see the staff responses to comments nos. 95, 154, 155, 164, and B-1). The staff assumes that the applicant will make these reports part of the record.

162. The third paragraph preceding the one in question has been modified to clarify some of the many influences that affect population density.

163. The staff knows of no data for natural populations of striped bass suggesting that fecundity is a function of population density.

164. Year-class fluctuations for the striped bass population spawning in the Hudson River can be approximated from the data in Tables V-15 and V-18 of Texas Instruments' First Annual Report,[11] which give the average annual catch per effort for bottom trawls and beach-seine hauls in the area between the Tappan Zee Bridge and the Newburgh-Beacon Bridge from 1965 through 1972. The ratio of maximum to minimum catch per effort is 487 for bottom trawls and 14.4 for beach-seine hauls; in both types of sampling, the catches are dominated by young-of-the-year striped bass.

The normal range of fluctuations in recruitment to the fishery is much less and can be crudely approximated by analyzing the fluctuations in commercial landings. The staff has done such an analysis using Hudson River landings, New York landings, Middle Atlantic landings, and Chesapeake Bay landings over 10-year periods, starting with 1963–1972 and going backwards in 5-year increments to 1933–1942 (Table XII-1). The average ratio of maximum to minimum yield for the commercial fishery is 4.2 for Hudson River, 2.8 for New York (including Hudson landings) and Middle Atlantic, and 2.1 for Chesapeake Bay.

The numbers of recruits (i.e., 3-year-old fish) in the striped bass population in the San Francisco Bay Estuary has varied greatly, ranging from 22 thousand to approximately 2.5 million and averaging 0.91 million.[43] The ratio of

Table XII-1. Values of minimum and maximum landings and the ratio of maximum to minimum for Hudson River, New York, Middle Atlantic, and Chesapeake Bay

Period	Hudson River			New York[a]			Middle Atlantic			Chesapeake Bay		
	Min (10^3 lb)	Max (10^3 lb)	Max/min	Min (10^3 lb)	Max (10^3 lb)	Max/min	Min (10^3 lb)	Max (10^3 lb)	Max/min	Min (10^3 lb)	Max (10^3 lb)	Max/min
1933–1942	11	35	3.2	19	266	14.0[b]	40	446	11.2[b]	642	3,286	5.1[b]
1938–1947	21	79	3.8	139	504	3.6	311	963	3.1	1,839	4,545	2.5
1943–1952	30	79	2.6	244	626	2.6	413	1,141	2.8	3,413	5,834	1.7
1948–1957	19	93	4.9	356	626	1.8	473	1,141	2.4	2,788	5,834	2.1
1953–1962	19	133	7.0	395	910	2.3	473	1,259	2.7	2,788	7,262	2.6
1958–1967	29	133	4.6	398	1,630	4.1	479	2,023	4.2	4,422	7,262	1.6
1963–1972	25	77	3.1	673	1,630	2.4	1,429	2,059	1.4	3,860	7,759	2.0
Average			4.2			2.8			2.8			2.1
Standard error			0.6			0.4			0.4			0.1

[a]Including Hudson River landings.
[b]Not included in average.

Sources:
T. S. Y. Koo, "The Striped Bass Fishery in the Atlantic States," *Chesapeake Sci.* 11(2): 73–93 (1970).
U.S. Department of Commerce, National Marine Fisheries Service, Fisheries Statistics Bulletins.

maximum to minimum number of recruits is 115. Sommani's analysis, based on use of a modified Ricker, spawn-recruitment curve, represents recruitment reasonably well. About 85.5% of the variation in recruitment over the 6-year period (1960-1965) is controlled by June-July outflow and 13.2% by the abundance of spawners. The relationship is significant at the 1% level. However, because of the small sample size (n = 6), any such conclusion based on this test alone must be treated with utmost caution.[43] With respect to East Coast stocks of striped bass, Koo[44] found no significant correlation between temperature and salinity and striped bass production.

Texas Instruments[11] found no statistically significant difference among beach-seine, catch-per-effort means for striped bass young-of-the-year for 1969, 1970, and 1972 after adjusting the means to a common temperature and salinity; this result suggests that a component of the year-class fluctuations may be due to differences in temperature and salinity regimes. However, there were still statistically significant yearly differences among the bottom trawl catch-per-effort statistics even after a similar covariance analysis. Texas Instruments states[11] that "the key physical factor that is probably controlling this estuarine ecosystem is quite likely the amount of runoff during the year.... In general, the 0-age class, which is best reflected in the beach-seine efforts, had negative correlations with runoff. [For all species, including striped bass and white perch, high] July runoff seemed to have had a negative effect on mean abundance." While the data in Tables V-16 and V-17[11] support this statement, the negative correlation coefficients are greater than -0.5 for white perch and striped bass for bottom-trawl and beach-seine data. On the other hand, several of the correlation coefficients for April, May, and August are positive and greater than +0.5. Further analyses of this type, based on more explicit a priori reasoning and perhaps including biotic variables such as indices of micro- and macrozooplankton abundance, are necessary.

The complete explanation of year class fluctuations in the striped bass population of the Hudson River is undoubtedly not simple and must involve consideration of:

a) factors influencing survival of young-of-the-year (e.g., temperature, salinity, dissolved oxygen, and freshwater flow regimes in the Hudson River, availability of food, and number of predators);

b) the controlling effect of the sport and commercial fisheries; and

c) The effect of the time period between recruitment to the fishery and age at sexual maturity.

165. For the discussions of biological impact, the staff defines short-term as one year or less (i.e., one seasonal cycle) and not 10 years. See staff response to comment no. 202.

166. The paragraph in question has been modified. However, this comment provides a good example of the disturbing manner in which the applicant proposes to test scientific hypotheses, that is, "presently planned meristic and electrophoresis studies are expected to provide definitive data that will confirm this hypothesis."

176. The staff holds that on the individual species level, the two species of greatest value from an economic, recreational, and social point of view are the striped bass and shad. In what way the evidence that shad are not impinged, etc., relates to the validity or lack of validity of the applicant's conclusion that shad have significant value escapes the staff.

186. Impingement data from January 1971 to December 1972 from Unit No. 1 were used by the applicant to make projections to Units Nos. 2 and 3. From December 1972 to March 1973, Units Nos. 1 and 2 either have not been operating or have been operating sporadically at reduced power or no power. The staff's opinion is that impingement data collected since December 1972 and prior to full power operation of Units Nos. 2 and/or 3 are of limited value in terms of reassessing the potential impingement impact at Indian Point.

188. In preparing the FES for IP-3, the staff has taken into consideration considerable relevant information received from the applicant since the issuance of the DES for IP-3. The staff has modified its analyses wherever this new information justified such modification [e.g., discussion of the Hudson-River, white-perch population in Section V.D.2.d(3)(c)].

The staff certainly has not adopted "the maximum possible approach" in evaluating the level of environmental effects as claimed by the applicant.

That this is the case is indicated by the staff's (a) reliance on the applicant's methodology and data in estimating the impingement impact (Section V.D.2.a); and (b) use in the striped bass young-of-the-year model of values of less than 1.0 for values of the probability of mortality upon entrainment (f_c).

189. The last sentence makes a conditional prediction (i.e., "could result" and not "will result"), which the staff feels is clearly supported by the preceding analysis. The question of how long it would take to create "irreparable damage" is discussed in Section V.D.2.d(3)(c).

191. The staff has obtained a number of values regarding the steam generator blowdown rate and used 10 gpm in its evaluation. The staff also accounted for a blowdown rate up to 50 gpm in Section V.E.1.b(3).

192. See Supplement No. 1 to the Safety Evaluation Report regarding the requirement of General Criterion 64 for monitoring principal releases from the Indian Point Plants. In Supplement No. 11 to the FFDSAR dated July 29, 1974, the applicant stated that monitoring equipment will be installed by May 1, 1975, in order to comply with Criterion 64.

200. See staff response to comment no. 186 above.

202. Long-term operation of the power plants refers to operation beyond five years. For Unit No. 2, long-term operation begins after 1978, and for Unit No. 3, it begins after 1980, assuming full power operation begins in 1975.

204. See staff response to comment no. 94 above.

205. The text has been changed. See, also, staff response to comment no. 146 above.

206. The text has been changed. See also staff response to comments nos. 162, 163, 164, and 165 above.

208. See staff response to comment no. 202 above. Operation of once-through cooling systems at Unit No. 2 and Unit No. 3 for five years may cause cumulative effects that will not appear until five to six years later. See Chapter V for a discussion of the results of the staff's young-of-the-year and life-cycle striped bass population models.

209. The impacts of wet natural-draft cooling towers, including land-use effects, noise, and economic effects, have been addressed in Section XI.C and Appendix G.

213. The information referred to in the comment is given in Section XI.C.

216. A re-examination of Table X-7 indicates that the entry entitled "Total capacity resources during summer peak load period" reflects whether or not the effective dates for new capacity, retirements, and deratings occur before or after the summer peak load period. These figures, not the total capacity resources at the end of the calendar year, were used to compute reserves during the summer peak period.

The ratings for the planned gas turbines in 1976 and 1977 have been changed to the summer ratings and the remainder of Table X-7 revised accordingly.

217. A clarifying statement and an additional reference have been added to the text.

218. The staff realizes that the applicant must use the revenue requirement method in actual practice, but this method includes taxes which are transfers within the economy and not a part of the generating costs per se. The revenue requirement method will give essentially the same generating cost as the staff method, provided the taxes are deleted from the fixed charge factor and the same discount rate is used for both methods.

Neither the DES nor the applicant's ER for Unit No. 1 considered the cost of replacement capacity and energy during downtime to allow cut-in of the cooling tower alternatives. The staff's position was that the normal 2 months per year downtime for scheduled maintenance over the 3-year construction period would probably suffice. However, Newman[45] stated that approximately 7 months of downtime would be required to accomplish the cut-in of the cooling tower. He then deducted the 2-month annual maintenance period leaving a 5-month period for which replacement power would be required.

220. The effects of salt deposition are discussed in detail in Section XI.C.3.c(1)(d) and Appendix G.

221. The staff is in agreement with this comment.

222. The text has been modified. The staff feels that NEPA requires a consideration of these alternatives.

223. With the present escalation rate for construction materials and labor, it is understandable that the capital cost for Astoria 6 (an oil-fueled plant) may reach or exceed $340/kW.

224. Many of the effects of closed-cycle cooling systems differ only in degree from those of the once-through cooling system described in Chapter V. The staff does not feel it necessary to repeat these discussions in Chapter XI. The effects of cooling towers are discussed in Chapter XI to the extent possible with the information available. Alternate cooling systems that the staff does not feel are feasible for the Indian Point Plant were discussed only in a general way. However, effects of natural-draft and mechanical-draft cooling towers have been discussed further in Appendix G.

225. The subject of construction schedule and other details for single natural-draft cooling towers at Units Nos. 2 and 3 has been presented in Appendix G. As one can see, the schedule allows for one year of excavation for the single tower at Unit No. 2 or at Unit No. 3 and 27 months for laying the foundation, constructing the tower shell, and purchasing and installing the electrical and mechanical equipment. The problems of derating the Plant at Units Nos. 2 or 3 have also been discussed. These include the incremental operating costs for auxiliary equipment and for loss of capacity due to the derating of the turbines because of the increase in back pressure to 3.95 in. of mercury (absolute).

227. The layout for the single towers at Units Nos. 2 and 3 is shown in Appendix G.

228. The text has been revised. The applicant is carrying out a sound survey in conjunction with operation with different cooling towers and will present this information in the environmental report on cooling towers due from the applicant on December 1, 1974. The subject of noise from the towers is discussed in Chapter XI.

236. Use of the number and weight of fish lost per year due to impingement is an accepted index of the environmental cost of impingement. When the applicant supplies the staff with adequate estimates on the total fish populations in the river,

the staff will estimate percent of harvestable or adult population destroyed per year for each important species. The staff has already made a preliminary estimate of this type for white perch (see last paragraphs of Section V.D.2.a).

237. See staff response to comment no. 236 above.

240. As used in this Statement, the staff's new striped bass young-of-the-year model deals with phenomena occurring during the period May to October, but not during the cold portions of the year when the applicant is planning to operate all three units at reduced flow.

242. The paragraph in question has been modified to more clearly indicate that the staff's assumption is a first order approximation that does fail to consider a number of factors, including the four itemized by the applicant.

243. Tables X-10 and A-3 in the DES give calculated volumes of water within the discharge plumes that are inside the isotherms of excess temperature above the temperature of the water in the river receiving the plumes. This receiving water temperature is usually not the ambient river temperature nor is it necessarily the site river temperature at Indian Point, although it much more closely approaches the latter. The distinction is important if, as in this comment, the near-field calculated results are compared with those obtained in the intermediate and far-field studies, because the latter two are usually associated with the river ambient temperature. (Table XI-10 in the DES has been deleted and the salient information incorporated into the text.)

The comment in effect compares the localized volume of heated water within the 4 F° isotherm in the plumes (Table A-3) to the well-mixed volumes of water in the river raised to a similar excess temperature (but above a different datum) as reported in the intermediate field studies in Table A-4 and in the far-field studies summarized in Table A-6 in the DES. These latter two studies, as well as the Alden Research Laboratory hydraulic model studies made for the applicant, indicate that the combined heat discharges from Units Nos. 1, 2, and 3 at Indian Point have the potential for raising the cross-sectional average temperature of the Hudson River by 3 or 4 F°, or more. For an ambient river temperature of 79°F, the Plant effluent could be discharged into water at 82 to 83°F. The near-field slot-jet analysis reported in Table A-3 of the DES is, therefore, the volume of water within a 4 F° isotherm in excess of 82 to 83°F, but is not the volume of water within a 4 F° isotherm in excess of the assumed ambient of 79°F.

With reference to the second part of the comment, the values given in DES Table XI-11 (as taken from DES Figs. A-5 and A-6) are for the temperatures in the river when the combined heat discharges of the Danskammer, Roseton, Indian Point, Lovett, and Bowline Plants are considered. Apart from the use of different datums for comparison mentioned above, it is not meaningful to compare the volume of water in a reach of the river affected by the heat from five power stations with the local volume of water at the discharge ports affected only by the Indian Point Plant heat discharge.

244. The staff feels that this is a possible means of reducing the residual chlorine concentration. It is a procedure being used in the cooling tower circulating water at the Palisades Plant.

246. The staff appreciates the commendation.

247. The staff has included a new benefit-cost analysis on the monetary loss to the fishery due to operation with once-through cooling. The staff's analysis is consistent with the NEPA and Senate Document 97.

248. The Section in question has been modified. Data provided to the staff by the applicant as of September 1, 1974 are not adequate to evaluate the degree of mitigation that might be achieved.

249. See staff response to General Comment No. 1.

250. The single natural-draft tower dimensions and cost estimate have been changed to agree with those presented by Newman.[45]

251. The staff's analyses indicate that wet natural-draft cooling towers have little potential for vegetation damage, assuming drift losses of 0.005% of circulating water flow and two cycles of concentration. Based on experience with full-scale natural draft cooling towers at LeHavre, France, the salt drift can be reduced to 0.00041% by newly improved drift eliminators.[46] The applicant should initially utilize the proper engineering design of cooling towers by incorporating

improved drift eliminators to assure that drift will be kept to a minimum of less than 0.001%. Impacts from cooling towers can be reduced through pretreatment of the makeup water, selection of tower construction materials (corrosion resistant) and design characteristics to avoid galvanic corrosion, controlling the number of recirculations and the concentration of TDS in the cooling water circuit, selection of amounts and types of chemicals needed for biocide control. (See Appendix XI-1 in the FES for IP-2, pp. A-XI-14 to XI-17.)

With natural-draft towers fitted with improved drift eliminators and operated in a manner consistent with these assumptions, the staff does not anticipate drift damage from natural-draft towers installed at Indian Point. It is important that this statement be made here, as the range of options available for reducing drift losses will be conditioned by restrictions placed upon intake of water from the Hudson.

As stated on pp. 17-17 to 17-18 of Suppl. 2 to Environmental Report for Indian Point Unit No. 3, if vegetation damage from salt deposition should become serious, the applicant can use fresh water from the New York State Chelsea Pumping Station, located 22 miles north of Indian Point.

Environmental Technical Specifications will be modified to take into account the changed mode of operation, and they will be designed to minimize impacts during operation of the towers.

252. The DES is consistent with this comment.

259. Computation of regional product was based on the applicant's service area because, with respect to Indian Point Unit No. 3, that is where the electrical generation and payrolls benefitting from the availability of this source of energy originate. The effects on the regional product, however, are not limited to the applicant's service area but are felt throughout the region.

The staff concurs that an income multiplier should have been employed to complete the computations and that the staff erred by not prorating payroll on the basis of future generation rather than future generating capacity. An income multiplier of 3 has been selected as being representative of the New York metropolitan area, which has many interdependent industries. For the purpose of prorating payroll, Unit No. 3 was found to represent 11.6% of the projected annual energy requirements for 1980. Section XI.H.7 has been revised accordingly.

260. The employment figure has been corrected using the revised method for computing regional product.

The typographical error pertaining to the percent sulfur in the kerosene used in gas turbines has been corrected.

The staff agrees with the above statement on atmospheric emissions except that the cooling tower derating could be made up by purchasing energy from nonfossil-fueled plants.

261. Table XI-13 deals strictly with stack emissions from fossil-fueled plants. Environmental damage from salt drift is discussed earlier in the same chapter.

262. The cost of capital was not omitted from the generating cost calculations, because a discount rate of 8.75% was used. The staff clearly stated that the figures used to calculate the 8.75% "vary from time to time and from utility to utility but are believed to provide a reasonable basis for calculations of present worth." If, in fact, the applicant's actual experience indicates a discount rate of 9.375%, then the present worth of the total generating cost calculated by the staff is overestimated rather than "grossly underestimated." The reason it would be overestimated is that as the discount rate increases, the present worth of the total generating cost decreases. In the FES Chapter XI, a discount rate of 10% has been used to correspond to present conditions.

a. See staff response to comment no. 218 above.

b. The applicant's statement is untrue. In the DES the staff computed the present worth of incremental generating cost by a summation from t = 3 to t = 30, or a period of 27 years. This present worth value was for November 1977, which was then backed down to November 1974, the anticipated in-service date of the existing Plant at the time the DES was issued, so it would be compatible with the total generating cost-present value of the Plant as is. The November 1974 present value was then correctly annualized over the 30 year book life of the Plant.

Since the DES was issued, the staff has changed the cooling tower construction period for the Unit No. 3 closed-cycle cooling system to begin in June 1977 and to end in April 1981. The calculations for the incremental generating costs have been revised accordingly.

c. See staff response to comment no. 218 above.

263. See staff response to comment no. 262 above.

264. This information is given in Sections V.D.2.a and XI.C.3.c (4)(b)(i).

265. The staff is not aware that any re-evaluation will result to neighboring property from an alternate cooling system requirement other than that involved when the entire Indian Point site was zoned for industrial use. Any devaluation of neighboring property due to industrial development of the Indian Point site with or without an alternate cooling system would be speculative.

266. The subject of the schedule for construction of closed-cycle cooling has been addressed in Appendix G. The closed-cycle cooling system at Unit No. 3 should be ready for operation by April 1981. The applicant will still have time to submit its final ecological study report to the staff for review by January 1977, before construction of the alternate cooling system begins in June 1977. See staff response to General Comment no. 1.

A(1). In the staff's opinion the assessment of the thermal impacts of Indian Point Unit No. 3 should be based on the Plant's maximum calculated capacity. See staff response to comment no. 1 above.

A(2). See staff response to comment nos. 48 and 49 above.

A(3). a. The staff recognizes the time lag in the tidal movements in the Hudson River estuary and the fact that the method used in the far-field mathematical model is an approximation. The staff believes: (1) that the effect of this approximation is not sufficient to significantly alter the general conclusions reached by the study, and (2) that since other approximations also are present in the study (such as the assumed constant cross-sectional area of the river's length from Troy to the Battery), adding the complexity of the refined velocity would not necessarily increase the accuracy of the calculations.

b. Since the staff's transient one-dimensional model did not accommodate an input for the thermal stratification factor, some of the cases in the study were made with a heat transfer coefficient to the atmosphere of twice that in other cases to show the possible effect of thermal stratification (DES, p. A-20, and Table A-6).

B(1). See staff response to comment no. 157 above.

E(1). Appendix E is in a standard form used by the staff for Environmental Statements, and the assumptions are clearly stated in the preface.

F. Appendix F, as it appeared in the DES, has been deleted. The zone and degree of influence of Hudson River striped bass is discussed in Section V.D.2.d(3)(c)(v).

G(1). The sentence — "The following weather conditions were assumed for the site:" — is, in the staff's view, simply a statement that introduces the list of assumed stability classes that follows. Note, however, that in making the thermal effect studies, the staff stated, in effect, that in the absence of definitive atmospheric data taken specifically at the Indian Point site, its assumptions would be as realistic and representative as possible based on the best information readily available to it.

G(2). "Plume rise" in the staff's analysis was taken to have the same meaning as defined in the reference work by Briggs,[50] "The rise of a plume center line or center of mass above its point of origin due to initial vertical momentum or buoyancy, or both." The dimensions of the plume are indicated in Fig. G-2.

G(3). If the plume rise equations given by Briggs[50] and those given by Hanna[51] are combined, it can be shown that tall, natural-draft cooling tower plumes have sufficient buoyancy reserve to penetrate commonly encountered local elevated inversion conditions. Definitive long-term data on local inversion conditions at Indian Point are needed for a positive assessment, but in the absence of such information, the staff believes it is reasonable to assume that the plumes from natural-draft cooling towers at Indian Point would penetrate most, if not all, local inversion conditions.

G(4). The sentence — "Some of the condensation may fall to the ground and some may remain suspended in the form of fog." — states that some of the condensation will fall to the ground as water droplets and that some will remain suspended in the air as ground-level fog. The third possibility, that condensation will cause a cloud that is not ground-based, is not the subject of discussion in the paragraph.

G(5). The staff used the relative humidity/dry-bulb temperature frequency data for Poughkeepsie, New York, that were furnished by the applicant,[52] because these were the only local data available to the staff. Although Poughkeepsie is within about 35 miles of Indian Point and is located in somewhat similar terrain on the east bank of the Hudson River, the staff did not assume that these data are precisely applicable to Indian Point nor has it speculated as to how the data should be adjusted for Indian Point conditions. The staff has, rather, assumed that its estimates of fogging frequency due to natural-draft towers, based on data that it seems reasonable to assume are somewhat representative, are not sufficiently severe to cause concern over the contribution of the towers to naturally occurring ground-level fog.

Likewise, the frequency distribution of wind speed used in the staff's analyses, as furnished by the applicant (ER, IP-3, Appendix C), was considered the best information available to the staff in making the cooling tower studies. Again, the staff believes that although the data are limited, it seems reasonable to draw general conclusions from the analyses, because the estimated resulting conditions of operation do not appear to be particularly severe or excessive.

G(6). The combined effects of the cooling tower drift and the naturally occurring airborne salt were considered in the DES, Section XI.C.3.c(1). See also staff response to comment no. 251 above.

M. FEDERATED CONSERVATIONISTS OF WESTCHESTER COUNTY, INC. (FCWC) (12/7/1973)

The staff notes the comments of the Federated Conservationists, a coordinating group of 59 organizations in Westchester County, concerned with environmental problems in the county. The group comments about the delay in the erection of the cooling towers at Indian Point and the interim operation prior to installation of cooling towers. The subject of the construction schedule on the cooling towers has been addressed in Appendix G. See DOI-Comment 1 on the same subject. During the interim operation with once-through cooling, the applicant will be required to comply with the Environmental Technical Specifications accompanying the operating license. The ETS are designed to limit the radiological and non-radiological discharges into the atmosphere and into the Hudson River, to require monitoring of the discharges, and to conduct surveillance studies of the effects of the discharges on man and his environment. The discharges will be required to meet the Atomic Energy Commission's rules and regulations and the State and Federal water and air quality standards in accordance with the Section 401 and 402 permits in the FWPCAA of 1972 and the Clean Air Act. In addition, to further minimize the impacts on the environment, the applicant shall be required to implement a plan of action, the requirements of which are presented in Chapter XI and the Summary and Conclusions of this Statement.

To assure that the applicant is operating the Plants in compliance with the Environmental Technical Specifications and the rules and regulations of the Commission and applicable law, the Commission carries out independent periodic inspections of the operations of the Plants. The reports of the inspections are placed in the public doucment room, such as the one at the Hendrick Hudson Free Public Library in Montrose, New York, for perusal of the public. Through its inspection and enforcement program, the Commission maintains surveillance over the operation of the Plants throughout their lifetime to assure compliance with the Commission's rules and regulations for the protection of public health and safety and the environment.

The administrative controls in the ETS also require an independent review and audit of all the applicant's operating procedures and practices. The applicant has established the Environmental Protection Committee, which is directly responsible to the senior officers of the Company and which will conduct periodic audit and reviews of the operating practices of the Company. These practices are reviewed by the Commission in its inspection program.

The applicant has available technical advice and review of the ecological programs by the Fish Advisory Board, the Hudson River Fish and Wildlife Cooperative and a number of leading consultants in this country and in England. See Section I.C. for additional details on the function of these groups. The staff and intervenors have attended meetings of these consulting groups, and the staff believes that independent views to solve the ecological problems have been freely expressed by the various experts.

The applicant has been involved in the management and planning of environmental controls of the Indian Point Plants in seeking solutions in various phases of generation, transmission, and consumption for a number of years. Some of the research efforts supported by the applicant include energy conversion, underground transmission, a five-year ecological study program, removal of fossil fuel pollutants, disposal of chemical wastes, and advanced energy production. Details of the research supported by the applicant are presented in the "1973 Report of Member Electric Corporations of the New York Power Pool and the Empire State Electric Energy Research Corporation Pursuant to Article VIII, Section 149-B of the Public Service Law, Volume 2."[53] These include research on methods of developing conservation of energy concepts and minimizing environmental impacts.

N. ROCKLAND COUNTY CONSERVATION ASSOCIATION, INC. (RCCA) (12/11/73)

This Conservation Association has written of its concern of atomic fission plants and favors a moratorium of such plants, because the Association believes the dangers of nuclear plants are irreversible and a legacy that "we should be ashamed to foist on future generations." The pros and cons of nuclear power plants have been a subject of much debate during the past few years.

The staff, however, knows of no basis for placing a moratorium on the operation of nuclear power plants. Differences of opinion as to what constitutes a properly designed, constructed, and operated nuclear power plant naturally exist. This is a healthy situation and one which contributes to greater safety, because the sober discussion of different opinions contributes to the furtherance of sound technological conclusions. The important thing is that safety questions be faced squarely and openly and that the questions be dealt with in a manner that assures the soundest possible judgments.

As with everything else, there is always some risk, no matter how small, in all human activities. The AEC Regulatory system is designed to assure that the most advanced procedures of science and technology are used to protect the public and thereby minimize risk. As a result, the safety record of licensed nuclear power plants is excellent. Whenever the AEC determines that an additional safety feature or further improvement is needed, there are those who seize upon this as a weakness and call for a moratorium. Rather, this should be recognized as a basic strength of the Regulatory process. The public interest is best served when the problems that arise are corrected, when improvements are made, and when these actions are taken in full public view.

Through this Statement and the Safety Evaluation prepared by the staff, a wide array of topics pertaining to the construction and operation of the Indian Point Nuclear Power Plants has been presented. These documents involve a staff independent review of the applicant's application to determine that the plant design and operation will be consistent with the Commission's rules and regulations. The entire licensing review involves extensive investigation by the staff and its consultants as to reactor safety of the plants, the financial qualifications of the applicant, the anti-trust aspects of the license application, and many other facets of the application to assure that the health and safety of the public is not endangered, and that the environmental impact of plant operation will be minimized, based on a cost-benefit analysis.

As stated in the Federated Conservationists Comment M, each license for operation of a nuclear reactor such as Indian Point contains Technical Specifications, which set forth the particular safety and environmental protection measures to be imposed upon the facility and the conditions of operation that are to be met in order to assure protection of the health and safety of the public and of the surrounding environment.

Through its inspection and enforcement program, the Commission maintains surveillance of the plant throughout its lifetime to assure compliance with the Commission's rules and regulations for the protection of the public health and safety and the environment.

In addition, in referring to future generations, the Conservation Association probably refers to one of the most important issues currently facing the Commission — the question of the ultimate disposal of high-level radioactive waste. Some of those problems have been addressed in Chapter IX. The staff has also commented on this same question in HEW-Comment 4, DOI-Comment 13, and EPA-Comment 9.

Many details on this subject have been desicribed in the Commision's reports, "Environmental Survey of Uranium Fuel Cycle," WASH-1248, April 1974,[2] and "Management of Commercial High-Level and Transuranium — Contaminated Radioactive Waste," WASH-1539, Draft Statement, September 1974.[3]

The Conservation Association also expressed its concern of the fish kills at Indian Point. This subject has been discussed in Section V.D.2. Although the staff does not agree that the fish kills are due to human fraility as referred to by Dr. John Lawler in the Conservation Association's comments, reduction of intake flow and velocity by operating with cooling towers should reduce the impingement and entrainment effects. These towers also will reduce the thermal discharges to the river that the Association comments on. The timing of the cooling towers has been discussed in Appendix G and in the DOI-Comment 1 and HRFA-SOS-Comment II and III.

The agencies that the staff requested to comment on the Draft Environmental Statement are those designated by the Council of Environmental Quality in its guidelines, 38 FR 20550 - 20562, August 1, 1973. Any interested group, agency, or party may also submit comments. The Commision welcomes any such comments that the Association recommends. However, it does not have the jurisdiction of taking the leadership in encouraging legislation that would tax all power companies their proportionate share to finance a private agency to conduct long-term impact studies on biological life by the plants along the Hudson River. For the association's information, the Hudson River Fish and Wildlife Cooperative, including representatives from State and Federal agencies and university facility, serves to provide guidance and advice to the applicant in studying the ecosystem of the Hudson River.

O. ENVIRONMENTAL DEFENSE FUND (EDF) (12/10/73)

The EDF expresses its concern on the siting of nuclear power plants such as the Indian Point Plants on a highly productive ecosystem such as the Hudson River estuary. The staff has found this to be the case by way of its detailed analysis of impingement and entrainment effects on the striped bass eggs, larvae, and young-of-the-year juveniles resulting from Plant operation. The staff's recommendation to retrofit Unit No. 3 with closed-cycle cooling towers is based on its study of ecological damage resulting from the once-through cooling system.

Once the closed-cycle cooling system is built, the applicant will need to use biocides to keep the circulating water clean. At this time, details of the water treatment system to be used are uncertain, but apparently chlorine and sulfuric acid will be needed to control alga growth and corrosion scale. The applicant will be required to limit the pH change and the residual chlorine concentration discharged in the blowdown. At the time when the operation with cooling towers commences, the applicant will be required to operate the new system in accordance with appropriate Environmental Specifications. The new specifications will be designed to limit the pH change and the chlorine discharges in accordance with applicable water quality standards.

The EDF refers to the question of redesign of rate structure as a possible alternative to need for construction of new capacity. The staff responded to a similar question from the NYS Department of Environmental Conservation. See staff response to NYS DEC-Comment 1 on the subject of energy conservation. The staff has modified Chapter XI to include a discussion of change in utility rate structure. However, the following is a more extensive discussion of peak load pricing.

A review of the daily peak load demands for the Consolidated Edison system shows that the highest peaks occur during the week (exclusive of holidays) the peak demands are reduced on Saturday, and the lowest peak demand occurs on Sunday. Generating requirements are also less on holidays than during the week, and load requirements are less at night than during the day. With peak load pricing, the Consolidated Edison electricity users, during times of peak use (on a daily basis), are billed at a higher rate to more accurately reflect the higher marginal cost of producing the peak power. The costs of supplying energy at peak periods are higher because high variable cost-low capital cost units (oil, combustion turbine) are used. The base and intermediate load portion of the load is supplied, in general, by high capital, low variable cost generating units (such as nuclear), which operate at higher rates of annual utilization to spread the capital cost over a great many megawatt hours of annual generation. In order to register consumption at different times by electricity users, an additional metering arrangement is typically required.

The effectiveness of peak load pricing as a mechanism for reducing system load peaks depends, to a large extent, upon the price elasticity of demand for use of the appliance or other load types causing peaks. For example, the electricity demanded for either air conditioning or space heating may turn out to be very unresponsive to price changes and may depend, instead, principally on outside temperature. In order to make correct estimates of this elasticity, disaggregation of load data and identification of the fraction of the load attributable to space conditioning would be necessary.

Futhermore, to the extent that peaks were flattened, the base or intermediate load requirements may reasonably be expected to rise as the system load factor increases. In theoretical terms, this substitution may be discussed in terms of the cross price elasticity of demand, which relates system off-peak electrical energy use to electricity price at the time of system peak. If peak load pricing were implemented, the rate of growth of Consolidated Edison system peaks might be reduced. However, improvement in the system load factor might increase the rate of growth of generating requirements for base and intermediate load.

Economic theory indicates that implementation of substantial revisions in rate structure such as peak load pricing could result in some changes in the pattern and growth of electricity demand. The body of literature on quantitative demand analysis for the electricity market does not address the effects of rate structure changes per se although price responsiveness by electricity consumers is generally indicated. Other authors have discussed the potential consequences in theoretical terms of rate structure changes upon demand for electricity. However, a review of the literature on this subject[54] does not indicate methodology commonly agreed upon by economists which the staff could use to estimate, devoid of substantial speculation, what effect peak load pricing would have upon projected electricity demand within the Consolidated Edison service area. A primary data deficiency is that peak load pricing is not used in the United States. Consequently, there is currently insufficient information for quantitatively assessing how this measure would affect service area load growth for a utility such as Consolidated Edison.

Relative to heat dissipation from once-through cooling, the staff discussed this point in Section V.C.1. The atmosphere will ultimately absorb most of the water heat from the thermal plume dispersed in the Hudson River. The applicant states that based on his calculations, about 60% of the heat is lost by evaporation to the atmosphere. Thus, the staff concurs with the EDF's quotation from the article "Economics of Thermal Pollution Control", by G. O. G. Löf and J. C. Ward, in the Resources for the Future Reprint No. 91, January 1971.[55]

The subject of wet-dry towers is addressed in Chapter XI.

P. NORTH BROOKHAVEN SPORT FISHERMAN'S CLUB INC. (NBSFC) (12/6/73)

In reference to the comments from this Sport Fishermen's Club, the staff reports that in the Indian Point Unit No. 2 proceeding, the Atomic Safety and Licensing Board ruled that operation of the once-through cooling system at Unit No. 2 would be required to terminate on May 1, 1978. The applicant took exception to this requirement before the Atomic Safety and Licensing Appeal Board, which ordered on April 4, 1974, that the date be delayed until May 1, 1979. Because of construction problems, particularly excavation for building cooling towers, the schedule for construction of the towers at Unit No. 3 was staggered by a year from that at Unit No. 2. Therefore, the proposed construction schedule shows the termination date for once-through cooling for Unit No. 3 to be September 15, 1980. The schedule for tower construction is discussed in Appendix G.

As discussed in the DOI-Comment 1, the interim period of operation will be kept under control by means of the Environmental Technical Specifications appended to the operating license. The plan-of-action will be implemented to minimize the environmental impact. See Section. XI.J for discussion of the plan-of-action.

The subject of the Cornwall pumped-storage facility was addressed in the NYS DEC-Comment 10.

Q. GREAT SOUTH BEACH MOBILE SPORT FISHERMEN (GSBMS) (12/9/73)

This organization recognizes the need for more power but also emphasizes the needs of man and his environment. The subjects of damage to the fishery by Indian Point Unit No. 1 and the curtailment of the Unit No. 2 pumps by the New York State Department of Environmental Conservation in February 1972 have been addressed in Sections I.B. and V.D.2 of this Statement. The staff concurs with the Sport Fishermen concerning the need for cooling towers to avoid irreparable environmental damage to the fishery over the long term. However, the staff assessment shows that the schedule of cooling tower operation is several years after the date for commencement of operation of Unit No. 3. The decision to allow once-through cooling during this interim period was based on a cost-benefit analysis, which weighed the additional costs of supplying the power by alternative sources against the benefits of damages that would be avoided in the Hudson River. The benefits were less than the costs, and the risk of producing an irreversible effect on the river ecosystem was deemed acceptable during this interim period. (See also staff responses to DOI-Comment 1.) During the interim period the operation of the Plant will be required to operate within the requirements of the Technical Specifications so as to protect the public health and safety and the surrounding environment. A new set of appropriate Technical Specifications will be required for operation with cooling towers.

R. WEST BRANCH CONSERVATION ASSOCIATION (WBCA) (12/14/73)

This Association reiterates the same concerns expressed in the above conservation groups. The cooling towers at Indian Point would serve the purposes of reducing the impingement, entrainment, and thermal effects on biota. The staff concurs with this Conservation Association that the use of cooling towers is mandatory to protect the biota from long-term damage. Towers have been used in Europe particularly for many years. They can be built of corrosion-resistant materials to aid in avoiding the use of corrosion inhibitors in the circulating cooling water in the towers.

S. CONNECTICUT COASTAL ANGLERS ASSOCIATION (CCAA) (12/18/73)

The staff notes that the Anglers Association recommends that further study and investigation of the environmental impact of such construction and operation seems to be imperative.

The applicant will be conducting additional postoperational studies in accordance with the Environmental Technical Specification Requirements to assure that there will be a minimal impact on the fishery prior to operation with cooling towers. The staff carried out its analysis of impacts and, based on a cost-benefit balancing, determined that cooling towers at Unit No. 3 are needed after September 15, 1980. The schedule for construction of the towers is discussed in Appendix G.

The subject of the proposed Cornwall pumped-storage facility was discussed the the NYS DEC-Comment 10. See Chapter XI for the benefits and costs of the Plant operation, including the impact on the value of sport and commercial assets of the Hudson River.

T. INTERESTED PARTIES IN THE INDIAN POINT PLANTS

The Regulatory staff received a number of letters from interested persons; namely, Mr. Kenneth E. Bay of Hastings-on-Hudson, Mrs. Harold Cooper of Riverdale, Mr. Don McLean of Garrison, Mr. John Nicholas, Jr., of Riverdale, Mr. Robert J. Rance of Massapequa Park, New York.

Their comments indicate encouragement in operating the Indian Point Units Nos. 2 and 3 with cooling towers as an abatement to pollution of the Hudson River. In the Commission's correspondence with these individuals in January 1974, the staff wrote that, at that time, the Atomic Safety and Licensing Board issued on September 25, 1973 the Initial Decision for the Licensing of Indian Point Unit No. 2, in which a closed-cycle cooling system should be in operation after May 1, 1978, to reduce the impacts on the aquatic biota of the

Hudson River. The applicant took exception to this condition before the Atomic Safety and Licensing Appeal Board. On April 4, 1974, the Appeal Board ruled on this exception and ordered that the closed-cycle cooling system at Unit No. 2 be delayed until after May 1, 1979. The construction schedule to meet this date is shown in Appendix G.

In the Draft Environmental Statement for Indian Point Unit No. 3, the Regulatory staff recommended that Unit No. 3 operate with an alternate closed-cycle cooling system after May 1, 1978. However, the staff has reconsidered this position in view of the Appeal Board Decision in the Unit No. 2 case and in view of the more recent staff study of the impact on the aquatic biota in the Hudson River. Because of the excavation and construction problems at the Indian Point site, the staff now believes that a closed-cycle cooling system at Unit No. 3 should be put into operation after September 15, 1980. The delay of two years for requiring an alternate cooling system at Unit No. 3 was assessed by the staff. The analysis indicated that, on a benefit to cost basis, once-through cooling should be permitted during this interim period. See also staff response to DOI-Comment 1. Although the impact to the river may be sizeable, the Technical Specifications and a plan-of-action will be in force to limit observable impacts during the interim period.

In addition, the staff analysis through the young-of-the-year and adult fish models indicates that the fishery will recover from the impact once the alternate cooling system is installed. The staff, however, recommends that the alternate system be installed as soon as practicable and that once-through cooling be terminated by September 15, 1980.

In reference to the concerns about the impacts on the fishery of the Hudson River from operation of the proposed Storm King pumped-storage facility, the staff has addressed this comment in New York DEC-Comment 10.

In addition, a concern was expressed about the activation of the Unit No. 3 resulting in release of radioactivity to the environment. As discussed in Section V.D and V.E of this Statement, a very small amount of radioactivity produced during operation of Unit No. 3 may be released to the Hudson River and to the atmosphere under controlled conditions after appropriate treatment, sampling, and monitoring. These releases of radioactivity to unrestricted areas will be in accordance with the Commission's regulations, as set forth in 10 CFR 20 and 10 CFR 50.

As specified in Appendix B, Table II, in 10 CFR 20, the allowable concentrations of radionuclides in air and water 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 guides of proposed Appendix I of 10 CFR 50, which requires releases to be as low as practicable. The radiation doses from the radioactive releases from Indian Point Unit No. 3, as shown in Chapter V of this Statement, will be but a very small fraction of that dose received from background radiation. During operation, the applicant will be conducting a radiological environmental surveillance program to assure that such releases and doses will be kept as low as practicable and meet the Commission's regulations.

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