DRAFT DETAILED STATEMENT ON THE ENVIRONMENTAL CONSIDERATIONS RELATED TO THE PROPOSED ISSUANCE OF AN OPERATING LICENSE TO THE CONSOLIDATED EDISON COMPANY OF NEW YORK FOR THE INDIAN POINT UNIT NO. 2 NUCLEAR GENERATING PLANT

DOCKET NO. 50-247

BY THE

U.S. ATOMIC ENERGY COMMISSION

DIVISION OF RADIOLOGICAL AND ENVIRONMENTAL PROTECTION

RETURN TO REGULATORY CENTRAL FILES
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SUMMARY AND CONCLUSIONS

1. This is the Draft Detailed Environmental Statement prepared by the U.S. Atomic Energy Commission, Division of Radiological and Environmental Protection, related to the proposed issuance of a license to Consolidated Edison Company of New York, Inc., for the operation of the Indian Point Nuclear Generating Plant, Unit No. 2 (Docket No. 50-247), located in the State of New York, Westchester County, Village of Buchanan, 24 miles north of the New York City boundary line.

2. The Indian Point Station will have three Units each with a pressurized water reactor. Although the present action is concerned with the proposed issuance of a license for Unit No. 2, this Statement considers the environmental impact of the simultaneous operation of Units Nos. 1 and 2 (285 and 873 megawatts electrical, respectively). Another environmental impact statement will be prepared for Unit No. 3, in which the accumulative impact from all three Units will be taken into account.

3. The environmental impacts, including beneficial and adverse effects, of the Indian Point Unit No. 2 in conjunction with Unit No. 1 are as follows:

a. About 35 acres of 239 acres of land formerly used as an amusement park, and later zoned for heavy industry, have been converted to the Plant facilities.

b. The applicant plans to develop an 80-acre forested park with a freshwater lake; the applicant also plans to build a new visitors' center, nature trails, gardens and public facilities which will enhance the value of the site to the general public. A 14-acre area has been transferred by the applicant to the Village of Buchanan and will be developed into a marina.

c. A minimal land area is being used for the right-of-way of the transmission lines from Unit No. 2 to the nearby Buchanan Substation from which the power is distributed to the applicant's system; no additional right-of-way is needed to distribute the electrical output of Unit No. 2. Transmission towers from Unit No. 2 to the Buchanan Substation were designed architecturally in accordance with State and Federal guidelines.

d. In constructing Unit No. 2, the change in pattern of land use was kept to a minimum and no additional roads or railroads were built; areas disturbed during construction are being restored by landscaping and planting.

e. A total of about 2,600 cubic feet per second* of water for once-through cooling and service water systems will be withdrawn from the Hudson River and heated up by about 15°F during passage through the steam condensers and heat exchangers of Unit Nos. 1 and 2. The thermal discharges from both Units Nos. 1 and 2 will be returned in a common discharge canal to the Hudson River via a 270-foot long, submerged multiport discharge structure; the discharge velocity will be about 10 feet per second.

f. The conclusions reached by the applicant in regard to the thermal discharges from Units Nos. 1 and 2 in meeting the New York State thermal criteria throughout the entire year have not been adequately demonstrated by the applicant, especially since the submerged jet depth is being changed from 18 feet to 12 feet below mean low water level.

g. The dissolved oxygen concentration in the discharge water at the outfall may be reduced to 3 parts per million (ppm) or less. If plant operations indicate an important reduction in dissolved oxygen, aeration of the cooling water will be required.

h. Small quantities of phosphate, hydrazine, boric acid, chromate, and soda carbonate discharged into the Hudson River on an intermittent basis are not expected to produce discernible biological effects.

i. Chlorination of the once-through cooling system will result in releasing cooling water containing 0.5 ppm of residual chlorine for up to 3 times per week for a total of 6 hours per week; the residual chlorine (and any chloramines formed from reaction with nitrogenous materials in the river water) may be toxic to aquatic life in the vicinity of the outfall.

j. In Unit No. 2, aquatic biota impinged on the intake structure or entrained in the cooling water will be exposed to severe mechanical, chemical (chlorine), and thermal conditions; as a consequence, up to 25% of the average number of eggs and larvae of certain species of fish that annually pass by the Plant may be killed; under the most adverse conditions, up to 100% of some of the entrained planktonic species may be killed; and fish kills of a magnitude two or three times greater than those caused by Unit No. 1 may occur.

k. Operation of Units Nos. 1 and 2 should not cause contamination of groundwater by either industrial or sanitary wastes.

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*1 cubic foot per second (cfs) is equivalent to about 450 gallons per minute (gpm).

l. Discharges of radioactive gaseous and liquid wastes to the environment during routine Plant operation will result in an insignificant radiological impact on man and biota.

m. Nearby residents will be exposed to a very low probability risk of accidental radiation exposure during abnormal operating conditions and during transport of radioactive material.

n. Operation of Unit No. 2 will allow the applicant to shut down or reduce the use of older coal-burning plants and thereby decrease the pollution load of the air near the plants.

o. Electrical energy needed to maintain the health and welfare of the people of New York metropolitan area and to support the economic growth of the area served by the applicant's power network will be generated by the Plant.

p. The local economy will be stimulated through taxes, direct employment, and visitors.

4. The following alternatives were 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. Location of the Station at other sites

e. Heat dissipation with wet evaporative, natural-draft and mechanical-draft cooling towers and spray ponds operated in the open-and-closed-cycle mode.

f. Heat dissipation with dry cooling towers

g. Reduction of biological damage to biota from entrainment and impingement by modification of the operation of the present intake-discharge structure for once-through cooling and relocation and redesign of the intake-discharge structure.

h. Consideration of the chlorinating scheduling and procedures in order to reduce the adverse effects of residual chlorine and chloramines on the water quality.

i. Replacement of species damaged by operation of the once-through cooling system

5. 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 the Plant's operation:

   a. The operation of Units Nos. 1 and 2 with the present once-through cooling system has the potential for long-term environmental impact on the aquatic biota inhabiting the Hudson River which could result in permanent damage to the fish population in the Hudson River, Long Island Sound, the adjacent New Jersey coast, and the New York Bight. The potential impact is due to possible damage to aquatic biota (including fish eggs, larvae, and plankton) from entrainment in the cooling water system resulting in exposure of the biota to severe mechanical, chemical (chlorine) and thermal conditions and impingement on the intake structure.

   b. The estimate of potential environmental impact identified above and discussed in this Statement is based on inconclusive and incomplete data from the applicant. Existing information is insufficient to accurately predict the degree to which the potential damage will eventually take place during operation.

   c. The benefits of meeting an urgent need for power in the New York area in the short-term outweigh the estimated corresponding environmental costs. The need for power for the metropolitan New York area has been adequately demonstrated in terms of decreasing reserve margins and increasing frequency of brownouts during peak load periods of the past several summer seasons. Indian Point Unit No. 2 will add needed new base-load capacity to the applicant's system and improve the reliability of service in the metropolitan New York area. Operation of Unit No. 2 will also permit obsolete base-load fossil plants inside New York City to be retired, thereby improving the air quality of the City. However, in the long-term, the estimated environmental cost could be of sufficient magnitude that it requires the applicant to carry out an extensive operational monitoring program; evaluate all the data developed; and propose and be prepared to implement alternative actions that will minimize impact to such an extent that no irreversible or irretrievable biological damage will occur to the ecosystem.

   d. The applicant will be required to develop and implement a comprehensive program acceptable to the of monitoring the physical, chemical and biological parameters to secure the basic data required to:

      (1) Determine whether the operating Plant meets the New York State thermal criteria throughout the entire year;

(2) verify the validity and establish the accuracy of the thermal analyses, particularly with regard to predictions of thermal plume behavior under different tidal influences, various fresh water flows, and at different times of the year;

(3) assess the significance of the magnitude of adverse effects on the biota in the estuary so that any adverse effects from chemicals, heat, impingement, and entrainment resulting from operation of Units Nos. 1 and 2 can be correlated with the findings from the physical-chemical monitoring program;

(4) determine the magnitude of mortality of aquatic biota due to impingement on the screens by number, size, type and age of of fish species; determine the magnitude of entrainment mortality of aquatic biota by species composition;

(5) determine the effects of thermal discharges on different species in the thermal plume including a determination of the duration of exposure of planktonic organisms to the various temperature increments, the amount of plume inhibition and augmentation of photosynthetic activity and the composition of the phyto-plankton community;

(6) develop chlorination procedures to minimize the residual chlorine and other biocide discharges into the Hudson River.

e. The applicant will be required to:

(1) continue its efforts to modify the present intake discharge structure and operating procedures to reduce biological damage from entrainment and impingement, and

(2) further investigate the benefits which could be derived by operation of a hatchery for replacement of damaged biota.

f. The applicant will be required to develop and implement a plan acceptable to the AEC for developing a detailed design study of a specific closed-cycle cooling system based on the most promising of the alternative closed-cycle systems discussed in the applicant's Environmental Report and Supplements and this Draft Detailed Environmental Statement that would be expected to minimize long-term ecological damage. This study will include an evaluation of the environmental impact of the alternative cooling system as well as identifying and evaluating the economic impact on the public. The applicant will be required to complete the detailed design study and a progress report on the results of the environmental monitoring program within a period of 15 months from the date of initiation of steady-state power operation. Within the second year of operation the AEC will evaluate the results of the monitoring program and the design study and will determine the extent of any actions to be imposed on the applicant to minimize the environmental impact.

6. The initial Detailed Environmental Statement (November 20, 1970) took into account and incorporated comments from the following agencies:

Department of Agriculture
Department of Defense
Department of Health, Education, and Welfare
Department of Housing and Urban Development
Department of the Interior
Federal Power Commission
New York State Department of Environmental Conservation
New York State Atomic Energy Council
Westchester County Department of Planning

7. The following Federal, State, and local agencies have been requested to comment on this Draft Detailed Statement:

Council of Environmental Quality
Department of Agriculture
Department of the Army, Corps of Engineers
Department of Commerce
Department of the Interior
Environmental Protection Agency
Federal Power Commission
Department of Health, Education, and Welfare
Department of Housing and Urban Development
Department of Transportation
Governor of the State of New York
New York State Agencies
- Department of Environmental Conservation
- Department of Public Service
- Department of Commerce
- Atomic Energy Council

Westchester County Department of Planning
Mayor of the Village of Buchanan

8. The date on which this Draft Detailed Environmental Statement is being made available to the public, to the Council on Environmental Quality, and to the above specified agencies is April 13, 1972.

TABLE OF CONTENTS

Page

APPENDICES

TABLES

Page

FIGURES

FOREWORD

This Draft Detailed Statement on Environmental Considerations (the Statement) related to the proposed issuance of an operating license to the Consolidated Edison of New York, Inc. (the applicant), for its Indian Point Unit No. 2 (Docket No. 50-247), has been prepared by the U. S. Atomic Energy Commission's (the Commission) Regulatory Staff (the staff) in accordance with the Commission's regulation, Title 10, Code of Federal Regulations, Part 50 (10 CFR 50) Appendix D, as revised on September 9, 1971 (36 FR 18071), and further revised on September 30, November 11, 1971, and January 20, 1972, and corrected on September 21 and December 16, 1971, implementing the National Environmental Policy Act of 1969 (NEPA). (P.L. 91-190, 83 Stat. 852).

Section 102(2) of NEPA calls for all agencies of the Federal Government to utilize a systematic interdisciplinary approach which will insure the integrated use of the natural and social agencies 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 which will insure that presently unquantified environmental amenities and values may be given appropriate consideration in decisionmaking along with economic and technical considerations; and to include in every recommendation or report on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment, 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 which would be involved in the proposed action should it be implemented.

In addition, Section 102(2) of NEPA requires the Commission to study, develop, and describe appropriate alternatives to recommended 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 on environmental problems.

This Statement reflects guidance of the Council on Environmental Quality as contained in the Guidelines published in the Federal Register on May 10, 1970 (35 FR 7390), on January 28, 1971 (36 FR 1398), and April 23, 1971 (36 FR 7724).

By application dated December 6, 1965, and amendments thereto (the application), the applicant applied for the necessary licenses to construct and operate a nuclear power reactor at the applicant's site at Indian Point, Village of Buchanan, Westchester County, New York. The application was evaluated by the Commission's regulatory staff and independent Advisory Committee on Reactor Safeguards (ACRS), both of which concluded that there is reasonable assurance that the facility could be operated at the proposed site without undue risk to the health and safety of the public. On October 14, 1966, the Commission, after a public hearing and after favorable recommendations from the Atomic Safety and Licensing Board (the Board), established by the Commission, issued Construction Permit CPPR-21 for this facility.

The application for a license to operate the Indian Point Unit No. 2 is presently pending before the presiding Board pursuant to a Notice of Hearing in this matter dated November 15, 1970. On October 19, 1971, the Facility Operating License No. DPR-26 was granted to the applicant in which the applicant was authorized to load fuel and perform subcritical tests. Technical Specifications contained in Appendix A attached to the license were incorporated in this license. On September 24, 1971 with supporting testimony of October 19, 1971, the applicant filed with the Commission and submitted a notice before the Board to issue an interim limited license for Indian Point Unit No. 2 for testing purposes up to 50% of full power. This motion is pending before the Board.

In accordance with Appendix D of 10 CFR 50, of June 3, 1970 (35 FR 8594), the staff transmitted on August 17, 1970 copies of the applicant's Environmental Report-Operating Licensing Stage of August 6, 1970, and updated operating license application for Indian Point Unit No. 2 to appropriate Federal and State agencies for review and comment. The applicant responded to the comments of the agencies. The Commission incorporated these comments in the Final Detailed Statement issued on November 20, 1970. The present Draft Detailed Statement supersedes the November 20, 1970 Statement.

The applicant submitted "Environmental Report Supplement No. 1 on Indian Point Unit No. 2 and Appendices Volumes Nos. I and II" on September 9, 1971. On September 9, 1971, the Commission issued a revised Appendix D to 10 CFR 50 (36 FR 18071). In compliance with this regulation, the applicant submitted "Supplement No. 2 to the Environmental Report on Transportation, Transmission Lines, and Accidents" on October 15, 1971, and "Responses to Environmental Questions Raised on October 12, 1971 by the Division of Reactor Licensing," on October 28, 1971, and "Supplement No. 3-Benefit-Cost Analysis" on February 15, 1972.

This Statement is based primarily on the applicant's Environmental Report and Supplements, its Final Facility Description and Safety Analysis Report (FFDSAR) and amendments thereto, the Commission's Safety Evaluation and Supplements, as well as on the referenced documents listed at the end of each chapter. Valuable insight into this assessment of impacts was gained from a visit to the Indian Point site and surroundings on September 2 and 3, 1971 by the staff and its consultants. This Statement considers the environmental impact of construction and operation of both Indian Point Unit No. 1 (Docket No. 50-3) and Unit No. 2. Indian Point Unit No. 3 (Docket No. 50-286) is currently under construction and the staff will prepare, in conjunction with the impact of Units Nos. 1, 2 and 3, a separate environmental statement for the proposed operation of Unit No. 3.

All material submitted by the applicant in support of its application, its Environmental Report and Supplements, and other pertinent documents are available for public inspection at the Commission's Public Document Room at 1717 H Street, N.W., Washington, D. C., 20545; and at the Hendrick Hudson High School, Albany Post Road, Montrose, New York. Copies of these documents also have been forwarded to appropriate Federal agencies, New York, and local officials for review and comment.

The applicant is required to comply with section 21(b) of the Federal Water Pollution Control Act, as amended by the Water Quality Improvement Act of 1970. In accordance with Appendix D, as revised, to 10 CFR 50, the operating license for the Indian Point Unit No. 2 will contain a condition to the effect that:

> "The applicant shall observe such standards and requirements for the protection of the environment as are validly imposed pursuant to authority established under Federal and State law and as are determined by the Commission to be applicable to the facility covered by this operating license."

The applicant is also required to comply with the Technical Specifications which will be issued with the proposed license.

I. INTRODUCTION

The Indian Point Nuclear Generating Plant Unit No. 2 (Indian Point Unit No. 2) (Docket No. 50-247) owned and operated by the Consolidated Edison Company of New York, Inc., (the applicant) is located on a 239-acre site on the eastern bank of the Hudson River in an industrial area, about 24 miles north of the New York City boundary line, at Indian Point, Village of Buchanan, in the upper Westchester County, New York State.

The applicant received a construction permit CPR-21 for Indian Point Unit No. 2 on October 14, 1966. The applicant applied for an operating license on October 15, 1968 and obtained a Facility Operating License No. DPR-26 to load fuel in the core and conduct subcritical testing on October 19, 1971. A limited operating license to test up to 50% of rated power is pending before a presiding Atomic Safety and Licensing Board.

The Indian Point site has three nuclear generating Plants on the Station with the following thermal and electrical output expressed in megawatts thermal or megawatts electrical.

(1)	Unit No. 1 (In operation since 1962)	-	890 MW(t) (total) 615 MW(t) (nuclear) 275 MW(t) (fossil)	285 MW(e)
(2)	Unit No. 2	-	2,758 MW(t)	873 MW(e)
(3)	Unit No. 3 (Under construction until 1973)	-	3,025 MW(t)[a]	965 MW(e)[a]

[a]Initial output

Each Unit utilizes the Hudson River as the water supply for once-through cooling systems.

The following chapters describe (1) the environment in the area, including the history, geography and geology, hydrology, climatology, ecology, land and water use including chemical characteristics, (2) the facility and its effluents, (3) the impacts from construction and operation of Unit No. 2 (Plant), (4) alternatives to the proposed action, (5) irreversible and irretrievable long term commitments of resources from effects of the Plant operation, (6) need for power, and (7) the benefits-cost accrued from the proposed issuance of an operating license. Wherever possible, the Statement takes into account the combined impacts from operation of Unit No. 1 and Unit No. 2. The applicant shall be required to release all discharges to the environment in accordance with Federal and State regulations.

A. SITE SELECTION

The selection of a site for construction of an electricity-generating facility depends on many factors. The generating capacity of the power plant is a primary factor. Large generating units (which are more economical than smaller units) place restrictive requirements on prospective plant sites. Power plants using fossil fuel (coal or fuel oil) must have available the means, such as railroads or navigable waters, of transporting bulk materials in large quantities. In addition, each fossil- or nuclear-fueled power plant requires a large volume of water for dissipating the waste heat inherent in the steam-electric cycle.

Another consideration in the selection of plant sites is the distance to the load centers, since transmission losses increase with distance. Nearness to existing transmission facilities decreases the capital investment required to place new power generation on line.

Public acceptance of a plant site is also desirable. Public pressure to preserve scenic natural features, or to prevent the placement of a power plant near residential areas of high population density, influences the ultimate selection of a power plant site. Suitable sites for large power plants are becoming increasingly scarce in the New York area. Limitations of the availability of the abovementioned requirements has restricted the applicant in slecting suitable sites to build power plants to serve the applicant's service area.

A primary consideration for choosing the Indian Point site for Unit No. 2 was that the site was pledged to nuclear power generation as early as 1956, when the construction permit for Unit No. 1 was issued by the Commission. Unit No. 1 had been in commercial operation for over three years when the applicant filed its application for a construction license for Unit No. 2 on December 6, 1965. The applicant has had difficulty in finding sites within or near its service area upon which the Commission might approve construction of a nuclear plant and which could also win public acceptance.

Contributing to the siting decision were the following facts: the population density in the nearby area was low, cooling water was available, the geology of the site was adequate, and no danger of flooding was possible. 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,[1] and studies had been made of the impact of incremental amounts of these discharges.

B. APPLICATIONS AND APPROVALS

Table I-1 lists the applications filed by the applicant and the approvals received from various governing bodies or agencies.[1] 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 Supplement No. 1.

TABLE I-1

FEDERAL, STATE AND LOCAL AUTHORIZATIONS
REQUIRED FOR CONSTRUCTION AND OPERATION OF
INDIAN POINT UNIT NO. 2 AND UNIT NO. 1

AGENCY	DATE OF ISSUANCE	PERMIT, LICENSE, ETC.
Federal		
Atomic Energy Commission		
Indian Point Unit No. 1 (Docket No. 50-3)	5-4-56	Construction Permit CPPR-1 (Docket No. 50-3)
	3-26-62	Unit No. 1 Provisional Operating License DPR-5
Indian Point Unit No. 2 (Docket No. 50-247)	10-14-66	Construction Permit CPPR-21 (Docket No. 50-247)
	9-23-70	ACRS Report Division of Reactor Licensing
	11-16-70	Safety Evaluation
	10-19-71	Facility Operating License No. DPR-26 to Load Fuel and Conduct Subcritical Testing
	Pending before ASLB and AEC	Facility Operating License to Conduct Tests Up to 50% of Rated Power
Indian Point Unit No. 3 (Docket No. 50-286)	8-13-69	Construction Permit CPPR-62

AGENCY	DATE OF ISSUANCE	PERMIT, LICENSE, ETC.
Federal		Section 10 Permits
Department of the Army New York District Corps of Engineers	2-23-66	Permit No. NANOP-E Place fill in Hudson River.
	3-15-66	Permit No. NANOP-E To construct a discharge channel extension wall, a screenwell structure, to place fill and to dredge.
	1-19-67	Permit No. NANOP-E Approval of revised plans to place fill in Hudson River. Such approval to supersede plans approved Permits dated 2-23-66 and 3-15-66.
	9-29-67	Permit No. NANOP-E Construct a screenwell, bulkheads, a discharge channel, to dredge, to place dredged material behind the bulkheads and to install temporary dolphins in the Hudson River.
	11-24-70	Permit No. NANOP-E Revised plans approved to supersede plans approved Permit dated 9-29-67. Additionally, install a steel outfall section consisting of 12 submerged openings.
	12-11-67	Permit No. NANOP-E Dredge flotation channel and construct ramp in Lents cove, Hudson River.

AGENCY	DATE OF ISSUANCE	PERMIT, LICENSE, ETC.
Federal (continued)		
Department of the Army New York District Corps of Engineers	Applied 6-24-72 Estimated Date of Receipt 4-24-72	Section 13 permits to control thermal, chemical and other discharges.
Environmental Protection Agency Through New York State Department of Environmental Conservation	Applied 7-15-70	Federal Water Quality Certificate under Section 21(b) of Water Quality Improvement Act of 1970
STATE OF NEW YORK		Discharge Canal and Outfall Structure
Department of Health	8-22-66	(No permit number) Approval of final plans for 214 foot cooling water discharge channel facilities.
Water Resources Commission Conservation Department	3-2-66	Permit No. 8-4-66 Construction of extension of discharge canal to separate discharge from intake to a point 300 feet south of present location.
Water Resources Commission Conservation Department	6-30-70	Permit No. 8-22-70 Extend discharge canal 98 feet downriver and protect with sheet piling at Indian Point generating station.
Department of Health	5-19-70	(No permit number) Outfall construction - construction of an effluent channel with a submerged diffuser.

AGENCY	DATE OF ISSUANCE	PERMIT, LICENSE, ETC.
STATE OF NEW YORK (continued)		Discharge Canal and Outfall Structure (continued)
*Department of Environmental Conservation Division of Pure Waters	12-10-70	Outfall Construction - construction of effluent channel with 12 submerged openings, 4 by 15 feet each, with 18 foot centerline depth submergence, including adjustable ports. Supersedes permits of 8-22-66 and 5-19-60.
		Chemical Discharges
Department of Health	6-10-59	Sewage and waste disposal.
Department of Environmental Conservation	11-13-70	Permit to discharge chemical solutions.
Department of Environmental Conservation	2-10-71	Permit to discharge chemical solutions.
		Dredging
Water Resources Commission Conservation Department	2-4-66	Permit No. 8-1-66 Deposit 50,000 cubic yards of rock spoil in Hudson River at Indian Point.
Water Resources Commission Conservation Department	4-13-66	Permit No. 8-11-66 Dredge an area of 135 feet by 63 feet by 22 feet deep. Dredged area to be used for concrete screenwell construction.
Water Resources Commission Conservation Department	6-22-67	Permit No. 8-31-67 Fill and dredge to carry out construction of new screenwell and relocate discharge canal.

*This Department was created in 1970 to take over and replace various functions of other State departments. Among other duties, it took over those of the Conservation Department which was abolished and those of water and air pollution control which had previously been under the Department of Health.

AGENCY	DATE OF ISSUANCE	PERMIT, LICENSE, ETC.
STATE OF NEW YORK (continued)		Dredging (continued)
Water Resources Commission Conservation Department	11-30-67	Permit No. 8-78-67 Dredge a channel approximately 150 feet wide by 1800 feet long in Lents Cove of the Hudson River.
		Air Quality
Department of Health	4-12-68	Permit No. HA 680101 Permission to construct two Babcock and Wilcox integral furnace boilers.
		Environmental
Hudson River Valley Commission	9-14-67	Screenwell and discharge line.
Hudson River Valley Commission	12-7-67	Dredging in Lents Cove
Hudson River Valley Commission	3-26-71	Changes in discharge canal.
		Water Quality Certificate
Department of Environmental Conservation	12-7-70	Water quality certification Indian Point generating station -- Units No. 1 and No. 2.
LOCAL		
Village of Buchanan	12-1-65	Permit No. 373 Building Permit for excavation for nuclear steam electric generating station.
	5-16-66	Permit No. 381 Building Permit for intake screenwell structure.
	5-24-66	Permit No. 387 Building Permit for turbine room, water bay and discharge water tunnel.

AGENCY	DATE OF ISSUANCE	PERMIT, LICENSE, ETC.
LOCAL (continued)		
Village of Buchanan	9-28-66	Permit No. 404 Building Permit for primary auxiliary building and waste hold-up tank pit.
	9-28-66	Permit No. 405 Building Permit for fuel storage building.
	9-28-66	Permit No. 406 Building Permit for containment building.
	2-18-67	Permit No. 411 Building Permit for control room.

Future Environmental Approvals

Future environmental approvals required by the applicant for the operation of Indian Point Unit No. 2 will include obtaining operating permits from the New York State Department of Environmental Conservation (Article 12, Public Health Law), the Department of the Army, Corps of Engineers (The Navigation and Navigable Waters Act, S407 - Refuse Act of 1899), and an operating license from the Atomic Energy Commission.

Application has been filed with the Department of Environmental Conservation for a permit for discharge of chemical solutions and an operating permit for the service boilers, and with the Department of the Army, Corps of Engineers for a permit to discharge effluents through the channel and diffuser into the Hudson River.

C. THE APPLICANT'S ENVIRONMENTAL STUDIES

Environmental studies[(1)] of the Hudson River and the land near Indian Point have been sponsored by the applicant. These studies are classified below.

(1) River flow:

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

(2) Meteorology:

Geophysical Science Laboratory, New York University

(3) Biology:

Ichthyological Associates
Institute of Environmental Medicine, New York University Medical Center
Marine Research Laboratory, Raytheon Company
Northeastern Biologists, Inc.

Other supporting organizations include:

Regional Economic Development Institute, Inc.
Bechtel Corporation
Norman Porter Associates
Texas Instruments, Inc.
Lamont Geological Observatory, Columbia University

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 the financial support,[2] are directed by the Hudson River Technical and Policy Committees that have representatives from State and Federal agencies: New York State Department of Environmental Conservation, New Jersey Division of Fish and Game, Connecticut State Board of Fisheries and Game (advisory only), U. S. Bureau of Sport Fisheries and Wildlife (noncommercial), and National Marine Fisheries Service (commercial). The committees outline the ecological studies and present their conclusions and recommendations to the applicant. In addition, the applicant has also organized the Fish Advisory Board consisting of expert biologists and engineers from the United States and Great Britain. These include 2 members from New York University, 3 from private consulting firms, and a nonvoting member from the New York State Department of Environmental Conservation.

The applicant has also conferred with the Westchester County Department of Planning[1] 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 for use of part of the site for public use and recreational purposes. Similarly, the State of New York Atomic Energy Council has expressed the opinion consistent with that of the Department of Planning, stating that nuclear power development may have resulted in an improved land usage.

REFERENCES FOR CHAPTER I

1. Consolidated Edison of New York, Inc., Supplement No. 2 to the Environmental Report, September 9, 1971.

2. Consolidated Edison of New York, Inc., "Cost Expenditures on Environmental Studies," Appendix T of the Supplement No. 1 to the Environmental Report, September 9, 1971.

II. THE SITE

A. GENERAL

The site of the Indian Point Nuclear Station with Units Nos. 1, 2, and 3 occupies 239 acres on the east bank of the Hudson River near Peekskill, New York. The site is about 24 miles north of 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 predominate environmental feature of this site is the Hudson River. The Hudson River at Indian Point cuts through the Hudson Highlands at sea level with a channel nearly a mile wide and an average depth of more than 30 feet. 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 is the largest and located about 2.5 miles northeast from the Station. The nearest site boundary on land is 0.32 miles from Indian Point Unit No. 2. The Penn Central Railroad serves both banks of the river; U.S. Highway 9W serves the west bank, and U.S. 9 (Albany Post Road) serves the east bank (Fig. II-1).

Of importance is the estuarine nature of the Hudson River. This river, which supplies the cooling water for the 3 Units, is a tidal estuary at this site. Tidal mixing brings salt water upstream beyond Indian Point during much of the year, which reaches occasionally as far as Poughkeepsie, 30 miles upstream from Indian Point. The upward extent of salt water varies strongly with the input of fresh water into the river and may be near the river mouth after a heavy rain. Along the river banks are rock quarries and industries that use the water. Years ago whaling vessels had their home ports along the river; more recently, 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 aquatic biota in the river is rich and diverse. The river near Indian Point serves as a spawning and nursery area for several important salt-water fish, including striped bass.

B. LOCATION OF STATION

The 239-acre Station site is on a point of land inside a big river bend. Three nuclear reactors, Indian Point Units Nos. 1, 2, and 3, and generator buildings are rather compactly placed on 35 acres near the river intake and the discharge structure for cooling water (Fig. II-2). The minimum elevation of the site, 15 feet, is well above the highest recorded flood of 7.5 feet. Farther from the river are the service areas, and the fuel storage tanks for Unit No. 1. The transmission lines travel from the reactors about 2,100 feet southeast to an existing switchyard located across the road (Broadway) from the other facilities.

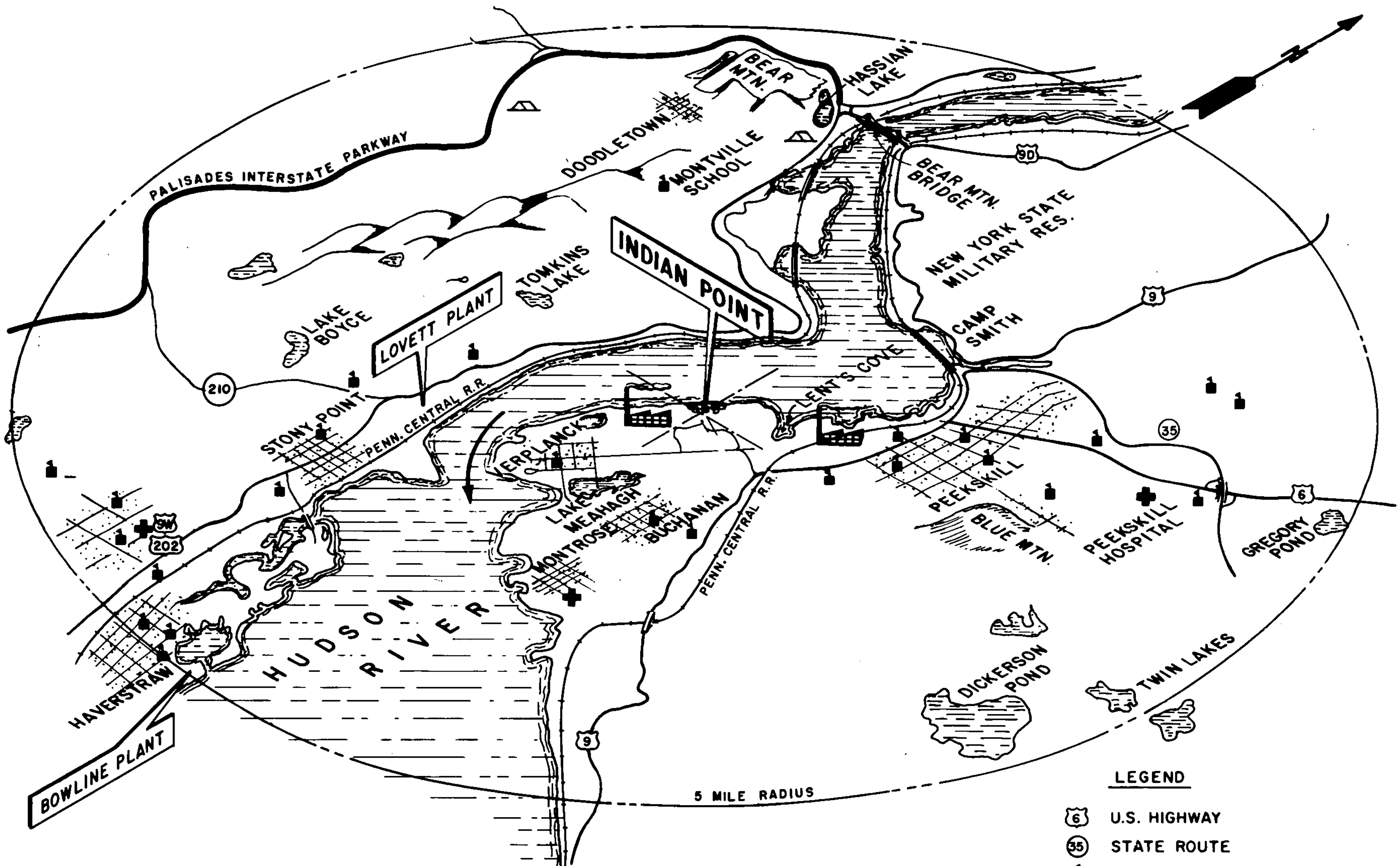

Fig. II-1
Indian Point 5 Mile Area.

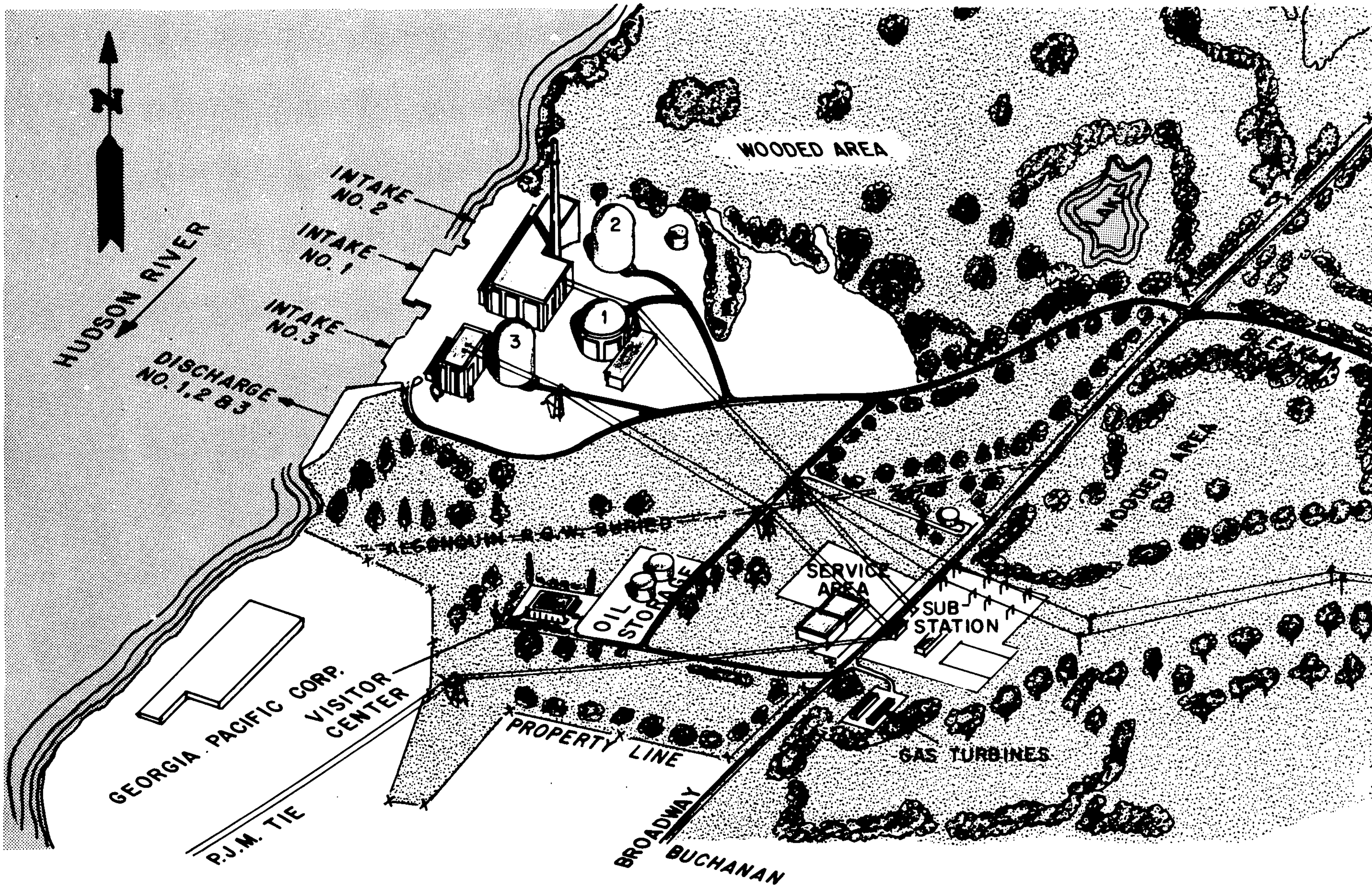

Fig. II-2
Indian Point Site

At the northern edge of the site there is an easement for the Buchanan sewer system and about 14 acres were transferred by the applicant to Buchanan for a marina in Lents Cove. A temporary visitors' center, which has been in use since 1959, is located on a hill overlooking the Station. The applicant also provides tours of its facilities. The applicant has plans to build a new visitors' center and to enhance the education, recreational and scenic value of the site.[2] Between Lents Cove and the reactor buildings the applicant has an 80-acre forest and a lake set aside for recreation. South of the reactor buildings is an easement 65 feet wide and 2,800 feet long for two large gas lines of the Algonquin Gas Transmission Company. The nearest public road (Broadway) is a minor road which at its closest is 1,700 feet to the southeast of the site. The Hudson River forms a border more than 4,000 feet wide to the west and northwest. Along the riverfront to the southwest the fence line of the Georgia-Pacific Corporation wallboard factory is about 1,100 feet from the reactors. North along the river, beyond Lents Cove, are red brick industrial buildings that contrast with the modern design of the Indian Point buildings, which can be seen clearly from Peekskill.

C. REGIONAL DEMOGRAPHY AND LAND USE

Westchester County, in which Indian Point lies, has long had industry along the river banks but otherwise serves as suburbia and exurbia for Metropolitan New York City. The hilly land with its lakes also provides water reservoirs and recreational facilities. The growth of corporate parks and the distribution and service industries have made the county as a whole a net importer of commuting workers. The permanent population within a 1-mile radius of the reactors is 1,080 (census of 1960); within a 5-mile radius, 53,040 (Fig. II-1). The nearest city is Peekskill, to the northeast; the nearest city of more than 50,000 is White Plains, 17 miles to the south. The communities of Verplanck and Buchanan are also within 2 miles of the site. From there southward are the contiguous residential and industrial areas of New York City, its outer ring of suburbs and its inner core. The population within 55 miles of Indian Point was 16.1 million in 1960 and 17.5 million in 1970 (the staff's estimate). Demographically the Station is well placed with respect to nearby populations.

Most of the people live in the southern quadrant, from southeast to southwest, which includes New York City; they numbered 13.8 million in 1960 and half a million more in 1970 (Fig. II-3). The remaining three quadrants had 2.3 million in 1960 and nearly a million more in 1970. A more detailed summary of the population distribution was prepared from the 1960 census;[3] the growth rates projected by the Regional Economic Development Institute in 1965 are slightly high for 1970. The staff has made a simple projection of the population distribution to the year 2000 (Table II-1) for use in an assessment of radiation dose.

About 66 people (1960 census) reside within a 1,100-meter (3,600 feet) radius of Unit No. 2, all of them to the east southeast. This distance has been used as the outer boundary of the low population zone in the analysis of a postulated fission product release. The outer boundary of the more densely populated area of Peekskill has been used as the population center distance which exceeds one and one-third times the distance from the reactor to the outer boundary of the low population zone as defined in 10 CFR 100.11.

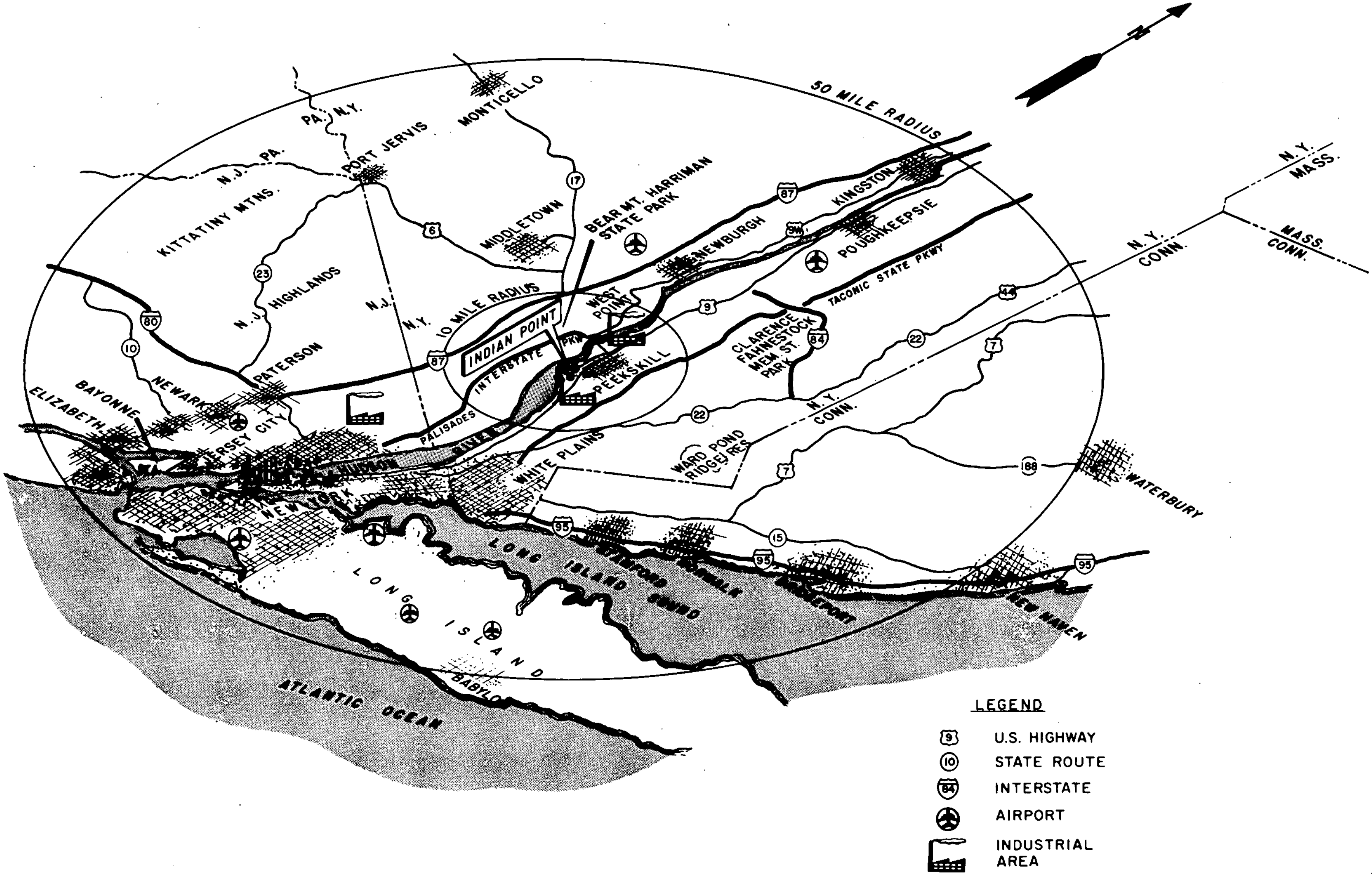

Fig. II-3
Indian Point 50 Mile Area.

TABLE II-1
PROJECTED POPULATION DISTRIBUTION FOR THE YEAR 2000
BY 22.5-DEGREE SECTORS

Sector	Population at a distance from center of site of -											
	0-1/2 mi.	1/2-1 mi.	1-2 mi.	2-3 mi.	3-4 mi.	4-5 mi.	5-10 mi.	10-15 mi.	15-25 mi.	25-35 mi.	35-45 mi.	45-55 mi.
East	0	687	886	510	1041	753	16065	26339	116062	165423	248696	463259
East-Northeast	0	37	8420	10400	4912	5311	16700	14359	54166	76490	98690	521146
Northeast	0	0	7113	29050	3612	4410	15157	9757	55087	90090	71386	276500
North-Northeast	0	0	355	4602	1137	2755	5702	5156	56009	103689	44081	31855
North	0	0	111	133	133	89	20142	13650	79916	66240	41326	43930
North-Northwest	0	59	52	148	266	9381	8199	22144	103824	28790	38570	56005
Northwest	0	0	177	111	355	576	554	20002	64346	39359	32921	33797
West-Northwest	0	0	177	59	89	0	3220	17860	24867	49927	27272	11588
West	0	0	89	399	266	0	199	14123	36078	67574	101762	39690
West-Southwest	0	0	473	724	325	332	739	10385	47289	85222	176251	67792
Southwest	0	0	155	1950	7445	2327	21051	39908	237907	794415	1309664	598964
South-Southwest	0	118	3176	451	3287	12187	39073	69431	428525	1503608	2443078	1130137
South	0	421	1330	111	111	665	60937	72503	583428	1625407	2527944	1091040
South-Southeast	0	406	2969	5879	362	222	29013	75576	738331	1747207	2612810	1051943
Southeast	0	886	2127	798	1507	1374	57635	37788	369166	873603	1306405	525971
East-Southeast	136	440	1137	281	2039	1898	8361	38320	177959	254355	398702	405373

The exclusion area for Indian Point Unit No. 2 includes Plant property within a 520 meter (1,700 feet) radius of the reactor containment. An exclusion radius of 520 meters satisfies both 10 CFR 100.3 and 10 CFR 100.11.

The closest schools are about a mile to the east and a mile to the south; altogether there are a dozen schools within 2 miles, many of them small schools. Nearby hospitals[4] are Peekskill Hospital (113 beds), 3 miles distant; a Veterans Administration Hospital (1,756 beds) at Montrose, 2.5 miles distant; New York State Rehabilitation Hospital (114 beds) at West Haverstraw, 4 miles distant; and the Letchworth Village Hospital (3,965 beds in a long-term unit, plus 64 additional beds) near Thiells, more than 5 miles distant. The nearest commercial airport is at White Plains, 17 miles. Airports are also located at Poughkeepsie near Newburgh as well as in metropolitan New York City.

Land use along the Hudson is varied. The good limestone has led to many quarries along the banks; one disused quarry is adjacent to the Station. Land is also used by a number of institutions: the prison at Ossining, the Veterans Administration Hospital at Montrose, the New York State Military Reservation (Camp Smith), the West Point Military Reservation. For recreation there are several sections of the Palisades Interstate Park on the west bank, parks and beaches on the east bank, as well as fishermen's landings. The river provides for commercial and pleasure boating.

The area immediately around and including Indian Point is zoned for heavy industry. The industries nearest the Station are a wallboard factory and a yeast plant. Use of the Indian Point site by the applicant was approved by the Westchester County Department of Planning.

A number of power stations planned, under construction, or in operation, are on the Hudson River that will add their thermal loads to the river (See Section III.D, Table III-1). A study of assimilation of thermal discharges into the Hudson from power stations, from industry and municipalities, prepared for the State of New York, lists the stations.[5] Within 10 miles of Indian Point, there are two operating stations, Indian Point Unit No. 1 (285 MW(e)) and Lovett (503 MW(e)) located 1.5 miles southwest of Indian Point on the west bank of the river; four stations are under construction, Indian Point Unit No. 2 (873 MW(e)), Indian Point Unit No. 3 (965 MW(e)), and fossil-fueled Bowline I (600 MW(e)) and Bowline 2 (600 MW(e)); and two projected nuclear generating stations, Verplanck Unit I and Unit 2 (2,230 MW(e)) to be located about 1 mile south of the Indian Point site on the east bank of the river.

Within 50 miles of Indian Point are two fossil-fueled plants - an operating facility, Danskammer (500 MW(e)), 23 river-miles north of Indian Point, and a power station that is under construction, Roseton (1,200 MW(e)), 22 miles north of Indian Point. A pumped storage hydroelectric station is planned at Cornwall (2,000 MW(e)), 13 miles to the north. To the south, about 38 miles from Indian Point, there is a fossil-fueled unit that is in operation within metropolitan New York at 59th Street (221 MW(e)).

D. HISTORIC SIGNIFICANCE

Except for troop movements in the Revolutionary War, Indian Point has no historic significance. In 1777 the British landed at Lents Cove to raid Peekskill. The nearest landmarks of consequence are St. Peter's Church and cemetery in Verplanck and St. Mary's cemetery along Broadway Road. Stony Point Battle Reservation is 2 miles downstream. The National Register of Historic Places[6] (including designated National Historic Landmarks) and the Hudson River Valley Commission's preliminary inventory of historic resources list many buildings and sites within several miles of the Station but none that are affected by it. The Hudson River Valley played an important role during the American Revolution. Table 2.1-1 of the applicant's Supplement No. 1 to the Environmental Report contains a list of historic places in the vicinity of the Station.

Only two archaeologic sites in Westchester County are mentioned by Ritchie.[7] "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." Indian Point was for many years before its acquisition by the applicant a commercial amusement area operated by the Hudson River Day Line and was overrun by relic collectors.

E. ENVIRONMENTAL FEATURES

1. Geology and Geography

The three reactors at Indian Point are built on a hard, dark gray, metamorphosed dolomitic limestone.[8] 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 only with 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.

Adjacent to the dolomite are schist and phyllite formations, and within a few miles to the east, the basic igneous intrusive rocks of the Cortlandt complex. To the west, across the river, are further exposures of limestone, schist, and phyllite, presumably the same formations as at the Station site, although less metamorphosed. On that side of the river there are also much younger Triassic rocks which do not occur on the east bank. These are the well-cemented conglomerates, sandstones, and red shales of the Newark series and the diorite and basalt similar to the rock that makes the Palisades.[8]

There are no truly major faults in or near the site. A number of minor earthquakes have been felt in the area over the last century or so, but there appears to be no danger of a destructive earthquake.

The Indian Point site is surrounded on all sides by high ground ranging from 600 to 1,000 feet 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 feet above the river level. The site, as stated above, has 80 acres of heavily wood land and a fresh water lake.[2]

2. Surface Water

The dominant environmental feature in the Indian Point area is the surface water of the Hudson River. It begins in the Adirondacks at an elevation of about 4,300 feet on the southwest slope of Mount Marcy and receives the Mohawk River about 150 miles downstream, just above Troy Dam.[9] Hilly, forested land along the river banks and the lakes near to the river also are predominate and serve as water reservoirs and recreational facilities.

Several municipalities utilize the Hudson for their principal water supply, as shown in Table II-2. The city of New York has also constructed a pumping station on the Hudson River at Chelsea, some 22 miles upstream from Indian Point. This station is to be used to supply Hudson River water to the city during drought periods when the water supply is low and the demand high. In addition, several of the small streams and lakes within a 5-mile radius of Indian Point are used for local municipal water supplies. Only two reservoirs, Camp Field which serves Peekskill and Stony Point on the west bank, are within 5-miles radius of the Station.

The average flow of fresh water for the entire Hudson River is about 20,000 cubic feet per second* (cfs), which is discharged from a watershed of 13,370 square miles.[9] At Indian Point, as well as elsewhere on the river, the flow of fresh water is subject to large variations, with maximum flows in excess of 30,000 cfs in the spring during thaws of late winter to minimum flows of 3,000 to 4,000 cfs in late summer.[9] Countering this downflow is a tidal upflow of ocean water, occurring twice a day, which carries the salt water front up beyond the Indian Point site during periods of the year except when the fresh water exceeds 20,000 cfs. Flow from the reservoir north of the dam at Green Island is regulated to maintain a minimum fresh water flow limit of 2,000 cfs during periods of drought.[10] During times of flooding, the runoff of fresh water may exceed seasonal averages. For instance, floods of 215,000 cfs (1936), 181,000 cfs (1948), and 135,000 cfs (1960) have been measured at Green Island.[11]

Below the dam at Troy, 150 miles above the mouth, the Hudson is under tidal influence. In general, the range between high and low tide is 4.5 feet at the Battery in New York City, 2.7 feet at West Point, and 4.7 feet at

*Note - 1 cubic foot per second (cfs) is equivalent to about 450 gallons per minute (gpm) flow.

TABLE II-2
MUNICIPAL WATER SUPPLIES DRAWN FROM THE LOWER HUDSON RIVER[9]

Community	Population Served	Average Use in mgd[a]
Green Island	4,016	0.37
Rensselaer	10,745	2.4
Highland	4,469	1.0
Port Ewen	2,622	.5
Poughkeepsie	63,590	7.36
	85,422	11.63

[a]mgd = million gallons per day.

Troy.[11] According to the U.S. Army Corps of Engineers,[11] the highest water level in the Indian Point region was between 7.3 and 7.5 feet above mean sea level (November 25, 1950). In general, the greatest flood threat in the middle and lower Hudson is associated with storm conditions where the effects of tide and wind are superimposed.[11]

In comparison with the runoff of fresh water, the tidal flux has a large effect on the volume and chemistry of the water flowing past the Indian Point site. At Indian Point, the peak tidal flow is approximately 300,000 cfs; it is often more than 30 times the input of fresh water.[9-13] Details of flow characteristics of the Hudson estuary are also discussed in the applicant's Appendices to Supplement No. 1 of the Environmental Report.[12] In Appendices II-1 and V-2 of this Statement, flow characteristics and their importance during fresh water flow and salt water flow are also presented.

The river at Indian Point is from 4,500 to 5,000 feet across and has a maximum depth of about 85 feet. The cross-sectional area in the region is about 160,000 square feet[10] but the 22-mile stretch from Indian Point to Chelsea is 140,000 square feet.[13] The total volume of the estuary, which is normally tidal fresh water, is approximately 29 million cubic feet and extends from Troy to Clinton Point, about 30 miles upstream from Indian Point.[11]

Tidal flow past the Station is more than about 1.8 x 10^5 cfs, 80% of the time, and it has been estimated that this flow is at least 2 x 10^4 cfs in a section 500 to 600 feet wide immediately in front of the facility. The net mean downstream flow due to runoff is in excess of 26,000 cfs 20% of the time; of 15,250 cfs, 40% of the time; of 10,500 cfs, 60% of the time; of 7,000 cfs 80% of the time; and of 4,000 cfs 98% of the time.[12]

Because of the variability of the input of fresh water, the salinity of the water at Indian Point is not constant. During the spring runoff period (March through early May), the water is essentially fresh; however, during periods of low flow in late summer and early autumn, saline water often reaches Poughkeepsie.[9] There is often a small increase in salinity from top to bottom;[11] however, in studies conducted for the applicant during the period April 1969 to April 1970 the maximum variation in salinity measured across the river (0.6 part per thousand (ppt)) was approximately the same as the maximum vertical variation (0.7 ppt).[14] Data from the same study show annual salinity ranges from 0 to 5.5 ppt,[16,17,18] although values up to 7.3 ppt were observed in 1964 during a severe drought.[13,14] This range of 0 to 5.5 ppt is the seasonally varying monthly mean. Peak salinities in the 4 to 5 ppt range occurs during late summer and fall, decreasing gradually through the winter to the lowest values (close to 0 ppt) during spring, at which time the fresh water runoff is the highest. Imposed on this is a chemically small but biologically significant tidal salinity variation less than 1.5 ppt.

Temperature ranges in the estuary at Indian Point occur on a seasonal basis. Temperature measurements taken by the applicant for the water intake of Indian Point Unit No. 1 during the summer months of 1967 ranged between 74 to 80°F, of 1968 ranged between 74-79°F, and of 1969 ranged between 74-79°F.[15] In October 1966, the applicant recorded that at no time did the cooling water inlet to the condenser for Indian Point Unit No. 1 exceed 83°F.[15] The applicant also collected temperature data from June-December 1969.[16] During the summer months, river temperatures ranged from 72 to 82°F with peak temperatures during August. A 10-degree F per month decrease in river temperature was observed from September to December 1969 at which time the river temperature stabilized at about 32°F.[17] During 1969-1970 the river temperature ranged from 34°F, which was maintained from January through early March, to 81°F in August.[13] There was little temperature variation across the stream, with a maximum variation of 2°F (1.1°C). The vertical temperature profile also showed little variation, with a maximum of 2.5°F (1.4°C) from top to bottom, the cooler water being on the bottom.[13]

Turbidity as measured with a Secchi disk ranged between 1 and 4 feet visibility, with higher turbidities nearer both shores. Dissolved oxygen (D.O.) at the Indian Point area is generally around 70% saturated at observed temperatures and for most of the year is around 6 to 7 ppm but varies seasonally from about 4 to 10 ppm.[13,18] The value for D.O. is dependent on the water Biochemical Oxygen Demand (BOD) which is high at locations near population centers.

Intrusion of salt water obviously influences the ionic constituents of the water at Indian Point. Consideration of average values as presented in Table 2.1-3 of the Supplement to the Environmental Report for Indian Point Unit No. 2[12] must be considered in this light. This table shows the variability of chemical constituents in part due to the tidal and fresh water flow. Nitrate and phosphate present are from both natural and man-made sources, including organic material in the river.

Water movements in saline reaches of estuaries such as the Hudson are also influenced by vertical variations in salinity. The movement is called the net nontidal movement and is caused by density-induced currents.[19,20] Typically, the slightly more saline water moves upstream along the bottom while less saline water moves in a seaward direction on the surface. This movement is caused by the dilution of the more saline water with the fresh water. The diluted saline water is less dense than the water around it and is pushed toward the surface by the more saline water along the bottom. The net result is a vertical movement of water at mid depth, an upstream flow along the bottom, and a downstream flow on the surface. All this movement is superimposed upon the tidal cycle and only occurs under saline conditions. This discussion is a gross oversimplification of the flow characteristics, which are considered further in Appendix II-1 of this Statement.

The importance of this nontidal (density) flow is related to its ability to increase the dilution of effluents into the Hudson during periods when the flow of fresh water is low. Thus it compensates to some degree for the reduced input of fresh water that occurs at certain times of the year. When the discharge of fresh water drops below 20,000 cfs, the salt front moves up past Indian Point, and the net nontidal flow becomes an important factor. Its importance for dispersion of thermal discharges is associated with the increased seaward velocity of the water at the surface and the fact that the less dense warmer water is in this region. Thus the nontidal flow carries the thermal effluent out of the area at a higher rate than would be expected from the flow of fresh water alone.

The distribution of suspended particulate matter and dissolved substances will likewise be affected by the density flow. However, if these materials are randomly distributed, the principal effect of the density flow will be to disperse the chemicals more rapidly; it will only slightly augment their removal from the estuary.

The density flow and its relationship to the concentration of effluents in the river are discussed in Appendix II-1 of this Statement.

3. Groundwater

Groundwater occurs at the Station site largely in the joints of the limestone rock, although it would probably be wrong to call this rock an aquifer.[8] The jointing and fracturing are irregular, and so are the permeability and porosity of the limestone. In the surrounding area, wells drilled in the limestone, and to a lesser extent in the schist and phyllite, yield a few gallons of water a minute, enough for modest domestic supplies. Locally, where the glacial till is thicker and more permeable than it was at the Station site, wells can be constructed which yield several hundred gallons of water a minute. A number of such wells serve industrial plants in the area. The only public water supply from wells within a 5-mile radius of the Station is the Stony Point system on the west bank of the Hudson. Locally, on the west bank the sandstones and conglomerates of the Newark series can supply modest amounts of water to wells, somewhat more than is supplied by the sections of glacial till.

Danger of contamination of the local groundwater supplies is minimal. Leaks, spills, or the leaching of any leakage near the Station would largely sink into the ground and be slowly carried to the Hudson River by the groundwater flow. Contamination of off-site groundwater supplies by radioactive materials released in normal operation at the Station site is very remote.[12]

4. Climate

Because the Hudson River is in a deep valley at Indian Point, the local and the general weather are not the same. At river level and 100 and 200 feet 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 miles per hour (mph). The valley winds predominate during the inversions that prevail 42%

of the time. The staff in its studies of gaseous effluents used the meteorological data of Report 372.3, pages 24-27.[21-23] The records for Bear Mountain, at 1,301 feet elevation, show winds from all directions during rainstorms; during thunderstorms south winds are predominant, with few winds being found from north to east.[24] Tornadoes are almost unknown in New York; the coastal hurricanes are the storms that bring the most wind.[25] Precipitation averages 46 inches per year and is rather uniform month by month; the measured annual range is from 36 to 63 inches. Because evaporation and soil retentivity are greatest 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° and 105°F.

5. Special 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 is not expected to have any influence on the terrain as presently constituted.

The site was formerly used by the U. S. Maritime Administration to dock its "moth ball" fleet. Prior to construction of Indian Point Unit No. 1, about 189 vessels were docked but by July 31, 1971, the entire fleet had been removed from the area. The site was formerly an amusement park that had been abandoned after its use as a park had diminished.

F. ECOLOGY OF THE SITE AND ENVIRONS

1. Terrestrial Ecosystem

The terrestrial plants at the Indian Point site are typical for the area. The forested sections are typical of an oak-maple-hemlock community. Other species, such as linden, cottonwood, sumac, hickory, dogwood, and wild cherry, are also present where they have been introduced into previously cleared areas. Wildlife at the site is composed of porcupines, woodchucks, squirrels, opossums, insects, and a variety of birds, as well as other species.[12] The site and surrounding habitats are by no means in a wilderness area, and the plants and animals are typical of those species which are adaptable to human intrusion.

2. Aquatic Biota

The aquatic biota of the area is diverse. Fig. II-4 shows a simplified food web for the Hudson River at Indian Point. A list of aquatic species found in the area by several investigators is included as Appendix II-2 of this Statement. The principal aquatic primary producers in the vicinity of Indian Point are phytoplankton. The high turbidity and deep water do not provide a

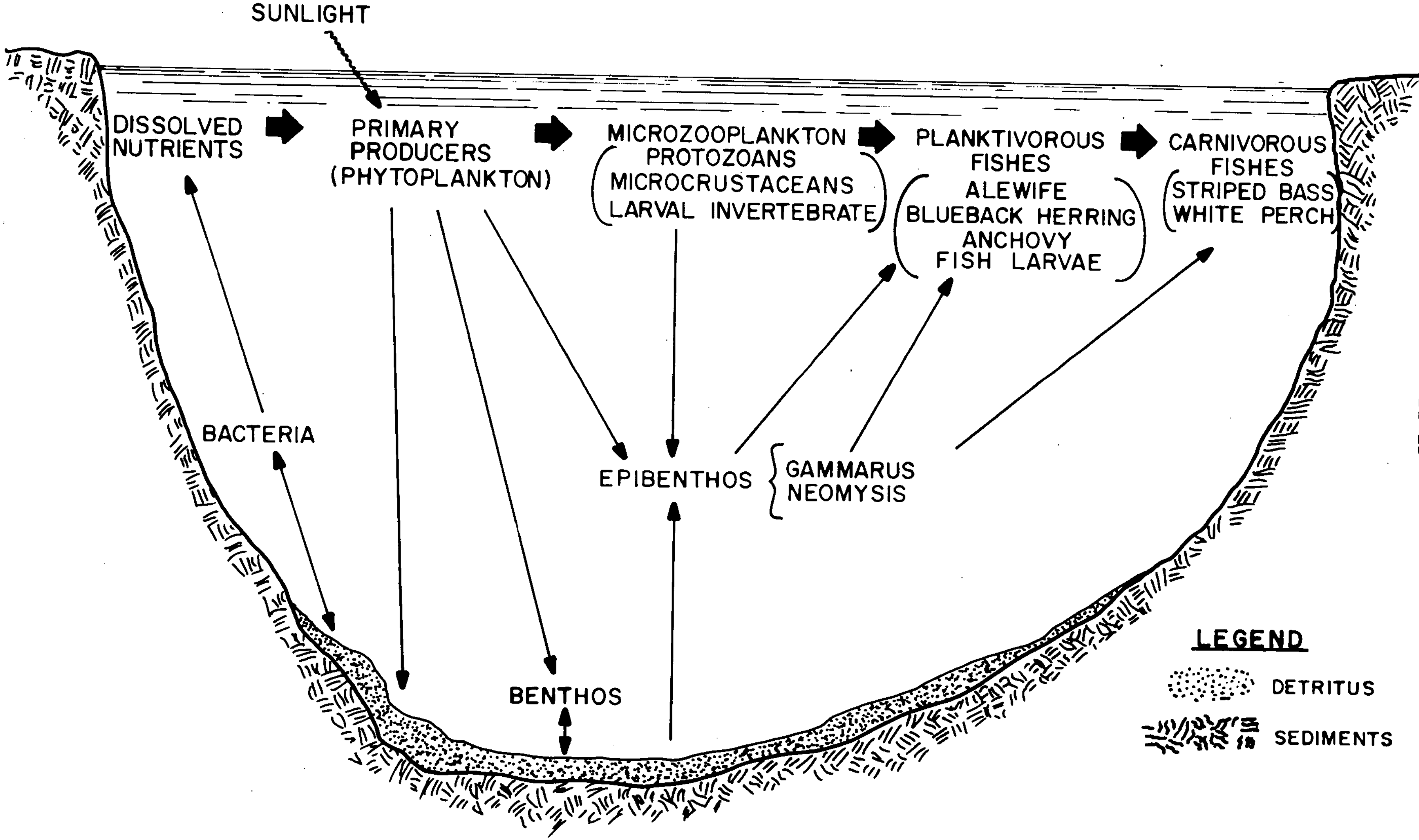

Fig. II-4
Simplified Aquatic Food Web for Hudson River at Indian Point.

good habitat for the development of extensive communities of periphyton or rooted vascular aquatics in the immediate vicinity of the Plant. However, such communities exist within the area that will be affected by operations at Indian Point. Howells and Weaver[26] studied the phytoplankton at Indian Point and found members of some 53 genera of planktonic algae.

The zooplankton of the area is represented by most major groups.[27] In general, the zooplanktonic species include protozoans, occasional medusal coelenterates, rotifers, nemertines, and microcrustaceans (including Cladocera, Ostracoda, Mysidacea, Copepoda, Amphipoda, Isopoda, and some Decapoda). Also included are the pelagic larvae and juveniles of larger forms. Included in this category are the larval stages of barnacles (Cirrepedia), larger decapods, annelids, and molluscs 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.[27]

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. In laboratory cultures with optimum temperature and nutrient supply, bacterial populations are able to double themselves within 18 to 35 minutes. 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 hours.[28] However, the generation times of bacteria in natural waters are not exceptionally short and are regulated by available food supplies. The generation times of bacteria in a series of impoundments range from 9 to 120 hours. In comparison, the maximum net production of phytoplankton in Lake Erken is about 150% of the standing crop per day.[27] This indicates that for short periods, the generation time of the phytoplankton may roughly equal that of the bacteria. The growth of bacteria in natural water does not normally outstrip the growth of phytoplankton so greatly that the bacteria continuously dominate the food supply of the zooplankton. On the contrary, it is only when the phytoplanktonic organisms die, releasing large quantities of nutrients for bacterial growth, that the bacteria may temporarily increase their role as an energy source for the zooplankton.[27]

Bacterial densities in the Hudson 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.[5]

b. Primary Producers

Planktonic algae are responsible for using energy from the sun to convert carbon dioxide, minerals, and water into the organic material of which they are composed. These organisms provide the basis for the food web of aquatic systems and are the principal food of most of the zooplankton[28] and many fish species as well.[29]

At Indian Point the dominant 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 cubic meter 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.[26] There was some variation in species composition across the river. However, 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%.[30]

As was indicated above, algae may have a very short generation time. Under optimum conditions some species are capable of producing 3 generations per day. However, the normal population growth rate is regulated by temperature, light, grazing by herbivores, and available nutrients.[31]

Many algae are capable of limited movement, although the movement is very 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 which are 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 feet deep.[5] Consequently, 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 which 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 1 to 3 times per day.(32)

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.(33,34) 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.(33)

Many of the larger zooplankters, including amphipods and euphasiids, 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(35) 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.(35)

The most abundant invertebrate utilized by fish in a 1964 survey, based upon examination of 190 fish stomachs, was the amphipod Gammarus.(36) Dipteran larvae and pupae, adult insects, and smaller crustaceans such as cladocerans, copepods, and ostracods were also important components of the stomachs. However, the individual size of the invertebrates in the stomachs varied with the sizes and ages of the fish caught.(36)

(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 (macrobenthos) 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. Generally, this fauna appears sparse both in the Indian Point area and throughout the lower part of the estuary.(36-38) In deeper portions of the Hudson River north of Indian Point and through the

Hudson gorge, grab samples commonly contain no specimens of macrobenthos. The microbenthos has not been sampled.(16-18, 36-38)

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.(16-18)

(3) Fish

As is typical of estuarine situations, there are a great number of species of fish (See Appendix II-3). 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 move into the area during periods of intrusion of salt water. In addition to the resident species and those which 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 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 II-3. 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, 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 areas for species that populate not only the Hudson River but Long Island Sound and the Atlantic Ocean near New York. The most prominent such species is the striped bass. There is considerable evidence that the Hudson is a major spawning area for the striped bass living in Long Island Sound. Besides being important commercially, he 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 a nursery area or both.

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

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

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III. THE STATION

A. GENERAL

The Indian Point Station owned by the applicant includes three Units, each consisting of a pressurized water reactor, a turbine-generator, and auxiliary equipment. Unit No. 1 has been operating since 1962, as a combined nuclear- and oil-fired fossil plant to produce 285 MW(e). Construction of Unit No. 2, with a capacity of 873 MW(e), will be completed by about April 1972. Unit No. 3 with a capacity of 965 MW(e) is under construction and is scheduled to be completed by 1973. The following discussion is limited to a description of Units Nos. 1 and 2.

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

B. EXTERNAL APPEARANCE

The stack for Unit No. 1 and the concrete containment vessels for the reactor Units dominate the landscape of the Indian Point site. Part of the stack for Unit No. 1 will be removed because of safety considerations. However, the structures housing the superheater, turbine-generators, and service facilities of the Units have been designed to integrate this complex so as to present an acceptable appearance from the river side. The whole Station can be seen from this side. The Unit No. 2 containment vessel, to the north of Unit No. 1, is taller than that of Unit No. 1, but the brick-faced turbine-generator building for Unit No. 2 is contiguous with that for Unit No. 1 and has a complementary architecture. The Unit No. 3 containment vessel, to the south, will be of the same size and construction as Unit No. 2 (see Fig. III-1). The two will form a symmetrical arrangement around Unit No. 1, as shown in Fig. III-2. Decorative concrete screens and boxes planted with appropriate shrubbery are to shield the pumps and other machinery of Units Nos. 2 and 3 so that no outside hardware will be visible from the river side. Similar mechanical equipment for Unit No. 1 is housed in a permanent structure. Form, color, and texture of the buildings have been considered so that the setting is enhanced and the feeling of intrusion is held to a minimum.

Landscaping of the area immediately surrounding the complex is in progress, in which the hilly and rocky terrain and the adjoining wooded areas are taken advantage of. The northern part of the site includes 80 acres of woodland,

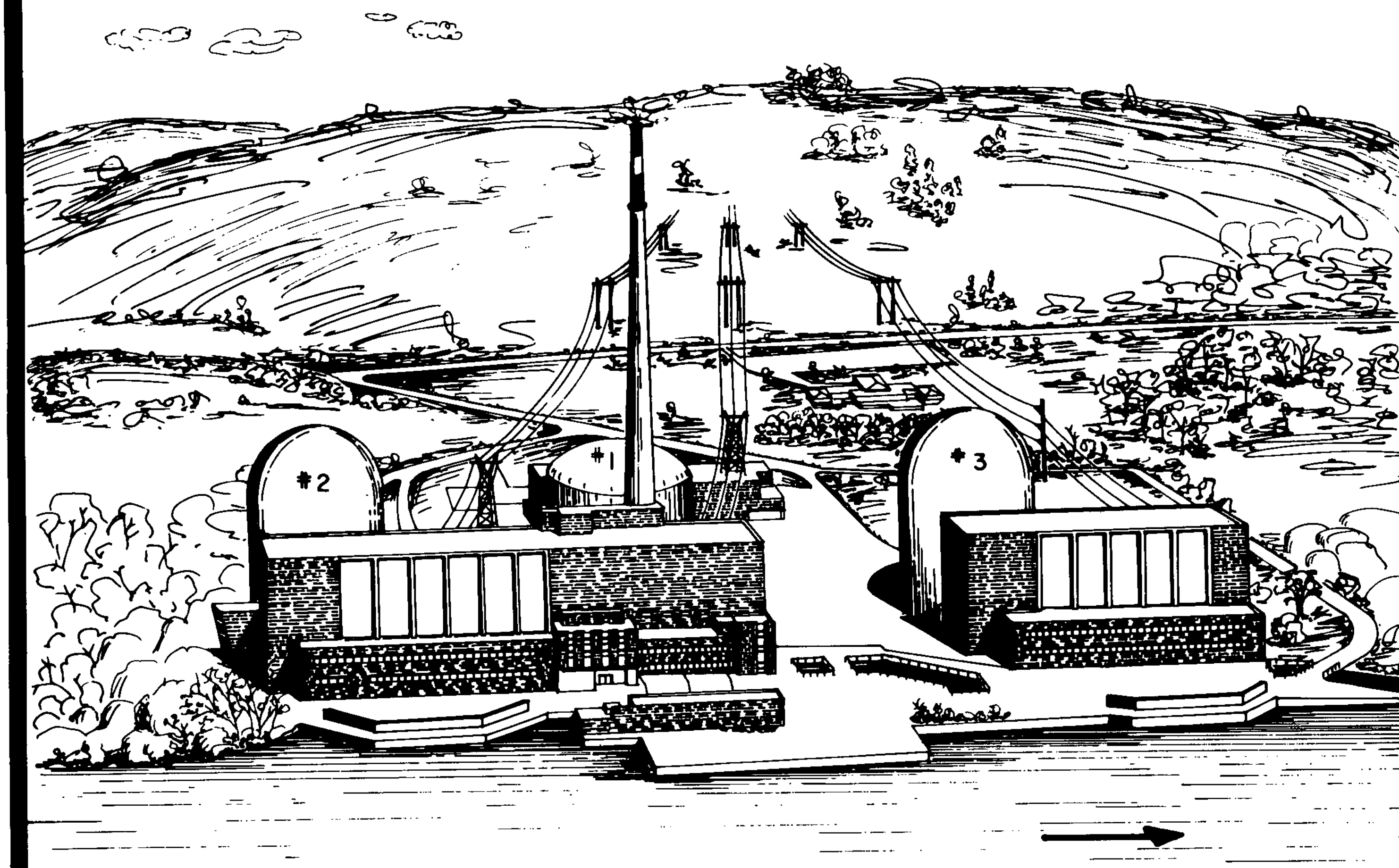

Fig. III-1
Representation of Indian Point Site.

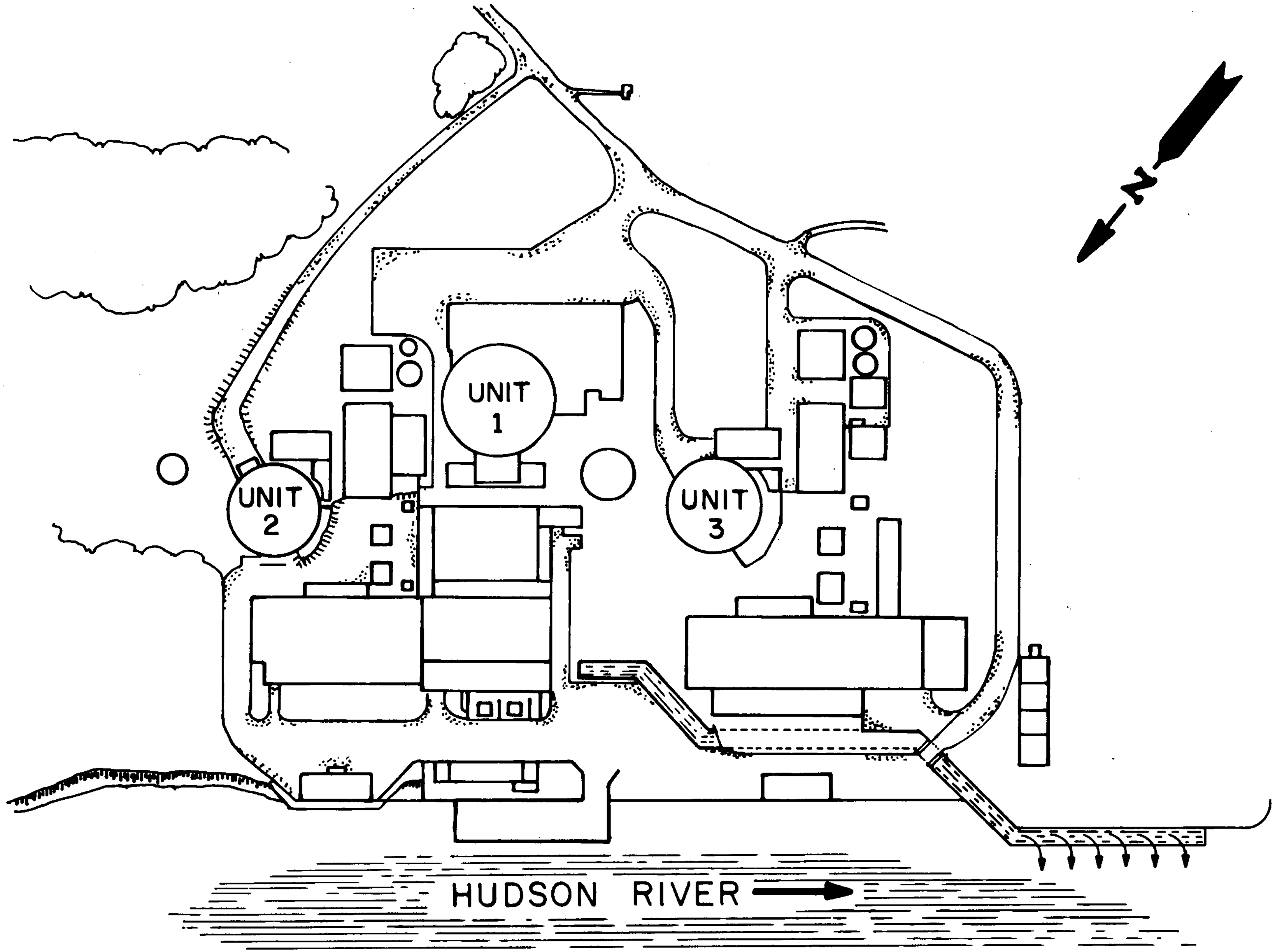

Fig. III-2
Indian Point Plant Site Layout.

including a freshwater lake. The applicant's plans call for this area to be developed into a public park, with picnic tables and benches located in shaded spots around the lake and with nature trails leading to the shoreline of the river and the Unit No. 2 turbine-generator building. A new visitors' center with parking and toilet facilities for public use will be provided at the site. A temporary visitors' center, which has been in use since September, 1959, is located on a hill overlooking the Station and the Hudson River. Exhibits and other information will be available showing a master plan for enhancing the educational, recreational, and scenic value of the site for the visiting public.[(1)]

C. TRANSMISSION LINES

According to the applicant, the transmission of electricity from Unit No. 2 to the load center will not require additional rights-of-ways for transmission lines. The new transmission lines are strung on existing towers or on new towers along the old right-of-way. Steel pole construction was used in the area between Unit No. 2 and the Buchanan Substation located across Broadway Road to improve aesthetic value as well as to incorporate the latest engineering knowledge (Fig. III-3). The structures are designed to carry the Unit No. 2 output of 873 MW(e) at 345 kV to the applicant's system at the Buchanan Substation 2,100 feet away from the turbine building.[(2)]

Two additional lines were strung from the Buchanan Substation to the Millwood Substation, a distance of approximately 9-1/2 miles, and two terminal positions were made at the Millwood Substation. These lines were placed on existing structures on existing rights-of-way so that additional changes from building Unit No. 2 did not result in any further modification of the environment because of construction of transmission lines. Approval from New York State for additions to the existing lines and structures were received. Furthermore, the electrical output from Indian Point Unit No. 2 will be transmitted from the Buchanan Station to the Pennsylvania, New Jersey, Maryland (PJM) interconnection.[(2)]

D. REACTOR AND STEAM-ELECTRIC SYSTEM

The Indian Point facility consists of three separate Units, each powered by a closed cycle pressurized, light water moderated and cooled nuclear reactor as its source of heat for generating steam to produce electricity. Unit No. 1 with a total capacity of 890 MW(t) (615 MW(t) nuclear and 275 MW(t) fossil) and an electrical output of 285 MW(e), (45 MW(e) is used in plant) was completed in 1962 by Babcock & Wilcox. It utilizes an oil-fired superheater for 112 MW(e) of capacity to supplement 163 MW(e) of nuclear power by superheating the saturated steam.[(3)] The steam electric system uses once-through cooling at a flow rate of 300,000 gpm to dissipate waste heat, including about 20,000 gpm for the service water system.

Units Nos. 2 and 3 were designed and are being built by the Westinghouse Electric Company, which has a turn-key responsibility, including the testing and initial startup of Unit No. 2. Construction of Unit No. 2, with an initial

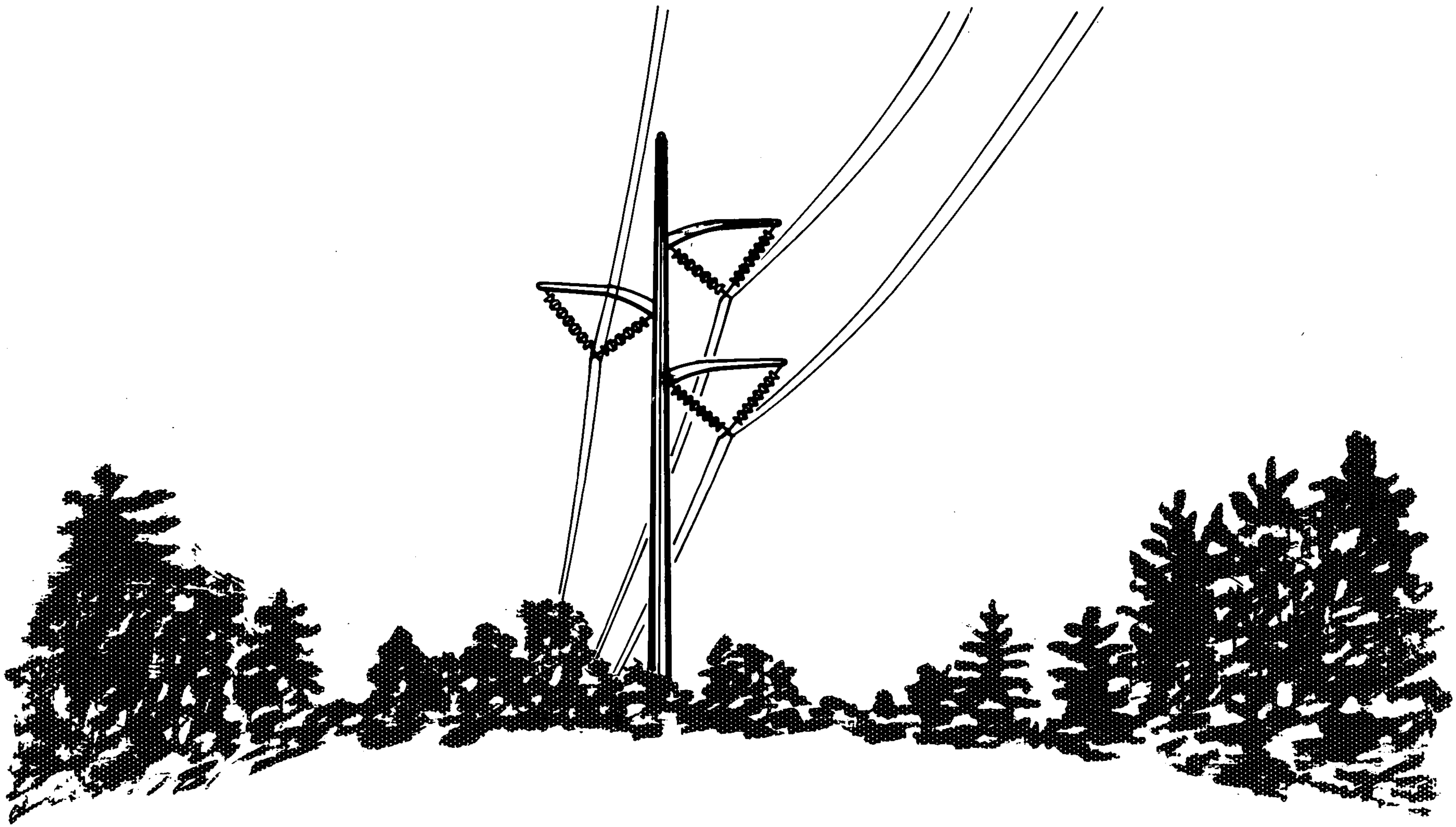

Fig. III-3
New Type
Steel Transmisson Pole

capacity of thermal output of 2,758 MW(t) and electrical output of 873 MW(e), essentially will be completed by April 1972. A Facility Operating License No. DPR-26 was granted to the applicant to load fuel and to perform subcritical tests on October 19, 1971. Unit No. 3 has an initial thermal output of 3,075 MW(t) and an electrical output of 965 MW(e), is approximately 60% complete, with service scheduled for 1973.

The reactor core in Unit No. 2 is fueled with slightly enriched uranium dioxide in the form of pellets which are contained in sealed zircaloy tubes, set in 193 fuel subassemblies. The fissioning of uranium-235 in the fuel rods is controlled by both a chemical shim (boron) in the form of boric acid and control rods, which consist of stainless-clad absorber rods of cadmium, indium and silver. Moderator and primary coolant water pressurized at an operating pressure of 2,235 pounds per square inch gauge (psig) is pumped through 4 separate primary coolant loops, each with a circulating pump and a vertical U-tube steam generator which serves to remove heat from the reactor. The primary coolant water is heated to a design temperature of 650°F in passage through the core to the steam generator in each loop and is pumped back to the reactor core for reheating. In the secondary system water at a design pressure of 1,085 psig and 427°F is converted to steam at 600°F in the steam generator which drives the tandem-compound turbine-generator unit, which incorporates 1 high-pressure and 3 low-pressure turbines on 1 shaft. The "spent" steam is condensed in 3 single pass condensers by water withdrawn from the Hudson River, and the resulting condensate is recirculated through the feedwater heaters and demineralizers to the steam generator. The cooling water is pumped at a maximum flow rate of 840,000 gpm through 6 pumps through single-pass condensers and is heated approximately 15°F before being discharged into the discharge canal. Each reactor has an individual water intake, but all three Units discharge their circulating cooling water into a common open canal. (See Section III.D for details of the cooling system.)

The primary system, consisting of the reactor, steam generators, circulating pumps, primary coolant piping, and pressurizers, is housed in a domed cylindrical reinforced-concrete containment vessel lined with steel. The secondary system and additional auxiliary systems are housed separately in adjacent buildings. Another building is provided for fuel handling purposes and for storage of spent fuel. (See Fig. III-2.)

These systems are described in detail in the applicant's Preliminary Safety Analysis Report (PSAR) and Final Safety Analysis Report Facility Description (FFDSAR) for Unit No. 2.

E. EFFLUENT SYSTEMS

1. Heat

a. Projected Heat Load on the Hudson River

One of the major concerns in the production of power by steam electric systems is the disposal of waste heat. Modern fossil-fuel plants convert thermal energy into electrical energy at an efficiency of about 38% while light water nuclear facilities have an efficiency of about 32%. In fossil plants, a maximum steam temperature of 1,050°F is attainable, while in current light water reactors the maximum steam temperature used is about 600°F. As a result, coolant water discharged from a nuclear plant contains 50% more heat per unit of electricity than that from a fossil plant. The simplest and most economical method is to utilize an easily available and adequate supply of water in a once-through cooling system. This has been a satisfactory and often used method up to the present time.

The environmental features of the Hudson River are described in Chapter II.E.2. Table III-1 shows the location of existing and planned steam-electric stations on the Hudson River. The facilities closest to the Indian Point site include the existing Lovett Plant (Orange and Rockland Utilities, Inc.) about 1 mile downstream; the Bowline Point Units Nos. 1 and 2 under construction by Orange and Rockland and the applicant, about 5 miles downstream; the existing Danskammer (Central Hudson Gas and Electric Corporation); and the Roseton Plant (under construction as a joint venture of Central Hudson Gas and Electric Corporation, Niagara Mohawk Power Corporation, and Consolidated Edison), both about 23 miles upstream. Table III-1 also shows some operating characteristics of these plants. Indian Point Unit No. 2 rated at 2,758 MW(t) and 873 MW(e) discharges heat of about 9.35 x 10^9 British thermal units (Btu) per hour to be dissipated to the cooling water. The Roseton facility, composed of two 600 MW(e) units (the first of which is scheduled for operation in November 1972 and the second in May 1973), utilizes a submerged jet type discharge system. Cooling water is discharged through a jet system 20 feet below mean low water (MLW) normal to the river flow at a location about 500 feet downstream from the intake and about 275 feet from shore. The Bowline Point Units Nos. 1 and 2, each with an output of 600 MW(e), are scheduled to be operational by the summer of 1972 (but will be delayed due to strikes) and by 1974, respectively. These Units also use a submerged jet discharge design. The jet system is located about 2,200 feet north of a channel connecting the intake pond entrance to the river and extends 1,200 feet out into the river. It utilizes 8 jets, 25 feet on centers, that discharge at 15 fps, 15 feet below MLW.

b. <u>New York State and Federal Thermal Discharge Criteria</u>

New York State has established standards for the discharge of waste heat into its waterways. These standards have varied during the operating history of Indian Point Unit No. 1. In 1950 the New York State Water Pollution Control Board (NYSWPCB) established "Rules and Classifications and Standards of Quality and Purity for Waters of New York State", which were later amended in 1954, 1956, and 1959. In 1962 the NYSWPCB was abolished and its functions were transferred to the NYS Water Resources Commission (WRC). In these standards the Hudson River at Indian Point was classified as "SB" waters. The use of SB waters is described as for "bathing and any other usages except shell fishing for market purposes". The quality standards for SB waters include criteria which specify that no heated liquids be discharged:

TABLE III-1

OPERATING CHARACTERISTICS OF EXISTING AND PLANNED
STEAM ELECTRIC GENERATING STATIONS ON THE HUDSON RIVER

Station	Location (mile point)	Rated Capacity, all units [MW(e)]	Flow gpm	Flow cfs	Temperature Rise, T_p (°F)	Thermal Discharge, H (BBtu*/day)[a]
Albany	140	400	352,000	784	11.0	46
Danskammer	66	508	308,000	686	14.5	54
Roseton	65	1,200	650,000	1,448	15.4	120
Indian Point (3 Units)	43	2,103	2,052,000	4,571	15.0	369
Lovett (5 Units)	42	503	323,000	720	14.8	57
Bowline (2 Units)	38	1,240	768,000	1,711	13.5	125
59th Street	5	221	168,000	374	6.0[b]	12
TOTAL		6,175	4,621,000	10,295		782

*Btu = British thermal unit.
Basis: H (Btu/day) = $1.2 \times 10^4 \times \text{gpm} \times T_p$(°F)

[a]BBtu/day = billion Btu/day.

[b]Monthly average operation, summer 1969.

Adapted from Quirk, Lawler, and Matusky, Engineers, New York City, "Environmental Effects of Bowline Generating Station on The Hudson River," Vols. I-IV, March 1971.(4)

"alone or in combination with other wastes in sufficient amounts or at such temperatures as to be injurious to edible fish or shell fish or the culture or propagation thereof,...; and otherwise none in sufficient amounts to make the waters unsafe or unsuitable for bathing or impair the waters for any other best usage as determined for the specific waters which are assigned to this class."
(6 NYCRR 701.4 et seq.)[3]

Primary administration of the provisions of these criteria were the responsibility of the New York State Department of Health (NYSDH) and is now under the jurisdiction of the Department of Environmental Conservation and is administered under Public Health Law, Article 12, Water Pollution Control. Control was exercised through conditions in a "Permit to Discharge Sewage or Wastes into the Waters of the State" dated August 1, 1961. This permit, issued to the applicant by the NYSDH, contained the condition (one of five in the permit), "THAT the discharge of waste shall be in accordance with the applicable provisions of Chapter XVI of the New York State Sanitary Code." This included the standard for SB waters as described above. There has been no substantive change in the standard for SB waters as they pertain to the discharge of waste heat.

The Federal Water Quality Act of 1965 encouraged the States to establish water quality standards for interstate streams and coastal waters by June 30, 1967. Due to a request from the Federal Water Pollution Control Administration (FWPCA) to upgrade state temperature standards, NYSDH reviewed the New York water quality criteria. In August 1967 NYS issued a document addressed to "Engineering Firms Practicing in New York State". The purpose of this document was "to advise and provide guidance to engineering firms, industries and others of water quality objectives and requirements for thermal aspects of discharges to the surface waters of New York State". The subject was "Thermal Aspects of Discharges on Water Resources" (Technical Bulletin No. 36). This bulletin was approved by the U. S. Department of Interior. This document stated that:

"To protect water resources, fishlife, and stream biota from effects of transient and long-range adverse temperature changes, careful studies of stream environment should be conducted where discharges of thermal significance are contemplated."

The document included guidance for the types of studies that should be conducted and stated, in part, that:

"These factors [of the studies] should be evaluated against the following criteria:

"Mixing Zone - The mixing zone will be separately determined for each discharge so as to minimize detrimental effects. Fish and other aquatic life shall be protected from thermal blocks by providing for a minimum fifty percent stream or estuarine cross-section and/or volumetric passageway, or establishing artificial fishways where considered necessary.

"Generally, the surface water temperature shall not exceed 90°F within the mixing zone.

"<u>Outside Mixing Zone</u> - Stream temperatures in excess of 86°F will not be permitted after mixing. Further, no permanent change in excess of 5°F will be permitted from naturally occurring background temperatures.

"<u>Outside Mixing Zone: Tidal Salt Water Classes</u>

Discharges shall not raise monthly means of maximum daily temperatures more than 4°F from September through May, nor more than 1.5°F during June, July, and August."

In July 25, 1969, revised temperature criteria were adopted as included in New York State Compilation of Code, Rules, and Regulations (6NYCRR 704.1(b)(4)).[3] These criteria are as follows:

"The water temperature at the surface of an estuary* shall not be raised to more than 90°F at any point provided further, 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°F over the temperature that existed before the addition of heat of artificial origin or to a maximum of 83°F, whichever is less. However, during 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°F, at any point of the estuarine passageway as delineated above, may be permitted."

These are the current State temperature criteria applicable to operation of Indian Point Units Nos. 1 and 2. They have not been approved by the U. S. Environmental Protection Agency.

In addition to the current temperature criteria, a new "Permit to Construct and Operate Waste Treatment Works and to Discharge Wastes into Waters of the State" (discharge permit) was issued to the applicant by the NYSDH in August 1966. This permit was issued by a letter, from the Municipal-Industrial Wastes Section of the Department of Health, which outlined qualifying conditions of the permit. The permit stated:

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* The lower Hudson River, including the Indian Point area, has been classified as an "estuary."

a. "that reports of the daily operation of the cooling water facility including laboratory tests and results shall be submitted monthly to the Department of Health".

b. "the temperature of the effluent shall not exceed a level that will produce a deleterious effect on fish life and propagation thereof in the receiving water".

The letter forwarding the permit also outlined other conditions:

"Required analyses. The minimum measurements and analyses of influent water and final discharge are: (1) flow, (2) temperature, ... The receiving waters shall also be measured for temperature."

"Performance. The facility is approved on the basis that it shall maintain a receiving water quality of Class SB standards and shall discharge an effluent that will not produce a deleterious effect on fish life or propagation."

Upon submission of the New York State thermal criteria to the Federal Water Pollution Control Administration (FWPCA) of the U.S. Department of Interior for review and comment, FWPCA found that the criteria were unacceptable. After the Environmental Protection Agency (EPA) was established on December 1970, attempts were made to resolve the disagreements between the State and Federal agencies. On November 10, 1971, EPA[7] recommended that the State thermal criteria of July 25, 1969 be revised to take into account the following recommendations for Federal approval.

(a) In accordance with Federal regulations (18 CFR 622.4(a)) public notice/public hearing procedures must be applied to further revise the New York State standards as adopted on July 25, 1969. Also, the revisions must be adopted in accordance with State laws, rules, and regulations.

(b) After the revised thermal criteria have been officially adopted by New York State, they should formally be submitted to the Environmental Protection Agency for approval.

The revisions recommended by EPA include the following regulations on thermal discharges regarding estuaries:

"The water temperature at the surface of an estuary shall not be raised to more than 90°F at any point. Further, in at least 50 percent of the cross-sectional area and/or volume of the flow of the estuary including a minimum of at least 1/3 of the surface as measured from water edge to water edge at any stage of tide, shall not be raised to more than 4°F over the temperature that existed before the addition of heat of artificial origin during the period from October through June or more than 1-1/2°F during the period July through September or a maximum of 83°F, whichever is less. Further the discharge must meet the additional requirement that no more than a distance of 1,000 feet 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 during the period from October through June or more than 1-1/2°F during the period from July through September. Because of the studies that have been made on the estuarial portion of the Hudson River, the need for limiting the temperature rise here during July through September to 1-1/2°F is waived and the conditions specified for October through June will be permitted year-round."[7]

In regards to the U. S. Army Corps of Engineers Permit program, the applicant applied for a Section 10 Permit to modify the discharge structure on May 22, 1967, which was approved on September 24, 1967. Application for Section 13 Permit under the Refuse Act of 1899 was made by the applicant on June 24, 1971. The application was administratively complete. New York State water quality certification has been obtained by the applicant for both Units Nos. 1 and 2 on December 7, 1970. The applicant is furnishing EPA public hearing transcripts and other information on studies made by the applicant. Estimated date of final action for approval for the Section 13 Permit is April 24, 1972.

c. Description of the Indian Point Cooling System

Water for Unit No. 1, at the rate of 300,000 gpm, is withdrawn from the river through an intake structure located behind the north end of a 247 foot long wharf and directly in front of the reactor building. The structure is composed of 4 intake cells each 11 feet 2 inches wide with the bottom 26 feet below MLW. Originally a skimmer wall extended downward to provide openings 12 feet 6 inches high but they were enlarged in April 1966 to the present size of 20 feet 6 inches. Each of the 4 cells contains a stop log gate, a trash rack, deicing header, chlorination system and a traveling screen ahead of the circulating water pumps. A fixed fine protective screen was added in 1967 at the entrance to each cell at the river's edge covering each opening to leave no recesses in which fish might get trapped.

The original discharge consisted of an open canal that released the effluent directly into the river about 320 feet downstream of the intake. Due to recirculation problems this was changed in 1966 to add a 214 foot extension parallel to the bank, but it continued to function as a surface discharge system. This system was used until the New York State water criteria standard was changed in 1969 to limit a maximum surface temperature to 90°F. Thus, in 1971 the applicant modified the discharge system to utilize a submerged jet 18 feet below MLW and to discharge the heated cooling water normal to the river flow. The applicant has since further modified the discharge structure during the past several months by changing the depth of the submerged jet from 18 feet to 12 feet as described below.[42,43]

The Unit No. 2 intake structure is located upstream of that of Unit No. 1. The reinforced concrete intake structure contains 6 main intake channels for 6 circulating water pumps and a divided service water intake channel. The Indian Point Unit No. 2 structure is designed with 6 large pumps, each having a capacity of 140,000 gpm capacity, and 6 small pumps for a total of 30,000 gpm of service water needs. At full capacity, the condenser flow is 840,000 gpm (1,872 cfs). Each main channel has openings 13 feet 4 inches wide by 26 feet deep, the top of which is 1 foot below the mean low level of the Hudson River, and serves as a skimmer wall to remove logs and debris floating in the river. Each channel contains stop log gates, trash bar screens, and traveling screens, de-icing headers and a chlorination system. The de-icer loop provides an inlet in front of the racks to melt the ice. Two de-icing pumps pump 80,000 gpm each of the warm circulating water through the de-icing loop into a de-icing spray header of the intake forebay. The fixed fine screens are at the mouth of the intake forebay to prevent fish from being trapped in the forebay. Figure III-4 is a diagrammatic sketch of the intake structure of Unit No. 2.

A trash rack composed of vertical steel bars 1/2 inch x 3 inch on 3-1/2 inch centers is located 30 feet from the river's edge inside each of 6 cell openings to protect the circulating pumps from logs, ice chunks, and large debris. Behind the trash racks is the provision for a fixed fine mesh screen (used on occasion) with one of the partitioned service water channels and 3/8-inch mesh mobile traveling screens. A de-icing spray header is located in the cell chamber ahead of all the screens so that heated water from the discharge canal can be recirculated at 160,000 gpm to the intake structure to melt ice that may form or tend to clog the screens. Appropriate mobile trash rakes remove material that collects on the racks and fixed screens, and a high pressure backspray from the service water supply serves to remove material that may have impinged on the up-pass of the traveling screen.

A sodium hypochlorite system is available to treat the incoming river water to control the fouling growth on the condenser tubes. A 15% sodium hypochlorite solution injected at a rate of 5 gpm is programmed through a control panel in the Unit No. 1 intake structure, and utilizes its two-4,000 gallon storage tanks and pumps. An automatic programmed control system initiates a cycle in which a slug treatment of the 6 water intake bays occurs in 2 groups of 3, through the service water intake bay. However, the automatic system can be manually operated such as to inject the sodium hypochlorite solution to 1/2 the condenser for 30 minutes and the other 1/2 for another 30 minutes. The frequency of injection will be limited to 3 hours per week, as discussed in Chapter V.D., for a total time of 6 hours of chlorination treatment per week for both Units.

Water from the six-900 horsepower (HP) circulating pumps is piped directly to the 3 steam condensers through six 84-inch diameter conduits, two going to each condenser. The water from each pump discharges into 1 of 2 inlet

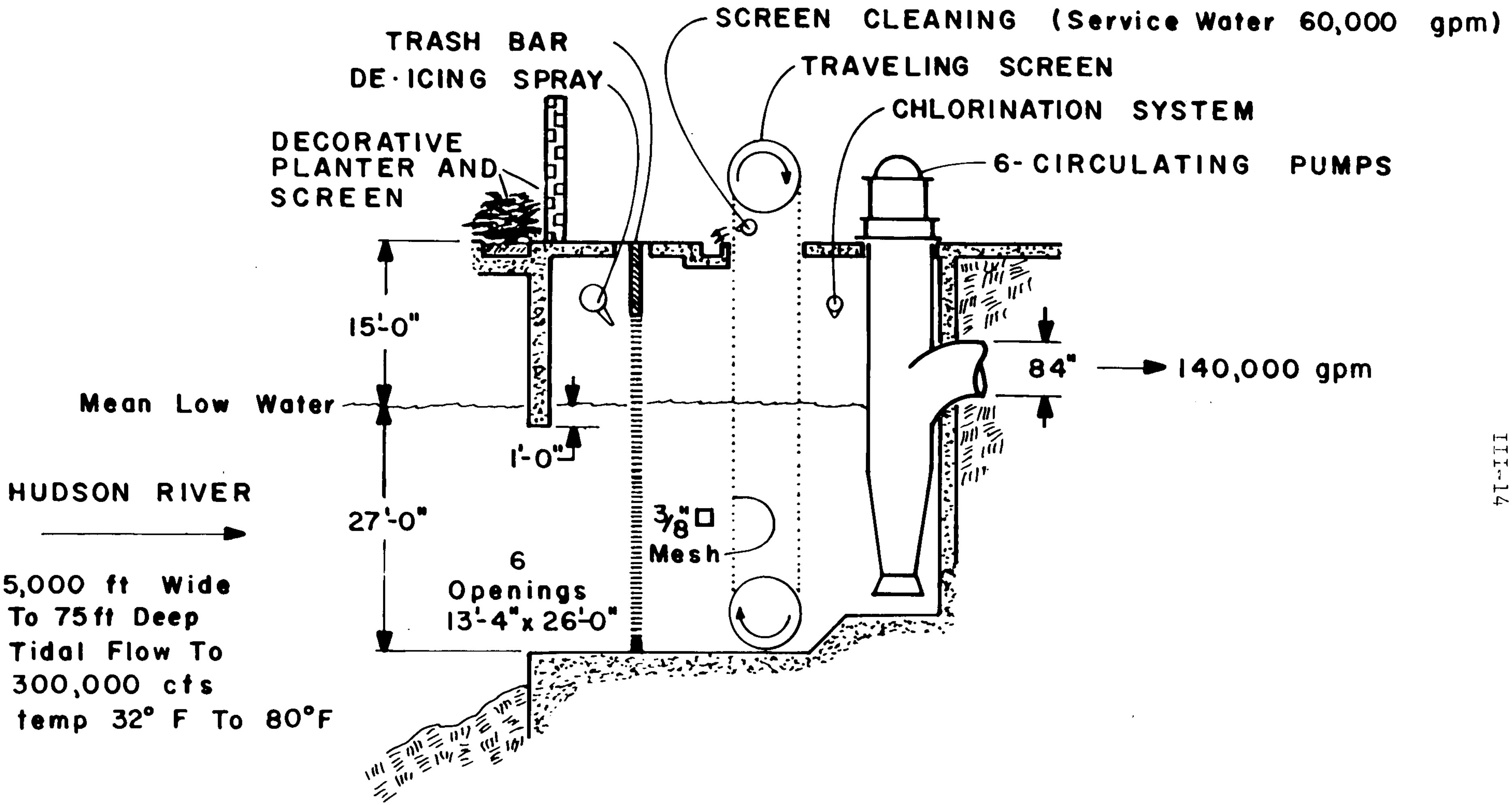


Fig. III-4
Diagrammatic Sketch of Intake Structure.
Indian Point Unit 2

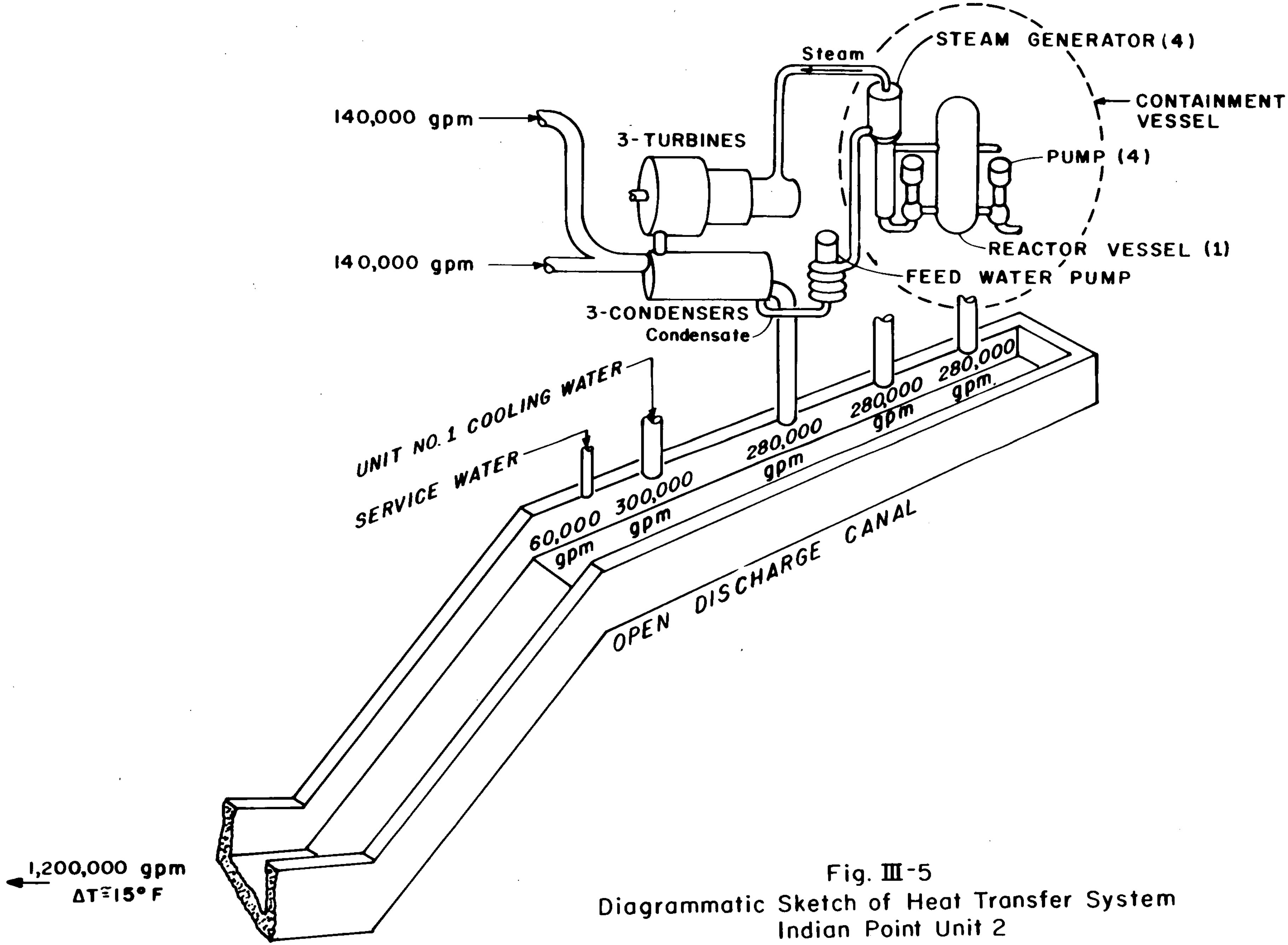


Fig. III-5
Diagrammatic Sketch of Heat Transfer System
Indian Point Unit 2

water boxes of the condenser. Each of the 3 condensers is a single-pass divided flow waterbox construction, with 96 inch diameter inlets and outlets. They consist of 50 feet long 1 inch O.D.* No. 18 BWG** admiralty tubes welded into silicon bronze tube plates, resulting in 306,000 square feet heating surface per condenser.

At full power operation, 840,000 gpm (1,872 cfs) of cooling water will be withdrawn from the river through the 6 pumps, but it is possible to operate at reduced flows. Flow through each of three condenser water boxes is normally 280,000 gpm, but the water boxes are divided by a separation plate so that flow through each half is normally 140,000 gpm. Operation at a minimum flow of 84,000 gpm is possible. At minimum conditions three half sections must be operated at a total flow of 252,000 gpm and at maximum condition of 420,000 gpm. The recirculation system to be installed prior to winter 1972-1973 will permit a net flow to the condensers with 84,000 gpm per pump.

Velocities of the water in the intake structure will vary according to the area available for flow. At full flow of 840,000 gpm, the velocities will be 0.9 fps through the 6 main openings, 1.01 fps through the trash bars, 1.44 fps through the fixed fine mesh screens, and about 1.9 fps through the traveling screen panels (see Appendix III-1).

An open discharge canal is used to collect all of the cooling water from Units Nos. 1 and 2 and the service water from both Plants and conveys it to the discharge facility located downstream from Unit No. 1. Figure III-5 is a diagrammatic sketch of the heat transfer system and canal.

The total maximum discharge can be about 2,600 cfs*** (668 cfs or 300,000 gpm from Unit No. 1 and up to 1,933 cfs or 870,000 gpm from Unit No. 2, and the temperature of the cooling water will be raised about 15°F.) Table III-2 indicates the variation in outfall flow rates, excess temperature increases of the heated cooling water waste, the peak temperature rise, and the dwell time of nonscreenable organisms from the point of entrance to the water box to the river during different pumping conditions of the intake-discharge system for Units Nos. 1 and 2.

The discharge facility is an evolution of the original discharge studies[(8)] and is now designed to handle the effluent from all three Indian Point Units operating at full capacity. It handles effluent from Unit No. 1 only at the present time. The 1966 change noted above was further extended in February 1970 to a point 960 feet from the Unit No. 1 intake. A modification in 1971 provided an underwater discharge system of 270 additional feet consisting of 12 slots each 4 feet high and 15 feet long located with the center line 18 feet below mean low water, so that thermal discharges will be jetted horizontally into the body of the river. Figure III-6 is a diagrammatic

* O.D. = outer diameter.

** BWG = Birmingham Wire Gauge.

*** The applicant states that a total of about 1,157,000 gpm (or about 2,580 cfs) would be used by both Units when service water is included.[(1)] The value of 2,580 cfs has been used in the staff's analysis.

TABLE III-2

INDIAN POINT UNIT NO. 2 INTAKE - DISCHARGE SYSTEM

Thermal Input Produced By MW(t)	Pumping Conditions	Flow Intake gpm	Discharge gpm	Daily Heat Loss to River MW(t)	Daily Heat Loss to River Btu	Daily Average Δt, °F	Dwell Time of Nonscreen-able Biota
(Without De-icing Loop) Unit No. 1							
890	2 pumps (full flow)	280,000	300,000	560	4.6×10^{10}	13	13 seconds* 35 minutes**
Unit No. 2							
2,758	6 pumps (full flow)	840,000	870,000	∿1670	15.2×10^{10}	15	
	(minimum flow)	504,000*	534,000			25***	18 seconds*
(With De-icing Loop)							
2,758	6 pumps (full flow)	680,000	710,000			20	40 minutes**
	(minimum flow)	344,000*	374,000			24.4***	

* Minimum water flow from water-box inlet to outlet
** Minimum flow from water inlet box to river entrance
*** See Reference 45 for further details

*Until recently, the submerged jet depth was 18 feet and all calculations discussed in this Statement are based on 18 feet.

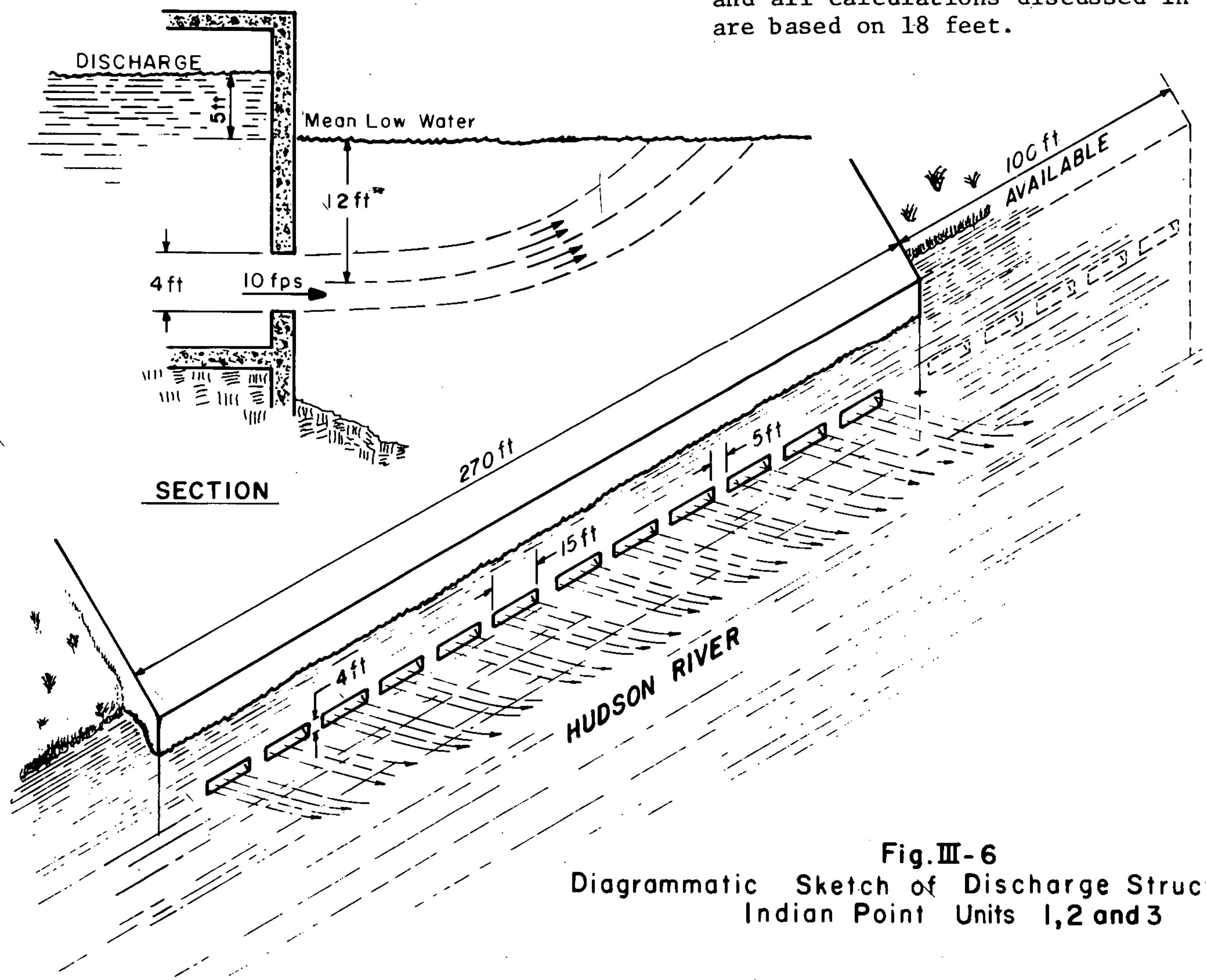


Fig. III-6
Diagrammatic Sketch of Discharge Structure
Indian Point Units 1, 2 and 3

sketch to illustrate this design. The applicant is presently modifying the depth of the discharge ports from 18 feet to 12 feet. This construction work should be completed by early April 1972. Ten of these submerged ports are equipped with fully adjustable gates so that a design discharge velocity of 10 fps may be maintained independent of the flow. Two gates (located farthest downstream) can be operated fully open or fully closed; i.e., they are not adjustable. The gates move in a vertical motion so that the adjusted openings are rectangular in shape with the centerline depth and height variable, according to gate position. A total discharge flow of about 1,157,000 gpm for both Units will occur with this discharge structure. When Indian Point Unit No. 1 is at full power, 560 MW(t) of heat is wasted and from Unit No. 2 1,875 MW(t) of heat is wasted and dissipated as heated thermal discharges.

A level control weir in the discharge canal will automatically maintain a predetermined head on the discharge water to provide the required jet velocity and also to reduce the head requirements on the intake pumps.

Warmed water from the discharge canal can be recirculated to the intake structures for de-icing purposes under extreme conditions by means of two 80,000 gpm pumps located adjacent to the discharge canal.

d. <u>The Hudson River Estuary and Its Cooling Capacity</u>

(1) <u>Topography and Fresh Water Flow</u>

The general characteristics of the Hudson River estuary are described in References 8-13, and only those features which bear directly on the analysis of thermal gradients at Indian Point are summarized in this section. Details of the flow characteristics of the estuary are also presented in Appendix II-1. Figure A.II.2, taken from Reference 14, shows the monthly average fresh water flows in the period 1918-1964, together with the monthly flows for the drought year 1964. Low fresh water flows generally occur from June through October, while the highest flows occur in the months of March through April. Reference 1 also reports details of temperature measurements and heat load on the Hudson River based on Indian Point Unit No. 1 operation.

Figure III-7 (from Reference 15) illustrates the frequency of low monthly and weekly flows. It may be seen that a low weekly fresh water flow of 3,000 cfs has a probability of occurring one out of ten years.

Salt water intrusion is an important feature of the flow at Indian Point since the presence of salinity is a clear indication of a dilution flow in excess of the fresh water flow. In addition, the salt water serves as a built-in tracer material which aids the analysis of the effects of thermal discharges. Figure III-8, adapted from Reference 15, shows the longitudinal variation of salinity from the mouth of the estuary to the limit of the salt intrusion for four fresh water flows ranging from 4,100 to 8,700 cfs. This longitudinal salinity distribution may be helpful in approximating the effective dispersion coefficient of the estuary, or an indirect indication of the presence of so-called "mixing flows" or "density flows" to be discussed below.

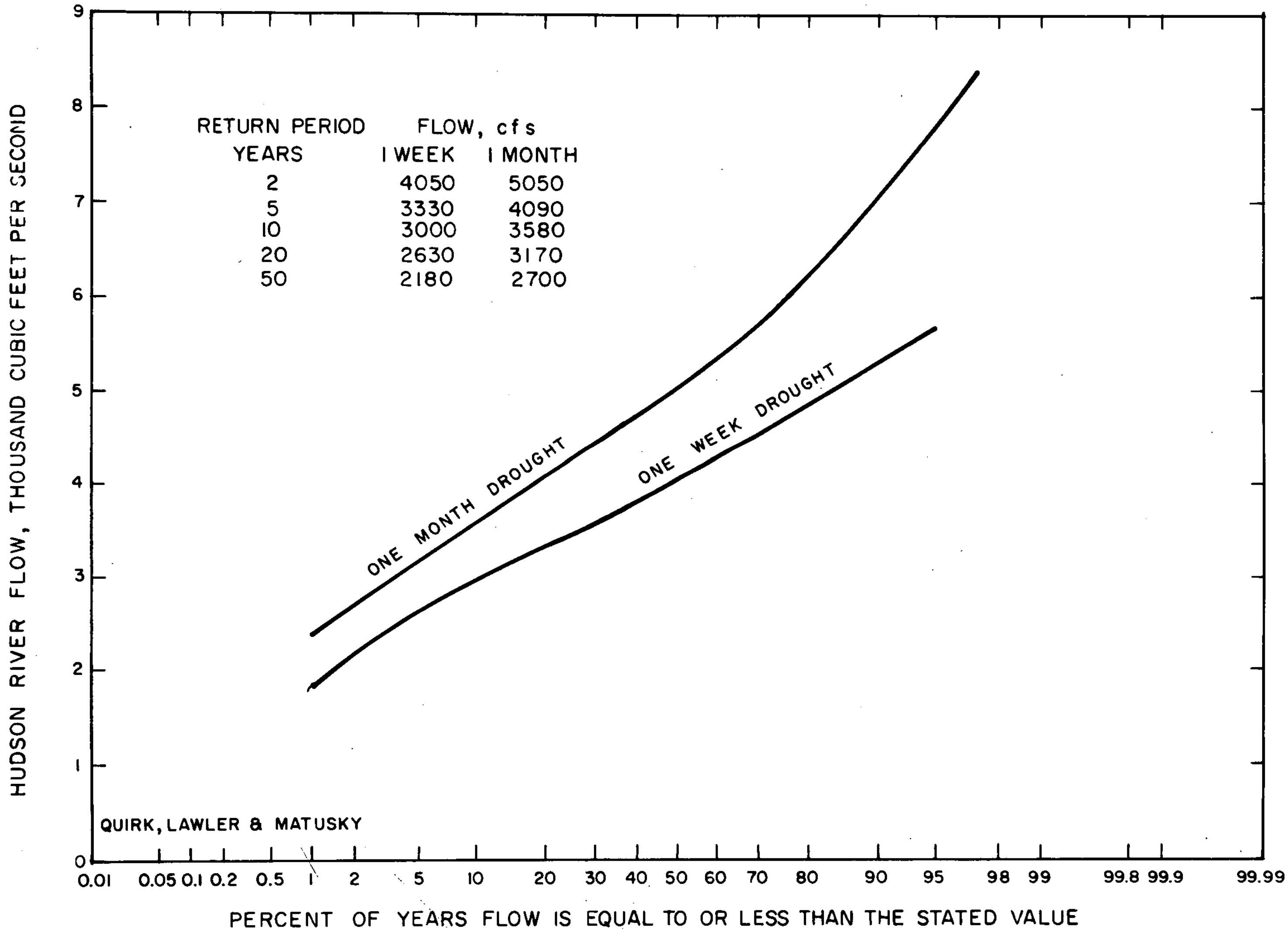


Fig. III-7 - Monthly and Weekly Drought Flow Frequencies at Indian Point

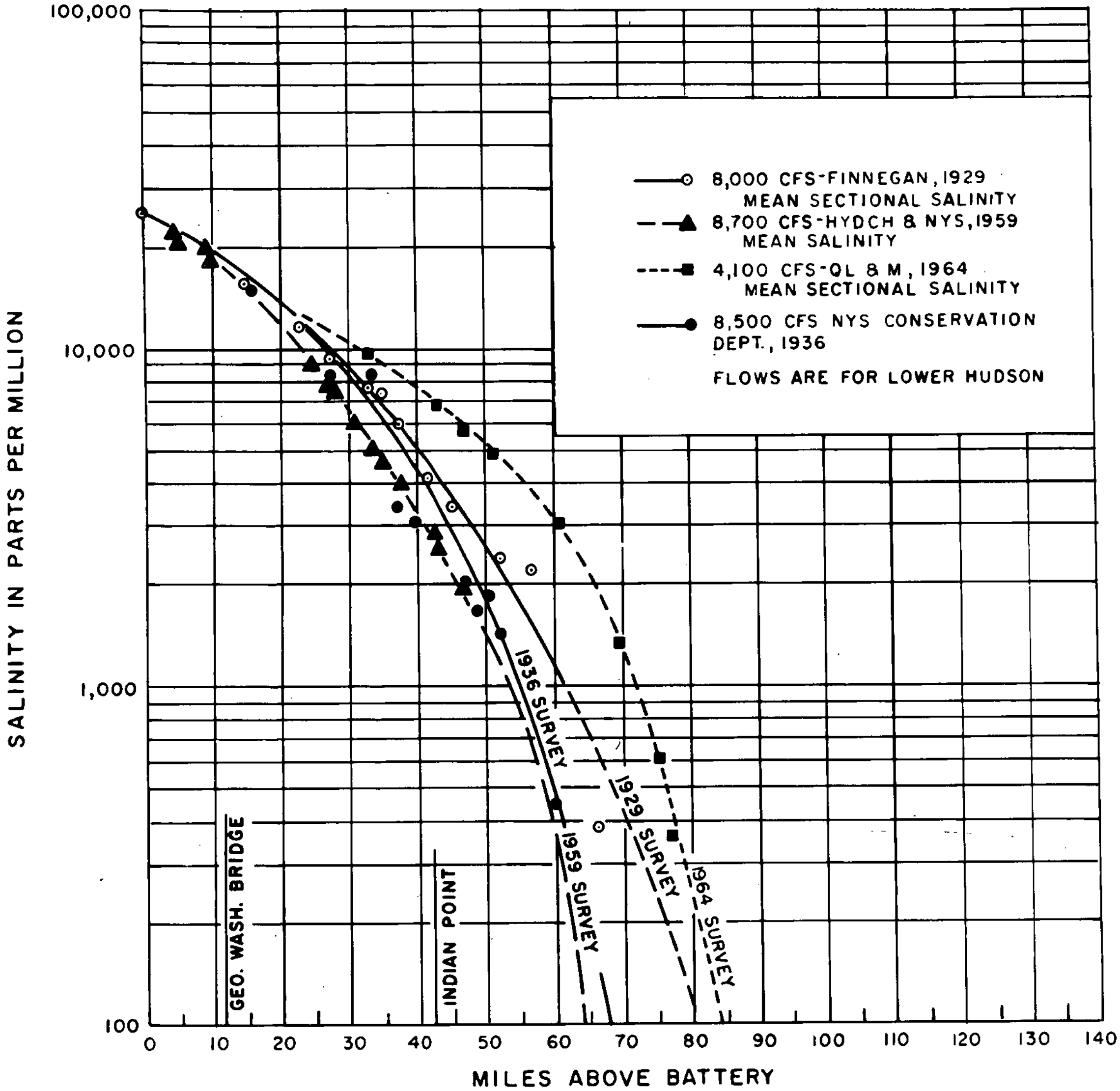


Fig. III-8 - Longitudinal Salinity Distribution in the Hudson

At fresh water flow in excess of 19,000 cfs, the salt intrusion is driven downstream from Indian Point for the entire tidal cycle. This flow situation may well be more critical with respect to the effects of thermal discharges than the 10% probability of low weekly flow of 3,000 cfs; i.e., there probably is less dilution flow at Indian Point at 19,000 cfs fresh water flow than at 3,000 cfs because the higher fresh water flow drives downstream the region of salt water admixing.

The variation of flow area at mean low water with distance from the Battery is illustrated in Fig. III-9, also taken from Reference 15. The mean low water flow area at Indian Point is 155,000 square feet. The highly variable nature of the flow area along the Hudson tends to limit the significance of analytic flow models, which usually assume constant flow area. Figure III-10 (from Reference 15) illustrates the cross section of the Hudson at seven locations from 1 mile downstream to 3,750 feet upstream from Indian Point. The channel is characterized by a wedge-shaped edge deep along the east bank in the vicinity of the Station site.

(2) Tidal Flows at Indian Point

Except at high and low water slack, the dominant flow at Indian Point is tidal. Figure III-11 illustrates the variation of flow velocity throughout one tidal cycle as measured along the axis of the channel.[9] If this velocity is assumed to exist over the entire flow cross section, the maximum ebb flow computes to be about 350,000 cfs and the maximum flood flow 275,000 cfs. It is interesting to note that a 13% variation in flow area occurs between high and low water slack, which partially accounts for the higher observed ebb velocities.

(3) Net Downstream Nontidal Flow

A seaward upper layer flow substantially in excess of the fresh water flow exists throughout the salt-water intrusion zone of partially mixed estuaries such as the Hudson. The source of this added flow (termed mixing flow and designated Q_m) at any location is a time-averaged landward flow of more saline water in the deep layers which ultimately joins the upper fresh water flow between the location of interest and the upstream limit of the salt intrusion. If we designate the average salinity of the lower layer as s_1, the average salinity of the upper layer, s_u, and the fresh water flow as Q_R, a simple salt balance yields in any cross section the total upper layer flow to be

$$Q_m + Q_R = Q_R \left[1 + \frac{s_u}{s_1 - s_u} \right] \qquad (1)$$

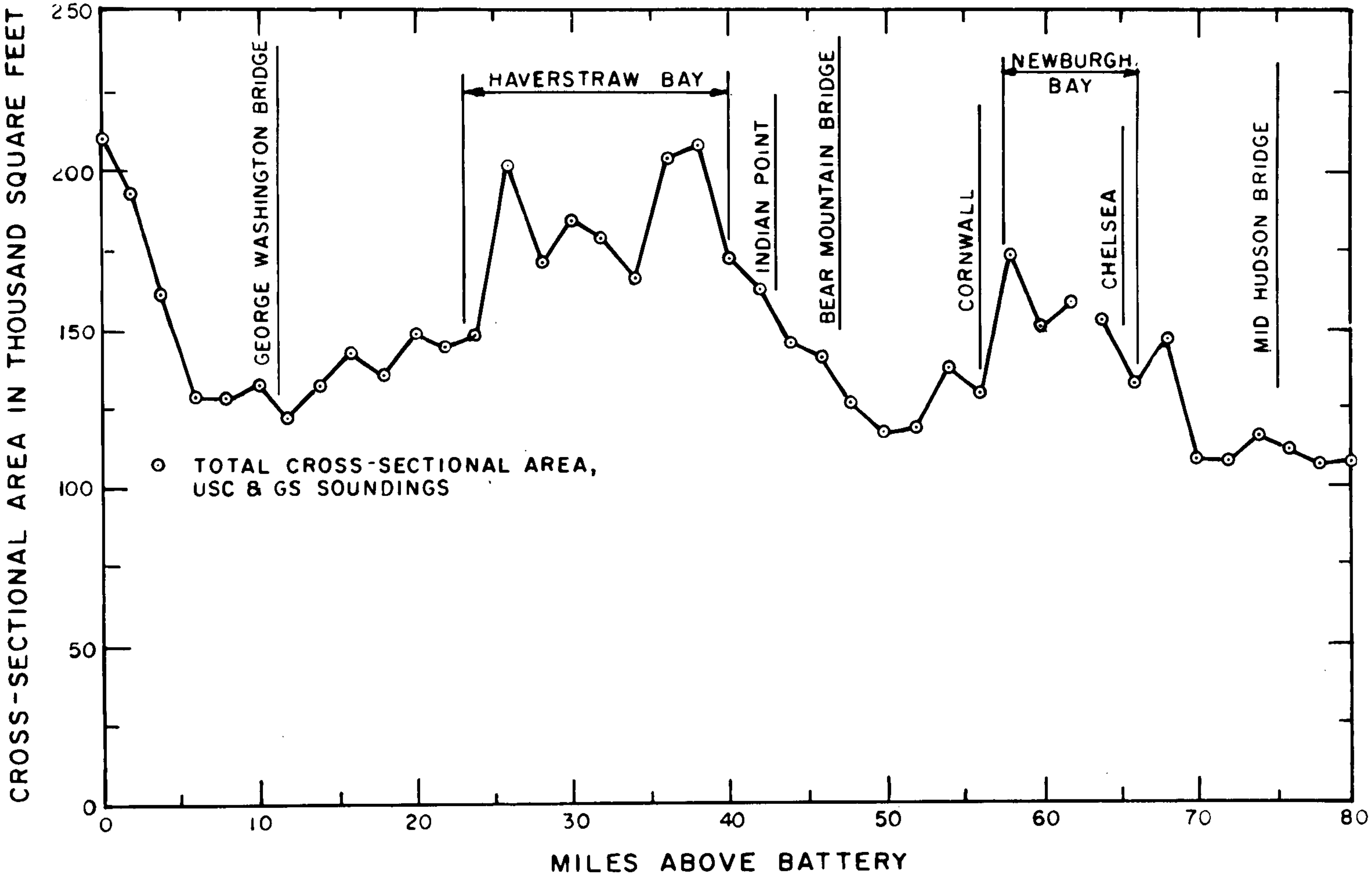


Fig. III-9 - Variation of Hudson Flow Area at Mean Low Water

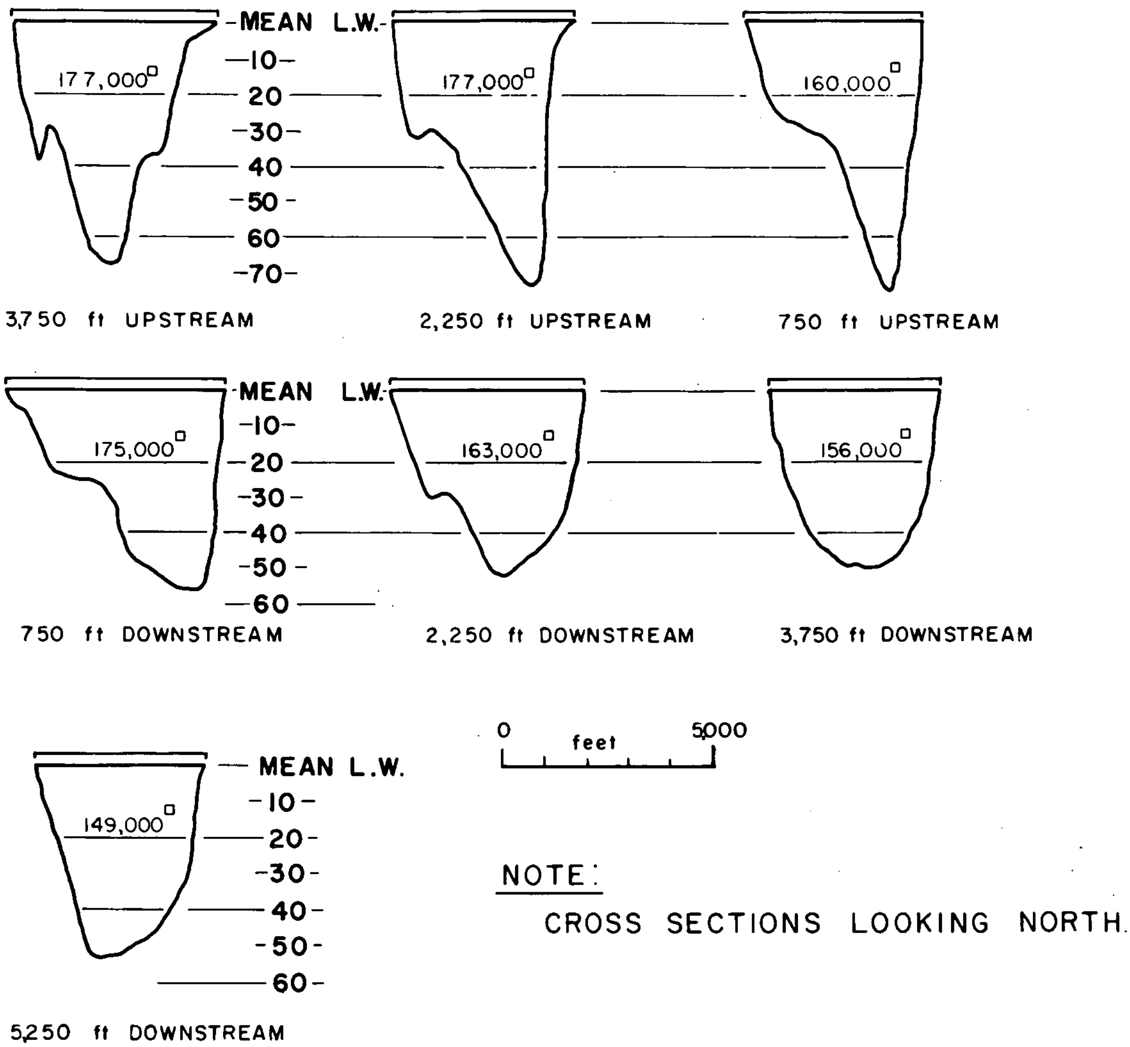


Fig. III-10 - Cross Sections of the Hudson near Indian Point, Looking Upstream

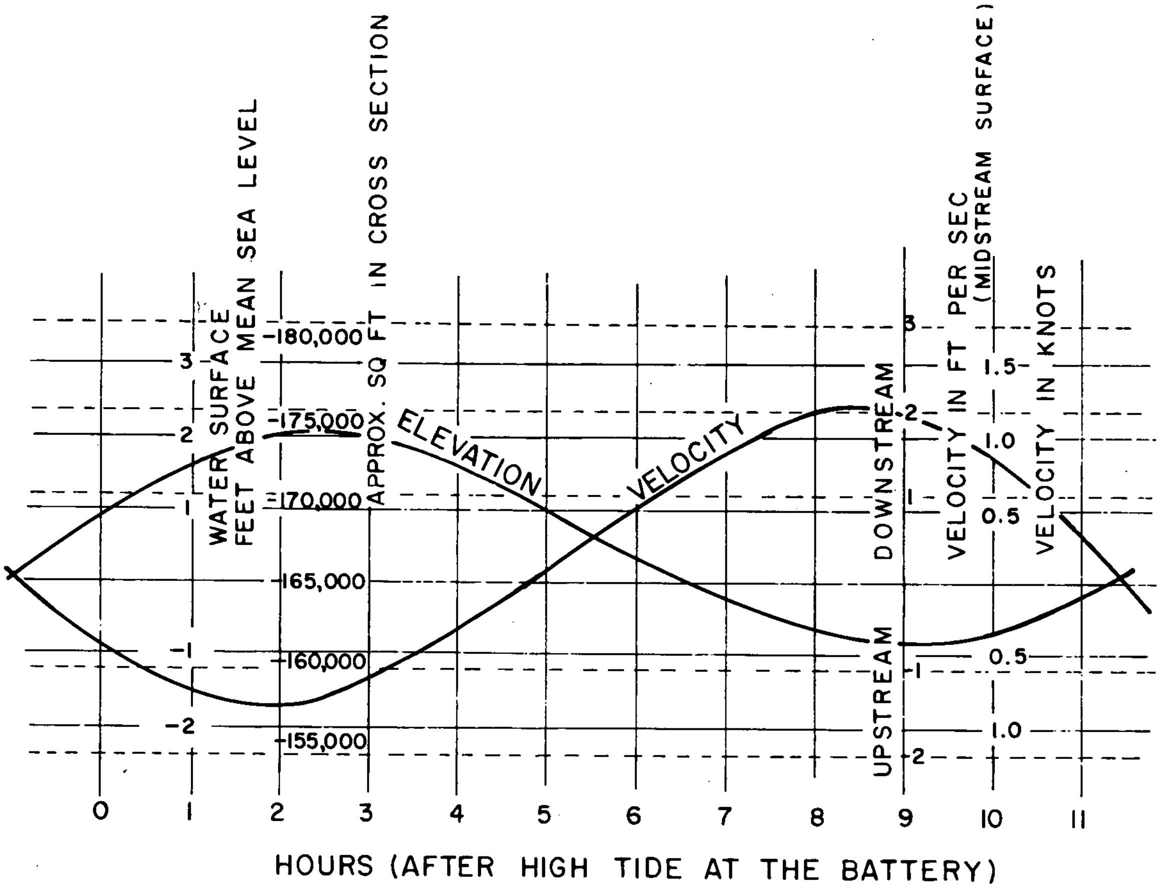


Fig. III-11 - Tidal Velocities and Level Changes at Indian Point

Equation (1) ignores salt storage changes and hence is valid only when flows are relatively steady. Thus the presence of more saline water at the lower depths is one indication of the presence of mixing flow, the magnitude of which may be roughly approximated using Equation (1). Note that doing so involves determining the difference $s_l - s_u$, which may involve large error when the difference is small. Such saline gradients with depth are reported in Reference 16 to exist in the Hudson through Mile Point 77 for a condition when the fresh water flow rate was 4,000 cfs.

The mixing flow calculated in Equation (1) is the upper layer flow in the downstream direction. This should not be confused with what is called dilution flow in Appendix II-1 and Appendix V-2. (This dilution flow is defined by Equation (1) in Appendix II-1.) These two appendices deal with the ecological effects of the Hudson River which are better described by the dilution flow concept mentioned above.

A second means for determining the magnitude of the mixing flow is by direct velocity determination. If a true area-average velocity is determined for maximum flood and ebb conditions, the net nontidal flow may be computed from the difference assuming a sinusoidal time variation over the ebb and flood periods. A determination of this type is attempted in Reference 16, for three cases: (1) data taken in October 1958 when Q_R was 10,000 cfs, (2) data taken in April 1959 when Q_R was 44,000 cfs, (3) data taken in September 1929 when Q_R was 8,000 cfs. The following conclusions were reached by the applicant's consultants:

1. For case 1 the presence of a net nontidal flow is indicated to exist by the velocity determinations, but they are not sufficiently accurate for quantitative determination.

2. For case 2, it was concluded that the measurements show that no net nontidal flow existed, and none was expected to exist at this high river flow.

3. Values of net nontidal flows were computed from data of case 3. For Indian Point a total upper layer flow of 22,000 cfs was determined, and values at other longitudinal locations were given.

The staff concurs with conclusions 1 and 2, but it cannot accept the values given for case 3 as significant. The reason is that in order to determine the net upper layer flow by taking the difference between flood and ebb flows, which are more than 10 times as high, far more extensive measurements than were undertaken in the survey are required for more precise determination of the area-average velocities. This appears to be a difficult undertaking. Furthermore, proof of valid results must be offered by satisfaction of the material balance,

Net seaward upper layer flow = Landward lower layer flow + Fresh water flow.

A proper flow material balance was not attained. However, the data of case 3 clearly indicate the presence of a mixing flow, as does case 1.

A third means for establishing the presence of a mixing flow in an estuary is by inference from the value of the dispersion coefficient as calculated from the longitudinal salinity gradient. Experience shows[17] that in fully mixed estuaries which show no saline gradient with depth, dispersion coefficients in the range 30 - 180 square feet per second (ft^2/sec) may be anticipated. In this case salt intrusion is solely a consequence of turbulent diffusion generated by the tidal back-and-forth sloshing. On the other hand, when saline dispersal also takes place via the mechanism of the mixing flow, values for effective dispersion coefficient as high as 13,000 ft^2/sec have been reported at the ocean entrance.[17]

In Reference 15, values for the dispersion coefficient (designated E) are computed by the applicant from the longitudinal salinity gradient. Values given for Indian Point range between 3,000 and 5,000 ft^2/sec for fresh water flows between 8,000 and 4,000 cfs. The same authors in Reference 11 report a value of 2,700 ft^2/sec at Indian Point for a fresh water flow of 3,000 cfs.

The presence of a net nontidal seaward flow in the salt-intrusion zone of the Hudson is clearly established by means of (1) observed vertical salinity gradients, (2) direct velocity measurements, (3) high computed values for the longitudinal dispersion coefficient. Of these three means for detection it is thought that only method 1 may be reliably used to obtain a reasonably accurate direct determination.

Vertical salinity gradients at 9 locations are given in Reference 16 for a condition when the river flow was relatively steady at 4,000 cfs for several months. Under these conditions salinity concentration in excess of 100 parts per million (ppm) extend to approximately Mile Point 85. These salinity profiles, taken in mid-channel during high water slack, are shown in Fig. III-12. Table III-3 lists the location and the salinities of the upper and lower layers taking the surface salinity to be representative of the upper layer flow and the deepest data point to represent the lower, landward flow.

The net nontidal flow computed by Equation (1) for Indian Point is 59,000 cfs when the freshwater flow is about 4,000 cfs. However, note that the values for the total upper layer flow in Table III-3 approach 17,000 cfs going upstream toward Mile Point 77.4, rather than the established freshwater flow rate, 4,000 cfs. This indicates that all the calculated values may be biased on the high side. To compute the net nontidal flow in this way, the river should be subdivided into a number of channels and the salinity gradient determined in each one. The net nontidal flow would then be determined by proportionately weighting the results for each channel according to the flow rate in each subdivided portion.

TABLE III-3
TOTAL SEAWARD UPPER LAYER FLOW COMPUTED FROM EQUATION (1)
USING SALINITY GRADIENT DATA FROM REFERENCE 16
(Fresh water flow = 4,000 cfs)

Location (mile point)	Salinity (parts per thousand) Upper Layer	Salinity (parts per thousand) Lower Layer	Total Upper Layer Flow from Eq. (1) (cfs)
22.8	12.50	12.95	115,000
32.3	10.35	10.55	170,000
42.6[a]	6.90	7.40	59,000
46.7	5.80	6.60	33,000
51.5	5.00	5.50	44,000
60.6	3.55	4.15	24,000
69.2	1.65	1.90	30,000
75.4	0.85	1.05	21,000
77.4	0.50	0.65	17,000

[a]Indian Point.

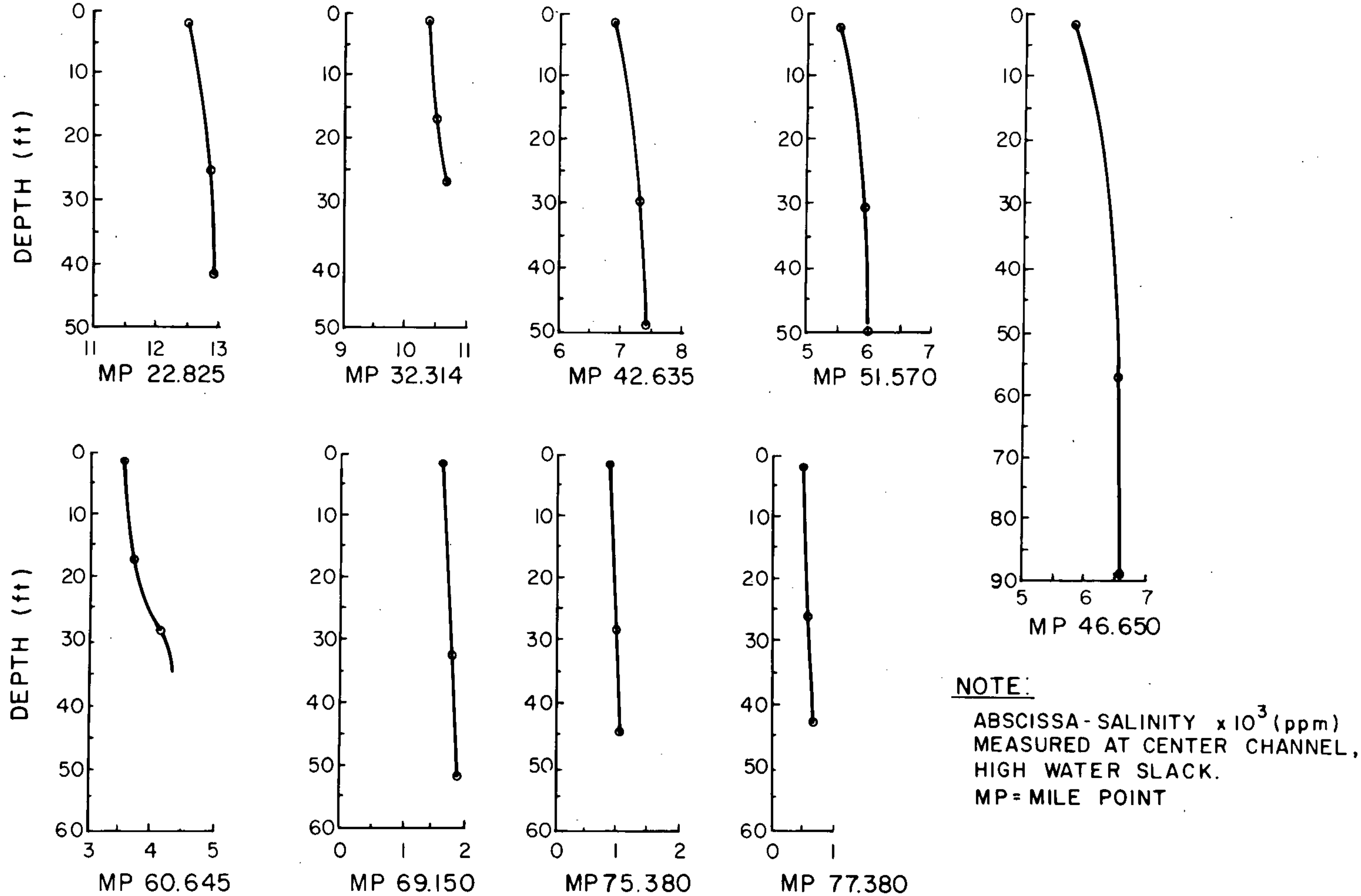


Fig. III-12 - Variation of Salinity with Depth in the Hudson at Nine Locations. Fresh Water Flow, 4000 cfs

e. General Description of the Thermal Plume

For the purpose of discussion and analysis, the thermal plume may be conveniently divided into three zones.

(1) The submerged jet region. This is the most critical portion of the thermal plume from the standpoint of satisfaction of water quality statutes. Beginning at an 18-foot depth and issuing with 10 fps velocity, the jet must entrain sufficient water to reduce its excess temperature from 15°F to some value such that a maximum surface temperature of 90°F is never exceeded. Since the jet velocity is high compared with the maximum oscillating tidal velocities in the channel, published submerged jet correlations[18-20] could perhaps be used with small error. These available correlations treat the case of zero ambient or constant ambient velocity. No correlations are available for this particular situation of fluctuating ambient velocity. The entrainment analysis performed on the Indian Point submerged jet given in Reference 21 contains some points of difference from the other published analyses. (See Section III.E.1.g)

(2) Near field isotherms - down to about 4°F excess isotherms. This is the region beyond the jet zone wherein oscillating tidal flows have a pronounced effect, yet near enough to the discharge so that the excess temperature is not yet dispersed across the channel. Again, a number of correlations are available for the near field plume for the case of zero or constant ambient velocity,[22-24] but none are available for the case of oscillating ambient flow. Very little appears in the literature on three-dimensional near field plumes primarily due to a lack of vertical diffusion coefficient data. The computational procedure performed on the Indian Point near field thermal plume, given in Reference 8, is geared particularly toward estimation of the percent of the width and depth of the channel covered by the 4°F isotherm.

(3) Far field temperature distribution. In this region the so-called one-dimensional approximation is frequently applied.[17] The excess temperature is assumed to be distributed uniformly in the lateral direction and diffuses upstream via the influence of the longitudinal dispersion coefficient. Movement upstream does not exceed the distance of one tidal excursion. The excess temperature extends farther downstream and decays with distance due to both dispersal and surface heat exchange.

f. Heat Dissipation Models Presented by the Applicant

The applicant has presented a number of heat dissipation models in order to predict the thermal effects caused by the once-through cooling system used in Indian Point. Those models can be divided as follows:

(1) mathematical model for the submerged discharge; (2) one-dimensional mathematical model for heat dissipation at the near and far fields; (3) two-dimensional mathematical model for the temperature distribution in a given cross section; (4) a net nontidal mathematical model for the completely mixed temperature at the Indian Point site; (5) hydraulic models. A short description of each one of those models as presented by the applicant in Appendices of the Supplement No. 1 to the Environmental Report for Indian Point Unit No. 2,[1] is presented here.

(1) Submerged discharge model.[21] A computer program was written based on 12 simultaneous equations which together describe the fluid mechanics of submerged jets. The model is based on the assumptions that the initial jet momentum, induced buoyancy, and river water entrainment are the controlling mechanisms involved and that drag forces and river boundary effects can be neglected. The model is written for a single circular submerged jet with a conical shape of constant slope. The slope of the cone changes once at the end of the zone of flow establishment. The trajectory of the jet center line may change, but each cross section is considered uniform in temperature and velocity. A number of steps are used to mark various interferences with external boundaries. This model is used to show compliance with the 90°F maximum temperature criteria.

(2) Near and far field heat dissipation model. A one-dimensional mathematical model[8] was developed to predict the cross sectional area average temperature rise along the length of the river. The final form of the adjusted area-average model is

$$\left.\begin{matrix}\Delta\bar{T}_1 \\ \Delta\bar{T}_2\end{matrix}\right\} = \frac{f_5 \times H \times \exp\left[\left(\frac{f_1}{f_2}\right)\left(\frac{f_3}{f_4}\right)\frac{U}{2E}\left(1 \pm \sqrt{1 + \frac{4K'E}{U^2}}\right) X\right]}{\rho\, C_p Q_R \sqrt{1 + \frac{4K'E}{U^2}}} \qquad (2)$$

in which:

$\Delta\bar{T}_1$ = area average temperature rise upstream of Indian Point, °F

$\Delta\bar{T}_2$ = area average temperature rise downstream of Indian Point, °F

H = thermal discharge, Btu/day

ρ = water density, lb/ft^3

C_p = water heat capacity, Btu/(lb °F)

Q_R = river fresh water flow, ft^3/day

U = fresh water velocity, Q_R/A, miles/day

E = longitudinal dispersion coefficient, square miles/day

x = distance from plane of discharge, miles

K^1 = temperature decay coefficient, day^{-1} (see below)

f_1 = correction factor used in the infinite receiver model (where all parameters are considered constant) to agree with the variable parameters segmented model, for temperature decay upstream of Indian Point

f_2 = same as f_1, but for downstream of Indian Point

f_3 = correction factor used to adjust the theoretical model to agree with observed data, for temperature decay upstream of Indian Point

f_4 = same as f_3, but for downstream of Indian Point

f_5 = correction factor used to adjust the theoretical model to agree with observed data at the plane of discharge

This model is based on the mass, momentum, and energy conservation principles but also includes 7 empirical adjustment coefficients which will be discussed later.

The temperature decay coefficient is defined as

$$K' = \frac{\overline{K}B}{\rho C_p A} \quad (TSF) = \frac{\overline{K}B}{\rho C_p A} \; \frac{\overline{\Delta Ts}}{\overline{\Delta T}} \tag{3}$$

in which:

$\overline{K}$ = meteorological surface heat transfer coefficient, Btu/(ft^2°F day)

B = river width, ft

A = river cross section area, ft^2

$\overline{\Delta Ts}$ = average surface temperature rise, °F

$\overline{\Delta T}$ = cross section area average temperature rise, °F

TSF = thermal stratification factor which is defined by

$$\mathrm{TSF} = \overline{\Delta T_s}/\overline{\Delta T} \tag{4}$$

(3) Cross section temperature distribution model. Two mathematical expressions were developed[25] for predicting the temperature decay in a given cross section for either the external or the surface temperatures:

$$\Delta T = \Delta T_m \exp(-KA) \tag{5}$$

and

$$\Delta T_s = \Delta T_{sm} \exp(-kb), \tag{6}$$

in which:

ΔT = temperature rise isotherm, °F

ΔT_m = maximum temperature rise at any point in the cross section, °F

A = that portion of the cross section within which the temperature rise equals or exceeds ΔT, ft^2

K = exponential decay coefficient for area, ft^{-2}

ΔT_s = surface temperature rise isotherm, °F

ΔT_{sm} = maximum surface temperature rise at any point across the width of the river, °F

b = that portion of the surface width within which the surface temperature rises equals or exceeds ΔT_s, ft

k = exponential decay coefficient for surface width, ft^{-1}

Equations (9) and (10) are used to show compliance with the 4°F temperature rise isotherms criteria for both 50% cross section area and two-thirds of the river width. (See Section III.D.1.b. for the New York State thermal criteria.)

(4) Net nontidal flow model.[16] The net nontidal flow phenomenon is suggested as having a high capability for dilution, far exceeding that of the river fresh water flow. It is assumed that complete mixing exists in each cross section, and the mathematical expression for the cross section area average temperature is

$$\overline{\Delta T} = H/\rho C_p Q_d, \tag{7}$$

in which:

$\overline{\Delta T}$ = cross section area average temperature rise, °F

H = heat discharge, Btu/day

ρ = water density, lb/ft^3

C_p = water heat capacity, Btu/(lb °F)

Q_d = total dilution flow, cfs

In this expression the applicant considers for the total dilution flow Q_d, the sum of both the upper seaward flow and the lower layer landward flow.

(5) Hydraulic models. Three hydraulic models have been constructed to simulate the various aspects of the Indian Point discharge.

Model I was used mainly for Indian Point Unit No. 1.

The second model (model II) simulates the Hudson River about 9,000 feet above and below Indian Point. It is a vertically distorted model scaled 1:250 in the horizontal dimension and 1:60 in the vertical.

Model III is an undistorted 1:50 scaled model of the submerged discharge which simulates about 900 feet along the east shore and 400 feet of the river's 4,000-foot width. The model was used for optimizing the parameters of the submerged discharge ports. In later stages it has been incorporated into Model II to study the effects of the submerged discharge on a large scale.

g. The Staff's Critical Review of the Applicant's Heat Dissipation Modeling

A detailed review of the heat dissipation models presented by the applicant revealed a number of inherent uncertainties which might affect the applicant's conclusions as to their predicted thermal effects on the Hudson River. As a general note it might be worth indicating that the applicant's presentation of the heat dissipation models is based on the combined effects of all three Indian Point Units. In addition, the various models and arguments presented as discussed in many sections of the Appendices of the Supplement to the Environmental Report, were written at different stages and for various purposes. This makes the review of many sections difficult.

The heat dissipation models presented by the applicant have deficiencies which make them subject to more rigorous verification by field studies. Field data are inadequate to support some of the assumptions used. The magnitude of the net non-tidal flow for different freshwater flow needs to be determined. It appears that, with only Units Nos. 1 and 2 in operation, the thermal plume may be dispersed in accordance with the New York State thermal criteria for the +4°F isotherm, but this has not been convincingly shown by the applicant's analysis. The staff is also concerned with compliance with the 90°F maximum surface temperature criteria, especially since the jet depth has been changed from 18 feet to 12 feet below the mean water level.[42,43] The applicant's mathematical models, in using an average area assumption, do not take into account local salinity or flow gradients. Improvements and refinements in these models and rigorous field studies to confirm these models are needed in order to use them to predict the actual dissipation of the thermal discharges from Indian Point Units Nos. 1 and 2. The applicant will be required to meet State and Federal regulations for all discharges. Details of the staff's evaluation of the applicant's analysis of heat dissipation of thermal discharges based on discharge at the 18 feet depth level with full flow of 2580 cfs through the discharge structure are discussed below.

(1) Heat load and discharge temperature. The applicant takes into account that 32% of the heat generated in the reactor, based on operating experience with Unit No. 1, is converted into electricity and 5% is assumed by the applicant as in-plant losses.[3] The rest (63%) is discharged into the river. It is the staff's opinion that 5% in-plant losses for such a large plant [about 2,100 MW(e) for Units Nos. 1, 2, and 3] is far too high.

The maximum river ambient temperature assumed by the applicant is 78°F to 79°F.[3] In a Report of Inquiry on Indian Point Unit No. 1, submitted by the Commission's Division of Compliance in October 1971 (see Volume II, Fig. B-4 and attachment B-3), there is detailed information on temperature measurements made by New York University. Based on those measurements, the maximum river temperature can be above 81°F in August. These temperatures were measured at three stations across the river section (east bank, mid-river, and west bank) at the Indian Point site while Indian Point Unit No. 1 was in operation. The heat dissipation analysis, which is used to show compliance with the New York State criteria of 90°F maximum surface temperature and 4°F excess temperature isotherm, should take this additional 2°F difference into account.

(2) Submerged discharge model. In Appendix M of the Supplement No. 1 to the Environmental Report, the applicant discusses the effect of the submerged discharge of Indian Point cooling water on the temperature distribution of the Hudson River. The submerged jet discharge model involves a number of uncertain assumptions which may be critical. The analysis assumes that the jet will have a conical shape with a constant slope of 0.15 in the zone of flow establishment and 0.25 in the zone of established flow. The length of the zone of flow establishment was taken as 5.2 times the length

of slot. None of these parameters are well established in the open literature. Specifying the slope of a jet expansion is another way of specifying the entrainment coefficient. This coefficient is a measure of the amount of diluting water entrained into the jet and has a direct effect on the rate of temperature decay. The value of the entrainment coefficient is not well established, and the few data available are reported as entrainment coefficients rather than as slopes of jet expansion. The sensitivity of the results to the choice of slope must be evaluated numerically. The end of the zone of flow establishment is taken as 5.2 times the length of slot. This relationship is close to one reported for a circular port and zero ambient velocity (6.2 times the diameter). Based on the definition of the zone of flow establishment, it is clear that the smaller dimension of the slot (4 feet) should be used rather than its length (15 feet) in evaluating the length of this zone.[21]

The model suggested assumes a uniform average temperature and velocity in each cross section along the jet. Therefore, it does not have the capability of predicting the temperature at the jet center line, which is higher than the average. To get an approximation of the center-line temperature, the applicant assumes that a cosine distribution exists between the boundary of the jet and its center. Cosine distributions are not commonly used. Most investigators assume a Gaussian distribution, which results in a higher peak temperature for the same average value. The difference between the two approaches might be about 15%, which in the staff's case comes close to an additional 1°F temperature rise. In addition, an unclear concept of a 3°F temperature rise at a jet boundary is used. The locations of those "jet boundaries" are not defined, nor is the 3°F value defined by the applicant.

The submerged discharge analysis is based on a single circular jet model. Since the actual discharge is composed of 12 ports, each 4 feet by 15 feet, centered at 20 feet apart, a problem of mutual jet interference exists. The initial distance between the jets at the discharge point is 5 feet. However, since the applicant's model is based on a circular jet, an equivalent diameter of 8.75 feet is used. This creates an initial clear distance between the jets of 11.25 feet compared to 5 feet in the actual design. Using the applicant's procedures but for only 5 feet initial clearance, we get interference at about 16.7 feet distance, compared to about 40 feet reported, and a dilution ratio of 1.5 at that point, compared to 2.37 reported. The temperature rise at that point (using again the applicant's procedures) becomes 12.4°F. If we add this to an intake temperature of 81°F, we get a maximum surface temperature of about 93°F.

It must be added at this point that the applicant has chosen to be conservative in its assumption that no additional entrainment will occur after the point of jet interference. This is certainly not true, and very conservative. However, evaluating the new entrainment coefficient or the new slope of the jet expansion is difficult and requires special investigation.

The applicant indicates that a minimum jet velocity of 10 fps will be maintained at the discharge point into the river. However, with all twelve ports fully open and with only Indian Point Units Nos. 1 and 2 in operation, the staff calculated that the discharge velocity will be about 3.5 fps. The applicant should specify the method of operating the ports that will guarantee a 10 fpc jet velocity.

Over all it seems that there are enough uncertainties in the applicant's analysis to require an additional revised analysis of the submerged discharge which will take those uncertainties into account. In addition, the depth of the discharge ports has just been changed from 18 feet to 12 feet. This may have a significant effect on the maximum surface temperature of the jet and makes the present results of the applicant's inapplicable. Furthermore, since the applicant plans to reduce the maximum pump flow of 140,000 gpm to as low as 84,000 gpm, then the corresponding temperature differential across the condenser increases and the circulating cooling water will increase in temperature, thereby causing a greater temperature increase of the plume as it is dispersed on the surface after being discharged at 12 feet. See Table III-2 for increases in the temperature differential of the thermal discharges depending on different pumping conditions.[44,45]

(3) Near and far field heat dissipation model. As discussed in Appendix K of the Supplement to the Environmental Report, this model was originally developed for showing compliance with the early New York State thermal criteria. However, in order to show compliance with the new state regulations, a new, less conservative model was needed. The adjustments made to the original model by arbitrarily using correction factors so that the results will agree with only one set of observed data from operation of Indian Point Unit 1 and extrapolating the model to predict the effects of Units Nos. 1, 2, and 3 together is unjustified.

The correction factors f_1 to f_5 are inserted in a seemingly arbitrary way. The model correction factors, f_1 and f_2, to convert the more complicated variable parameters segmented model to an infinite constant parameter model are based on comparison of the two models for one set of conditions. Why the two models should differ by the same factors for other sets of conditions is not clear. The correction factors f_3, f_4, and f_5 to correct the mathematical model to the observed data are also based on one set of field conditions (April 1967) which are quite different from the examined ones. The observed data are for surface discharge, 482 MW(t) waste heat load, 17°F condenser temperature rise, winter meteorological conditions (April 1967) (Appendix J of Supplement No. 1), and river flow of 40,000 cfs. The case examined is for submerged discharge, 4153 MW waste heat load (almost ten times as much), 14°F condenser temperature rise, summer meteorological conditions, and river fresh water flow of 4,000 cfs (a tenth as much). The differences are too large to justify such an extrapolation. In addition, since the observed data are not under controlled laboratory conditions, it is difficult to be sure that some unexpected conditions did not exist when the field measurements were taken. The size of the factors f_3, f_4 being so large (about 15) also makes the adjustment questionable. The factor f_5, which is as low as 0.54, has a direct effect on the results, and a change in this factor can change the conclusions from acceptable to unacceptable temperature rises.

The longitudinal dispersion coefficient E is supposed to take into account all the turbulent diffusion and mixing caused by various movements (tidal movements, net nontidal flows, density mixing, etc.). In spite of many investigations, there is no reliable method for predicting E. The applicant derives an expression for E based on comparison between measured salinity profiles and a steady-state diffusion differential equation for salinity concentration. However, the values which were calculated by this method and reported in Fig. B-6 in Appendix J, seem to be too high. More investigation and field data are needed to establish the correct value of this longitudinal dispersion coefficient.

The thermal stratification factor (TSF)[8] is defined as the ratio between the surface average temperature rise and the cross sectional area average temperature rise. In reality, none of those temperatures are uniform. Experimental field measurements are the only way to get proper values for the TSF. The only field measurements taken for both surface and cross section temperatures are those taken on July 1966 and April 1967 by Northeastern Biologists, Incorporated (NBI). A TSF of 3.0 was found for the July 1966 conditions and 6.0 for the April 1967 conditions. The applicant uses the lower value of 3.0 for adjusting the mathematical model in the January 1968 report (Appendix J to Supplement No. 1). For the February 1969 report (Appendix K to Supplement No. 1), the applicant uses a linear interpolation between a minimum value of 1.0 for effluent channel temperature of 3.4°F (complete vertical mixing) and a maximum value of 3.0 for effluent channel temperature of 14°F. Although this compromise seems to be reasonable, the basic value of 3.0 is the result of field measurements taken at conditions quite different from the ones for maximum severity. The field measurement data on Unit No. 1 were taken for surface discharge, for a waste heat load of 482 MW(t), and a 17°F condenser temperature rise. The most severe conditions are based on submerged discharge, 4153 MW(t) waste heat load (almost ten times as much), and 14°F condenser rise where Units Nos. 1, 2, and 3 are all in operation. The differences in all three conditions are expected to result in a lower TSF as compared to the July 1966 data. The extrapolation of the results, taken under this single set of conditions, to such a wide variety of conditions is not justified.

(4) Cross section temperature distribution model. This model is used for evaluating temperature distributions and generating isotherms, primarily to check the extent of the 4°F isotherm. This type of analysis calls for a three-dimensional model which is perhaps difficult to develop. The applicant's model for that purpose is necessarily highly simplified and relies heavily on field data. The only field data used are those collected on April 1967 (Appendix J to Supplement No. 1), as mentioned above when the one-dimensional model was discussed. The same objections to extrapolations exist here and for the same reasons.

In addition, the surface and area boundaries should be considered from the point of maximum temperature rise. In the case of submerged discharge, the maximum temperature rise ΔT_{sm} is located at the point where the plume center line reaches the surface and not at the shore line. In the case discussed in Appendix M of the Supplement to the Environmental Report, the plume reaches the surface about 125 feet of the shore. This was not taken into account when evaluating the 4°F surface boundary by the applicant.

An attempt has been made to use the applicant's procedure for a set of pessimistic values for the thermal stratification factor (TSF = 1.5), the longitudinal dispersion coefficient (E = 9 square miles/day), and an unadjusted model ($f_5 = 1.0$). The results show that the 4°F temperature rise isotherm for ΔT_{SM} = 12°F will extend to about 40% of the river cross sectional area (compared to a limit of 50% by the New York State Department of Health criteria) and about 86% of the river width (compared to a limit of 66% allowed).

It must be emphasized here, however, that all those calculations were made for the combined effects of all three units. Since the extent of the 4°F isotherm is directly related to the heat load discharge, one tends to believe that the applicant will not have too much difficulty in proving compliance with the 4°F isotherm criteria with only Indian Point Units Nos. 1 and 2 in operation.

(5) Net nontidal flow model. The net nontidal flow phenomenon is suggested by the applicant as being the main reason for disagreement between the mathematical model and the observed data from July 1966 and April 1967. As mentioned in Section III.D.1.d, the phenomenon evidently does exist and should be taken into account. However, the concept that the amount of water available for dilution is the sum of the upper layer seaward flow and lower level landward flow[16] is unjustified. The warmer and lighter discharged water tends to float to the upper level, and most of the dilution process takes place along it. The lower level flow is probably inactive in this respect, since the discharge port is less than 20 feet deep. Even when using the upper layer flow only, the phenomenon is certainly very helpful in diluting the warm discharged water and should be included in any realistic model of the Hudson River. However, more field data are needed to evaluate quantitatively the upper layer flow for different times of the year and under various fresh water flow conditions. See discussion in Section III.D.1.d.

2. Radioactive Wastes

The operation of a nuclear reactor results in the production of radioactive fission products, the bulk of which remain within the cladding of the fuel rods. During operation of the reactor, small amounts of fission products may escape from the fuel cladding into the primary coolant; also, some radioactive materials are produced as a result of neutron activation of corrosion products, of water, of dissolved chemicals, and air in the coolant. Some of these materials in low concentrations may be released into the atmosphere as gases or into the Hudson River to unrestricted areas as liquids by carefully controlled processes after appropriate treatment, monitoring, and sampling and analysis.

The radioactive waste treatment systems presently incorporated in the Indian Point Plant Unit No. 2 are described in the Final Facility Description and Safety Analysis Report (FFDSAR),[25] the applicant's Environmental Report, Supplement No. 1,[1] and Supplement No. 2.[2] The quantity of radioactivity that may be released to the environment during operation of both Units at full power will be in accordance with the Commission's regulations as set forth in 10 CFR Part 20 and 10 CFR 50.

Our evaluation of Unit No. 2 is based on the systems described in the[1] FFDSAR and assumes that changes to the waste evaporator have been completed. Other planned modifications to Unit No. 2 to further reduce the releases of liquid and gaseous effluents were not considered, since the changes are not expected to be completed until the end of the first fuel cycle. Details of the parameters used in the source term determination are prescribed in Appendix III-2.

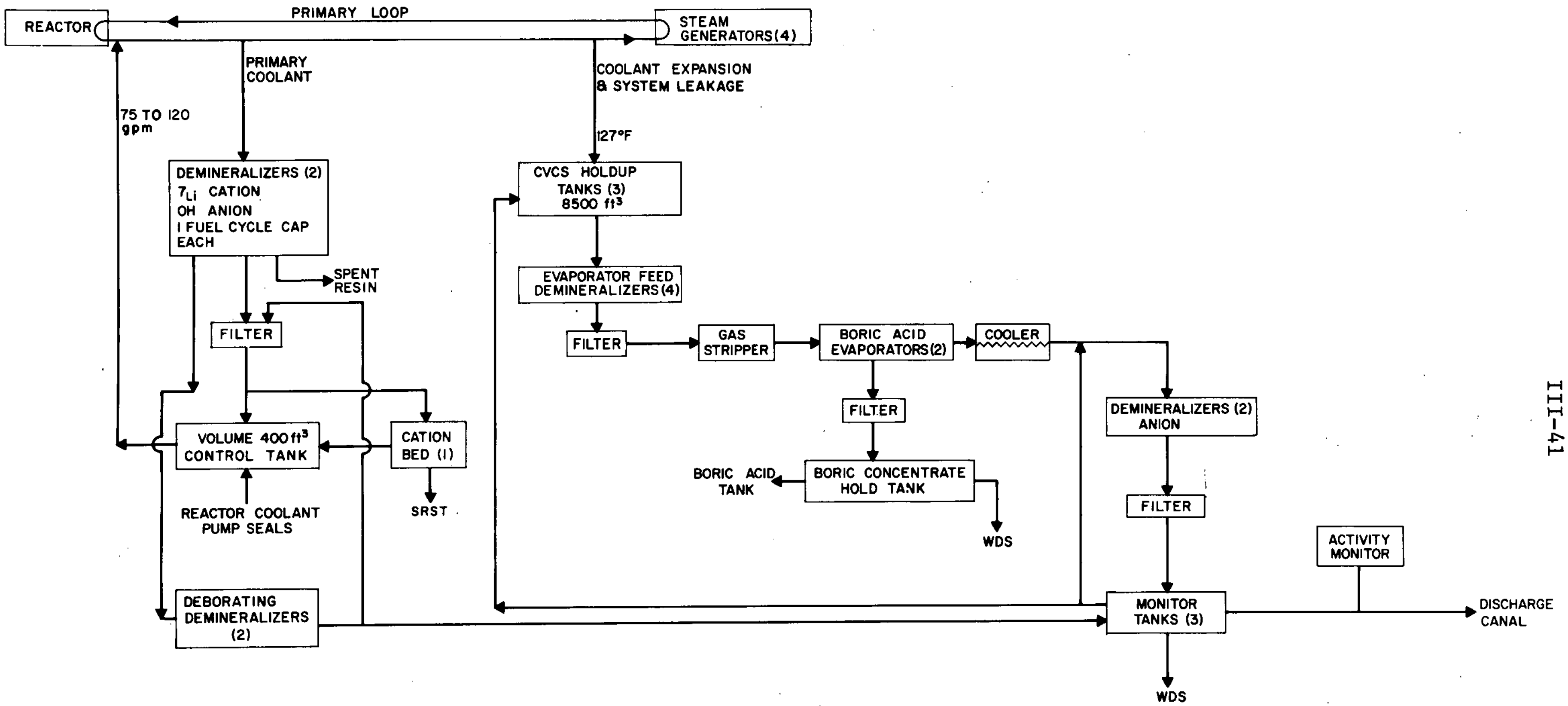
a. Liquid Wastes

The liquid waste system is designed to reduce radioactive materials in liquids discharged from the Indian Point Unit No. 2. The system is divided into three parts: the chemical and volume control system (CVCS), which will process radioactive water discharged from the reactor system; the waste disposal system, which will collect and treat liquids from the secondary loop including equipment and floor drains; and a collection system to handle liquid wastes from the laundry and showers.

(1) Chemical and Volume Control System

Two process systems are located within the CVCS of Unit No. 2 (Fig. III-13). The proper functioning of these systems will greatly reduce the burden placed upon the waste disposal system. Most of the radioisotopes present in the waste effluents originate in the reactor coolant.[26] To maintain a low level of radioactivity in the primary coolant a part of this coolant will be withdrawn to the CVCS and processed through one of two mixed-bed demineralizers to remove ionic impurities, fission products and corrosion products except cesium, yttrium, molybdenum and tritium. (These isotopes are removed slowly or not at all by the demineralizers and are assumed to pass through without any removal for the purpose of this analysis.) On an intermittent basis the effluent from the demineralizers will be processed through a second demineralizer to reduce all radioactive isotopes except tritium.[27] In the later stages of core lifetime the coolant effluent from the mixed-bed demineralizers will be routed to one of two deborating demineralizers. The effluent from both demineralizers will be filtered and returned to the volume control tank for reuse or sent to the monitor tanks for reuse or discharged into the Hudson River.

The second part of the CVCS will process liquids that drain from reactor coolant pump seals, accumulators, pressurizer relief tanks, and valve and flange leak-offs and the excess coolant let down during reactor startup. These liquids will be collected in one of three holdup tanks and processed on a batch basis. Liquid from one of the holdup tanks will be passed through one of four evaporator-feed demineralizers to reduce the concentration of radioisotopes except tritium, and will be filtered, degassed, and sent to a



LEGEND

WDS = WASTE DISPOSAL SYSTEM

SRST = SPENT RESIN STORAGE TANK

CVCS = CHEMICAL AND VOLUME CONTROL SYSTEM

Fig. III-13

Primary Coolant Purfication in Chemical and Volume Control System. Indian Point Unit 2 boric acid evaporator. The distillate from the evaporator will be processed through a demineralizer, filtered, and transferred to one of the three monitor tanks. The contents of the tanks will be sampled and analyzed. The system is provided with recycle capability if the monitor tank activity is above permissible discharge limits. If the quality of the distillate is such that it can be reused, it will be transferred to the primary coolant storage tank. The boric acid concentrate will be either reused or discarded to the batch tank in the waste disposal system and removed as solid waste. The values in Table III-4 are based on the release of 4 primary system volumes per year and an over-all decontamination factor of 10^5 for the evaporator-demineralizer combination for all isotopes except iodine and tritium. A 10^3 D.F. for iodine was used.

(2) Waste Disposal System

The waste disposal system will process liquids from equipment drains and leaks, laboratory drains, decontamination drains, demineralizer regeneration, and flood drains as shown in Fig. III-14. These liquid wastes will be collected in a waste holdup tank and analyzed for radioactivity. Liquid wastes that require no further cleanup will be transferred to the waste condensate tank for monitored discharge into the Hudson River via the discharge canal. Liquids requiring further treatment will be processed in batches through a waste evaporator. The amount of activity discharged will be determined from an analysis of each batch of waste in the condensate tank and either released to the discharge canal through a continuous monitor or returned to the waste holdup tank for reprocessing. The concentrates from the waste evaporator will be packaged as solid waste.

The applicant is planning to install a steam generator blowdown purification system which will process the blowdown from both Unit No. 1 and Unit No. 2. This system will contain a flash tank, a filter, and a mixed-bed demineralizer. The demineralizer effluent will be monitored and released into the discharge canal. The present system contains a monitored blowdown tank which is vented to the atmosphere. Blowdown liquids are released without treatment to the discharge canal. The anticipated release from steam generator blowdown shown in Table III-4 is based on a continuous primary to secondary system leakage of 20 gpd and a 10 gpm steam generator blowdown.

The effluent from the Plant laundry and contaminated showers will be collected in the laundry drain tank, transferred to the waste condensate tank, and released to the discharge canal after appropriate sampling and analysis. Laundry wastes are expected to be a minor source of radioactivity.

The anticipated release from the waste disposal system shown in Table III-4 is based on a decontamination factor of 10^4 for the waste evaporator for all isotopes except iodine and tritium. Iodine was assumed to

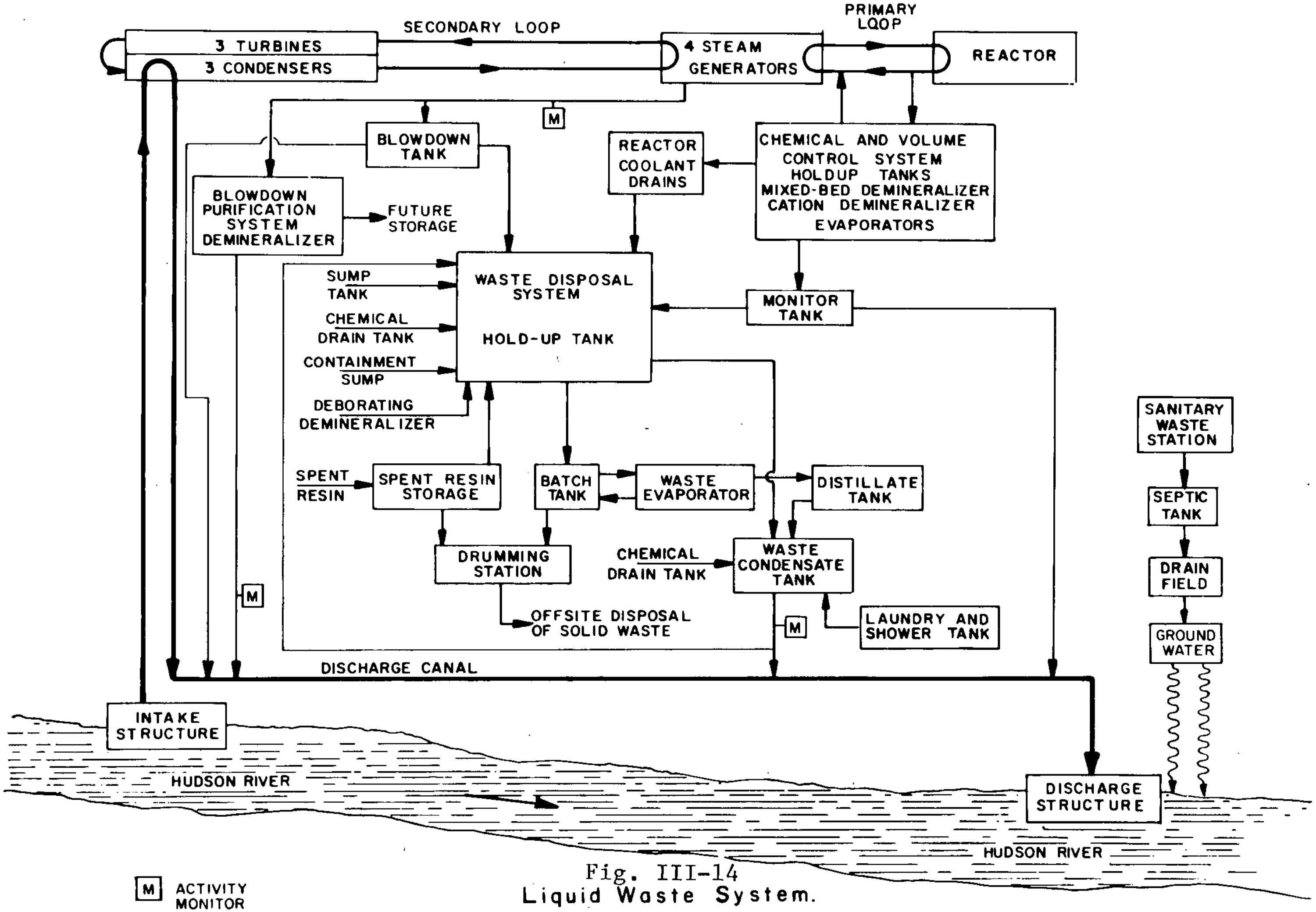


Fig. III-14
Liquid Waste System.
Indian Point Unit 2

TABLE III-4

ANTICIPATED ANNUAL RELEASE OF RADIOACTIVE MATERIAL IN LIQUID EFFLUENT FROM INDIAN POINT UNIT NO. 2

Nuclide	Steam Generator Blowdown (Ci/yr)	Chemical Volume Control System (Ci/yr)	Waste Disposal System (Ci/yr)
Rb-86	0.018	*	*
Sr-89	0.015		
Sr-90	0.0005		
Y-91	0.019		
Zr-95	0.002		
Nb-95	0.002		
Mo-99	5.51	0.005	0.018
Te-99m	0.61	0.004	0.016
Ru-103	0.002		
Te-127m	0.012		
Te-129m	0.11		
I-130	0.009	0.002	0.006
Te-131	0.031		
I-131	8.1	0.59	2.06
Te-132	0.62		0.002
I-132	0.12	0.056	0.19
I-133	3.46	0.56	1.92
Cs-134	7.1	0.004	
I-135	0.62	0.14	0.45
Cs-136	2.05	0.001	0.005
Cs-137	6.06	0.003	0.012
Ba-140	0.016		
Ca-140	0.003		
Ce-141	0.003		
Ce-144	0.002		
Pr-143	0.002		
Co-60	0.019		
Cr-51	0.018		
Mn-54	0.015		
Mn-56	0.045		
Fe-55	0.048		
Fe-59	0.019		
Co-58	0.47		
TOTAL	∿ 35	∿ 1.4	∿ 4.7

H-3 $\leq$ 1000 Ci/yr

* Isotopes with computed amounts less than 0.001 curies per year were not reported but are included in the total.

have a reduction factor of 100. Based on our analysis of the radwaste system as described in the FFDSAR, the estimated annual releases from the waste disposal system will be about 6 curies year.

(3) Releases from Unit No. 1

The anticipated annual release of liquid radwastes from Unit No. 1 is given in Table III-5. At the present time the liquid wastes generated within Unit No. 1 are collected during a 2-week period in 75,000 gallon tanks and released to the discharge canal after an additional delay of about 5 days.

The amounts of radioactivity released from Unit No. 1 in the past have been reported in References (30-35); these are summarized for the years 1962-1970 in Table III-6.

(4) Combined Effluents from Unit No. 1 and Unit No. 2

The 40 curies per year expected to be released from Unit No. 1 and the 6 curies per year from Unit No. 2 will be diluted with an average of about 1 million gallons per minute flow of the circulating coding water. If the blowdown release from Unit No. 2 is added to the other releases, then the annual releases from the Indian Point Station into the Hudson River are estimated to be 81 curies. When all Plant modifications become fully effective, this would be 8 Ci/year.

b. Gaseous Waste

During operation of the facilities, radioactive materials released to the atmosphere in gaseous effluents 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 primary source of gaseous radioactive waste is from the degassing of the reactor coolant. This is principally from the exhaust of cover gas from waste holdup tanks, and the venting of the CVCS and other equipment. Additional sources of gaseous waste activity include the auxiliary building exhaust, the vent from the steam generator blowdown tank, the turbine building exhaust, the reactor building containment air and the condenser air ejectors. The gaseous waste system, shown for Unit No. 2 in Fig. III-15, contains a vent header which will collect radioactive gases vented from the various holdup tanks, pressure relief tanks and the CVCS. The gases will be compressed and stored in one of 4 large decay tanks. The control arrangement is such that 1 decay tank is filled at a time. When the fourth tank is being filled, the first tank will be emptied. Based on the evaluation of the applicant's data it appears that the 4 large decay tanks have sufficient capacity to permit a holdup time of 45 days at Unit No. 2, and up to 60 days at Unit No. 1. Prior to being released, the contents of each tank will be

TABLE III-5

ANTICIPATED ANNUAL RELEASE OF RADIOACTIVE
MATERIAL IN LIQUID EFFLUENT FROM INDIAN POINT UNIT NO. 1

ISOTOPE		Ci/Yr
I-131		15.5
I-132		1.01
I-133		6.56
I-134		0.79
I-135		3.53
Cs-137		0.41
Sr-89		0.05
Sr-90		0.01
Co-58		1.18
Co-60		0.49
F-18		3.38
Na-24		5.03
Cu-64		0.42
Mn-54		1.63
	Total	40.00

H-3 1500 Ci/yr

TABLE III-6

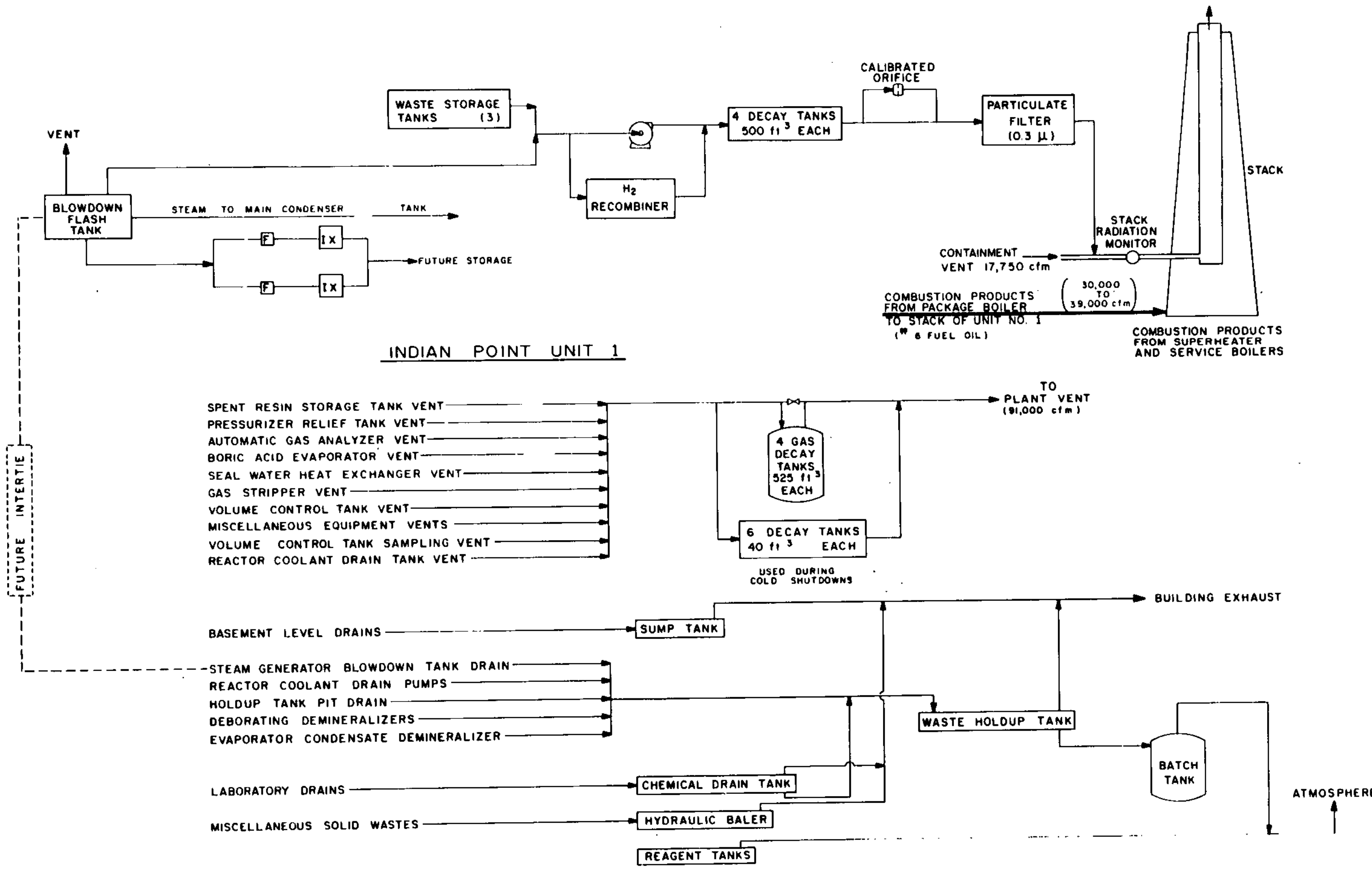
SUMMARY OF LIQUID RADIOACTIVE RELEASES
FROM INDIAN POINT UNIT NO. 1

Year	Activity Released[1] (Ci)			Plant[2] Capacity	Activity Release (Ci) for 100% Plant Factor		
	H-3	Other	Total	Factor (%)	H-3	Other	Total
1962(5 mo.)	--	0.13	0.13	27.7	—	0.47	0.47
1963	--	0.16	0.16	38.0	—	0.42	0.42
1964	--	13.1	13.1	24.6	--	53.25	53.25
1965	488.4	26.31	514.71	46.4	1052.59	56.70	1109.29
1966	130.76	42.58	173.34	50.3	259.96	84.65	344.61
1967	366.53	28.25	394.78	68.3	536.65	41.36	578.01
1968	795.8	35.25	831.05	64.9	1226.19	54.31	1280.51
1969	1079.46	28.33	1107.79	72.1	1497.17	39.29	1536.46
1970(6 mo)	378.20	4.29	382.49	14.1	2682.27	30.43	2712.70

[1] U. S. Atomic Energy Commission, Division of Compliance, "Report of Inquiry into Allegations Concerning Operation of Indian Point 1 Plant of Consolidated Edison Company", Vol. II, October 1971.

[2] U. S. Atomic Energy Commission, Division of Reactor Development and Technology, "Operating History of U. S. Nuclear Power Reactors".

Fig. III-15 - Gaseous Effluent Flowsheet Indian Point Unit No. 2



sampled and analyzed. The decision to discharge the gas to the Plant vent through high efficiency particulate air (HEPA) filters or to return it to the CVCS for reuse and additional decay will be based on the analysis of radioactivity level. Provisions have also been included for transferring gas between tanks. Besides the 4 large gas-decay tanks there are 6 smaller tanks. These tanks are reserved for use during degassing of the reactor coolant and purging of the volume control tank. The gas released from the decay tanks will be combined with ventilation air from the auxiliary building and discharged to atmosphere through the Plant vent. The discharge point for Unit No. 2 is about 193 feet above the building grade; for Unit No. 1 it is from about 10 feet above the top of the superheater stack, 255 feet above building grade.

The containment building, primary auxiliary building, and the fuel storage building are designed for handling of radioactive materials. The separate exhaust systems have also been designed to ensure that air flow is from areas of low potential to areas having a greater potential for accidental release of airborne activity. The atmosphere in the primary auxiliary building is discharged through prefilters and HEPA filters to the Plant vent. In addition, a fan has been provided for diluting the concentration of activity in the air discharged by the Plant vent system.

Following power operation it may be necessary to use the containment treatment system for pre-access cleanup during shutdown. The treatment system consists of a prefilter, HEPA filters and charcoal adsorber through which the containment air will be circulated. Prior to entry, the containment building atmosphere will be vented without further treatment through the containment purge exhaust system and discharged to the Plant vent. Air will be exhausted from the fuel storage building through a prefilter and HEPA filters prior to being released to the Plant vent.

Atmospheric discharges from the condenser air ejectors, which remove radioactive gases that have collected in the condenser as a result of primary to secondary leakage, will be continuously monitored and released without treatment through a vent stack located on the roof of the turbine building. Offgas from the steam generator blowdown tank will be vented directly to the atmosphere without treatment. Turbine building ventilation air will be discharged separately without treatment.

Staff estimates of the anticipated annual release of radioactive nuclides in the gaseous effluent, based on the radwaste systems described in the FFDSAR on Unit No. 2 and on existing equipment in Unit No. 1 are summarized in Table III-7. Table III-8 contains a summary of airborne radioactive releases from Indian Point Unit No. 1[3] and shows that essentially all of the iodine released to the atmosphere as gas is due to the blowdown. The staff's calculated release of 0.64 curies of iodine-131 per year exceeds the Technical Specification for Unit No. 2, which require that discharge of iodine-131 be less than 0.18 ci/year.

In Supplement No. 1 to the Environmental Report dated September 9, 1971, the applicant described several proposed modifications to the gaseous waste system. The proposed changes include the installation of an iodine

TABLE III-7

ANTICIPATED ANNUAL RELEASE OF RADIOACTIVE NUCLIDES IN GASEOUS EFFLUENT FROM INDIAN POINT UNITS NOS. 1 AND 2

Isotope	Discharge rate (Ci/year)				
	Unit No. 1	Unit No. 2 (45-day decay)			
	Total (60-day decay)	Containment purge	Gas processing system	Steam generator leak	Unit No. 2 total
^{85}Kr	177.0	13	791	2	806
^{87}Kr	2	0.04		3	3
^{88}Kr	6			10	10
^{131m}Xe	8	10	63	3	76
^{133}Xe	1045	1005	1500	682	3187
^{135}Xe	2	0.018		3	3
^{138}Xe	1	0.007		2	2
^{131}I	0.37	0.018		0.62	0.64*

*This release will be limited to 0.18 Ci/year by the Technical Specifications.

TABLE III - 8

SUMMARY OF AIRBORNE RADIOACTIVE RELEASES
FROM INDIAN POINT UNIT NO. 1

	Reported Releases*			For 100% Plant Capacity Factor	
	Noble and Activation Gases (Ci)	Iodines and Particulates (Ci)	Plant Capacity Factor(%)	Noble and Activation Gases (Ci)	Iodines and Particulates (Ci)
1962	--	--	27.7	--	--
1963	0.007	--	38.0	0.018	--
1964	13.2	--	24.6	53.7	--
1965	23	--	46.4	49.6	--
1966	56	--	50.3	111.3	--
1967	23	Neg.	68.3	33.8	--
1968	55.2	Neg.	64.9	85.1	--
1969	600	0.025	72.1	832	0.035
1970	1,800	0.075	14.1	12,800	0.532

*The data for 1962 to 1966 were taken from the Semi-Annual Operating Reports of Consolidated Edison. The data for 1967 to 1970 were obtained from the Commission's Division of Compliance records.

removal system (charcoal adsorbers) in the Plant vent to reduce any gaseous release of radioiodine from containment purge or auxiliary building, and an intertie between Unit No. 2 and Unit No. 1 steam generator blowdown lines. Testimony presented by the applicant at the Atomic Safety and Licensing Board on July 13, 1971, indicates that the proposed modifications will be completed by the end of the first fuel cycle.

c. Solid Wastes

Radioactive solid wastes will consist mainly of spent demineralizer resins, evaporator concentrates, and filters. Concentrates from the waste evaporator will be put into steel drums, and mixed with vermiculite and cement. Spent resins will be packaged the same way after "cooling" in the waste-resin storage tank for 1 to 6 months. The sluice water will be separated from the resin and returned to the waste holdup tank. Each drum will be stored in a shielded area prior to being shipped offsite. Miscellaneous solid wastes such as paper, rags, clothing, and glassware will be compressed in 55-gallon drums by a baler. The filled drums will be stored in a shielded area in the drumming room until shipped offsite. All solid waste will be packaged and shipped to a Federally-licensed burial ground in accordance with the Atomic Energy Commission's and Department of Transportation's regulations. Based on plants presently in operation, it is expected that approximately 100 to 200 drums of solid waste will be transported offsite each year. Details of transportation of wastes and their impact are discussed in Chapter V.F.

3. Chemical Discharges and Sanitary Wastes

a. Chemical Wastes

Several routine operations of the Indian Point Unit No. 2 will contribute to the discharge of chemical wastes into the environment as a result of operation of the Plant: leakage from the primary coolant system, steam generator blowdown, regeneration of demineralizers, and cleaning of the condenser tubes. The different water treatment procedures carried out by the applicant are governed by the use of several systems (primary, secondary, condenser and service water) rather than by operating at different power levels. Thus the chemical additions and discharges are the same for both partial and full power operation with minor exceptions. Liquid radioactive wastes are discussed above in Section III.D.2. Some of these operations were initiated at the onset of operation during subcritical testing, and will continue during zero power testing, and power escalation up to 50% and 100% of rated power.

In practice, the cooling water circulating through the once-through condenser system and service water system for a total maximum flow of 870,000 gpm of Unit No. 2 serves to dilute any discharged chemicals. These dissolved effluents will be monitored by the applicant in the discharge canal to assure that the chemical wastes discharged into the Hudson River will meet the limits of effluents established by the New York State Department of Environmental

Conservation. A list of chemicals utilized in the various Plant systems and the amounts and concentration limits at the confluence of the discharge canal water with the Hudson River are given in Table III-9. In addition to thermal discharge standards established by New York State, the State Department of Environmental Conservation has established water quality standards depending on water use. A set of applicable criteria for the Hudson River at Indian Point is classified "Class SB" (NYS Part CRR 701.4)[5] as shown in Table 2.3-2 of the applicant's Supplement No. 1. All discharges will be subject to regulation by the New York State Department of Environmental Conservation pursuant to section 1230 of the Public Health Law and to Federal regulations under section 21(b) of the Water Quality Improvement Act of 1970 and Section 13 of the Rivers and Harbors Refuse Act of 1899. The applicant has applied for the permits for Section 13. The estimated date of final action is April 24, 1972. Since the regulation is phrased in terms of general criteria rather than specific numbers, the applicant is proposing to meet certain discharge limits with respect to concentrations of various chemicals at the confluence with the Hudson River which it believes satisfy the criteria. The basis for these limits was obtained in part from bioassay work performed by the Raytheon Company and New York University as consultants for the applicant.

During the operation of the two nuclear power units at Indian Point, 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 in liquid effluents into the Hudson River through a discharge canal common to both Unit No. 1 and Unit No. 2. The chemical wastes will be diluted by the cooling water. During shutdown, 20,000 gpm of cooling water will be utilized in Unit No. 1 and 30,000 gpm of cooling water in Unit No. 2 for dilution of chemical wastes. In full operation, a total of 300,000 gpm from Unit No. 1 and 870,000 gpm from Unit No. 2 for a total of about 1.1 million gpm of water flow will be used to dilute the chemical wastes. For this analysis, a more conservative approach was used in order to discuss the more adverse conditions when dilution of the wastes would be less (see Table III-9). Chemical discharges are not power dependent but the concentration levels are flow dependent. Details of the chemical discharges from Unit No. 1 are described in Section D, Volume II of Reference 3.

(1) Releases from Primary System

The standard chemicals utilized in the primary systems to control pH and oxygen levels include lithium hydroxide and hydrazine. These chemicals will be added to the primary coolant to obtain the desired water chemistry. The CVCS described in the FFDSAR is designed to maintain the chemistry and purity of the primary coolant, the desired boric acid concentration, and the volume of water and pressure in the primary system.

Lithium hydroxide is used for pH control in the primary 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

TABLE III-9

THE DISCHARGE OF CHEMICALS TO THE HUDSON RIVER FROM INDIAN POINT UNITS NOS. 1 AND 2[a]

Chemical Discharged	Max. Sustained Releases, lbs/day		Max. Conc. at Discharge Point to Hudson River[b] (ppm)		Max Releases from Both Units[c] (ppm)	NYS Allowable Conc. of Chemical Discharges (ppm)
	Unit No. 1	Unit No. 2	Unit No. 1	Unit No. 2		
Lithium hydroxide[d]	2.5	2.5	0.01	0.001	<0.1	-
Boric acid (Boron)[d]	600	600	.75	0.7	50	-
Sodium hydroxide	156	12	1.2	1	10	e
Sulfuric acid (SO_4)	450	-	6	-	10	e
Sodium Phosphate (PO_4)	24	15	0.0013	0.07	1.54	-
Hydrazine	24	5	0.006	0.007	0.1	-
Cyclohexylamine	2.5	12	0.0004	0.003	0.1	-
Morpholine	2.5	12	0.0004	0.003	0.1	-
Sodium sulfate	Neutralization product of NaOH and H_2SO_4		4.6	0.7	10	d
Sodium carbonate	2 %	30	7.0[f]	-	7[f]	d
Chlorine	15%[h]	15%	0 to 0.5[h]	0 to 0.5[i]	0.5	0.5
Potassium chromate (Cr VI)	Intermittent use	30	0.05	0.05	0.05	0.05
Detergent[g]	1.5	1.5	0.02	0.01	1.0	-

[a]Sulfate, caustic soda, and soda ash together represent 5 to 10% of the permissible concentrations of the total dissolved solid (TDS) that can be discharged into receiving waters.

[b]Discharge during full power operation with 300,000 gpm for Unit No. 1 and 870,000 gpm flow for Unit No. 2 of condenser coolant in the discharge canal.

[c]Values normalized to a nominal flow of condenser coolant in the discharge canal of 100,000 gpm.

[d]These releases would occur only in the event of evaporator breakdown.

[e]These represent the concentration of dissolved solids that can be discharged into the river.

[f]Soda ash used in a 2% solution for 8 hours to wash the Unit No. 1 flue gas passages of the superheaters, economizers and air preheaters, 4 times per year and discharged continuously during the cleaning period at 7 gpm into a flow of 20,000 gpm of service cooling water during Unit No. 1 shutdown.

[g]Alkyl benzene sulfonate.

[h]Chlorination treatment for 30 minutes of each inlet water box 3 times per week.

[i]Intermittent discharge - 1 hour, 3 times per week for a 30 minute treatment of each water box of 3 condensers.

system, the maximum concentration that could be expected under the conditions of evaporator breakdown* occurring simultaneously in each of the two Units to be about 2.2 ppm with a maximum waste disposal flow rate of 25 gpm, yielding a possible sustained release of 5.0 pounds per day from the two Units. The actual concentration entering the Hudson River at the confluence of the discharge water is expected to be about 0.01 ppm during normal operation.

A maximum of 2,000 ppm of boron as boric acid is used for reactivity control in the primary coolant. A breakdown of both boric acid evaporators would possibly necessitate the release of 600 pounds of boric acid per day from each Unit. The maximum discharge rate would be 25 gpm. This gives a concentration of 50 ppm of boron in the form of boric acid at the confluence of the discharge water into the Hudson River.

Potassium chromate is used as a corrosion inhibitor in the closed cooling water system of Indian Point Unit No. 2. 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 pounds per day would occur.

Sources of chemical wastes during operation of Indian Point Unit No. 2 will include concentrates which are blown down to the discharge water to which has been added sulfuric acid to control the pH, for use as makeup for various Plant systems. The concentrates from the flash evaporator blowdown have a pH between 7.0 and 8.5. No measurable release of sulfuric acid is anticipated from Indian Point Unit No. 2. Sodium hydroxide also is used during normal operation of the primary system demineralizers to regenerate the spent resins as hydroxyl or anion forms once every 4 to 7 days for 2 hours. Excess sodium hydroxide is drained to the waste disposal system where it is processed by the waste evaporator. It is also used for pH control in the waste evaporator. The wasted distillate would be discharged at the rate of 25 gpm into the discharge canal for a total of 0.5 pounds per day waste. Assuming evaporator breakdown, the maximum concentration of sodium hydroxide that could be discharged in this event would be about 5,000 ppm at a discharge flow rate of 25 gpm at the rate of 12 pounds per day. The expected concentration in the discharge canal water is 10 ppm during normal operation.

The Plant laundry that serves both Units will use 6 pounds 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. The laundry water may be discharged at a rate of 25 gpm or processed through the waste disposal system.

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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.

(2) Releases from Secondary and Auxiliary Systems

Releases from the secondary and auxiliary systems involve sodium phosphate, which is used to control the steam generator acidity, as well as in combination with sodium hydroxide which is used in the treatment of the house service boilers of Units Nos. 1 and 2. In Unit No. 2 the phosphate concentration level (expressed as phosphate) of no more than 250 ppm at any one time nor 10 ppm on a sustained basis will be obtained at a maximum discharge rate of 200 gpm such that the concentration at the point of discharge into the river is 1.5 ppm. At the maximum flow rate of 200 gpm the expected sustained release (expressed as PO_4) is 24 pounds per day from Unit No. 2 and 15 pounds per day from Unit No. 1.

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 maximum flow rate is 200 gpm and the expected sustained release is 5 pounds per day during normal operation resulting in a concentration of 0.1 ppm at the point of discharge into the Hudson River. However, a discharge of 100 ppm 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 and will be discharged at a flow rate of 40 gpm. The maximum possible release rate would be 24 pounds per day at a maximum concentration of 50 ppm.

Either cyclohexylamine or morpholine, used to adjust feedwater and steam pH, will not exceed a concentration in the steam generator blowdown of 5 ppm released on a sustained basis at a maximum flow rate of 200 gpm. The nuclear boilers in Indian Point Unit No. 1 are blown down continuously at a maximum rate of 40 gpm containing a maximum concentration of 5 ppm cyclohexylamine. The expected sustained release of either amine is 12 pounds per day from Indian Point Unit No. 2 and 2.5 pounds per day from Unit No. 1. The resultant concentration of either amine discharged from both Units will be 0.1 ppm at the discharge point into the river.

Sodium hydroxide is also used at Indian Point Unit No. 1 for acidity control in the house service boilers and make-up water evaporator and for regeneration of the water treatment mixed bed ion exchangers. The combined sustained release is expected to be 36 pounds per day from the boiler blowdown and evaporator blowdown. The regeneration of the mixed-bed ion exchangers scheduled to occur would yield a total release of 120 pounds per day. Although no measurable releases of sulfuric acid are anticipated from Indian Point Unit No. 2, sulfuric acid is used in the water treatment cation and mixed bed ion exchanger regenerations for Indian Point Unit No. 1. These regenerations occur approximately once every 4 days for a duration of 2 hours. Of these 2 hours, 1 hour is used for neutralization of caustic by sulfuric acid. However, a 4% sodium hydroxide solution would yield a total release of 120 pounds per day. The excess sulfuric acid is neutralized prior to discharge during the mixed-bed regeneration process. However, release of sulfuric acid at a concentration level of 3% is discharged at the rate of 450 pounds per day at a flow rate of 30 gpm during cation-bed regeneration of Unit No. 1. The total concentration of the excess sulfuric acid amounts to 10 ppm at the point of discharge into the river, but will be neutralized by sodium hydroxide before release.

Soda ash, used four times per year to wash flue-gas passages in the superheater of Indian Point Unit No. 1, could release 5 ppm at the discharge point. A 2% solution used for 8 hours is discharged continuously during this period at a rate of 7 gpm.

In the discharge canal, the applicant also has an Automatic Environmental Systems Unit (AES) into which water from the discharge canal is pumped and serves to monitor pH, dissolved oxygen, salinity, temperature, and cupric ions once per hour. The probe for cupric ions has an actual effective lower limit sensitivity for copper of the order of 1 ppm.[41]

In reference to chlorination of the cooling water in the condenser tubes of Unit No. 2, two procedures are indicated in the applicant's Environmental Report. An automatic programmed control system is arranged to initiate a cycle once a day or more often. Each cycle will consist of slug treating the six circulating water intake bays in two groups of three and then the service water intake bay. Another procedure is to chlorinate each condenser with a 15% sodium hypochlorite solution at a rate of 5 gpm at a different time for approximately 1 hour, three times a week. These two procedures would result in different total amounts of sodium hypochlorite released on a weekly basis. However, in either case, the concentration of residual chlorine in the water discharged into the Hudson River will be required to be below 0.5 ppm to meet State standards.

Table III-9 below summarizes the maximum concentrations of treatment chemicals that would be expected to be in the discharge canal at the point of discharge to the Hudson River. These values are compared with the New York State regulations governing the concentration of chemicals in the effluents discharged to receiving waters. The applicant has proposed that the chemical discharges with respect to concentrations released to the confluence with the Hudson River will meet the discharge limits for the "Class SB" standards applicable to the Hudson River at Indian Point and established by New York State. Table III-10 shows the concentrations of chemicals already present in the Hudson River during different flow conditions.

b. Sanitary Wastes

Sanitary wastes from Unit No. 2 will be treated by the facility now used for Unit No. 1. The facility contains comminutors, septic tanks, and sand filter beds. The existing facility appears to be adequate to process wastes from Unit No. 2 on the basis of capacity, design parameters, and site percolation tests. Description of the capacity is presented in Table 2.3-4 of the applicant's Supplement No. 1 to the Environmental Report. The facility has been approved by the New York State Department of Health and the Westchester County Health Department.

TABLE III-10

CHEMICAL ANALYSIS OF THE HUDSON RIVER NEAR INDIAN POINT, OCTOBER, 1964, TO SEPTEMBER 30, 1967†

	Concentration, ppm		
	Minimum	Maximum	Average
Silica (SiO_2)	2.6(b)	3.9(b)	NA
Iron (Fe)	0.05(a)	0.12(b)	NA
Aluminum (Al)	NA	NA	NA
Manganese (Mn)	0.00(b)	0.02(b)	NA
Calcium (Ca)	19	82	35.6
Magnesium (Mg)	3.9	184	45.8
Sodium (Na)	5.5	1,700	39.7
Potassium (K)	0.8	60	17.2
Bicarbonate (HCO_3)	54	82	67.3
Sulfate (SO_4)	23	420	127.2
Chloride (Cl)	8.5	3,020	749.1
Nitrate (NO_3)	0.2	1.8	0.7
Phosphate (PO_4)	NA	NA	0.3††
Dissolved Solids	NA	NA	NA
Hardness (as $CaCO_3$)	64	966	295.5
Dissolved oxygen	5.5*	11.5*	8.4*
Biochemical Oxygen Demand (5-day, 20°C)	1.4*	4.6*	2.7*
Salinity	100	7,200**	950

	Physical Parameters (Units as indicated)		
	Minimum	Maximum	Average
Temperature, °F	34.7*	77.0*	51.8*
pH	7.1*	7.5*	7.3*
Color	0*	25*	15*

†Data collected by U. S. Geological Survey at Tompkins Cove, N. Y. (MP 42.5) unless otherwise noted.
NA=Not available or results too few to average.
(a) USGS Station at Verplanck, N. Y.
(b) USGS Station at Tompkins Cove, N. Y. [sampling frequency ‡ (†)]
†† from NYU studies
* from intake at IBM facility (MP 71.6)
** from QLM studies.

In the future, should the load on the sanitary system exceed the percolation rate, the applicant states that the effluent will be chlorinated and discharged into the river. See Chapter V D on the problem of toxicity of chlorine and the staff's analysis of effects of chlorine on biota.

4. Other Wastes

Energy is derived from burning fossil fuel, as well as nuclear fuel, at the Indian Point facility. Steam produced in the secondary loop of Unit No. 1 is further heated in a superheater before the steam enters the turbine. Nuclear fuel provides about 163 MW(e) and oil provides about 112 MW(e) of the 275 MW(e) generated by Unit No. 1. In addition, Unit No. 1 contains three service boilers and Unit No. 2 contains two. Combustion products from all these units are discharged through the superheater stack of Unit No. 1. The rated capacity(37) of the superheater is 842,000,000 Btu/hr. The three boilers in Unit No. 1 are rated at 50,600,000 Btu/hr, and those in Unit No. 2 are rated at 60,000,000 Btu/hr.(37,38) The capacity of the superheater alone exceeds 250,000,000 Btu/hr, which means that atmospheric discharges from the Indian Point plant would lie within the scope of 42 CFR 466(39) if it were a new plant. A new plant would be limited to the discharges listed in Table III-11 according to regulations of the Clean Air Act. However, "These proposed regulations do not include provisions for implementation of Section III(d) of the Act, under which States would be expected to establish standards for existing stationary sources of certain pollutants."(39) The maximum quantity of each pollutant estimated on the basis of oil consumption at full load is listed in Table III-11 for the superheater only and for the superheater plus the five package boilers. These calculations are based on the listed rates of consumption of No. 6 fuel oil with a heat rating of 18,400 Btu/lb. They are also based on two sulfur concentrations, namely, the fuel now in use, with a nominal 1% sulfur, and the fuel to be used in the future,(1) containing no more than 0.37% sulfur. In connection with this reduction, the staff notes that the New York City code on air pollution control(40) requires a reduction of sulfur content in No. 6 (bunker) fuel oil from 1% to 0.3% by October 1, 1971.

The expected particulate discharge listed in Table III-9 is less than 30% of the maximum proposed in 42 CFR 466 for new plants; the discharge of sulfur dioxide exceeds the maximum by nearly 40% with a fuel oil containing 1% sulfur but will be only half the limit after the change to oil with 0.37% sulfur has been made. The nitrogen oxide discharged is 20% in excess of those specified in 42 CFR 466. Since Indian Point Unit No. 1 is not a new plant, the proposed regulations can serve only as a guideline.

TABLE III-11

ATMOSPHERIC DISCHARGES FROM FOSSIL-FUEL COMBUSTION AT INDIAN POINT

Component	lb/million Btu		
	Limits Set by 42CFR466[a]	Indian Point	
		Superheater Only	Superheater + 5 Boilers
Particulate	0.2	0.055	0.055
SO_2	0,8	0.41 or 1.1[b]	0.41 or 1.1[b]
Nitrogen oxides	0.30	0.36	0.36
Oil consumption (lb/hr		44,564[c]	59,832[c]

[a]Reference 39, which contains proposed standards for new fossil-fuel plants.

[b]The lower value is based on 0.37% S, the higher value on 1.1% S in the fuel oil.

[c]See Reference 38.

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IV. ENVIRONMENTAL IMPACT OF SITE PREPARATION AND STATION CONSTRUCTION

A. SUMMARY OF CONSTRUCTION

Construction of Indian Point Unit No. 1 was completed in 1962 and that of Unit No. 2, which started in December 1965, will be completed by about April 1972. The construction of Unit No. 3 is about 70% complete. This Unit is scheduled to be operational in 1973. For Unit No. 2 the first major milestone of completion of Plant construction was achieved on June 29, 1970 when the applicant conducted a hydrostatic test of the reactor coolant system. Hot functional tests were also completed on March 3, 1971. Prior to core loading the applicant conducted major testing of vapor containment and structural integrity of the Plant's physical facilities. On October 19, 1971, the applicant received a Facility Operating License No. DPR-26 to load fuel and to conduct subcritical tests. A request for testing the reactor system up to 50% of rated power is pending before the presiding Atomic Safety and Licensing Board. The applicant has received all the necessary Federal, State, and local permits and licenses for the necessary construction work as described in Chapter I, Section A.

B. IMPACTS ON LAND, WATER AND HUMAN RESOURCES

1. Area and Water Use Involved

The major impact on land use occurred during the construction of the major facilities on the site, beginning with the construction of Unit No. 1 in 1956. Plant construction of all 3 Units has only modified approximately 35 acres of the 239-acre site. The original site was the Palisades 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. Furthermore, the site was close to the applicant's major load center of New York City so transmission line losses would be kept to a minimum. Construction of Unit No. 2 did not require purchase by the applicant of additional rights-of-way to build transmission towers. Thus, the particular site selected for Unit No. 2 resulted in a minimal adverse impact on the land actually used to build the facility, the land used for building transmission lines, or alternate sites to build a nuclear power plant. The site was zoned for heavy industrial use.(1)

During construction, few impacts of any significance resulted in land use since no changes were needed for rebuilding or relocating highways, expressways, railroad lines or gas lines. Heavy construction equipment and other materials were transported to the site on highways already in existence or up the Hudson River by barge, thereby not causing any relocation of main arteries of transportation. Much of the construction work and impacts resulting from construction are limited to the confines of the site itself.

The main boundaries of the site have essentially not been altered from construction activities going on within the site. As construction becomes completed, and the work forces and equipment begin to diminish, orderly restoration of the site will begin to accelerate.

The applicant plans to complete landscaping and development of the site for recreational purposes within a year after construction of Unit No. 3 is completed.

The size of the site is sufficient to reduce any noise levels from construction at the site boundaries so as not to create a noise problem for off-site residents. However, a temporary relocation of wildlife may have resulted from the noise and congestion of construction activities. However, about one half of the site still remains in its natural state. This has kept any disturbance of wildlife habitat to a minimum. Upon completion of the construction work, a natural reestablishment of wildlife in the area may be accomplished, particularly because of the 80-acre forested park and lake area being established by the applicant for public use.[(2)]

The thermal modeling and ecological monitoring studies (see Chapters III and V) conducted by the applicant during the past several years have indicated that to meet the New York State thermal criteria standards, the intake-discharge structure had to be modified from being a surface discharge in which the heated cooling water was discharged parallel to the eastern bank of the Hudson to being a submerged jet discharge in which the cooling water was discharged normal to the river through a submerged structure of 12 ports located about 18 feet below the mean low water level of the Hudson River. At the present time the submerged jet discharge structure is being changed from 18 to 12 feet. As described in Chapter III, Section E.1, the submerged discharge structure has 12 ports through which the cooling water is discharged at 10 fps. All field work preparatory to receipt of adjustable gates is complete. Fabrication of the gates is also complete. Installation of the gates will begin after the river thaws in early April 1972.[(3)]

Of the 12 ports, 10 ports will have adjustable gates such as to control the flow volume and rate through the ports. Two ports, the most southerly gates, can be either completely opened or completely closed since they are not adjustable. Positioning of their gates (opened or closed) will be dependent on operation of the Units Nos. 1 and 2 to maintain a discharge velocity of 10 fps.

The intake system is also being modified for Winter 1972-1973 to reduce the intake flow velocity from 0.9 fps to 0.54 fps through the fixed protective screens of the inlet forebay of the condenser system.[(5)] This reduction will be accomplished by recirculation of the cooling water in which the flow velocity will be reduced from 140,000 gpm per pump to 84,000 gpm per pump. The reduction of flow by recirculation of the discharge water may aid in reducing any potential fish kill from impingement on the fixed protective and traveling screens, as described in Chapter V.D. Reduction in flow will be accomplished primarily during the winter months when the river water is colder and when the white perch is greatest in abundance in the vicinity of Indian Point.

During construction, some diesel powered machinery was used, thereby causing some combustion products to be released to the atmosphere. This effect would be the same on any other large construction project. The air pollution created would be intermittent and localized.

Furthermore, during modification of the intake-discharge system, destruction of some benthos resulted from dredging and filling. This work was to modify the structure authorized by the U.S. Department of the Army, Corps of Engineers.

After components are constructed, certain initial Plant operations such as flushing out equipment are carried out. Some of the initial startup operations involve non-routine releases of chemicals into the Hudson River. In Section 2.3.4 of the applicant's Supplement No. 1 to the Environmental Report,[2] a number of processes involve chemical discharges, the concentrations of which will be kept below the limits proposed by State and Federal regulations. These processes, concentrations and amounts of chemicals discharged are outlined in Table IV-1. It is expected that discharges will be conducted in a batch process. Although the discharges are to be kept within State and Federal limits, the applicant should use due precaution in discharging large amounts of chemicals at any one time because of the toxic effects of some of these chemicals on fish and other aquatic biota.

2. Manpower Effects

Since most workers commuted from nearby communities to the Plant site, the impact of manpower on the local environment was negligible. At times traffic around the site increased particularly when the peak manpower of about 1,200 workers were present at any one time on the site for construction of Unit No. 2. As construction is being completed, the average manpower of 1,000 used for Units Nos. 2 and 3 will decrease. Thus, the congestion is temporary and will not occur after construction is completed. A relatively small work force of about 275 people will be needed to operate and maintain the reactor facilities after construction is finished.[4]

3. Environmental Considerations

Detailed analysis of the environmental impact of the site preparation and Plant construction would have only limited value at the time of this Statement since the construction of Indian Point Unit No. 2 is largely completed. The applicant has indicated in its Environmental Report[1] and Supplement No. 1[2] that the disturbed ground around the construction site will be "landscaped in

TABLE IV-1

POSSIBLE NON-ROUTINE CHEMICAL DISCHARGES DURING PLANT STARTUP

	Process	Intermittent Concentration ppm	Maximum Discharged Amount lb/day
Phosphates*	Steam generator pH control	250	12
Hydrazine*	Steam generator oxygen control	100	24
	Primary system oxygen control	100	170
Lithium Hydroxide** (as lithium)	Primary system pH control	10	17
Potassium Chromate** (as chromium)	Corrosion inhibitor	50	94
Boric Acid** (as boron)	Chemical shim for primary system	500	850
Sulfuric Acid	pH control of flash evaporator blowdown	non-measurable	
Sodium Hydroxide	pH control of spray tank Regeneration of demineralizer Waste evaporator pH control	10	0.5
Sodium Hypochlorite	Once-through condenser 3 times per week	0.5	

*Morpholine and/or cyclohexylamine will be discharged simultaneously.
**For a batch of 200,000 gallons of primary coolant which might have to be discharged at a rate of 300 gpm into the Hudson River at any one time.

an attractive manner, ...to improve the aesthetic and recreational value of the site." The exact extent of the landscaping effort was not defined, although excavated material was used to level the site area.(2)

According to the applicant, "effort was exercised to eliminate from view unsightly operating equipment" by erecting masonry walls to block the view of certain equipment from river traffic and the opposite shore. The applicant stated that "attention had been given to the form, color, and texture of the buildings so that the setting is enhanced and the feeling of intrusion is held to a minimum."

Because of ongoing construction of another nuclear power plant, Unit No. 3, much of the site is still under the influence of the operation of construction equipment. Consequently, the removal of construction equipment, debris, and temporary structures, and the final landscaping have not been completed. The time schedules for their completion depend upon the time schedule for the construction of Unit No. 3.

The applicant has developed a master plan to enhance the benefits of the site through preservation of the 80-acre forested area, restoration by landscaping and planting areas of the site disturbed during construction and encouragement of the educational aspects of the site by building a new visitors' center.

The 80-acre plot will be maintained for use of the visiting public in which picnic tables and benches, nature trails, enlarged parking and recreational facilities will be available to the public. After about 14 acres of land were given by the applicant to the local community, a public marina along the Hudson River is being developed by the Village of Buchanan. Expanded and improved facilities, including a new visitors' center for public use, will not be foreclosed by operation of Unit No. 2. As of August 1970, about 400,000 visitors had visited the original visitors' Center overlooking the site on top of a hill.

In short, Unit No. 2 is largely constructed, and consideration of the environmental impact of the remaining site preparation and construction is overshadowed by the ongoing construction of another nuclear power plant at the same site.

C. CONTROLS TO REDUCE OR LIMIT ENVIRONMENTAL IMPACTS

Landscaping with native species and replanting of the areas disturbed by the construction effort will enhance the appearance of the Indian Point Station. The development of the 80-acre forested plot with the lake will also improve the recreational facilities for the public. Removal of construction debris, temporary facilities and other equipment after completion of construction, will also add to the attractiveness of the site. The applicant's master plan to enhance the benefits of the site and the reestablishment of the natural area along the picturesque Hudson River will improve the usefulness and appearance of the site.

Modification of the intake-discharge structure and improvements of operating techniques to minimize ecological damage of aquatic biota of the Hudson River are essential to assure that the natural ecosystem will be preserved in the long-term during operation of the Unit No. 2 in conjunction with Unit No. 1 during the 40-year Plant lifetime.

REFERENCES FOR CHAPTER IV

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3. Letter dated February 16, 1972 from H. Woodbury, Consolidated Edison Company of New York, Inc., to L. R. Rogers, U. S. Atomic Energy Commission, including Information on the Status Report on the Installation of Gates on the Outfall Structure.

4. Letter dated October 28, 1971 from W. J. Cahill, Jr., Consolidated Edison Company of New York, Inc., to P. A. Morris, U. S. Atomic Energy Commission, on Responses to Questions on Environmental Aspects of Indian Point Units Nos. 1 and 2.

5. Letter dated November 10, 1971, from L. Trosten, LeBoeuf, Lamb, Leiby, and MacRae, to A. MacBeth, Natural Resources Defense Council, Inc., on Answers to Set I questions.

V. ENVIRONMENTAL IMPACTS OF INDIAN POINT UNIT NO. 2 OPERATION WITH UNIT NO. 1 OPERATION

In this chapter, the effects on the environment of Indian Point Unit No. 2 operation in combination with Unit No. 1 operation are described and assessed. A wide range of factors was considered in the environmental review. Indian Point Unit No. 2 is essentially completed, and has been operating under Facility Operating License No. DPR-26, authorizing loading of fuel and conducting subcritical testing, as granted on October 19, 1971. The impacts of major concern on the environment are those due to the operation of the once-through condenser cooling system. The impacts of mechanical shock, entrainment and impingement effects, and the thermal, chemical, and radioactive discharges on man and his environment are the major points of this consideration for operation at 100% of rated power. The summary of the impacts of Plant operation in conjunction with Unit No. 1 is presented in Chapter VII.

A. LAND USE

The use of 239 acres of land zoned for industrial use on the Hudson River for operation of Indian Point Unit No. 2 should not produce appreciable alterations in the public use of the general environment surrounding the reactor site beyond those caused by operation of Unit No. 1.

1. Aesthetics

The major impact on land use in regard to operation of the Indian Point Unit No. 2 occurred during Plant construction and construction of the transmission lines for Unit No. 1 and construction of Unit No. 2 facilities. The major aesthetic impacts on the land resulting from operation of Unit No. 2 are the use of uncultivated, abandoned land on which construction of man-made facilities such as buildings, parking lots, transmission lines, 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 fresh water lake, and building a new visitors' center to encourage educational aspects of the facility for public information on peaceful uses of atomic energy. Page 2.2.1-2 of the applicant's Supplement No. 1 to the Environmental Report[1] shows the layout of the buildings, park and lake area on the overall master plan. Following completion of construction of Unit No. 3 and subsequent cleaning up, restoration and landscaping, the attractiveness of the site should improve. At that time the area for the Station facilities will comprise about 35 acres of the site.

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 beneficial rather than construction of some other facility which could destroy the entire site. Furthermore, since 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. Another area, the Trapp site, about 1 mile south of the Station will also be beautified.

The remainder of the site will be developed for multiple public use. About 14 acres of the site adjacent to Lents Cove were transferred by the applicant to the Village of Buchanan to be developed into a marina. The applicant has been in contact with the county planning department 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. Access

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

The Palisades Interstate Park located across the river from Indian point site should not be affected by operation of Indian Point Unit No. 2 and Unit No. 1.

3. Noise Impact

Because of the size of the site, the operation of Unit No. 2 should not create noise levels resulting in an annoyance to the offsite residents. The forested topography of the site acts as an acoustical shield, thereby absorbing most of the noise from the Station operation.

4. Historical Impact

As stated in Chapter II.D. use of the land for a power plant site will have no effect on any historical landmarks in the general vicinity of the Hudson River. The closest historic landmark is the Stoney Point Battlefield Reservation on the west side of the Hudson River about 2 miles from the Plant.(1)

5. Climatic Effects

The atmosphere will ultimately absorb most of the waste heat from operation of Unit No. 2 and Unit No. 1, using water from the Hudson River 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 which blow up and down the river valley and the high probability of inversion occurring, 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,[2] no serious atmospheric effects are expected from heat dissipation by the once-through cooling. Wispy steam fog over the thermal plume may occur, depending on the plume size. Church[3] has indicated that steam fog will form if the vapor pressure difference between the air and water is 5 millibars or more and the air temperature is at or below freezing. The air layer next to 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 rise but a short distance off the river surface. Observation of steam fog over thermal discharges indicate that the visible plume will be thin and wispy and that the fog will rarely penetrate more than 10 to 50 feet inland before disappearing. It is not expected that the density of the fog will be sufficient 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.

6. Transmission Facilities

A single 345-kV transmission line will deliver the output of the Indian Point Unit No. 2 to the Buchanan Substation located within 200 feet of the Indian Point site. No added right-of-way was required, and the line is parallel to an existing 138-kV transmission line now in service. The 345-kV circuit will be supported by three tapered steel poles. 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]

B. WATER USE

Evaluation of the environmental impact of the operation of Indian Point Unit No. 2 must include the simultaneous operation of Units Nos. 1 and 2 and their additive effects. This is especially important in reference to the effects of all the liquid wastes released into the Hudson River. The following discussion only includes the impact of Plant operation on man's use of water and does not include biological considerations, which are discussed in Chapter V.D.

About 1,200,000 gpm of river water is withdrawn, passed through the cooling system and discharged into the Hudson. This volume represents a relatively large fraction of the Hudson River volume, particularly at low fresh water flows. At Indian Point in the springtime, only fresh water flows past the site; the percentage of river volume withdrawn through the once-through cooling system for Units Nos. 1 and 2 is about 13% to 8.6% of the total river flow when the fresh water flow is 20,000 to 30,000 cfs. During the summer, when the salt front has moved northward, the percentage of water used for the 2 Units will be about 12% based on 22,000 cfs seaward flow. The withdrawal of fresh water flow by the once-through cooling system amounts to about 13% (at 20,000 cfs) during late spring to about 35% at 7,300 cfs during the summer. During a drought (one year out of 10 years) the use of fresh water flow by the 2 Units could range up to 86% (at 3,000 cfs). At a maximum flow rate of 870,000 gpm through the discharge canal thermal discharges with an excess temperature isotherms of 15°F at the outfall will be dispersed normal to the direction of river flow at 10 fps through a 12 port-submerged jet discharge structure at 12 feet below the mean low water level. Federal and New York State standards for thermal discharges, with which the applicant must comply, are adequately conservative for the protection of nonbiological aspects of the Hudson estuary at Indian Point. Thus, the applicant's use of the Hudson River should not interfere with other industrial or community utilization of this resource, except as related to the thermal load of the river. As discussed below in regard to the thermal load, the operation of this Plant using once-through cooling may preclude the construction of similar units nearby in the future. It is therefore important to quantify, if possible, the extent of the thermal effects of the operation of Units Nos. 1 and 2 in detail so that plans for future thermal discharges into the river can be properly evaluated. Table III-2 of Chapter III outlines the intake and discharge flows of the once-through system.

The planned discharges of chemical and radioactive wastes as discussed in Chapter III, Sections 2 and 3 are sufficiently diluted that they should not affect other present industrial or community uses of the Hudson. Table III-9 outlines the concentration and amounts of chemicals which will be discharged during normal operating conditions. It is conceivable that during the life span of this facility, increased industrial usage of the Hudson in the Peekskill area could increase the load of polluting chemicals to significant levels, especially during periods of low fresh water flow. If such a situation develops, the discharge of all waste chemicals should be coordinated in which environmental factors will be considered to minimize any temporarily excessive pollution loads. The applicant's use of the Hudson for convenient disposal of waste materials should reflect consideration of the environmental consequences of these discharges and should not be continued if found to be detrimental to the quality of the Hudson River water. The applicant shall be required to monitor all chemical, thermal, and radioactive discharges in order to demonstrate that the discharges are in compliance with State and Federal regulations throughout the year. The ecological monitoring requirements and limitations on chemical and other discharges will be included in the Technical Specifications for the Plant.

Operation of Units Nos. 1 and 2 should not cause contamination of groundwater by either industrial or sanitary wastes. If such contamination did occur, the contaminated groundwater would end up in the Hudson, where it would be further diluted. Because of the location of the Plant, the use of groundwater by other business concerns in the area would be unaffected.

Section V.D.1.b. and V.D.2.c. outline the effects of Plant operations on water quality, including dissolved oxygen and the chemicals added during Plant operation and discharged either continuously or intermittently into the Hudson River. The use of sodium hypochlorite to clean the once-through condensers results in the most important impact on water quality criterion of toxicity to biota. Residual chlorine will be limited to the New York State regulations of 0.5 ppm in the Station's effluent and is not expected to affect any present or future use of the river water directly by man. Details of chlorine toxicity to aquatic biota are discussed below in Chapter V.D.

The other chemicals such as boric acid, phosphates, chromates, sodium hydroxide, and sulfuric acid, which are listed in Table III-9 above, will be discharged in most cases in a batch process and will be low enough in concentrations such as to result in no important increases in concentration of those chemicals already present in the Hudson River during operation of Units Nos. 2 and 1. Table III-10 of Chapter III shows the natural concentrations of salts and with Table III-9, one can determine the incremental amount of chemicals added to the system for operation purposes. These discharges will be monitored by the applicant to verify that they meet the Federal and New York State water quality regulations. The toxic effects of these chemicals on aquatic life are described below.

Furthermore discharges of chemical and radioactive effluents into the Hudson River as planned and described in Chapter III should not affect other present uses of the Hudson River by industry or communities during the period of operation of Indian Point Unit No. 2 at 100% power.

C. AIR USE

The operation of Indian Point Unit 2 would not greatly increase the level of nonradioactive air pollutants in the area. It would, however, allow the applicant to reduce the number of coal-burning plants in operation and thereby decrease the pollution load of the air in the areas where plants are shut down. The major contribution to air pollution is the combustion products listed in Table III-11 discharged from Unit No. 1 through its oil-fired super heaters.

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

A large quantity of ecological information has been gathered concerning the Hudson River. Much of this information is applicable to the Indian Point site and is briefly summarized in Chapter II.F and Appendices II-2 and II-3 of this Statement. A significant proportion of this information has been obtained through research sponsored by the applicant through contracts with Raytheon Company, New York University, Ichthyological Associates, Northeastern Biologists, Bechtel Corporation, Alden Research Laboratories, Norman Porter Associates, and Quirk, Lawler, and Matusky Engineers. At present, investigators from the NYU Institute of Environmental Medicine are conducting biological sampling programs related to the operation of the Indian Point Units.

Information to answer most of the principal ecological questions associated with the operation of Indian Point Units Nos. 1 and 2 is not yet available. The proposed studies as outlined in the applicant's environmental report will answer some of these questions. However, other studies should be included, and these are discussed along with their purposes in Chapter D.4 on Non-Radiological Biological Monitoring Program.

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

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

Our analysis is divided into three sections:

<u>Section V.D.1</u> - develops pertinent environmental information related to predicting the effects of Plant operation.

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

<u>Section V.D.3</u> - applies the important factors identified in Section V.D.2 to the biological community at Indian Point.

1. Ecological Studies

a. Radiation Effects

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

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

Aquatic organisms are exposed to both internal and external radiation.[7,9] 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.[10] As a result of these complications, the external dose from radionuclides concentrated in the substrate is difficult to estimate from the projected releases.

In addition to radiation from external sources, aquatic organisms are exposed to radiation from radionuclides within their tissues. Doses resulting from this source of exposure are generally much greater than doses from external sources, except perhaps for benthic or epibenthic organisms living in association with substrates in which radionuclides have been concentrated. Organisms accumulate radionuclides either directly from the water through epithelial tissue or by assimilation of their food. Transient releases of radionuclides into the environment are followed by transient peaks of radioactivity along the food-chain pathways.[5] Knowledge of these pathways and of the rates of assimilation and turnover of radionuclides is essential for prediction of time-dependent concentrations in the biota. However, chronic releases will result in steady-state concentrations in the biota, and, in these instances, concentration factors can be used to approximate the eventual equilibrium levels of radioactivity.[5] Consequently, by using concentration factors such as those listed in Table V-1, it is possible to estimate the internal doses the various organisms will receive if continually exposed to radionuclides released by Plant operations.

b. Effects on Water Quality

(1) Dissolved Oxygen

The following analysis is derived from a recent review by Coutant.[7]

Since warm water holds less oxygen in solution than cooler water, increasing coolant water temperatures by 15°F with the possibility of reaching 34°F at the peak temperature for water flowing at the lowest practical rate through the hottest condenser tube, as predicted for the Indian Point facility during condenser passage,[1,9] will theoretically result in some loss of oxygen, which may subsequently influence aquatic organisms. For example, the concentration of oxygen in water in equilibrium with air at 82.4°F is 7.9 ppm, whereas at 111.2°F the saturation concentration is 6.1 ppm. Another factor theoretically tending to lower dissolved oxygen concentrations in the water passing through a condenser is the partial vacuum existing at the discharge end of the condenser. This partial vacuum results from the fact that the discharge end of the condenser lies above the hydraulic gradient. This situation is common to all steam plants. Vacuum pumps are often installed in the cooling circuit to remove any accumulated air in order to reduce the effect of oxygen on corrosion of condenser tubing.

These theoretical considerations have been examined in a number of studies at operating power stations throughout the world. Alabaster and Downing,[13] after examining the literature and conducting their own studies in Britain, acknowledged that the oxygen content of water used for direct cooling may change slightly in its passage through electrical generating

TABLE V-1
CONCENTRATION FACTORS FOR ELEMENTS IN AQUATIC PLANTS, INVERTEBRATES, AND FISHES

Nuclide	Concentration Factor					
	Plants	Reference	Invertebrates	Reference	Fish	Reference
Sr	3,000	(7)	4,000	(7)	500	(9)
Y	10,000	(9)	1,000	(9)	100	(9)
Mo	100	(9)	100	(8)	100	(9)
Tc	100	(9)	25	(9)	1	(9)
Te	100	(9)	25	(9)	1	(9)
I	200	(7)	1,000	(7)	100	(9)
Cs	25,000	(7)	11,000	(7)	9,500	(7)
Ba	500	(9)	200	(9)	10	(9)
Cr	100	(8)	50	(8)	200	(8)
Mn	35,000	(7)	140,000	(7)	25	(9)
Co	2,500	(7)	1,500	(9)	500	(9)
Zn	1,500	(8)	150	(8)	10	(8)
H	1	(9)	1	(9)	1	(9)
Ce	35,000	(8)	9,000	(8)	35,000	(8)

stations. This appeared to be partly due to the turbulent flow in the effluent outfall causing water unsaturated with oxygen to pick up this gas, while supersaturated water lost it.

Dissolved oxygen analyses of samples taken by Alabaster and Downing[13] showed that most unheated water was not saturated, that there was either a slight rise or little change in concentration in the heated water discharged from the condensers, and that, as a result, the effluent was supersaturated with respect to oxygen (and other gases). These authors made the further (very pertinent) observation that the changes were generally small compared with those occurring in most natural waters through plant photosynthesis and respiration and through the oxidation of organic effluents.

Adams has reported similar analyses at California power stations.[14] Measurements of dissolved oxygen at intake and outfall points showed that dissolved-oxygen concentrations were not decreased in passing through the cooling water system. Rather, the water merely became supersaturated with oxygen. As the temperature of the effluent dropped in the mixing zone, saturation values dropped correspondingly, with little loss of dissolved oxygen.

Once the cooling water has entered the main body of water, rates of oxygen demand by organic materials (both living and decomposing) will be increased because of the higher temperature. In waters that are heavily loaded with decomposing organic matter, this additional demand can exceed the rate of reoxygenation through the water surface (from the air), and dissolved oxygen levels could fall below those normally expected.[15]

In the Hudson River estuary near Indian Point, there is a relatively low load of decomposing organic matter.[16] Raytheon Company[17] found that dissolved oxygen in the Hudson River water in the Indian Point area ranged from low summer values of 3 ppm to high winter values of 11 ppm. Normally the dissolved oxygen concentration in the coolant water discharged from Indian Point Unit No. 1 is slightly less than that in the intake water. Although recent information from discussions with the applicant indicates a sampling error in calibration of instrumentation used for dissolved oxygen analysis, Raytheon Company[17] noted a distinct drop in dissolved oxygen across Unit No. 1, and intermittent low levels of dissolved oxygen in the river near the site. As an example, Raytheon cited that in early November 1969, the dissolved oxygen in the effluent (3.7 ppm) was 34% less than that in the intake water. Since the dissolved oxygen intake concentration of 5.3 ppm and the effluent concentration of 3.7 ppm observed in both instances were less than 50% of the theoretical saturation value, the rise in water temperature does not seem to entirely account for the decrease, thus lending credence to the applicant's opinion that the Raytheon data were in error. In either event, it cannot necessarily be assumed that the change in dissolved oxygen which might occur across the condensers of Unit No. 1 would be the same for Unit No. 2.

Any reduction in dissolved oxygen across the condenser would not seem likely to affect the Hudson River as a whole, since the water which has been through the condensers will be spread at the surface, where it will be exposed to maximum exchange with the atmosphere. However, in view of the low dissolved oxygen levels which were reported by Raytheon Company[17] during September of 1969 (as low as 2.7 ppm), the staff is not yet satisfied that the operation of Units Nos. 1 and 2 will not at times reduce the dissolved oxygen levels below tolerable limits. Aeration of the discharge cooling water will be required by the applicant to avoid this problem, if plant operations indicate important reductions in dissolved oxygen.

(2) Chemicals

(a) Sodium Hypochlorite - Residual Chlorine

Merkens[19] found that at a pH of 7.0, 0.08 ppm of residual chlorine killed half of his test rainbow trout in 7 days. Zillich[20] found chlorinated sewage effluent to be toxic to fathead minnows at residual chlorine concentrations of 0.04 to 0.05 ppm. Basch[21] found that 50% of a population of rainbow trout could tolerate 0.23 ppm for only 96 hr. Arthur and Eaton[22] found that half of a population of the invertebrate *Gammarus pseudolimnaeus* survived 96 hours at a concentration of 0.22 ppm and that reproduction was reduced when chronic concentrations (for 15 weeks) were maintained at 0.0034 ppm. They also found that the highest concentration that produced no effect on the life cycle of the fathead minnow was 0.016 ppm. Sprague and Drury[23] showed an avoidance response by rainbow trout to free chlorine levels of 0.001 ppm.

The concentrations to be released at Indian Point (0.5 ppm) are much greater than any of the toxic concentrations discussed above. When sodium hypochlorite is injected into water, it dissociates to form sodium ions and hypochlorite ions. The hypochlorite ions will rapidly react with nitrogenous material to form chloramines that are exceedingly toxic. Toxicity from residual chlorine and the chloramines is related to exposure based on concentration and the length of exposure. Thus, it is expected that toxic concentrations will at times be produced in the Hudson, in the vicinity of the Plant. For further discussion see Section V.D.2.c. and Appendix V.1.

(b) Sodium Hydroxide, Lithium Hydroxide, Sulfuric Acid

The toxicity of these compounds is related to their ability to alter pH. Because of the buffering capacity of the dilution water, discharges of these substances are not expected to alter the pH appreciably, as indicated by pH measurements made during releases of these chemicals from Indian Point Unit No. 1.[17] As a consequence, no effects on the aquatic biota are expected as a result of discharges of these chemicals.

(c) Boric Acid

The minimum lethal dose for minnows exposed to boric acid for 6 hours at 68°F was found to be 18,000 to 19,500 ppm.(24) Wallen found that 18,000 ppm was needed to kill 50% of test mosquito fish in 24 hours and that 5,600 ppm caused 50% mortality in 96 hours.(25) Boric acid can be toxic to freshwater fish without lowering the pH to 5.0. Thus, pH is not a reliable index of toxicity of boric acid. However, concentrations of up to 2,000 ppm have been found nontoxic to fish,(24) and over 1,000 ppm are required for 50% inhibition of the utilization of oxygen by synthetic sewage. On the other hand, many terrestrial plants are sensitive to concentrations of boron in the range of 1 ppm.(24)

Sustained releases of this substance by the Indian Point station will be diluted at least to 50 ppm before being discharged into the Hudson, and additional dilution due to mixing with the main body of water will reduce the concentration even more. However, under certain conditions the resulting concentrations might be toxic to the aquatic biota of the area. For further discussion see section V.D.2.c.

(d) Hydrazine

Hydrazine is a fuming oily liquid with a penetrating odor and is a violent poison. Hydrazine hydrate, $NH_2NH_2H_2O$, a fuming refractive liquid with a faint characteristic odor, is miscible with water and is presumably the form of N_2H_4 dissolved in water that will be released from Indian Point.

At 0.7 ppm, hydrazine hydrate caused fingerling trout to lose equilibrium in less than 24 hours. On the other hand, hydrazine hydrate had no effect on sea lampreys exposed for 24 hours at a concentration of 5 ppm.(24) Corti reports that rainbow trout exposed to 146 ppm of hydrazine at pH 8.35 and 56.3°F demonstrated an adverse reaction after 14 to 18 minutes and succumbed completely in 22 to 35 minutes.(24)

Dilution in the discharge canal at 0.1 ppm and further dilution in the Hudson will reduce concentrations to levels below those known to produce toxic effects.

(e) Soda Ash (Sodium Carbonate)

The threshold concentration of sodium carbonate for immobilization of *Daphnia magna* in Lake Erie water at 77°F was reported to be between 424 and 300 ppm. The minimum lethal concentration for *Daphnia* was shown to be 300 ppm, and at 800 ppm all were killed. The threshold of toxicity toward *Daphnia* depends on the dissolved oxygen content of the test water. At 73.4°F for a 100-hour exposure the threshold toxicity level was 552 ppm at a dissolved oxygen concentration of 6.5 ppm, but only 267 ppm when the dissolved oxygen dropped to 1.53 ppm. The toxicity of this compound to fish was reported to range from 60 to 1,200 ppm.[24]

The concentrations of soda ash to be released during shutdown of Unit No. 1 when cleaning of the flue-gas passages of the superheater into the Hudson will be below those known to produce toxic effects on aquatic organisms.

(f) Potassium Chromate

The toxicity of potassium chromate toward aquatic life varies with the species, temperature, pH, and other compounds that are present. Extensive literature exists on the toxicity of chromates.[21] In general, fish are more tolerant of chromium salts, but many invertebrates and aquatic algae are very sensitive. Toxic effects on *Daphnia magna* have been observed at values less than 0.01 ppm, and toxic effects on many microcrustaceans and algae at concentrations less than 1 ppm. Toxicity to fish begins around 5 ppm.

The 0.05 ppm concentration of chromates in the water in the discharge canal at Indian Point is sufficient to affect sensitive organisms. However, the releases will be intermittent and of short duration, and the additional dilution by Hudson River water will reduce the levels below those known to produce toxic effects.

(g) Sodium Phosphate

The toxicity of phosphates has been discussed by McKee and Wolf.[24] *Daphnia magna* was the most sensitive organism discussed, being affected by levels above 50 ppm. Most other organisms were much less sensitive. In comparison, the proposed releases will be a maximum of 1.5 ppm, a level that should not be toxic.

c. 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 or an ecosystem. Generally, tropical and subtropical species are more stenothermal (tolerate only a narrow range of temperatures) than those of higher latitudes, and marine forms are more stenothermal than freshwater or estuarine ones.[26] In this connection, Naylor[27] noted that estuarine species were more tolerant of heated effluents than marine forms and concluded that some cold-water stenothermal species may be eliminated by heated discharges while eurythermal (tolerate a wide range of temperatures) species may be increased.

Planktonic forms are most susceptible to temperature fluctuations resulting from power plant operations since 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.[26] Larval development also requires narrow ranges of temperature.[28] 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 stenothermal species.

(1) Decomposers

The temperature of the Hudson, even during the summer, is below the optimum for most bacteria. Increasing the water temperature increases the bacterial multiplication rate when the environment is favorable and the food supply is abundant. Increasing the water temperature within the growth range of the bacteria causes a more rapid die-off when the food supply is limited.[29] Consequently the few degrees increase in temperature due to the discharge of heat by the Plant would be expected to favor increased bacterial growth during most of the year, only if the standing crop of bacteria is less than the carrying capacity of their food supply. Because of metabolic considerations, increases in temperature which favor population growth may be counteracted by a reduction in the carrying capacity of the area. However, if, in addition to the increased temperature, there is an associated increase in available organic material, increased standing crops of bacteria might be experienced. Bacterial counts in the influent and effluent water of a power plant on the Patuxent River estuary when there was a rapid heat change (but no chlorination) were found to remain constant.[27]

(2) Producers

Inherent in the question of availability of different algal groups as food for invertebrates is the succession of these algae with increasing temperature. As Patrick[31] noted in her review of the effects of temperature on freshwater algae, each species in nature has its own range of temperature tolerance and its range of optimum growth, photosynthesis, and reproduction. Diatoms are represented by the largest number of species with relatively low temperature tolerances; namely, to temperatures below 86°F. The tolerances of the green algae cover a wide temperature span. The blue-green algae have more species that are tolerant of very high temperatures.

There are some species in all groups, however, that tolerate the unusual extreme for their group. Under normal seasonal conditions, there is a succession of species on the same substrate. This succession is largely the result of changes in water temperature and light intensity through the optima for the various species. As the temperature increases or decreases, one species replaces another as the dominant organism. In nature, there are also many other pressures upon a species, including interspecies competition and predation, so that the temperature of maximum development in a stream may not be exactly the same as the optimum range for growth in the laboratory. Figure V-1[32] indicates the most commonly observed type of population shift. This figure is generally accepted, although, as Coutant[11] points out, it is a generalized pattern, which is not always followed by algal populations in the field.

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. Reports by Trembley[33] indicate that the periphyton grown on glass slides was dominated more completely by blue-green algal species in the discharge canal of the Martin's Creek Power Plant on the Delaware River when the temperature exceeded 94.1°F. There were fewer species on the slides than when the water was cooler, but those remaining were represented by a larger number of individuals. This condition is generally recognized as an indication of an abnormal community structure. It is difficult to determine, however, how much of the alteration of community structure was due to chlorination of the cooling water.[11]

Foerster[34] discussed the apparent early arrival of spring seasonal successions in periphyton of the discharge canal of the Yankee Atomic Power Plant on the Connecticut River. Buck[35] reported a noticeable shift from diatoms to blue-green algae in plankton in the area of thermal effluent. These planktonic forms were presumably derived from the periphyton populations of the mile-long canal, although a detailed report of this study has not yet been published. Similar changes in the species composition of plankton in cooling water were reported by Beer and Pipes,[36] who described a shift from diatom dominance in the inlet to dominance by unicellular green algae in the effluent canal of the Dresden Station on the Illinois River.

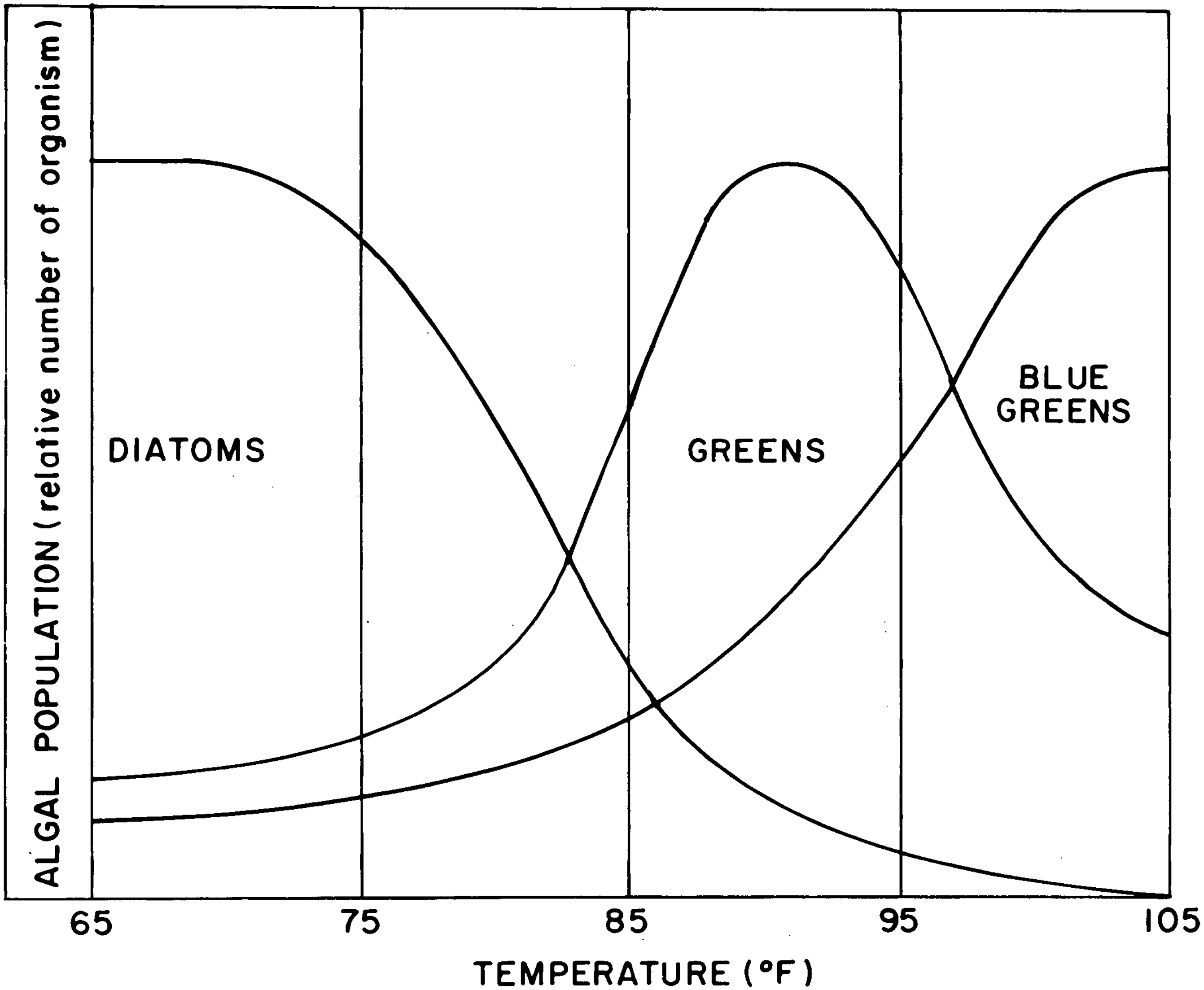

Fig. V-1
Population Changes Among Algal Groups with Change in Temperature.

In a September survey, Oscillatoria (a blue-green filamentous alga) covered all bottom materials in shallow water of the discharge canal and the river bed close to the confluence of the discharge from the John Sevier Steam Plant (Tennessee Valley Authority) with the Holston River, Tennessee.[11] No large-scale replacement of cold-water marine algae by warm-water-tolerant forms, however, was found by North[37] at the Morro Bay discharge canal. The entire algal flora was simply depleted at the warmer temperature.

The lethal temperature of the algae varies with the species.[31] For most of the algal species studied to date, the lethal temperature is in the range from 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 an 18°F temperature change. Diatoms suited to warmer temperatures can tolerate temperature changes of from 27°F to 36°F.[31]

At Indian Point, the diatom Melosira is dominant throughout most of the year, although their dominance declines during the summer period of high temperatures and salinity. Many other species are also consistently present.[38] 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.[39] The pattern of dominant algal forms (Fig. V-2) conforms to the typical pattern previously described (Fig. V-1), although the shifts in abundance of the green and blue-green algae seem to be occurring at lower temperatures than would be predicted. For further discussion, see sections V.D.1.c and V.D.3.a(2).

(3) Consumers

The physiology of aquatic organisms are affected by temperature. Changes in temperature may cause increases in metabolism, changes in food conversion abilities, changes in reproductive capacity, changes in behavior, or even thermal death. Fry et al.[40] described the thermal responses of fish and divided the total range of temperature experience of an organism into several zones. They discerned an upper and a lower zone of thermal resistance and a central zone of thermal tolerance, bounded respectively above and below by an upper and a lower lethal temperature. The lethal temperature is defined as that temperature which, when a fish is brought rapidly to it from a different temperature, will kill a stated fraction of the population (generally 50%) within an indefinitely prolonged exposure. In the zones of thermal resistance an organism can survive for a definite period of time that becomes longer as the temperature approaches the lethal temperature.

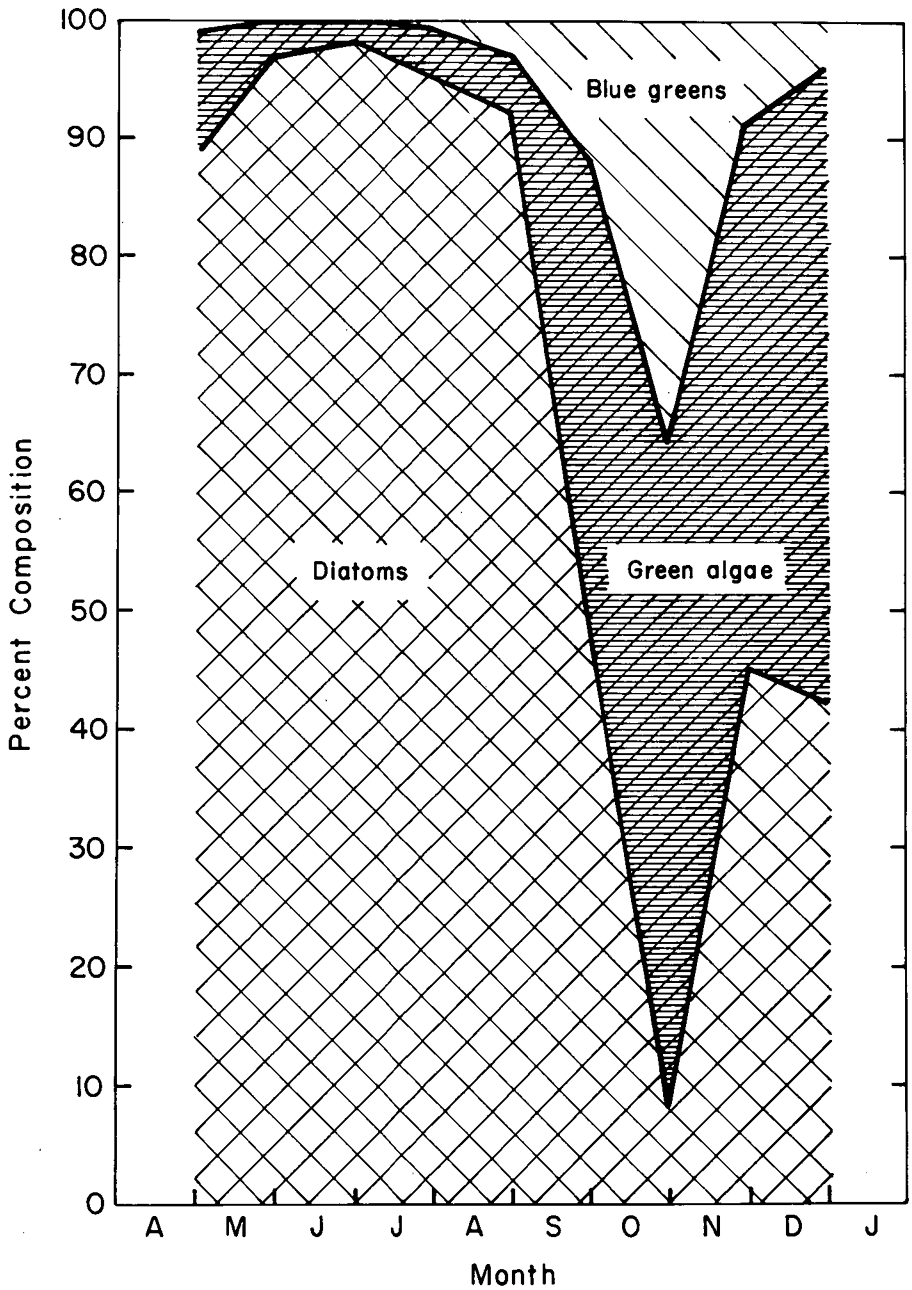

Fig. V-2
Relative Proportions of Diatoms, Green, and Blue-Green Algae in the Standing Crop at Indian Point, 1970.
(East Channel Station)

Previous thermal history affects the lethal temperature, this history being referred to as acclimation temperature. In general, a history of cold temperatures results in a low lethal temperature, while a history of warm temperatures produces an elevated lethal temperature.

There is accumulating evidence that many cold-blooded (poikilothermic) species are capable of considerable adjustment of their metabolic activities to a wide range of temperatures. This adjustment to warmer temperatures is evidenced by increased upper and lower lethal temperatures. The range of adjustment may be considerable, as, for example, in the goldfish, which has an upper lethal temperature that varies from approximately 78.8°F to 104°F. This hardy species may be one of the universal cases in this respect.[11]

Elevation of lethal temperature is not directly proportional to elevation of acclimation temperature, but rather some fraction of it. The result is that the acclimation temperature and the upper lethal temperature tend to converge upon the ultimate upper lethal temperature, at which both the acclimation and the lethal temperature are the same.

The time necessary for thermal acclimation varies among species, as has been shown by several workers.[11] Adjustment to higher temperatures is generally fairly rapid; data of Alabaster and Downing[13] indicate an elevation of about 1.8°F per day for the roach; Sprague[41] found that acclimation temperatures could be raised 4.5°F to 9°F per day for several crustaceans. Once acquired, tolerance to high temperatures may persist for considerable periods after return of a fish to a lower temperature. Heat exposure during acclimation need not be continuous. An intermittent exposure to a different temperature for sufficient hours per day can produce the same acclimation temperature as a continuous exposure. According to several authors,[11] acclimation to low temperature usually tends to shift the lower thermal limits downward, and acclimation to high temperatures tends to shift the lower limits upward. Since intermittent brief exposure to high temperatures can result in markedly increased resistance to heat which is not readily lost during subsequent exposure to low temperatures, possible increased susceptibility to reduced temperatures may result in areas where organisms regularly encounter thermal plumes.

By testing species in the laboratory, Brett[42] noted that a slow rate of decrease in environmental temperature is of greater importance for maintaining life than a slow rate of increase. Thus, lethal cold can be more important than lethal heat as a factor affecting survival of some species exposed to thermal plumes. Deaths resulting from the inability of fish to rapidly acclimate to lowering temperatures have been reported by several authors.[43,44]

Upon exposure to altered temperatures, the duration of the exposure, the size of the fish, and its thermal history are important in determining its survival. Eggs and larvae are exacting in their temperature requirements, while subjuveniles and juveniles appear to be more eurythermal, and adults tend to be broadly stenothermal.[28]

Based upon the few data on upper lethal temperatures reported in the literature, larvae of temperate marine fishes have lower upper lethal limits than the adults do.[26,28] The experimentally derived median upper temperature for temperate species is 78.8°F for larvae and 86°F for the adults.[28] Although the upper limits for larvae and adults differ, the absolute ranges of temperatures tolerated are approximately identical.[28]

The eggs of some species may be especially sensitive to fluctuations of temperature. For instance, one of the most important effects noted in the study on eggs of the American smelt (Osmerus mordax) in Maine was the large increases in mortality during fluctuations in daily water temperature of as much as 12.6°F, as observed by Rothschild.[45] In contrast, striped bass eggs (Morone saxatilis) were found to survive in water whose temperature varied from 55° to 75°F daily.[46]

The thermal tolerances of invertebrate herbivores that are generally most active in grazing algal populations are poorly known. Coutant[47] observed a reduction in the normal complement of Delaware River invertebrates when the daily maximum temperature was near 89.6°F. Chironomids larvae, which are generally important as periphyton harvesters, persisted in the zone where algae were accumulating. Other studies have noted depletions of invertebrates in warmed water.[11]

The effects of thermal discharges on benthic communities have been reviewed by Stewart.[49] In general, the number and distribution of bottom organisms decrease as water temperatures increase, with a tolerance limit close to 90°F for a "balanced" population structure. Studies of particular species of macroinvertebrates have shown that lethal temperatures vary considerably with the type of organism. In some cases a particular species may be stenothermal for one developmental stage and eurythermal for another. Thus, a large number of species are able to tolerate higher temperatures than those at which they can reproduce. In a study on the York River, in Virginia, Warinner and Brehmer[50] found that the community composition and abundance of marine benthic invertebrates in the river were affected by thermal discharge over a distance of 1,000 to 1,300 feet from the discharge outfall, and they concluded that during the months of high normal river temperatures there was clear evidence of biological stress.

At power plants where benthic communities are destroyed in summer, the reverse is often the case in winter.[49] Massengill[48] reported not only colonization, but also a 10% to 40% increase in standing crop in the discharge canal at the Connecticut Yankee Atomic Power Plant, as compared to other stations on the Connecticut River.

Results of thermal tolerance studies conducted on species of aquatic organisms that occur in the Hudson near Indian Point are reported in Table V-2. The actual predictive utility of these figures is limited, since acclimation temperatures have not often been reported. In most cases, however, these data should be regarded as optimistic estimates of upper lethal limits of the populations as a whole, because, as McCauley[51] has stressed, lethal temperatures quoted in the literature usually have been determined for individuals of the more hardy stages of postembryonic development.

In predicting responses to increased temperature, it is important to note that a temperature need not kill the organisms directly to produce effects on a population. For instance, brook trout were found to be comparatively slow in catching minnows at 63°F and virtually incapable of catching them at 69.8°F. This resulted in the trout virtually starving to death.[11] Many other types of sublethal effects on populations are known to occur.

Rates of metabolism and activity of organisms increase with increasing temperatures over most of the tolerated temperature range and then often drop suddenly near the upper lethal temperature. Such rates vary with different species, processes, and levels or ranges of temperature and may be modified by salinity and oxygen factors. It is often considered that the effects of elevated temperatures on a biological system increase the rate of biochemical reactions within the system by 100% to 600% for each 18°F increase,[52] although this rate does not necessarily hold for extreme temperatures. By applying this concept it is apparent that even a slight temperature increase may have far-reaching effects, because a number of metabolic functions will be accelerated with a temperature increase even though the organism may not be killed outright. Fortunately, the actual metabolic increases upon exposure to elevated temperatures are often less than would be anticipated from strictly thermodynamic considerations where metabolic rate would typically vary directly with temperature.[11] If their oxidative processes are independent of temperature (thermally insensitive), then the rate of oxygen utilization would be relatively constant over a wide temperature range. Studies involving many species of invertebrates indicate that over certain parts of a temperature range in which they can be held for prolonged periods, animals tend to be metabolically independent. This kind of response is intermediate between the two extremes. In general, this thermal range of metabolic insensitivity coincides with the temperature regime of the animal's habitat. For such species, slight changes in their thermal environment would have little effect as long as such changes remained within the zone of metabolic insensitivity. However, changes which exceeded this zone could have an adverse effect.

The temperature requirements for reproduction in many species are confined to narrower ranges than for other physiological functions.[28,52] Most aquatic animals have restricted temperatures for breeding. Photo-period effects and rising temperatures in the spring induce development of the gonads, and actual spawning takes place when a certain temperature level is reached.

TABLE V-2

UPPER TEMPERATURE LIMITS OF AQUATIC SPECIES FOUND IN THE HUDSON AT INDIAN POINT BASED ON LABORATORY STUDIES AND FIELD OBSERVATIONS[26,28,67,76]

Species	Acclimation Temperature °C.	Upper Critical Temperature* °C.	Criterion
Alosa pseudoharengus	15	23	T*
" "	-	31.4	T
" "	-	26.7-32.2	T
Osmerus mordax	-	21.5-28.5	T
Pseudopleuronectes americanus	7-28	22-29	48 hr TL_m
" "	-	27.9-30.6	T
" "(adult)	-	27	T
" "(juvenile)	-	22-29	T
Microgadus tomcod	-	29	T
" "(2 cm)	-	19-20.9	T
" "(14-15 cm)	-	23.5-26.1	T
" "(22-29 cm)	-	25.8-26.1	T
Menidia menidia	7-28	22.5-32.5	48 hr TL_m
Morone saxatilis (adult)	-	32	T
" "	-	25-27	Field observation
" "	4.4	23.9	8 hr LD_{50}
" "(juveniles)	-	35	T
Morone americanus	4.4	27.8	8 hr LD_{50}
Fundulus heteroclitus	7.2	37	8 hr LD_{50}
" "	-	40	T
" "	28	37	T
Neomysis mercedes	15	25	24 hr LD_{50}
" "	6-20	22-23.6	48 hr LD_{50}
" "	15	27	5 hr LD_{50}
Neomysis americana	1-25	15-28	24 hr LD_{50}
Crangon septemspinosa	15	27.5	24 hr LD_{50}
Monoculoides sp.	15	29	24 hr LD_{50}
Gammarus fasciatus	15	31.5	24 hr LD_{50}
Acartia tonsa	-	33	lethal in 4 days
" "	5-25	31	100% lethal in 2 hr

*T = Maximum Tolerated Temperature.

This value varies for different species, and in some species the whole proc may be reversed.(26)

A temperature stimulus of some kind is often required for inducing sexual activity in aquatic animals. This threshold is often quite critical and may occur with a temperature rise of only 1.8° or 3.6°F.(42) Brandhorst(53) believed that spawning activity in herring was induced by the suddenness of the temperature change rather than by the magnitude of the change *per se*. Generally, low temperatures during pre-spawning periods delay spawning, and higher temperatures hasten it.(28,42)

Fish attracted to discharge canals and in residence there for several months may be induced by higher temperatures to spawn earlier than might otherwise be expected.(11) Premature spawning can be speculated to have many repercussions in the receiving water, ranging from loss of progeny due to lack of proper food to species changes brought about by the dominant large warm-water fry. The problem is not unique to discharge canals but occurs in cooling ponds and mixed water bodies wherever the water temperature is elevated.(11)

Few of the theoretically predicted changes in reproductive schedules have been studied at power plants, and observations are generally limited to evidence that premature spawning can and does occur. For instance, white suckers (*Catostomus commersonni*) spawned prematurely in the discharge canal of the Martin's Creek Power Plant on the Delaware River.(54) Spawning activities were observed earlier there than elsewhere (times not given). Young of the year were active in the spring in the canal and apparently left the warmer water as the temperature rose in summer. Very small fry of several other species (rearing determined them to be principally minnow species) were found in the canal prior to normal spawning times. They probably were spawned in the canal, instead of having passed through the condensers, although it was not certain.(11)

The attraction of fish to warm areas associated with thermal discharges may cause additional problems. For instance, fish attracted to warm discharge canals of power plants, and forced by their own temperature selection behavior to remain there, subject themselves to speeded metabolic rates compared to their seasonal norm in other parts of their environment.

At the Connecticut Yankee Atomic Power Company's plant on the Connecticut River, Merriman *et al.* (55) have identified "skinny fish" in the winter accumulations of brown bullheads (*Ictalurus nebulosus*) and white catfish (*I. catus*) in the discharge canal. The weight-length ratio, or "condition factor," exhibited significant declines throughout the winter months. Fish tagged early in the winter of 1968-1969 and recaptured four months later had lost an average of 20% of their weight, some having lost 60%. Comparisons of tagged and untagged fish in weekly collections indicated that this marked weight loss was not the result of the tagging but was indicative of the resident canal population as a whole. Populations in the cooler river water outside the canal also showed some condition loss, but at a much slower rate. The poorer condition was also identifiable in these two species of fish caught in the canal in the summer. Channel catfish (I. punctatus), on the other hand, showed no such decline in condition at any season.

Significance of the weight losses for ultimate survival of the populations in the Connecticut River has yet to be established, but the persistence of the effect beyond the winter was demonstrated through tagging and recovery studies.[11] Early fall returns from fish tagged in the canal the previous winter revealed that these fish had not made up their past winter's weight loss over the summer.

As a corollary to feeding rate and quantity of food consumed, the effect of temperature upon the growth of fish is an important factor in considering the effects of heated effluents but is one which has been studied essentially using freshwater fishes in the laboratory. The general relation between growth rate of fish and temperature has been discussed by several authors.[42,56] In general, reduction in growth rate can be expected with increasing temperature above optimum for the species, especially if the availability of food does not increase. This situation is the result of reduced food conversion efficiency, which in some cases may be intensified by behaviorial changes such as reduced effectiveness as a predator or reduced appetite.

d. Entrainment

The importance of entrainment is related to the relative quantity of organisms withdrawn, the level of mortality incurred, the ecological role of the entrained organisms, and the reproductive strategy of the species involved. The importance of these factors will be different for different species. Consequently, detailed considerations of the effects of entrainment must be done separately for each species.

Mortality of entrained organisms is caused by mechanical damage, thermal shock, and chemicals discharged into the water. Mortality caused by other factors associated with Plant operations would, of course, be additive.

(1) Decomposers

As previously indicated in Chapter II.F, bacteria are generally tolerant of exposure to changes in temperature that far exceed the predicted temperature rise of Indian Point Unit Nos. 1 and 2 cooling water and are also unlikely to be physically damaged as a result of entrainment. The only extensive bacterial mortality which might be encountered would be at times when the sodium hypochlorite is being added to the circulating water to control fouling in the condensers.

(2) Producers

Entrainment effects on algal populations have been determined by examining the ability of the algae to produce organic matter. Using this method in studies on the York River, Virginia, Warinner and Brehmer[50] showed that the responses of phytoplankton to entrainment depended on the ambient stream temperature as well as on the change of temperature imposed by the condensers. At low winter temperatures (32° to 50°F), temperature rises increased production. During the summer (temperatures 59° to 70°F), slight additional temperature increases increased production, but larger increases (greater than 10°F) depressed it. The greater the temperature rise in summer, the greater was the depression of the affected plankton's ability to photosynthesize.

Similar results were shown by Morgan and Stross[57] for the Chalk Point Power Plant on the Patuxent estuary off Chesapeake Bay. In this study, temperature rises of about 14.5°F stimulated photosynthesis when natural water temperatures were 60°F or cooler and inhibited photosynthesis when temperatures were 68°F or warmer. Passage through the condensers at times, however, contributed additional damage (perhaps mechanical or chemical) that nullified stimulation by temperature rise at cool temperatures and increased inhibition at warmer ambient levels. Return of phytoplankton to the cool temperatures of the mixed estuary at the end of the discharge canal did not allow recovery of photosynthetic ability. In relating the observed changes in productivity to the entire estuary, the authors noted that real reductions in productivity might occur only if the rate of photosynthesis is not nutrient limited. They concluded that, since Stottlemyer[58] found that nutrient limitation was only a sporadic occurrence, reduction in photosynthesis by another factor (the power plant) must, therefore, reduce the amount of material available for passage through the food chain.

In contrast, another study showed rates of photosynthesis that were similar for power plant intake and effluent water when incubated at the prevailing temperature for each source, although some differences were significant.[28] Algae in heated water had a higher rate of photosynthesis than algae incubated at ambient temperatures. The highest rates of photosynthesis occurred at temperatures between 80.6° and 91.4°F. The highest rate observed was for effluent water incubated at 86.9°F. No consistent reduction of photosynthesis was observed in the vicinity of the discharge canal during field studies.

(3) Consumers

Entrainment analysis of the coolant system should include an estimate of zooplankton mortality and the potential for a rapid recovery downstream of the power plant. Such an analysis was carried out in May 1964 at the Paradise Generating Station at Green River, Kentucky.[59] Biologists of the Tennessee Valley Authority found that the volume of zooplankton was drastically reduced during passage through the single-pass coolant system of the plant. However, organisms that bypassed the plant were found to reproduce at an accelerated pace in water that was warmed by mixing with a thermal discharge, 16°F above an ambient of 82°F (Fig. V-3). Coutant[11] observed that decreases in zooplankton volume could not be attributable to thermal shock effects alone. Other factors might include mechanical destruction in the condenser or piping system and predation upon carcasses and weakened individuals at or near the plant discharge. The Green River reports shed no light on these processes.[11]

Heinle[60] conducted an extensive series of laboratory and field experiments to determine the effect of condenser passage on zooplankton in the brackish Patuxent estuary in the vicinity of the Chalk Point power station of Potomac Electric Power Company. Instead of examining survival alone, the reproductive success was observed in subsequent laboratory culture of populations that had experienced the thermal, mechanical, and chemical shocks of condenser passage. Entrained populations of some copepods were generally not as fit for reproduction as control groups, even when the exposure temperatures were below the laboratory-determined lethal temperatures. Part of this effect was attributed to chlorination of cooling water as a normal operating routine at the plant. While effects of condenser passage were identified by this research, the methodology and the lack of control over such variables as chlorination yielded results of uncertain predictive utility. Within the estuary, population densities of the zooplankton organisms remained high despite high rates of natural predation and the additional losses attributable to the power plant. Certainly, the reproductive potential of the entire population exceeded the effects of the condenser passage.

Normandeau[61] identified clear effects of condenser passage on summer zooplankton and phytoplankton at the Merrimack Generating Station. Samples taken above the inlet and in the discharge canal indicated a reduction in population density of nearly all zooplankton and diatoms after passing through the power plant. These effects were definitely related to absolute temperature, being discernible principally when the condenser cooling water was elevated in July to temperatures above 100°F. The increase in temperature by itself was not the apparent causative factor; rather, mortality was evidenced when the maximum temperature attained exceeded the tolerance limits of the species. The zooplankton population depressions were also evident in the mixing zone in the Merrimack River downstream of the plant, although cooling water was a small percentage of the total river flow at this point.[61]

On the other hand, other studies indicate little or no damage following entrainment. Adams[14] reported that the discharge canal of the Humboldt Bay Nuclear Plant on the California coast was a favorable site for natural setting of native oysters (Ostrea lurida), cockles (Cardium corbis), littleneck clams (Protothaca staminae), butter clams (Saxidomus giganteus), gaper clams (Tresus nuttalli), and about half a dozen other bivalves. The net flow in the canal was always outward because of domination by the cooling water flow, and complete evacuation of the canal, as revealed by dye studies,

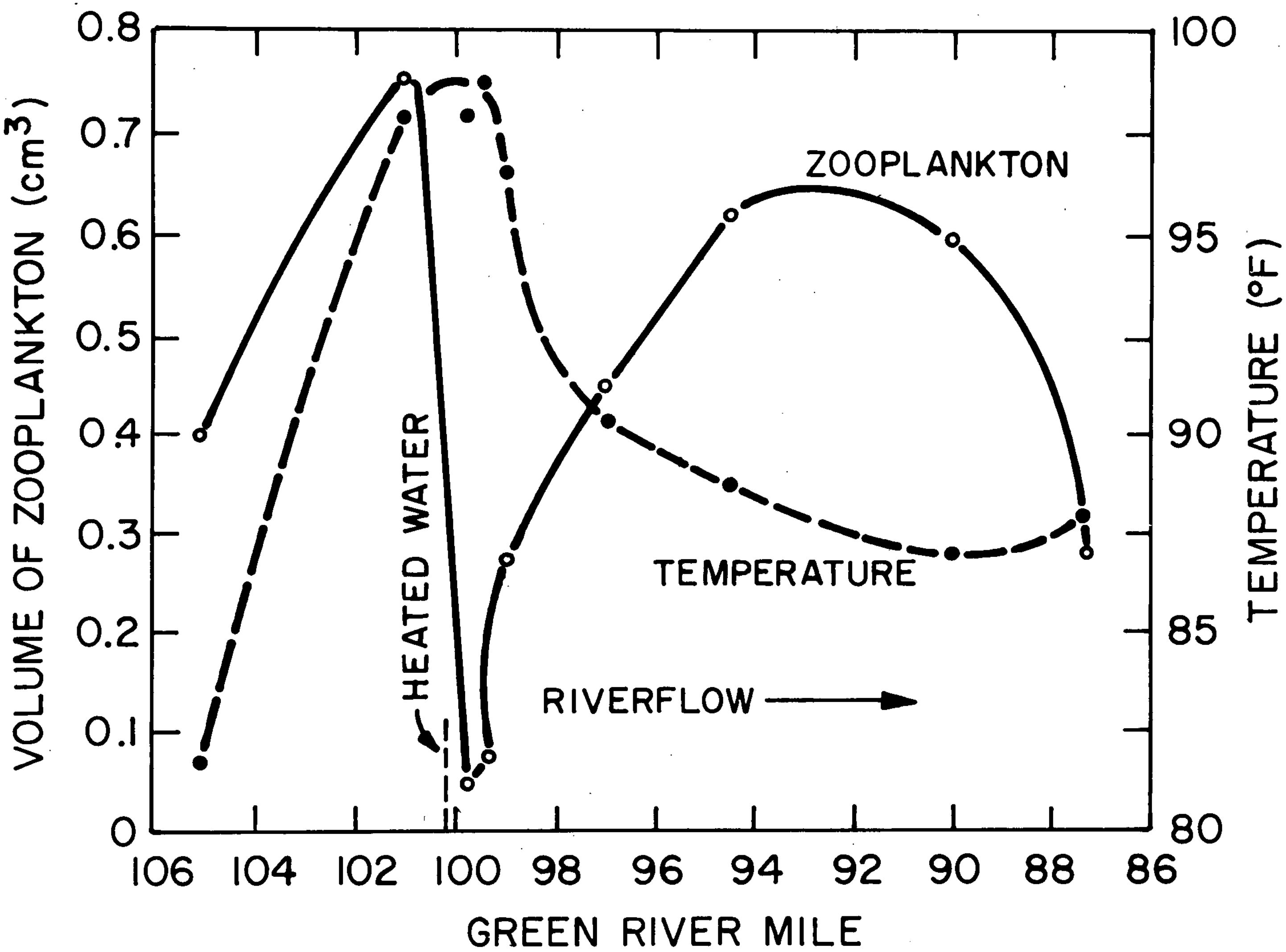

Fig. V-3
Zooplankton and Water Temperatures in the Green River, Ky., Near the Paradise Steam Plant, May 26 - 27, 1964.

took place in less than 3 hours. Therefore, some of the free-swimming stages of these bivalves had to pass alive through the condenser system of the power plant in order to colonize the canal. Similar successful passage must have occurred at the Chalk Point Power Station on the Patuxent estuary to account for high densities of invertebrates found in the discharge canal.[62,63]

Profitt found that after the passage of minnows through condensers of a power plant, several hundred were seen dead and dying along the banks of the effluent canal.[73] In another study, preliminary observations obtained at the Connecticut Yankee Atomic Power Plant on the Connecticut River indicated that larval river herring (Alosa spp.) were able to successfully pass through condensers in July in which the temperature was raised to 93°F. All larvae were judged to be in good condition following the rapid thermal shock and collection by plankton net in the plant's discharge canal.[72] However, more detailed studies[74] at this site found that no larval or juvenile fish of the 9 species which were entrained in the condenser cooling-water system of the plant survived when the temperature of the canal water exceeded 86°F. Among these species were several that are found at Indian Point, including alewives, blueback herring, white perch, and American eels.

In contrast to these findings, Kerr[75] found that juvenile striped bass and Chinook salmon that passed through the condenser system of a power plant had generally high survival. Unfortunately the ambient water temperature was not reported. Kerr acknowledged the fact that the small striped bass would "readily go into a state of shock" during the experiments, and as Coutant[11] pointed out, the data from Kerr's study have little predictive value for application to other power plants.

In connection with Kerr's observation that the juvenile striped bass would go into a state of shock, it is important to recognize that considerable mortality may result from such shock which would not cause death from physiological causes and would consequently not be observed in laboratory studies. Thermal death, with a end point such as (for fish) cessation of beating of the opercula as is often used in laboratory studies, may not be the most pertinent ecological effect of acute thermal shock to organisms exposed to elevated temperatures. Heat death of cold-blooded organisms has been observed to follow a common pattern which includes, in sequence, loss of equilibrium, coma, and physiological death. These observations have been made with several species of fish and with amphibians and reptiles. They probably hold, in essence, for lower forms as well. The early stages of heat death, while not "death" in themselves, may lead to death through immobilization in the area of adverse temperature (which may prolong exposure until death results) or through stimulation of predatory activity upon the heat-injured organisms. Both results have been observed in the field and in laboratory experiments.[11]

A concept of a critical exposure to heat, which causes equilibrium loss, similar to that proposed by Cowels and Bogert,[66] would seem to be of paramount significance in understanding the relations of aquatic populations to thermal shock in condenser cooling water of a power station, as was noted by Mihursky and Kennedy.[67] It is increasingly recognized that the demise of animal populations is not absolutely dependent upon the physiological death limits of individuals, but involves broad ecological considerations such as breeding densities and predator-prey relationships. Equilibrium loss in the natural environment is a critical occurrence for the survival of an organism because it greatly increases the organism's susceptibility to predation.

The effect of equilibrium loss in providing stimulatory cues to predators may be a particularly important feature in fish and other animals shocked by condenser cooling water. Mossman[68] cites several points of evidence that suggest release of predator attack by any behavior associated with weakness. Coutant[11] has specifically studied the effects of acute thermal shock and found that the vulnerability of thermally shocked juvenile salmonids to predation by larger fish increased. When both shocked and control fish were offered simultaneously under laboratory conditions, the shocked fish were found to be selectively preyed upon by larger fish. Relative vulnerability of shocked fish to predation increased with duration of sublethal exposure to lethal temperatures. Effects were also shown well below doses causing equilibrium losses.

Confirmation of the potential importance of predation on shocked organisms in the field situations of thermal discharges can be found in the many references to predators being attracted to points of thermal discharge. Although preference for a particular temperature range may be the predominant attractant for some organisms, it hardly would apply to concentrations of fish-eating gulls.[69] Neill[70] reported intensive feeding by fish on entrained zooplankton in the outfall area of a power plant on Lake Monona. Young-of-the-year bluegills congregated at the periphery of the discharge plume and fed on zooplankton. Several large long-nose gar, their stomachs distended by an abundance of zooplankton, were taken in and near the discharge. Bigmouth buffalo, yellow bass, bluegills, black crappies, and brook silversides caught near the outfalls were suspected of feeding heavily on zooplankton, although confirming data were not collected. Abundant zooplankton was entrained by this plant in cooling water taken from 100 meters offshore and 5.2 meters below the water surface. The temperature rise of 18°F may have killed or debilitated the zooplankton sufficiently that predation upon them was easier than it was in the unheated water of the lake.

Obviously, it is impossible to make absolute statements concerning the mortality of organisms which will be drawn through any given plant. The possibility is high that some fraction of the organisms entrained will be killed or damaged by the entrainment. Unfortunately, such data have not been compiled for Indian Point Unit No. 1 during critical periods of the year, although preliminary observations indicate that at least some of the organisms entrained survive.

e. Impingement

A major problem encountered during the operation of Indian Point Unit

No. 1 has been that of fish mortality resulting from impingement on the fine mesh screens used to filter out debris that could cause damage to the circulating water system. The available information concerning these fish kills has been compiled by the applicant,[64] and an analysis of the information has been reported and summarized by the Commission's Division of Compliance.[65] The following discussion is based on the information contained in these documents.

In March, 1963, fish were entering the open intake forebays and subsequently killed and collected on the traveling screens. Striped bass, tomcod, and white perch comprised most of the fish that were 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 not effective either.

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, was reducing the fish's ability to avoid the intake.

The actual effectiveness of the fish protection efforts during the period 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.

During the spring and summer of 1967, fine mesh (0.375 in. square wire mesh) screens were designed to eliminate the possibility of 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 were not included.

Substantial fish kills 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. This point was graphically illustrated in Fig. 6 of the applicant's report concerning the fish kills at Indian Point.[64] These data indicate that the magnitude of the fish kill was reduced from highs in excess of 16,000 to 18,000 fish per screen washing on February 1-3, to sustained counts of less than 50 fish per washing after February 6, 1970. However, collections of fish on the traveling screens when the fixed screens are in place do 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. For instance, when the traveling screen count was reported to total 388 for March 6 and 7, 1970, there were approximately 120,000 fish netted in front of the fixed screens (Table 3, Reference 64). In essence, the impingement problem was simply shifted from the traveling screens to the fixed fine mesh screens.

On February 29, 1972, the Commission was informed by the applicant that the New York State Department of Environmental Conservation sent an order to halt the testing of 2 of the 6 circulating pumps because of substantial fish kills. During a 4-5 day testing period, the applicant collected 30,000 to 40,000 white perch per day on the protective screens. An estimate of 150,000 fish were killed during the several days of testing. The applicant has already experienced substantial fish kills during testing of the pump several months before.

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 Plant's condenser cooling water system. Fish appear to be caught against the screens by the force of the river water drawn into the Plant. 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 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 plant caused by discharge of heated river water from the Plant.

The most important contributing factor is the capturing capacity of the large volume of water withdrawn from the river at high velocities. The only action that really seems to reduce the level of mortality is a reduction in the intake velocity. Present evidence indicates that a reduction in the water velocity may greatly reduce the fish kill problem (Fig. V-4).

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 very low (34°F) winter temperatures.

These kills have included some 23 species, white perch being by far the predominant species and accounting for over 60% of winter fish kills. However, because of the large number of fish involved, substantial numbers of other species are also killed. For instance, from data obtained by the Raytheon Corporation the total of fish killed from November 6, 1969, to January 11, 1970, was 1,310,345 fish; 137,649 of these were striped bass.[65]

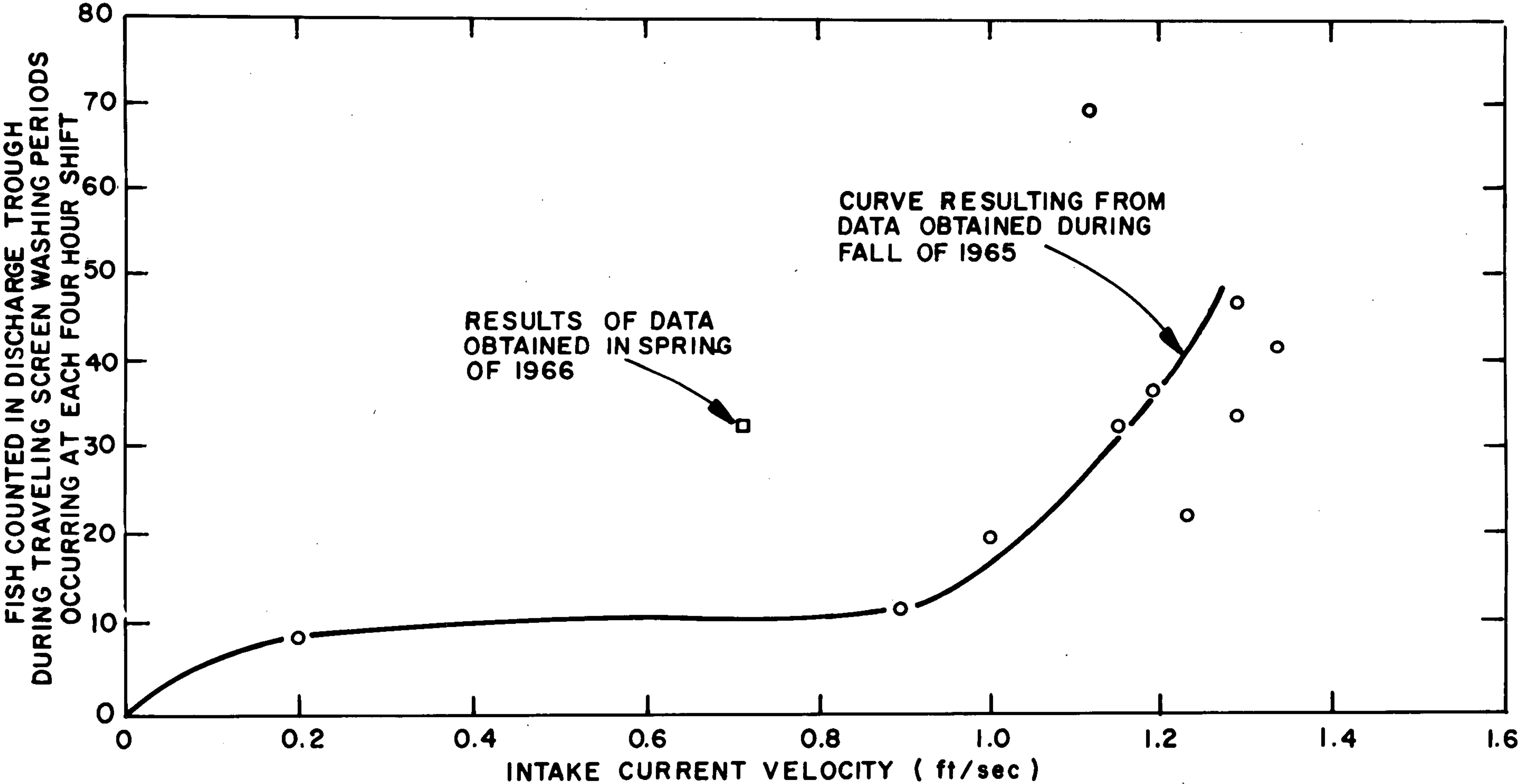

Fig. V-4
Fish Count Per Screen vs Average Current Velocity.

The fish that have been collected on the intake screens, identified, and measured are generally larger than 45-50 mm in length.[64] Since smaller fish are known to exist in the area, it is assumed that the minimum screenable size (at least for striped bass) is in the neighborhood of 40-45 mm. Smaller fish would be expected to go through the plant.

Indian Point Unit No. 2 has an intake structure similar to that of Unit No. 1 and is likely to produce similar fish kills. For further discussion see Section V.D.2.f.

f. Population Effects

(1) Direct Effects

An important aspect of the response of a population to abnormal mortality is associated with the manner in which the density of the population is controlled. The degree of crowding (density) and the pattern of dispersion of individuals (whether random, uniform, or clumped together in a limited area) are especially important in determining the degree of interaction between individuals of the same and of other species. Some populations tend to be self-limited in that the rate of growth decreases as the density increases. Such populations tend to level off in density before saturation, thus assuring that adequate resources are maintained. Other populations are not self-limited but tend to grow in geometric sequence (for example 2, 4, 8, 16, 32, etc.) unless checked by forces outside the population. Such populations are generally limited by habitat resources or predation.

The generation time is another important factor in determining the response of populations to mortality. Species with very short generation times (hours or days) whose populations are regulated by density-dependent factors, such as resource limitations, would be able to maintain population levels in spite of increased mortality. Population maintenance in species with longer generation times (months or years) would require increased reproductive capability in the survivors in order to maintain the population level.

On the other hand, a species whose population is regulated by factors other than its own density, e.g., predation, or competition with other species, could not compensate for changes in survivorship of the other individuals in the population. Consequently, a sustained removal of a significant portion of such species would ultimately eliminate the population in the area, provided of course that there was no additional source of reproductive stock moving into the area from elsewhere.

The possible effects of increasing mortality to a population were examined by Jensen[71] in conjunction with a well-studied population of brook trout. He used a mathematical model for yield which was fitted to the extensive data on a trout population. His results showed that a 5% increase in mortality of the 0+ age group decreased the yield of the trout fishery. In addition, an increase of mortality to 50% of the 0+ age group caused the population to become extinct, although the effect did not become apparent for several years because of normal variations in reproduction and yield.

(2) Indirect Effects

Less obvious effects might accompany chronic exposure to increases in temperature (or radiation and chemical stresses from plant releases). These effects 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.

The importance of this type of consideration can be seen in the following hypothetical example. Phytoplankton species A is the principal food of zooplankton species B, which is the principal food for early larval stages of a dominant fish species. A power plant in the area begins to operate and increase the surface temperature several degrees over ambient. Because of poor light penetration in the slightly turbid water, the principal zone of phytoplankton growth is in the upper, thermally altered layer. Phytoplankton species X is better fitted to grow and reproduce in the warmer water and replaces species A. However, X is a poor-quality food for zooplankton B. As a consequence, the population of B zooplankton decreases and the food supply for the larval fish is diminished, causing significant reduction in their yearly production. As the numbers of these fish decline through several seasons, the reproductive capacity of the population declines, and they exert less and less of an influence in the area. If this species were a top carnivore, changes in its population could result in changes in the populations of other fish species as well. Changes in these populations would also have their effects, etc.

The above hypothetical example is presented to demonstrate one manner in which 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 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 alterations in their chemical and physical habitat must be known.

All this information would be needed to produce reliable predictions of the 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. At Indian Point, the complexity of the interactions of the biota with each other and through natural cycles of salinity and temperature is very difficult. Unfortunately, even if all of the relationships were known, reliable biological predictions of the indirect effects of the operation of the facility could not be developed with the present state of the art. As a result, our assessment of these aspects of environmental effects of Plant operation will be necessarily qualitative. However, it is important to understand that over an extended period of time these effects may have far greater consequences than the direct effects on the biota.

2. Sources of Potential Biological Damage

a. Radioactive Discharges

Radiation doses to aquatic organisms living in the Hudson at Indian Point have been calculated. The staff has estimated the internal dose to organisms living in the effluent canal which will result from releases of radionuclides by Indian Point Units Nos. 1 and 2 (Table V-3). These estimates are based on the assumption of no recycling of released radionuclides through the cooling water intake.

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

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

where:

D = dose in millirads per year,
E = effective absorbed energy for man in Mev,[76]
k = constant = 1.87×10^7,
X = concentration factor, and
C = concentration of radionuclide in the effluent canal in microcuries per milliliter.

TABLE V-3

INTERNAL RADIATION DOSES TO AQUATIC ORGANISMS LIVING IN THE INDIAN POINT EFFLUENT CANAL
(The nuclide concentrations are based on estimated annual releases from Unit No. 2 and continued operation of Unit No. 1 at past levels. C = concentration of radionuclide in the effluent canal, E = effective absorbed energy, X = concentration factor.)

			Plants		Invertebrates		Fish	
Nuclide	C (μCi/ml)	E (Mev)	X	Dose (millirad/year)	X	Dose (millirad/year)	X	Dose (millirad/year)
^{3}H	7.5×10^{-7}	0.01	1	0.14	1	0.14	1	0.14
^{89}Sr	2.5×10^{-11}	0.55	3,000	0.69	4,000	0.93	500	0.112
^{90}Sr	1.5×10^{-12}	1.1	3,000	0.093	4,000	0.12	500	0.015
^{90}Y	3.6×10^{-16}	0.89	10,000	6.1×10^{-5}	1,000	6.1×10^{-6}	100	6.1×10^{-7}
^{91}Y	2.4×10^{-14}	0.59	10,000	2.7×10^{-3}	1,000	2.7×10^{-4}	100	2.7×10^{-5}
^{99}Mo	1.2×10^{-11}	0.71	100	0.016	100	0.016	100	0.016
^{99m}Te	1.0×10^{-11}	0.08	100	1.5×10^{-3}	25	3.8×10^{-4}	1	1.5×10^{-5}
^{129m}Te	1.7×10^{-13}	1.1	100	3.0×10^{-4}	25	7.5×10^{-5}	1	3.0×10^{-6}
^{131}I	9.1×10^{-9}	0.44	200	15	1,000	75	100	7.5
^{132}Te	1.2×10^{-12}	1.9	100	4.4×10^{-3}	25	1.1×10^{-3}	1	4.4×10^{-5}
^{132}I	6.3×10^{-10}	1.9	200	4.5	1,000	22.	100	2.2
^{133}I	4.5×10^{-9}	0.44	200	7.4	1,000	37.	100	3.7
^{134}Cs	8.7×10^{-12}	1.1	25,000	4.5	11,000	2.0	9,500	1.7
^{135}I	2.1×10^{-9}	1.3	200	10.	1,000	50.	100	5.0
^{136}Cs	3.0×10^{-12}	0.65	25,000	0.92	11,000	0.40	9,500	1.7
^{137}Cs	2.1×10^{-10}	0.59	25,000	59.	11,000	26,000	9,500	22.

TABLE V-3 (Continued)

Nuclide	C (μCi/ml)	E (Mev)	Plants X	Plants Dose (millirad/year)	Invertebrates X	Invertebrates Dose (millirad/year)	Fish X	Fish Dose (millirad/year)
^{140}Ba	2.4×10^{-14}	2.3	500	5.1×10^{-4}	200	2.0×10^{-4}	10	1.0×10^{-5}
^{144}Ce	1.9×10^{-15}	1.3	35,000	1.6×10^{-3}	9,000	2.2×10^{-4}	35,000	1.6×10^{-3}
^{60}Co	2.4×10^{-10}	1.5	2,500	17.	1,500	10.	500	3.4
^{54}Mn	8.1×10^{-10}	0.51	35,000	271.	140,000	1084.	25	0.19
^{56}Mn	5.8×10^{-4}	1.9	35,000	0.07	140,000	0.29	25	5.1×10^{-5}
^{58}Co	5.9×10^{-10}	0.61	2,500	16.7	1,500	10.	500	3.3
^{134}I	4.0×10^{-10}	1.5	200	2.2	1,500	11.	100	1.1
^{18}F	1.7×10^{-9}	0.89	2	0.056	3	0.84	3	0.84
^{24}Na	2.5×10^{-9}	2.7	500	63.4	100	13.	100	13.
^{64}Cu	2.1×10^{-10}	0.25	2,000	2.0	500	0.5	50	0.05
TOTAL				480		135		64.

The concentration factor (X) is derived by dividing the radionuclide concentration in the organism per unit wet weight by the radionuclide concentration in the water to which the organism is exposed. The values used (Table V-1) were experimentally determined values obtained from the literature. Better factors for the Hudson could be obtained by careful analysis of the data gathered in conjunction with the operation of Unit No. 1.[10,65,77-80] This procedure would provide more accurate dose estimates, since the concentration factors vary in different environments as a result of various physical, chemical, and biological conditions. However, the maximum values obtained from the literature for freshwater ecosystems were used in the dose calculations in most cases. These factors often represent extreme cases and very likely overestimate the concentration factors that will occur at Indian Point. If the actual concentration factors are less than the assumed values, the internal dose has been overestimated. The use of the effective absorbed energy for man also tends to overestimate the dose.

The concentration factor multiplied by the radionuclide concentration in the water (in microcuries per milliliter) provides an estimate of the body burden of the radionuclide (in microcuries per milliliter). The concentration in the organism's body multiplied by the effective absorbed energy and the constant k gives the radiation dose to the organism in millirads per year for that particular radionuclide. The total internal dose can be calculated as the sum of the doses from the various radionuclides.

The internal radiation doses were estimated using this technique with the concentrations of radionuclides that will be released from Indian Point Units Nos. 1 and 2 (Table V-3). This assumes that no radionuclides would be in the intake water and that the radionuclides released are diluted by 2.0×10^{15} cc per year in the discharge canal.

The calculated doses to the aquatic organisms living in the diluted concentration of discharged activity are much higher than they would receive from background radiation but considerably less than the levels which are needed to produce observable effects in aquatic organisms. As a result of these considerations, no discernible radiation effect is expected in the aquatic community of the Hudson River as a result of Indian Point activities.

b. Dissolved Oxygen

Data gathered by Raytheon Corporation during the operation of Indian Point Unit No. 1 indicated a drop in dissolved oxygen in the cooling water between its intake and discharge into the Hudson.[17] However, other data compiled from studies at Indian Point indicate that the Raytheon data resulted from improper calibration of their instruments. Acceptance of either alternative is not necessarily indicative of operational effects of Unit No. 2. The much greater condenser flow and higher temperature rise for Unit No. 2 make the dissolved oxygen problem potentially more severe. Operation of other plants indicates that it is not possible to predetermine operational effects on the concentration of oxygen in the water that passes through the power plant. Such effects must be determined during actual plant operation, but they may be intensified indirectly by higher water temperatures, which result in a higher biological demand for oxygen by the aquatic community to satisfy an increased metabolic activity.

Any such reduction in dissolved oxygen could be extremely harmful to the aquatic community during the occasional periods when the dissolved oxygen levels are low as a result of natural occurrences. If there is an oxygen reduction caused by operation of Unit No. 2, steps could be taken to reduce the potential problem by installing an aeration system in the discharge canal to increase the oxygen content of the cooling water before discharge into the Hudson River during periods when the dissolved oxygen in the river is low.

c. Chemical Discharges

Many of the chemicals that will be released during Plant operations are toxic to aquatic organisms. The toxicity of these is discussed in Section V.D.1.b. The magnitude of the response of the biota to toxic chemicals depends on the concentration of the chemical, the duration of exposure, and variations in species sensitivity. Table V-4 compares the equilibrium concentrations of chemical releases with minimum concentrations we found in the literature which produce toxic effects. The equilibrium concentrations are based on sustained releases at the proposed concentrations of chemicals presented in Table 2.3.3 of Reference 1 and a fresh water flow of 4,000 cfs (for further discussion see Appendix II-1). These values are excessive estimates of the concentrations that will actually be encountered during operation, because they assume a continuous discharge at the proposed levels, which will not occur. As indicated in the table, potential problems could exist only with releases of boron, chromate, and sodium hypochlorite if these releases were maintained for a long period of time.

(1) Boron

The 50 ppm concentration of boric acid (9.45 ppm of boron) in Table III-9 represents a maximum release rate which might occur following evaporator breakdown and could not be sustained for an indefinite period of time. The maximum sustained releases of this compound will be 1,200 lb of boron per day, which could result in a concentration of up to 0.055 ppm in the river. This level would probably never be reached in the Hudson and is well below toxic levels. Consequently, releases of boron should not cause detrimental effects on the biota.

TABLE V-4
COMPARISON OF MINIMUM TOXIC LEVELS OF CHEMICALS WITH THE MAXIMUM CONCENTRATIONS WHICH COULD OCCUR IN THE HUDSON AS A RESULT OF SUSTAINED RELEASES AT MAXIMUM DISCHARGE CONCENTRATIONS IN PARTS PER MILLION

Chemical	Effluent Concentration ppm	Equilibrium Concentration ppm	Minimum Toxic Level ppm	% of Toxic Level
Phosphate	1.54	0.85	50	1.7%
Hydrazine	0.1	0.055	0.7	7.9%
Boron*	9.45	4.85	0.1	4,900%*
Chromate*	0.05	0.027	0.01	270%*
Residual Chlorine**	0.5	0.27	0.0034	8,000%*
Soda Ash	5.0	2.76	68	4%

*Not expected to actually reach toxic levels. See text.

**Toxic levels will be exceeded during periods of low flow. See text.

(2) Chromates

The releases of chromates to the Hudson are also expected to be intermittent rather than continuous. Such intermittent releases are expected to be infrequent and, as a consequence, should not raise the concentration of chromates in the Hudson to a point where toxic effects would occur.

(3) Residual Chlorine

The residual chlorine levels represented in the table are also high estimates of levels in the Hudson, because discharges will be intermittent and most of the initial biologically active compounds will degrade in time. The applicant claims[1] that the condenser systems will be chlorinated three times a week for 1 hour at each exposure, with a combined output of 6 hours per week. Implementation of this proposed schedule will require manual override of the installed automatic chlorination system, which is capable of a maximum interval of 24 hours between chlorination injections.[1] During chlorination, high mortalities of organisms that pass through the Plant is expected and may approach 100% for many species. The concentrations in the thermal plume will also exceed levels known to affect sensitive organisms. With a concentration of 0.5 ppm and a flow of 2,580 cfs, the discharge would require dilution with more than 390,000 cfs of river water to reduce the concentration to levels that would not be toxic to sensitive organisms. This volume is greater than the average flow of water past the Plant. Since complete mixing will require a considerable length of time, it is evident that a large number of estuarine organisms will be exposed to levels of residual chlorine higher than those known to produce deleterious effects in aquatic life. However, the probability of causing serious impacts to aquatic organisms would be lessened by chlorination schedules which coincide with peak tidal flows during daylight hours. This would reduce the exposure of many planktonic crustaceans and larval fish because of their vertical diurnal migration patterns and the fact that most of the toxic chlorine compounds will be in the thermal plume, which will be spread out on the surface. Even with these precautions a large portion of the biota would still be exposed to deleterious levels of residual chlorine. Because of the mobility of some organisms and the variations in the physical characteristics of the plume, currents and other facts, we cannot predict the duration of the exposure of the biota to these levels of residual chlorine, also the applicant reports that there is a 1 ppm chlorine demand of the river water which reduce the residual chlorine availability to some unknown extent. Because of the effect of these variables is not presently known, the applicant shall be required to monitor taking into account the above mentioned points on chlorination treatment.

d. Thermal Discharges

As described in Chapter III.D.1, large amounts of heat will be discharged to the Hudson River during Plant operation. Some published upper critical temperatures* for species found at Indian Point are given in Table V-2. During periods when ambient water temperatures are about 80°F, many of these organisms will be living near their upper limits and probably above their thermal range of metabolic insensitivity (see Chapter V.D.1.c). Additions of large quantities of heat to the Hudson at these times could conceivably result in changes in the biotic community. Such changes might not be readily apparent, especially if they involve planktonic microcrustaceans or algae. Secondary effects from such changes could also occur.

If the intake water temperature is 81°F and the discharge water is 96°F (temperature rise of 15°F in the condensers) with a flow rate of 2,675 cfs, the organisms in about 10,000 cfs of water will be exposed to temperatures in excess of 85°F, about 5.6% of the water on each pass (see Appendix II-1). By the time the temperature is reduced to 83°F, organisms in 11.25% of the water have been exposed to temperatures of 83°F or more. Since planktonic organisms may pass the area several times, their chance of exposure to temperatures in excess of 83°F is very high but will vary with the dilution flow as indicated in Table V-5 (see Appendix V-2 for method of computation).

The duration of such exposure is very important in determining possible effects on the organisms so affected. Once the thermal plume reaches the surface, the rate of mixing will rapidly decrease. The duration of exposure to the increased temperature can be roughly estimated from the configuration of the thermal plume and the flow rates of the Hudson. Preliminary calculations indicate that elevated temperatures could last several hours. Information on dwell time as a function of different pumping flows are shown in Table III-2. In view of the low tolerance of many of the species to increases in temperature and the high probability of exposure to elevated temperatures, some thermal effects are anticipated.

e. Entrainment

Large numbers of planktonic organisms will pass through the condensers during Plant operation, and, more importantly, a considerably larger proportion of the biota will be withdrawn with the addition of Unit No. 2 (Fig. V-5). These organisms will include bacteria, planktonic algae, many invertebrate species, fish eggs and larvae. Table V-6 lists the fish species in the area whose eggs or larvae are known to be vulnerable to entrainment. During their passage through the Plant, these organisms will be exposed to mechanical, thermal, and chemical damage. High mortality may result, especially for fragile species or during periods of chlorination. The methods used to determine the fraction of organisms entrained are presented in Appendix V-1. The monthly average probability of randomly distributed plankton moving downstream to be withdrawn

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*Maximum tolerable temperature.

TABLE V-5

PROBABILITY OF EXPOSURE OF RANDOMLY DISTRIBUTED ORGANISMS IN THE HUDSON AT INDIAN POINT TO VARIOUS LEVELS OF TEMPERATURE INCREASES RESULTING FROM PLANT OPERATIONS. VALUES WERE DERIVED USING COMPUTATIONS BASED ON PRINCIPLES OUTLINED IN APPENDIX V-2 ASSUMING A CONDENSER ΔT OF 15°F, AVERAGE TIDAL FLOW OF 180,000 cfs, AND 2,675cfs DISCHARGE OF HEATED WATER TO THE HUDSON.

Dilution Flow (cfs)	Number of Chances	Probability of exposure at least 1 time				
		ΔT = +15°	ΔT = +9°	ΔT = +7°	ΔT = +5°	ΔT = +3°
2,000	90.00	.740	.895	.945	.983	.995
3,000	60.00	.592	.777	.856	.935	.974
4,000	45.00	.490	.676	.766	.871	.936
5,000	36.00	.416	.594	.688	.806	.889
6,000	30.00	.361	.528	.621	.745	.840
7,000	25.71	.319	.475	.564	.690	.793
8,000	22.50	.286	.431	.517	.641	.748
9,000	20.00	.258	.394	.476	.598	.706
10,000	18.00	.236	.363	.441	.559	.668
11,000	16.36	.217	.336	.411	.525	.633
12,000	15.00	.201	.313	.384	.495	.601
13,000	13.84	.187	.293	.361	.468	.571
14,000	12.85	.175	.275	.340	.443	.545
15,000	12.00	.164	.259	.321	.421	.520
16,000	11.25	.155	.245	.305	.401	.498
17,000	10.58	.146	.233	.290	.383	.477
18,000	10.00	.139	.221	.276	.366	.458
19,000	9.47	.132	.211	.264	.350	.440
20,000	9.00	.126	.202	.252	.336	.423
21,000	8.57	.120	.193	.242	.323	.408
22,000	8.18	.115	.185	.232	.311	.394
23,000	7.82	.110	.178	.223	.300	.380
24,000	7.50	.106	.171	.215	.289	.368
25,000	7.20	.102	.165	.207	.279	.356
26,000	6.92	.098	.159	.200	.270	.345
27,000	6.66	.094	.153	.194	.262	.335
28,000	6.42	.091	.148	.187	.254	.325
29,000	6.20	.088	.144	.181	.246	.316
30,000	6.00	.085	.139	.176	.239	.307
31,000	5.80	.083	.135	.171	.232	.299
32,000	5.62	.080	.131	.166	.226	.291
33,000	5.45	.078	.127	.161	.220	.284
34,000	5.29	.076	.124	.157	.214	.277
35,000	5.14	.074	.121	.153	.209	.270
36,000	5.00	.072	.117	.149	.203	.263
37,000	4.86	.070	.114	.145	.198	.257
38,000	4.73	.068	.112	.142	.194	.251
39,000	4.61	.066	.109	.138	.189	.246
40,000	4.50	.065	.106	.135	.185	.241

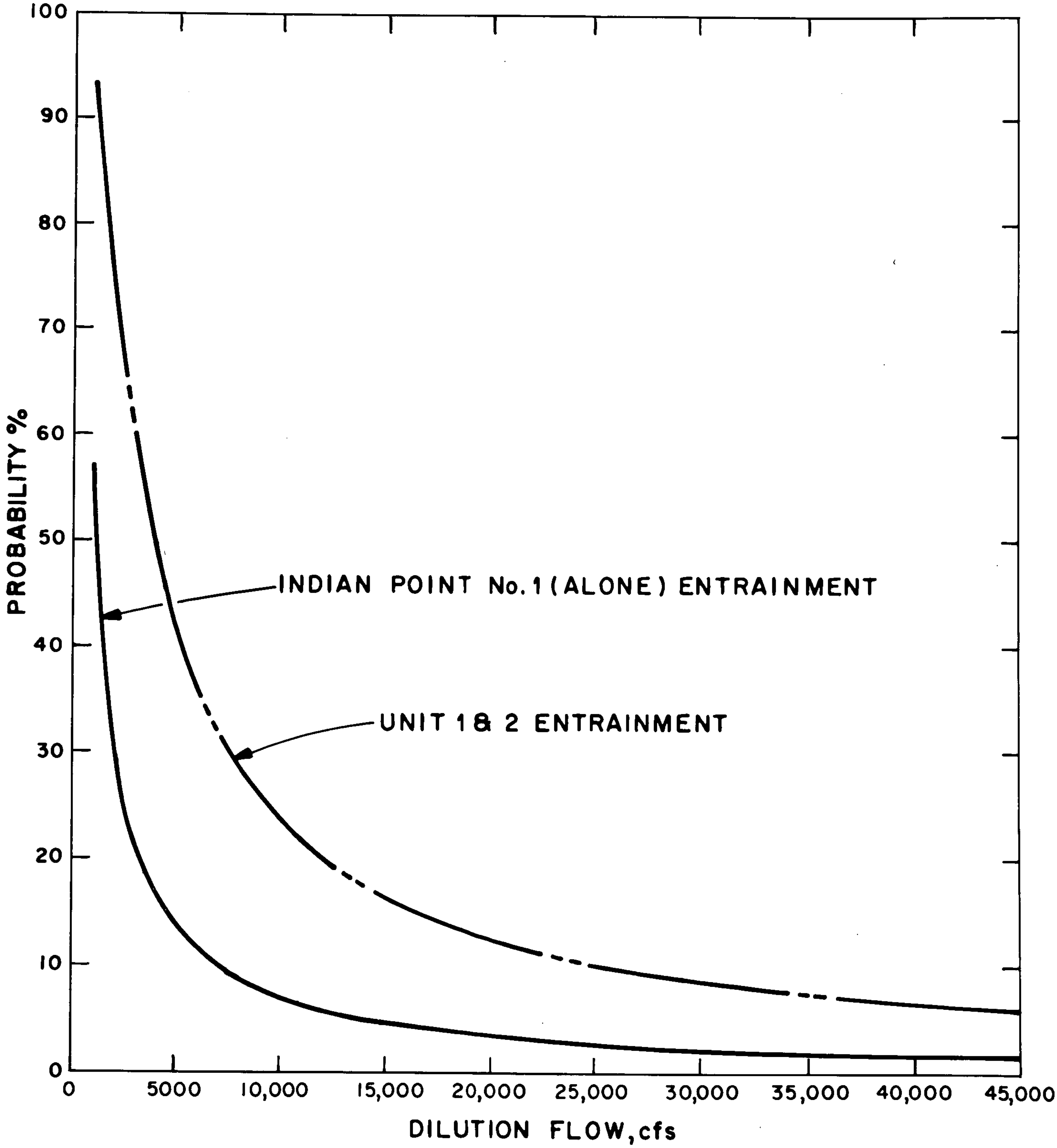

Fig. V-5
Comparison of Entrainment Probability of Indian Point Unit I and Units I and 2. Zero Recirculation is Assumed.

Table V-6

LIST OF ESTUARINE FISHES WITH VARIOUS LIFE STAGES WHICH ARE SUSCEPTIBLE TO ENTRAINMENT AND IMPINGEMENT AND WHICH HAVE BEEN COLLECTED DURING SAMPLING PROGRAM AT INDIAN POINT

Species	Entrainment			Impingement
	Eggs	Larvae	Post-larval	
Striped bass	**	**	**	**
White perch	*	**	**	**
Tomcod	*	**	**	**
Bay anchovy	*	**	**	**
American eel			**	*
Smelt		**	**	**
Blueback herring		**	**	?
Alewife		**	**	*
Atlantic silverside		**	**	*

*Life stage present and susceptible to entrainment or impingement.

**Important fraction of local population may be subject to entrainment or impingement.

varies from a low of about 6% in April to a high of 31% in August, although during drought conditions withdrawal may exceed 45%. Plankton that migrate via density flows to maintain their position in the river will be the most susceptible to entrainment, since they may remain in the area for several weeks.

f. Impingement

As a result of the experiences encountered during the operation of Indian Point Unit No. 1, it is very likely that large numbers of fish will impinge on the intake screens of Unit No. 2 as well as Unit No. 1. Because of the increased water requirement, there is a possibility that the impingement mortality will increase proportionately.

In the applicant's Environmental Report of August 6, 1970, its Supplement No. 1 of September 9, 1971, letter to the Commission dated October 19, 1971, the Commission's Final Detailed Statement of November 20, 1970, and the February 1972 fish kill from testing 2 pumps of Unit No. 2 mentioned on V.D.1e there is a discussion of the problem of fish kills occurring on the Hudson River from operation of Indian Point Unit No. 1 and the action being taken to reduce the fish kills prior to full power operation of Unit No. 2. At Indian Point Unit No. 2 protective screens have been installed at the outer face of the intake structure in guides already provided in the walls; however, preliminary calculations (see Appendix III-I) indicate that the water velocity through the outer fixed screens (1.44 fps) with normal pump operation will exceed that of Unit No. 1 (1.17 fps). If Unit No. 2 is placed in operation before some acceptable method of reducing the intake velocities is installed, the fish kills will probably exceed those experienced at Unit No. 1. The species and size composition of the fish will probably be about the same as for Unit No. 1, but the numbers of fish killed will be larger.

Reduction of the intake velocity through the outer fixed screens would probably reduce the mortality of the number and size of fish, particularly the juveniles. The applicant has stated that it plans to reduce the flow per pump from 140,000 gpm to 84,000 gpm to reduce the intake velocity on the screens prior to the winter of 1972-1973.

The applicant has been conducting continuing ecological and engineering studies on the topic of fish protection. During pump operations of Indian Point Unit No. 2, any fish impingement problem must be evaluated and designs developed to minimize it. The applicant has been in contact with the Indian Point Fish Advisory Board and a number of other Federal, State and local organizations to discuss the overall program in order to provide for fish protection in connection with operation of the Indian Point plants. Besides reduction of the intake velocity presented to the presiding ASLB, other techniques that can be used include developing bypasses for fish.

In the testimony of October 19, 1971, the applicant has estimated the quantities of fish to be collected daily at the intake structure of Indian Point Unit No. 2. These predictions depend 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 are operating and (2) the number of pumps operating. Based on these different conditions of operation of the pumps and the time of year, the applicant predicted that the higher fish kills would occur during the winter months. Based on these variables, during winter operation, a 6-pump full flow operation has been estimated to result in about 593 pounds per day of fish collected and 6-pump at reduced flow causes 437 pounds per day of fish collected at Indian Point Unit No. 2. At an average weight of 1/4 ounce per fish, these values would amount to about 38,000 and 30,000 fish collected per day, respectively. The fish kills would consist primarily of white perch (80%). During the winter the catch is more than 90% of white perch. Striped bass are collected throughout the whole year but amount to about 4% of the total fish collected. Many factors, including the daily movements of fish in the vicinity of the intake, influence the actual collection of fish each day.

During the later part of February 1972, the applicant was testing 2 circulating water pumps, one at full flow (140,000 gpm) and the second at reduced flow (84,000 gpm) on Unit No. 2 over a period of 4-5 days. A fish kill was estimated by the New York State Department of Environmental Conservation to amount to about 175,000 white perch, striped bass, and other fish which had been impaled and killed on the Plant's water intake screens during the previous week. On January 6, 1971, the applicant also experienced a fish kill of 75,000 over several days when 2 pumps on Unit No. 2 were tested. Information on the problems of fish kills from operation of Unit No. 1 is presented in the "Report of Inquiry into Allegations Concerning Operations of IP-1 Plant of Con Ed" Dated October 1971.[65]

3. Probable Biological Effects

The operation of Indian Point Unit No. 2 as presently designed should have little effect on the terrestrial biota on and off the site. On site, no serious detrimental impacts are expected, as the terrestrial biota of the area consist of forms tolerant of human intrusion. After construction is completed the re-establishment of wildlife on the site should occur, particularly with the forested park available for a nature habitat.

The primary impact of the operation of the facility will be associated with the aquatic environment. Several significant problems have been perceived, and some plausible consequences of operation are described in this section. Background material to the conclusions stated in this section may be found in other sections of this Statement.

a. Direct Effects of Plant and Station Operation on Biota

(1) Decomposers

Based on the staff's analysis, the staff believes that no important changes will occur in bacterial populations as a result of Plant operations.

(2) Producers

The staff's analysis indicates that significant changes could occur in the phytoplankton community as a result of Plant operation. However, the staff cannot at this time quantitatively assess the magnitude of the possible changes or the probability of their occurrence.

Information related to the operation of other power plants indicates that the assimilative capacity 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 (and downstream as well). Two possible consequences from this source of damage to the producer populations could occur: a decrease in production and a change in composition.

Reduced production would reduce the food input to other trophic levels. The maximum possible consequence, which would result from a complete "reproductive kill" of the entrained organisms, would be a yearly reduction of 17% of phytoplankton productivity at Indian Point, with much higher reductions during the low flow periods of the summer. The magnitude of these figures would be altered by changes in productivity in the thermal plume. When ambient river temperatures are below optimum for algal growth, productivity would be significantly increased in the plume. This effect would be amplified because the increase in temperature would be greater in the upper layer, which is the photosynthetically active zone. 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, 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 import of food (algae) to the rest of the community during late summer as a result of both "reproductive death" and inhibition in the plume.

A different type of change in the algal populations resulting from the "reproductive death" and plume inhibition during late summer would be more likely. Strong selection would occur and would favor algae with higher thermal optima and tolerance. The net result could be significant increases in the populations of blue-green algae and concurrent reductions in green algae and diatoms.

The staff believes that significant changes may occur in the algal populations. Present data 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 (Figs. V-2 and V-6). Complete interpretation of these data are 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 effects, the additional operation of Indian Point Unit No. 2 may greatly magnify the changes. These changes would be easily detected by the proper biological sampling program.

(3) Consumers

(a) Benthic Fauna

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 direct effects will be the result of the interaction of four factors: entrainment of larvae, thermal discharges, hypochlorite releases, and intake scouring. The velocity of the intake water is expected to cause scouring over a small area of the bottom adjacent to these structures and may eliminate these areas as suitable habitats for some benthic species. The thermal discharges and hypochlorite releases are also expected to make the benthic habitat less suitable in the area near the outfall. Benthic organisms would be continuously or intermittently exposed to slight increases in temperature, depending on their location and the tidal conditions. In addition, the periodic releases of residual chlorine could intensify the problem. Many of these organisms have planktonic larvae which 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.

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 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 available evidence, changes are expected to occur in the species composition and density of the benthic community but these

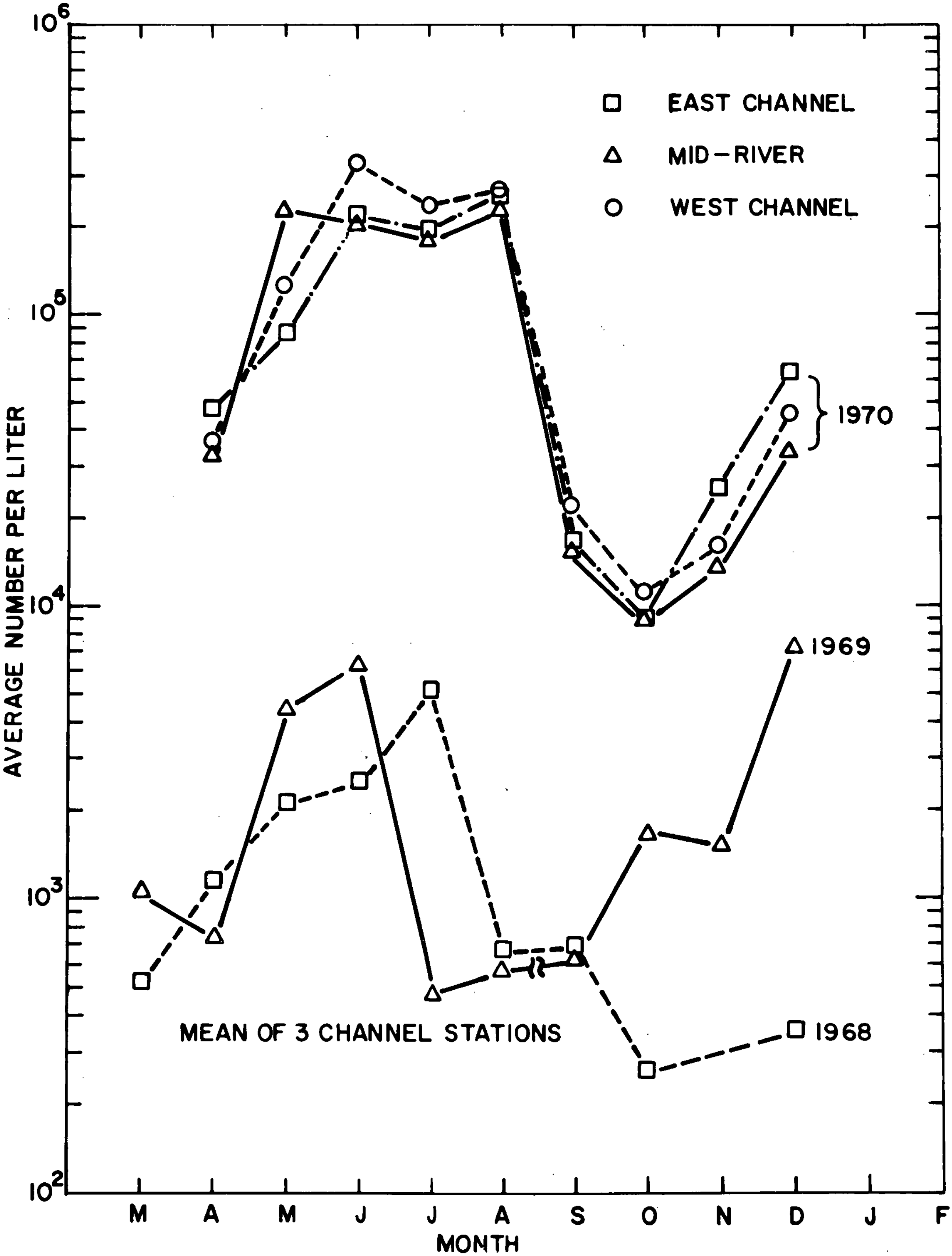

Fig. V-6
Phytoplankton Abundance.
Indian Point

changes will probably not be of sufficient magnitude to be important to the estuary as a whole.

(b) Zooplankton

The combined influences resulting from Plant operations may affect the zooplankton community. These effects will result from additions of residual chlorine, entrainment, and exposure to the thermal plume. 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 reduction in the concentrations of microcrustaceans during late summer as a result of Plant operation.

Larger epibenthic crustacean components (amphipods and mysids) of the zooplankton will be similarly affected. Most of these species undergo diurnal vertical migrations in which they leave their substrate and move up into the water column at night and 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 have little predictive utility as related to the populations as a whole. The reasons are that the available 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 long (annual) generation time and is temperature-sensitive. These organisms move in and out of the Indian Point area with the salt front. During periods of high fresh water runoff, the Neomysis are concentrated downstream from the Indian Point site. However, as the salt front moves up north of the Plant, these animals move upstream into the Plant vicinity. Thus, the population which is present at Indian Point is composed of the same individuals which were previously located downstream. Data compiled by Raytheon Company demonstrate the seasonal and salinity effects which influence the distribution of Neomysis at Indian Point.[17]

The concentration of Neomysis juveniles upstream from the Station indicates the potential for an impact on the Hudson population of these organisms. It appears from these data that the zone which will be influenced by Station operation is an important nursery area for the Hudson aquatic population. As a consequence, deleterious effects of Station operation in this locality may be felt throughout the region of the Hudson which depends on this nursery area for recruitment.

An important consideration is that the Neomysis migrate vertically in the water column on a diurnal cycle and are more numerous on the surface at night but at mid depth or the bottom during the day.[17] Such migrations enable these organisms to passively migrate upstream or downstream using the density flows and thereby to remain within a zone of preferred salinity. However, this life style also causes these animals to be susceptible to being entrained with the condenser cooling water. The fraction of the population which will pass through the Plant is uncertain. However, organisms within the volume of water which passes the Plant will be exposed about four times a day. Since they remain in this zone for several weeks, they will probably be exposed a large number of times, resulting in a significant proportion of these animals having passed through the Plant (Table V-6).

Destruction of large numbers of *Neomysis* may occur but might not affect the yearly recruitment rate. However, large reductions in the standing crop of *Neomysis* would preclude their availability as food for other organisms at Indian Point. Again, the possibility of reproductive inhibition via residual chlorine toxicity could inhibit the development of compensatory increases in reproductive potential at the same time that the populations are decreasing from destruction by Plant operation. The net result would be that recruitment to the *Neomysis* population at Indian Point would depend on immigration from other locations.

A further complication in determining the effects of destruction of *Neomysis* by the Indian Point Station is that this region may be an important nursery area for the Hudson population, with high net annual emigration to Haverstraw Bay and the Tappan Zee, where they serve as food organisms for young fish. Obviously, if net emigration has a much greater effect than mortality in maintaining a stable population of *Neomysis* near the salt water front, additional reduction of the population at Indian Point could cause serious reductions in the populations elsewhere as well.

Operation of Unit No. 2 will decrease the reproductive potential of the Hudson for *Neomysis* to some extent. High entrainment mortality will reduce the standing crop of *Neomysis* but may be compensated for by increased immigration from other areas. Similar arguments apply to *Gammarus fasciatus* and other species with long generation times.

(c) Fish

Fish life of the Hudson at Indian Point will be subjected to stresses by Plant operations. Recruitment rates and standing crops of several species may be appreciably lowered. These include the tomcod, bay anchovy, blueback herring, alewife, eel, white perch, and striped bass. Direct effects on other important species such as American shad, the two sturgeons, and the freshwater forms are not expected to be important.

The striped bass is the best-studied species in the area that appears to be vulnerable to population changes and will be used to illustrate possible Station impact. Adult striped bass migrate upstream in the spring and spawn upstream from Indian Point. The eggs and larvae drift with the currents in a net downstream direction; large numbers pass the Plant. Several studies have indicated that the principal nursery area for the species is below Indian Point in Haverstraw Bay but that there are some less extensive nursery areas upstream. High entrainment mortality of larvae and eggs as they drift past Indian Point Units Nos. 1 and 2 could result in a loss of 25% or more of the larvae and eggs that pass the Plant en route to their nursery area (see Appendix V-II). Based on the sizes and numbers of the young of the year in the estuary in late July and August, it appears that 75% to 90% of the surviving portion of the total yearly reproduction is below Indian Point. If we assume: (1) that all those fish migrated past the Plant during a life stage which was susceptible to entrainment; (2) that density-independent factors are responsible for mortality in the populations; and (3) that entrainment mortality is 100%, then the operation of Indian Point Units Nos. 1 and 2 will effectively reduce recruitment resulting from reproduction by about 19% to 22%. This is a maximum estimated loss of recruitment which would result from entrainment of 25% of the striped bass eggs and larvae that pass the Plant and would not likely be reached. However, losses of the young of the year and 1-year age classes from impingement on the intake screens will add to the actual entrainment mortality and could offset the increases in survival during entrainment, so that the total yearly recruitment loss for each subsequent year class in the population may be as high as 15% to 20% from direct effects of Plant operation. Sustained reproductive losses of this magnitude over a long period of time would result in substantial reductions of the striped bass populations that spawn in the Hudson, including those of both the Hudson itself and the area from the south New Jersey coast to Long Island Sound.

The principal assumption in these predictions which could effectively reduce the rate of recruitment loss is that the mortality rate of each life stage is independent of the density of the species. This assumption is probably valid or nearly so after the first year but is probably not valid for the first year of life. In simplified terms, the reproductive strategy of the species is to supersaturate the nursery areas with young striped bass and let density-dependent mortality reduce the population to a level near the maximum production capability of the estuary. Thus, the number of recruits leaving the estuary each year is relatively stable and is somewhat independent of the number of eggs spawned, provided sufficient spawn is produced to saturate the nursery areas. Thus, relatively stable recruitment is maintained over a wide range in the standing crop of adults. Therefore, changes in the standing crop of adults caused by commercial or sport fisheries would not affect recruitment so long as sufficient breeding stock is maintained to saturate the nursery areas. However, the reduction of the number of breeding individuals caused by exploitation of fisheries would reduce the margin of supersaturation by which recruitment remains constant. The level of spawning activity needed to saturate the nursery would be regulated by two factors - the number of recruits it could support and the rate of mortality caused by density-independent factors. Thus maintenance of recruitment requires sufficient spawn so that density-independent mortality does not reduce the juvenile population to levels much below the carrying capacity of the nursery areas. If density-independent mortality in the nursery areas is increased to the point that the density-dependent factors no longer play a significant role in the recruitment rate and the mortality rate of the adult population remains unchanged, the standing crop of the entire population will begin to decline and will continue to decline as long as the mortality rates remain constant.

At present, the staff is not able to determine the level of the compensatory reserve of the striped bass population. As a consequence, it is not possible to evaluate the extent to which the operation of Indian Point Units Nos. 1 and 2 will influence the striped bass populations. There are three important factors which may significantly alter the conclusions. First, the fish could move downstream past the site at a rate determined by the longitudinal dispersion coefficient. This would move them through the area of susceptibility at a faster rate and thereby reduce the overall susceptibility of the population. If this situation were the case, then the density of larval fish should be less in the Indian Point area than in areas upstream where reproduction is greater and the longitudinal dispersion coefficient is less. Unfortunately, no such pattern was observed in past studies.

A second factor which could significantly influence the rate of entrainment is related to the density flow which may be present during periods of salt water intrusion. The larval striped bass migrate vertically in the water column, occupying the seaward-moving (surface) zone at night and the inland-moving zone (near the bottom) during the day. If the density flow is well developed at Indian Point, then they will move more slowly through the area than can be predicted using the net downstream flow. In effect, this factor could substantially increase the proportion of larvae which are entrained and simultaneously reduce the number which migrate into Haverstraw Bay.

The third important factor is that a substantial portion of the larvae which are migrating downstream may stop at upstream nursery areas rather than migrating into Haverstraw Bay. This may result in most of the density-dependent mortality being exercised in smaller or less productive upstream nursery areas which do not supply a large portion of the recruitment to the adult population. This situation would cause the upstream nursery areas to have a proportionately larger compensatory reserve than those below Indian Point. As a consequence, the probability of reducing the density of larval striped bass to below their compensatory reserve is greater for Haverstraw Bay than for the upstream, less important areas.

The actual initial reduction in recruitment is expected to be small, if, in fact, it occurs at all. The level of recruitment loss will be determined by the proportion of the 0+ age class that is killed by density-independent factors, such as other power plant operations. This is a particularly important factor, since the use of water for the production of electricity in the spawning area as currently planned will exceed the net downstream flow of the river. It is expected that the population will be able to maintain stable density until density-independent losses from this and subsequent power plants exceed the buffering capacity of the population. The staff's analysis indicates that operations at the Indian Point site may play the predominant role in deciding the future of the striped bass of the Hudson River. There will be little effect on the standing crop of the striped bass that use the estuary for reproduction as a result of the Indian Point operations unless and until the increase in mortality decreases the recruitment rate. However, if and when recruitment rates are significantly reduced, a positive feedback loop, the length of cycle of which will be several years in duration would be formed which will greatly reduce the entire population level and simultaneously destroy that portion of the fisheries which is maintained by recruitment from reproduction in the Hudson.

These same arguments apply to other species that spawn in the area and may cause important losses of recruitment to local populations of the alewife, blueback herring, bay anchovy, tomcod, smelt, and Atlantic silversides, as well as striped bass.

b. Indirect Effects

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 the increased 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.

The staff believes adequate evidence is not available to properly evaluate the qualitative or quantitative aspects of the indirect effects of the operation of the Indian Point facility but that a high potential for important changes do exist. However, the ecological monitoring program will be required to be carried out by the applicant which will provide an early indication of any long-term irreversible indirect effects on the ecosystem.

4. Biological Monitoring Program

a. Data Analyses

The staff does not agree with many of the conclusions expressed by the applicant in Supplement No. 1 to Environmental Report for Unit No. 2.[1] It is apparent that many of its conclusions are not consistent with the data acquired by its consultants. On page 2.3.6-5 of this Supplement, for example:

"The Hudson River, upstream and downstream from Indian Point, is used by migrating and resident fish species for spawning and as a nursery area. Based on the data which have been collected, Con Edison believes that the operation of Unit No. 2 will not have an adverse effect on the Hudson River Fishery. Of the six key fish species chosen by the Hudson River Policy Committee to be investigated and be used as ecological indicators, four (alewife, blueback herring, striped bass, and American shad) spawn upriver from Indian Point. Therefore, their eggs and larvae are not vulnerable to the intake and thermal plume at Indian Point" (page 2.3.6-5 of Reference 1).

Extensive data gathered by the Raytheon Company (17,81,82) and by Northeastern Biologists, (83) both of which are consultants for the applicant, clearly show that larvae of the striped bass, alewife, and blueback herring are susceptible to the intake and thermal plume.

In other cases the applicant presented conclusions concerning the impact of its proposed operations without providing any discussion of an analysis upon which its conclusions are based. For example:

"As discussed in Section 2.3.3.4, these thermal discharges will result in a temperature distribution in the Hudson River within the surface temperature limits established by the New York State Criteria Governing Heated Discharges. Moreover, the actual temperature distribution with Units 1 and 2 in operation will be below these limits most of the time. Therefore, it can be stated that thermal discharges will not adversely effect the aquatic environment. It may also be added that the sphere of influence of this thermal discharge is small as compared to the extent of the river in the vicinity of Indian Point and therefore, effects on biota, if any, will be local" (page 2.3.6-6, Reference 1).

In view of our analysis, it is difficult to understand how these conclusions were reached. The "sphere of influence" of the thermal discharge is certainly not small but will in fact extend in both upstream and downstream directions for distances proportional to the fraction of water that has been present at Indian Point (see Appendix II-1). In addition, the applicant apparently assumes that no adverse effects will occur within the legal discharge limits but provides no explanation of its assumption.

In view of the staff's assessment of the magnitude of the possible biological impact of Plant operations and its view that the simple gathering of data is not sufficient for environmental protection, the staff feels that regorous examination of available data together with new data from the post-operational monitoring program should be done by the applicant and its consultants, including the Fish Advisory Board and the Hudson River Fish Technical Committees in the light of present knowledge concerning the environment in the Hudson River and elsewhere. This statement applies equally well to the analyses of data gathered in ongoing and future studies. From such information a plan of action should be developed by the applicant in cooperation with State and Federal officials Fish and Wildlife Service to minimize the potential ecological damage to the biota.

b. Study Design

The ecological studies conducted for the applicant are designed and supervised by two types of committees:

> "In order to assure the adequacy of all ecological studies conducted by Con Edison, the studies are directed by the Hudson River Policy and Technical Committees. Each of these committees consists of representatives from New York State Department of Environmental Conservation, New Jersey Division of Fish and Game, National Marine Fisheries Service (formerly the U.S. Bureau of Commercial Fisheries) and the U.S. Bureau of Sport Fisheries and Wildlife. In addition, representatives from the Connecticut State Board of Fisheries and Game Participate as advisors in all Policy Committee meetings. The committees outline and supervise the studies and ensure that they are performed in a professional manner. The committees present their conclusions and recommendations to Con Edison.
>
> "In addition to the Hudson River Policy and Technical Committees, Con Edison has organized a Fish Advisory Board consisting of expert biologists and engineers from the United States and Great Britain" (page 2.3.6-9 of Reference 1).

c. Present Studies

The ongoing research at Indian Point was outlined in the applicant's Supplement No. 1 to Environmental Report[1] as follows:

> "In November 1970, New York University Institute of Environmental Medicine was contracted by Con Edison to perform studies on the effect on passing aquatic organisms through the condenser. These studies are being done at Unit No. 1 located at Indian Point. . . . . . . Two consecutive years of such investigation are envisioned. Studies will also be conducted on non screenable organisms passing through the condenser of Unit No. 2, which is scheduled to go into operation in 1972.
>
> "Scope of this work includes studies on survival, extent of mechanical damage, thermal shock tolerance and effects on reproductive potential of entrained organisms. Effect on the productivity of the entrained phytoplankton is also under investigation. Consideration is being given to such aspects as recycling of already exposed organisms to the condenser passage, time required for passage through the condensers, exposure in the discharge canal and reproduction rates of organisms in the ambient water" (page 2.3.6-7, Reference 1).
>
> "Monitoring programs have been utilized at the Indian Point site as early as 1958. These programs are of three general types. The first of these, which utilizes the Automated Environmental System

(AES), concentrates primarily on the thermal, chemical and hydrological aspects of the environment. The second program deals exclusively with environmental monitoring related to radiological aspects of plant operation. In addition, many biological, hydrological and mechanical aspects of the environment are monitored in connection with studies being done for Con Edison by various consultants" (page 2.3.6-12, Reference 1).

"The Automated Environmental System (AES) has been used since 1969 and continuously monitors temperature, dissolved oxygen and pH in water pumped directly from in front of the intake canal from a depth of 13 3/4 feet below mean low water. In addition, temperature, dissolved oxygen, pH, salinity and cupric ion are monitored in water pumped directly from the effluent canal from a depth of 5 1/2 feet below mean low water. . . . . . The AES unit also maintains a tide and temperature record of the Hudson River immediately surrounding the Indian Point site" (page 2.3.6-12, Reference 1).

"Con Edison's radiological environmental monitoring program includes measurements of radioactivity in fresh water, river water, river sediments, fish, aquatic vegetation, vegetation, soil and air in the vicinity of the Indian Point station. This program began with a survey instituted in 1958 (four years prior to operation of Unit No. 1) to determine the radioactivity in the environment in the vicinity of the Indian Point station. The purpose of this survey was to determine the natural background radioactivity and to show the variations in the activities that may be expected from natural sources, fallout from bomb tests, and other sources in the vicinity. The program has been continued to the present so that changes in the environment resulting from operation of Unit No. 1 could be accounted for, and will be continued throughout the operating lifetime of all three units.

"Aquatic vegetation from the lake on site and other nearby lakes is sampled during the growing season and analyzed for gross beta activity, and a gamma spectrum is also run. Aquatic vegetation is collected from the Hudson River at points at the discharge canal, one-half, one and two miles downstream from the plant. This vegetation is analyzed in the same manner as the lake aquatic vegetation. Bottom sediment is taken from the Hudson River in the vicinity of the plant and at points one-half, one and two miles downstream. This sediment is measured for gross beta activity and is also analyzed for gamma activity.

"River fish caught in the vicinity of the plant are measured for gross beta and a gamma spectrum analysis is made. Land vegetation is sampled primarily in the downwind direction from the plant at points one-quarter, one-half, one and two miles south of the plant" (page 2.3.6-18, Reference 1).

d. Planned Studies

The applicant has stated its intentions concerning the implementation of future studies. The scope of these studies was described in Supplement No. 1[1] to the Environmental Report for Unit No. 2 as follows:

"Plans are in progress for a continuation of the study performed by the Raytheon Company during 1969-70 as a long term ecological study in the vicinity of Indian Point to assess any effects with respect to the operation of the station. These studies will be directed by the Hudson River Policy and Technical Committees and financed by Con Edison. This ecological work will investigate the interaction of plant operation with the environment of the river.

"The survey will include sampling macro and microplankton, fishes, benthic organisms and water chemistry, as a continuation of the work performed during 1969 and 1970. Con Edison proposes to continue the collection of such data until December 1975, with decreasing sampling intensity from year to year. A discussion of some particular aspects follows.

"Thermal plumes were mapped by infrared aerial photography in conjunction with bathythermograph readings from boats during 1969 and 1970. Mapping will be done when Unit No. 2 goes on-line with tide stages, discharge gate configurations and seasons as variables. Mapping will also be done in 1974 when Unit No. 3 is expected to go on-line.

"Entrainment studies will be continued at Unit No. 1 for two years and at Unit No. 2 for one year. It is expected that a two year study will provide the data needed to determine the effect of passing non-screenable organisms through the plant.

"Con Edison has been monitoring the traveling screen washings for impinged fishes since 1970. These data are necessary to determine the species composition being collected. This monitoring will be extended to Unit No. 2 when the unit begins commercial operation.

"Con Edison proposes that the food habits of five major fish species from the Indian Point area be investigated. These studies will enable a further evaluation of the position of white perch in the food web and its relationship, if any, to striped bass. Con Edison proposes to also investigate the food habits of the different size groups of each species.

"A study will be undertaken to determine the age and growth of white perch and striped bass. This data will be used to further evaluate the population dynamics of these species in the Hudson River.

"This study will also supply pertinent data needed to estimate the natural mortality of each species. It is felt that such data would be of value in any meaningful assessment of the effect on the fish population of such other factors such as entrainment in the plant intake, as well as commercial and sport exploitation.

"Con Edison is also proposing that a tagging study be performed on white perch and striped bass at the Indian Point site. Population estimtes, and movement patterns of these fish need to be studied by tagging and recapturing before an evaluation can be made on the effect of exploiting them at the intakes.

"The data from such a study will be useful in making population estimates and the recaptures will also supply data useful in determining movement patterns. This movement data, in turn, may be utilized to determine whether the plants are effecting a local population, a migrating population or populations that aggregate in the area only during winter.

"It is thought that fish kills at Indian Point during winter months are partly attributable to the lethargic condition of fish. A scientific evaluation of such a lethargic state and the extent to which it contributes to fish kills is proposed. No work has been done on response of white perch and other Hudson River fish species to near freezing temperatures. It is not unlikely that considerable mortality may be occurring under natural conditions and these dead fish may be collecting on the intake screens. It is therefore proposed that tests be conducted at near freezing temperatures (33 ± 2 F.) to determine survival, swim speed and the scope of activity of white perch" (page 2.3.6-12, Reference 1).

e. Needed Information

In order to properly evaluate the biological impact of the operation of Indian Point Units 1 and 2, several questions must be answered and several aspects of the biota must be monitored:

1. The flow characteristics of the Hudson within the zone bounded by the length of the tidal excursion from low to high tide in the upstream direction and throughout Haverstraw Bay in the seaward direction will be detailed in both vertical and horizontal cross sections through complete tidal cycles under a variety of lunar phases and a variety of fresh water inflows. These studies should include not only steady-state conditions but also conditions of net upstream and net downstream movement of salt water.

2. The magnitude of entrainment mortality will be determined by the applicant. For these studies, samples should be taken from both ends of

the canal, i.e., as close to the condenser as possible and just before the water is discharged into the river. In addition, several locations in the plume should be sampled. These samples should be compared with those taken at the intake and from various stations in the river and held several days to determine any latent mortality. Organisms that survive should be cultured to determine any loss of reproductive capabilities. The species composition must be determined and compared to the river as a whole and should include both producer and consumer species.

3. The sensitivity to residual chlorine will be determined for all life stages of common or otherwise important species which are present at Indian Point. The tolerance limits must be compared to levels in the thermal plume and the river.

4. The thermal plume will be mapped, and the duration of exposure of organisms to the various temperature increments should be determined. The species composition of the plume must be measured and compared to the adjacent segments of the river. The amount of inhibition and augmentation of photosynthetic activity in the plume would have to be established. In addition, the composition of the phytoplankton community must be carefully monitored.

5. The reproductive status and food requirements of the more abundant consumer species must be determined. The species of crustaceans included need to be those which appear to be most susceptible to entrainment or thermal damage. The fish species involved would have to include those species which have eggs or larval stages susceptible to withdrawal. Among these would be the bay anchovy, white perch, tomcod, blueback herring, alewife, smelt, and striped bass.

6. Data gathered concerning thermal effects and entrainment mortality will include times when the ambient temperature is at its yearly maximum.

7. Radiological monitoring will continue and be applied to dose calculations for terrestrial and aquatic organisms.

8. The monitoring of impingement of fish on the screens will include counts of those impinging on the outer fixed screens as well as the traveling screens.

The data collected would have to be analyzed in view of the present knowledge and applied to the populations of organisms in the Hudson at Indian Point.

E. RADIOLOGICAL IMPACT OF ROUTINE PLANT OPERATION ON MAN

1. Introduction

Radioactive nuclides during operation under normal working conditions will be released as liquids and gases from both Indian Point Unit No. 1 and Unit No. 2. The release of these effluents will be conducted in accordance with the limitations set forth in 10 CFR 20[84] and the guidance of 10 CFR 50[85] to keep the levels of radioactive material in effluents to unrestricted areas "as low as practicable." Operating experience with similar power plants licensed for operation by the Commission has shown that actual releases of radionuclides from these plants have generally been small fractions of the limits set forth in 10 CFR 20, consistent with the Commission's policy of limiting radioactive releases to the lowest practicable level. Information on radioactive releases from operating experience of pressurized power reactors is shown in Appendix III-2.

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

2. General Considerations For Determination of Dose Estimates

Pathways for external (radiation source outside the body) and internal (radiation source inside the body) exposures are schematically illustrated in Fig. V-7. Immersion in the gaseous effluent as it is diluted and dispersed could lead to external exposure, while the dispostion of radioactive particulates on the land surface could lead to direct external exposure and to internal exposure by the ingestion of food products through various food chains. Similarly, swimming in waters in which radionuclides have been discharged could lead to external exposure, while the utilization of these waters for fishing, drinking, irrigation, or food preparation could lead to internal exposures. The doses calculated for the internal exposures are estimates of the total dose an individual will accrue within his lifetime from each intake.

Annual radiation doses, both to individuals (in millirem (mrem), where 1 millirem is 1/1000 rem) and the population (in man-rem) near the reactor are estimated. The man-rem or population dose is the sum of the total body doses to all individuals in the population considered. The dose estimates are based on an all adult population. For the case of radioactive iodine in milk, the dose estimated for a 1-year-old child is about 10 times as large as for an average adult.[85] Estimates of individual doses are made for total body, liver, kidney, bone, thyroid, and gastro-intestinal tract. Where they are significant, the estimates of dose to organs other than total body are discussed.

Factors for converting internal radiation exposures to dose were obtained with models and data published by the International Commission on Radiation Protection[89] and other recognized authorities.[83] These models and data have been incorporated in computer programs[90] to facilitate estimation of dose. Factors for converting external radiation exposures to dose were obtained with a computer code containing models adapted from standard tests.[89,90]

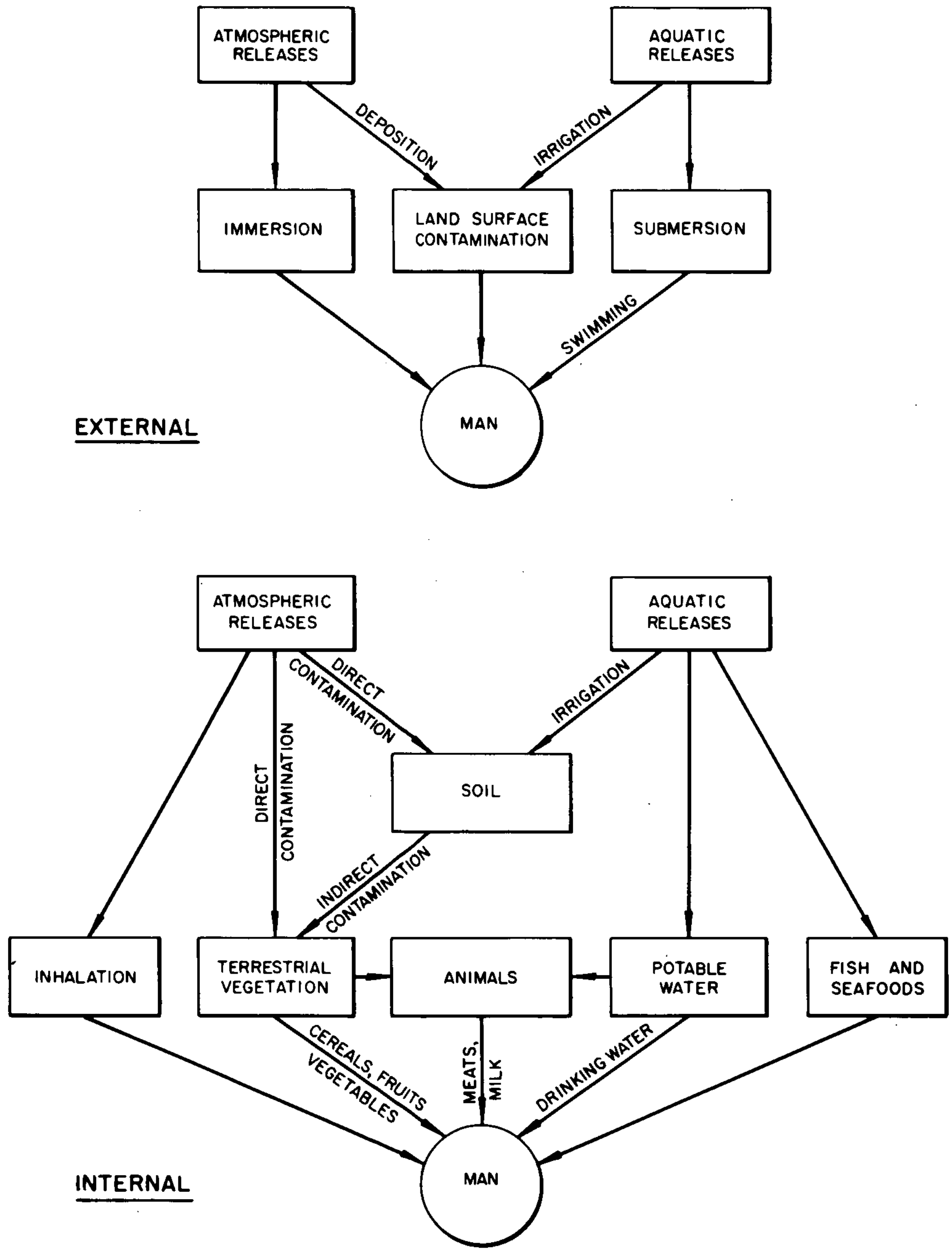

Fig. V-7 - Pathways for External and Internal Exposure of Man from Atmospheric and Aquatic Releases of Radioactive Effluents.

a. Dispersion of Gaseous Effluents

Average annual concentrations of radionuclides contained in the air and deposited on the ground at distances up to 50 miles from the Station site were obtained from an atmospheric transport model[91,92] for which a computer program was developed.[93] The deposition velocities used in the calculations for the noble gases (krypton and xenon), methyl iodide (CH_3I), elemental iodine (I_2), and particulates were 10^{-6}, 10^{-3}, 1, and 1 cm/sec. respectively. In this model, the reduction of radionuclide concentrations in the air at ground level by radioactive decay and deposition on the ground are taken into account.

b. Dispersion of Liquid Effluents

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

3. Estimates of Dose

Estimates of doses to individuals and the population within 50 miles which result from radionuclide effluents discharged during normal operation of Indian Point Units 1 and 2 are treated below. Estimated doses to an individual for several exposure pathways are given in Table V-7. The population dose from immersion in gaseous effluents is given cumulatively as a function of distance in Table V-8. The estimates of dose due to gaseous effluents are based on the anticipated radionuclide releases given in Section III.E.2 of this report and the actual site specific meteorological data of Indian Point as given in Supplement 1 to the Environmental Report on Indian Point Unit No. 2. The anticipated radionuclide releases in liquid effluent as described in Section III.E.2 is diluted at the point of discharge by a factor ranging from 2 to 40, depending upon the variations of flow of the Hudson River.

a. Gaseous Effluents

The average concentrations of radionuclides at ground level were estimated in each of sixteen 22.5° sections at various distances from the site. The concentration of gaseous effluent released from Indian Point Unit No. 1 is calculated for release from the 80-meter stack. The gaseous effluent from Unit No. 2 is released from the exhaust vent on top of the containment building 65 meters above the ground level. However, no credit is taken for this release height, and the ground level concentrations are calculated for a surface release.

(1) Dose Estimates for Immersion and Ground Contamination

The highest estimate of total body dose [about 0.15 millirem per year (mrem/year) of release] occurs for an individual located along the southern site boundary. The population dose from immersion for persons living within 50 miles

TABLE V-7

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

Pathway	Location or Amount	Total-Body Dose (millirem)	Thyroid Dose (millirem)
Air immersion and surface contamination	0.6 mile S	0.15	0.15
Inhalation of contaminated air	0.6 mile S	< 0.01	0.13
Terrestrial food chain	0.6 mile S	< 0.01[a]	< 1.3[a]
Aquatic food chain	16 lb/year	0.02	0.14
Swimming - (Hudson River)	1% of year	< 0.01	< 0.01

[a]Based on the assumption that all of the individual's food, excluding milk, was produced at this location.

TABLE V-8

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

Distance	Cumulative Population (1970)	Cumulative Population Dose (man-rem)	Individual Average Dose (millirem)
0-1	2,213	0.20	9.0×10^{-2}
0-2	18,552	0.43	2.3×10^{-2}
0-3	30,175	0.53	1.8×10^{-2}
0-4	39,465	0.59	1.5×10^{-2}
0-5	65,830	0.82	1.3×10^{-2}
0-10	211,373	1.4	6.8×10^{-3}
0-20	916,379	3.9	4.2×10^{-3}
0-30	4,302,799	8.2	1.9×10^{-3}
0-40	10,710,185	12	1.2×10^{-3}
0-50	16,507,168	15	8.7×10^{-4}

of the Station is 15 man-rem as based on 1970 census data. The dose estimate of 0.008 millirem per year of release to an individual from external exposure to ground contamination is due primarily to the surface deposition of ^{131}I.

(2) Dose Estimates for Inhalation

The estimated total-body dose of 0.0005 millirem per year of release to an individual located at the northern or southern site boundary is based on an inhalation rate of 2×10^7 cc/day.[87] The corresponding estimates of dose to the gastrointestinal tract and thyroid are, respectively, 0.003 and 0.13 millirem per year of release. The total dose to the thyroid from external exposure and internal inhalation exposure to the gaseous effluent would be 0.28 millirem per year of normal radionuclide release.

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

Deposition of radioparticulates and iodine occurs from the stack 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 utilizing all of these mechanisms exists for nuclides carried into the soil by rainfall and subsequently into food plants through their roots. A general purpose environmental model[94] was used to estimate the resulting dose to an individual. The total-body estimate of less than 0.01 millirem per year of release at 0.6 miles in the southern direction is based on the assumption that all of the individual's vegetables and meat are produced at this location.

An estimate of dose from ^{131}I was made for the pasture-cow-milk-man pathway. An effective deposition velocity of 1 cm/sec was used to calculate the rate of elemental radioiodine deposition on pasture grass. The same general environmental model used above converted the deposition rate to a radioiodine concentration in milk. The dose to an individual was estimated assuming 0.6 liter intake of locally produced milk per day. The estimated thyroid dose to an individual drinking this milk is less than 0.15 millirem per year of normal radionuclide release.

b. Liquid Effluents

The anticipated quantities of radionuclides in the liquid effluents discharged from the radioactive waste systems of Units Nos. 1 and 2 are listed in Table III-4 and -6. These effluents will be mixed with an average cooling water flow of 2.0×10^{15} cc/year and then further diluted by a factor ranging from 2 to 40 after this water is discharged into the Hudson River. Radioactive decay and river dilution are accounted for in the calculated concentration of each radionuclide.

(1) Dose Estimates for Ingestion of Fish

The highest dose to an individual from fish consumption is estimated to be 0.02 millirem per year of release by assuming that he consumes 20 grams of fish per day (6,350 g per year is the per capita figure for the United States)[(6)] and that all of the fish consumed come from the Hudson River around the site, where the average dilution of the discharged effluent was assumed to be 20. Radionuclide concentrations in the fish were assumed to be in equilibrium with those in the river. The radionuclide concentrations in fish were determined by multiplying the radioactivity levels in water by concentration factors (radionuclide concentration in fish flesh divided by radionuclide concentration in water).

A population dose from ingestion of fish is difficult to estimate due to the lack of fish harvest data for the Hudson River. If it is assumed that 10% of the approximately 16 million people living within 50 miles of the site obtain 10% of their fish from the Hudson River, an annual population dose of 3.2 man-rem is estimated.

(2) Dose Estimates for Ingestion of Hudson River Water

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

(3) Dose Estimates for Swimming in the Hudson River

Swimming in the river was considered a potential source of external exposure. The estimate of less than 0.01 millirem per year of radionuclide release for the radiation dose to an individual was calculated under the assumption that he would swim in the river 1% (1 hour per day for three months each year) of the year. The estimated population dose of 0.47 man-rem was obtained by assuming that 1% of the population living within 50 miles of the site spends 1% of the year swimming in the river.

4. Assessment of Annual Dose Estimates

A summary of estimated annual doses which might be expected by individuals at points of maximum exposure to the gaseous effluents appear as the first three entries in Table V-7. These doses are not reduced by shielding factors, occupancy factors, or diet source factors. Even with the assumptions used, the sum of the estimated annual individual doses for total body is less than 2% of natural background dose and less than 0.3% of the exposure limits of 10 CFR 20.

The last three entries in the Table V-7 are based on reasonable dilution and intake assumptions which are stated. The estimated doses are so small that large changes in the assumptions would still not result in doses which are a large percentage of natural background.

The estimated population dose from the release of gaseous effluents is shown in Table V-8. The average doses within 50 miles of the Station is less than 0.001% of the natural background dose. Individuals spending all of their time within 2 miles of the reactor would receive only about 0.09% of the typical background dose of 100 millirem per year. This is far below the normal variation in background dose and represents no measurable radiological impact on the population from the operation of Indian Point Units Nos. 1 and 2. Similar considerations for the liquid effluents indicate that no discernible radiological impacts are expected. A summary of the annual radiological impact from all sources is presented in Table V-9.

5. Radiation Monitoring

The applicant began a preoperational radiological environmental monitoring program in 1958 to determine the levels of radioactivity prior to Plant operations (operation of Indian Point Unit No. 1 began in 1962) and to show the variations in the levels that could be expected from natural sources, fallout from weapons testing, and other sources in the vicinity of Indian Point.[97] The program included measurements of radioactivity in samples of fresh water, river water, rainwater, river bottom sediments, fish, aquatic vegetation, soil, terrestrial vegetation, and air in the environs of the Indian Point Station. In addition, the New York State Department of Environmental Conservation has conducted extensive radiological surveys in the vicinity of the Indian Point Station since 1958, and the New York University Institute of Environmental Medicine has conducted a research program on the ecology of the Hudson River since 1964, which includes some radioecological work. Both these programs are continuing. Although the New York University Institute of Environmental Medicine research program is not a monitoring program, the results of this research are germane since they provide information about the distribution of radionuclides in the river system.

The radiological environmental monitoring survey program for Indian Point Unit No. 2 will be a continuation of the preoperational studies and Indian Point Unit No. 1 post-operational environmental monitoring surveys.[97] The survey program is designed to be conducted at three different program levels, the program level in use at any particular time being dictated by the Station releases for the preceding month. A detailed tabulation of the program levels, criteria governing program level used, and a map showing sampling and measurement locations are given in Section 2.3.6.3 of the applicant's Supplement No. 1 to the Environmental Report. Both the applicant's and New York State's radiological environmental monitoring programs are geared to provide more intensive surveillance in the event of a significant increase in radioactive discharge from the Station.

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

TABLE V-9

INTEGRATED ANNUAL DOSE TO THE GENERAL POPULATION FROM THE OPERATION OF THE INDIAN POINT STATION

Pathway	People	Man-rem
Cloud (immersion)	16,000,000	15
Fish	1,600,00	3.2
Swimming	1,600,000	0.47
Transportation of Irradiated Fuel	300,000*	1.8**
Transportation of Radioactive Waste	180,000	0.9
	Total	∿ 21.4

*This includes 10 people close by and 2 drivers as well as 300,000 people along the route.

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

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

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

1. Transportation of Nuclear Fuel and Solid Radioactive Waste

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

The applicant has indicated that cold fuel for the reactor will be transported by truck either from Cheswick, Pennsylvania, a distance of 450 miles, or Columbia, South Carolina, a distance of about 800 miles. The applicant has indicated the irradiated fuel will be transported by truck or rail to Morris, Illinois, a distance of about 1,000 miles. The present plans are to transport the irradiated fuel by truck from the site to the nearest railhead (about 1.5 miles from the site boundary) and by rail the remainder of the 1,000 miles to the Midwest Fuel Recovery Plant in Morris, Illinois. Future shipments of irradiated fuel may be by truck only. The solid wastes will be transported by truck to Morehead, Kentucky, for disposal, a distance of about 600 miles. Transport of radioactive material will be conducted under the Commission's regulations 10 CFR 71, and the Department of Transportation's (DOT) regulation's 49 CFR 173.[100]

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 8 truckloads of 7 containers each will be required each year to meet the needs of both reactors.

b. Transport of Irradiated Fuel

Fuel elements removed from the reactor will be unchanged in appearance and will contain much of the original U-235 (which is recoverable). As a result of the irradiation and fissioning of the uranium, the fuel element will contain large amounts of radioactivity, mostly fission products. As the radioactivity decays, it produces radiation and "decay heat." The amount of radioactivity remaining in the fuel varies according to the length of time after discharge from the reactor. After discharge 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 90 days cooling period in approved casks designed for transport by either truck or rail. The cask will weigh perhaps 30 tons for truck or 100 tons for rail. To transport the irradiated fuel from Unit No. 2, the applicant estimates 22 truckload shipments per year with 3 fuel elements per cask and

1 cask per truckload; or 10 rail carload shipments per year with 7 fuel elements per cask and 1 cask per carload. With the addition of 13 truckloads or 6 carloads for transporting the irradiated fuel from Unit No. 1, that would be a total of 35 truckloads or 16 carloads per year from both units. An equal number of shipments will be required to return the empty casks.

c. Transport of Solid Radioactive Wastes

The applicant estimates that from 100 to 150 drums of solid radioactive wastes will be produced in operating Unit No. 2 each year. Spent resins and waste evaporator bottoms will be solidified in a mixture of vermiculite and cement and soft, solid wastes such as paper, rags, etc., compacted in DOT approved Specification 17-H drums 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. 2 each year. We estimate an equal number of truckloads from Unit No. 1, to average 15 truckloads per year from both Units.

d. Principles of Safety in Transport

Protection of the public and transport workers from radiation during the shipment of nuclear fuel and waste, described in Sections G. 2 and G.3, is achieved by a combination of limitations on the contents (according to the quantities and types of radioactivity), the package design, and the external radiation levels. Shipments move in routine commerce and on conventional transportation equipment. Shipments are therefore subject to normal accident environments, just like other nonradioactive cargo. The shipper has essentially no control over the likelihood of an accident involving his shipment. Safety in transportation does not depend on special routing.

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

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

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

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

Each package in transport is identified with a distinctive radiation label on two sides, and by warning signs on the transport vehicle.

Based on the truck accident statistics for 1969,[101] a shipment of fuel or waste from a reactor may be expected to be involved in an accident about once every six years. In case of an accident, procedures which carriers are required[102] to follow will reduce the consequences of an accident in many cases. The procedures include segregation of damaged and leaking packages from people, and notification of the shipper and DOT. Radiological assistance teams are available through an inter-Governmental program to provide equipped and trained personnel. These teams, dispatched in response to calls for emergency assistance, can mitigate the consequences of an accident.

2. Radiological Impact - Transportation

Exposures During Normal (No Accident) Conditions

a. Cold Fuel

The transport of cold fuel has been described in Section F. 1.a. Since the nuclear radiations and heat emitted by cold fuel are small, there will be essentially no effect on the environment during transport under normal conditions. Exposure of individual transport workers is estimated to be less than 1 millirem (mrem) per shipment. For the 8 shipments, with two drivers for each vehicle, the total dose would be about 0.02 man-rem* per year. The radiation level associated with each truckload of cold fuel will be less than 0.1 mrem/hr at 6 feet from the truck. A member of the general public who spends 3 minutes at an average distance of 3 feet from the truck might receive a dose of about 0.005 mrem per shipment. The dose to other persons along the shipping route would be extremely small.

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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).

b. Irradiated Fuel[4]

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

For the combination truck-rail shipment, the individual truck driver would be unlikely to receive more than 15 mrem in the short trip to the railhead. We estimate that during the transfer of the cask from the truck to the rail car, 4 men might work for an hour at an average distance of 6 feet from the cask and might receive individual doses of about 10 mrem/hr.

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

The total dose to transport workers for the 16 shipments by truck and rail, assuming 2 drivers on each truckload, would be about 1.2 man-rem.

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

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

c. Solid Radioactive Wastes

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

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

G. PLANT DISMANTLING AND DECOMMISSIONING

Under the Commission's regulations in 10 CFR 50, an application must contain information sufficient to demonstrate that the applicant possess or has reasonable assurance of obtaining the funds necessary to cover the estimated costs of permanently shutting the Plant down and maintaining it in a safe condition. It is expected that the applicant will supply detailed dismantling information to the Commission at such time that an application for an amendment for dismantling of the facility to the operating license is filed. The staff will at that time conduct a Safety and Environmental Evaluation of the decommissioning procedures proposed by the applicant.

1. Impacts on the Environment

Dismantling the Plant will have many of the same impacts on the environment as the original site preparation and Plant construction. There will be temporary disturbances due to the dismantling activities and the permanent restoration of most of the site to ecological productivity.

It is expected that the dismantling of the Plant will cost several millions of dollars and take more than a year to complete. During that time, workmen will be on the site, quantities of debris, salvageable material, and radioactive material will be transported from the site by truck, barge, or sail. Concrete and other construction materials will be used to entomb the reactor and associated highly radioactive components. A considerable amount of earth-moving will be required to restore the parking lots and other areas to usable grade levels, and finally, a security fence will be erected on the ground above the entombed reactor site.

To the extent that any structures of components are not completely demolished and their foundations removed, that small amount of land will be committed to non-productive use. If the soil under any structure which has been demolished is not replaced or cleared of chemical contamination, that land will be non-productive until natural processes leach the chemicals away.

2. Radiological Impacts on Environment

The dismantling of the Plant will have radiological impacts characteristic of transporting from the site irradiated fuel and radioactive wastes. See Section V.F.

The radioactive materials not transported offsite most likely will be entombed with the reactor and associated components. The entombment will be designed to maintain its integrity, to provide time for radioactive decay of activated and fission products. In addition, the entombment will be permanently placarded to identify it as a radioactive area.

After dismantling is completed and the site is maintained in a safe condition, it is anticipated that the proposed action will have no significant radiological impact on the environment.

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100. 49 CFR § 173.398; 10 CFR § 71.36.

101. Federal Highway Administration, "1969 Accidents of Large Motor Carriers of Property," December 1970.

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VI. ENVIRONMENTAL IMPACT OF POSTULATED ACCIDENTS

A. PLANT ACCIDENTS

A high degree of protection against the occurrence of postulated accidents at Indian Point Unit No. 2 is provided through correct design, manufacture, and operation, and the quality assurance program used to establish the necessary high integrity of the reactor system, as considered in the Commission's Safety Evaluation dated November 16, 1970 and the Supplements to the Safety Evaluation. 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, in spite of the fact that they are extremely unlikely, and engineered safety features are installed to mitigate the consequences of these postulated events. 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 staff's safety review, extremely conservative assumptions were used for the purpose of comparing calculated doses resulting from a hypothetical release of fission products from the fuel, against the 10 CFR 100 siting guidelines. The calculated doses that would be received by the population and environment from actual accidents would be significantly less than those presented in the staff's 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 the Supplement No. 2 to the Environmental Report, dated October 15, 1971.[1]

The applicant's report has been evaluated, using the standard accident assumptions and guidance issued as a proposed amendment[2] to Appendix D of 10 CFR 50 by the Commission on December 1, 1971. 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 consequence end of the spectrum have a low occurrence rate, and those on the low consequence end have a higher occurrence rate. The examples selected by the applicant for these classes are shown in Table VI-1. The examples selected are reasonably homogeneous in terms of probability within each class, although the staff considers the release of the waste gas decay tank contents as more appropriately in Class 3, and the steam generator tube rupture as more appropriately in Class 5.

Certain assumptions made by the applicant do not exactly agree with those in the proposed Annex to Appendix D, but the use of alternative assumptions does not significantly affect overall environmental risks. Table VI-2 reflects the types of accidents described in the proposed amendment to Appendix D, 10 CFR Part 50, published in the Federal Register on December 1, 1971, for comment and interim guidance.

The staff's estimates of the dose which might be received by an assumed individual standing at the site boundary in the downwind direction, using the assumptions in the proposed Annex to Appendix D, are presented in Table VI-2. The staff's 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 around the site for the year 1980.

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 which are anticipated during Plant operation 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 failure and some steam generator leakage, the events in Classes 3 through 5 are not anticipated during Plant operation but 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 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 basis of protection systems and engineered safety features. Their consequences could be severe. However, the probability of their occurrences is so small that their environmental risk is extremely low. Defense in depth (multiple physical barriers), quality assurance for design, manufacture and operation, continued surveillance and testing, and conservative design are all applied to provide and maintain the required high degree of assurance that potential accidents in this class are, and will remain, sufficiently small in probability that the environmental risk is extremely low.

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 within or comparable to the Maximum Permissible Concentrations (MPC) of Table II of 10 CFR 20. Table VI-2 also shows that the estimated integrated exposure of the population of 21,000,000 (estimated 1980 population) within 50 miles of the Plant from each postulated accident would be orders of magnitude smaller than that from naturally occurring radioactivity, which corresponds to approximately 2,100,000 man-rem per year based on a natural background level of 100 millirem per year. 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. It is concluded from the results of the realistic analysis that the environmental risks due to postulated radiological accidents are exceedingly small.

TABLE VI-1

CLASSIFICATION OF POSTULATED ACCIDENTS AND OCCURRENCES

Class	AEC Description	Applicant's Example(s)
1.0	Trivial incidents	Trivial Consequences
2.0	Small releases outside containment	Small valve or pipe leak in the auxiliary building
3.0	Radwaste system failures	Waste gas decay tank valve leak, inadvertent discharge of the contents of a waste liquid tank or waste gas decay tank
4.0	Fission products to primary system (BWR)	Not applicable
5.0	Fission products to primary and secondary systems (PWR)	Normal operation with fuel failures and steam generator leaks
6.0	Refueling accidents	Dropped fuel assembly inside containment
7.0	Spent fuel handling accident	Dropped fuel assembly outside containment
		Onsite transportation accident
8.0	Accident initiation events considered in design basis evaluation in the SAR	Loss of coolant, rupture of waste gas decay tank, control rod assembly ejection, steam line break, steam generator tube rupture
9.0	Hypothetical sequence of failures more severe than Class 8	Extremely small probability of occurrence

TABLE VI-2

SUMMARY OF RADIOLOGICAL CONSEQUENCES OF POSTULATED ACCIDENTS

Class	Event	Estimated Fraction of 10 CFR 20 Limit at Site Boundary 1/	Estimated Annual Dose to Population in 50 Mile Radius, Man-rem
1.0	Trivial incidents	2/	2/
2.0	Small releases outside containment	2/	2/
3.0	Radwaste system failures		
3.1	Equipment leakage or malfunction	0.095	49
3.2	Release of waste gas storage tank contents	0.37	190
3.3	Release of liquid waste storage tank contents	0.004	2.3
4.0	Fission products to primary system (BWR)		
4.1	Fuel cladding defects	N. A.*	N. A.*
4.2	Off-design transients that induce fuel failures above those expected	N. A.*	N. A.*
5.0	Fission products to primary and secondary systems (PWR)		
5.1	Fuel cladding defects and steam generator leaks	2/	2/
5.2	Off-design transients that induce fuel failure above those expected and steam generator leak	0.002	1.1
5.3	Steam generator tube rupture	0.12	65

Class	Event	Estimated Fraction of 10 CFR 20 Limit at Site Boundary[1/]	Estimated Annual Dose to Population in 50 Mile Radius, man-rem
6.0	Refueling accidents		
6.1	Fuel bundle drop	0.02	10
6.2	Heavy object drop onto fuel in core	0.34	180
7.0	Spent fuel handing accident		
7.1	Fuel assembly drop in fuel rack	0.012	6.5
7.2	Heavy object drop onto fuel rack	0.05	26
7.3	Fuel cask drop	N. A.*	N. A.*
8.0	Accident initiation events considered in design basis evaluation in the safety analysis report		
8.1	Loss-of-coolant accidents		
	Small Break	0.21	190
	Large Break	1.8	5,800
8.1(a)	Break in instrument line from primary system that penetrates the containment	N. A.*	N. A.*
8.2(a)	Rod ejection accident (PWR)	0.18	580
8.2(b)	Rod drop accident (BWR)	N. A.*	N. A.*
8.3(a)	Steamline breaks (PWR's outside containment)		
	Small Break	<0.001	0.34
	Large Break	0.001	0.65

Class	Event	Estimated Fraction of 10 CFR 20 Limit at Site Boundary1/	Estimated Annual Dose to Population in 50 Mile Radius, man-rem
8.3(b)	Steamline breaks (BWR)		
	Small Break	N. A.*	N. A.*
	Large Break	N. A.*	N. A.*

1/Represents the calculated fraction of a whole body dose of 500 mrem or the equivalent dose to an organ.
2/These releases are expected to be in accord with proposed Appendix I to CFR 50 for routine effluents (i.e., 5 mrem/yr to an individual from all sources).

* N. A. means not applicable.

B. TRANSPORTATION ACCIDENTS

1. Cold Fuel

The cold fuel to be transported to Indian Point has been described in Section G.F.1.a. Under accident conditions other than accidental criticality, the pelletized form of the nuclear fuel, its encapsulation, and the low specific activity of the fuel, limit the radiological impact on the environment to negligible levels.

The packaging is designed to prevent criticality under normal and severe accident conditions. To release a number of fuel assemblies under conditions that could lead to accidental criticality would require severe damage or destruction of more than one package, which 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 transport, persons within a radius of about 100 feet from the accident might receive a serious exposure but beyond that distance, no detectable radiation effects would be likely. Persons within a few feet of the accident could receive fatal or near-fatal exposures unless shielded by intervening material. 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 and normally would not recur. Residual radiation levels due to induced radioactivity in the fuel elements might reach a few roentgens per hour at 3 feet. There would be very little dispersion of radioactive material.

2. Irradiated Fuel

Effects on the environment from accidental releases of radioactive materials during shipment of irradiated fuel (see Section V.F.1.b.) have been estimated for the situation where contaminated coolant is released and the situation where gases and coolant are released.

a. 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 which 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 Plant.

Leakage of liquid at a rate of 0.001 cc per second or about 80 drops/hour 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 millirem and only a very few people would receive such exposures.

b. 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 feet or so of the accident might receive doses as high as a few hundred millirem. Under average weather conditions, a few hundred square feet might be contaminated to the extent that it would require decontamination (that is, Range I contamination levels) according to the standards[3] of the Environmental Protection Agency.

3. Solid Radioactive Wastes

It is highly unlikely that a shipment of solid radioactive waste will be involved in a severe accident during the 40-year life of the Plant. If a shipment of low-level waste (in drums) becomes involved in a severe accident, some release 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 clean-up might be required, no significant exposure to 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.

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 Station, 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.

REFERENCES FOR CHAPTER VI

1. Consolidated Edison Company of New York, Inc., Supplement No. 2 to the Environmental Report on Indian Point No. 2, October 15, 1971.

2. Annex to Appendix D of 10 CFR 50, "Consideration of Accidents in Implementation of the National Environmental Policy Act of 1969" (FR 36: No. 231, pp. 22852-22854), December 1, 1971.

3. 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 and 2 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 or chloramines to the Hudson River.

5. Releases of radionuclides to the environment.

6. Reduced dissolved oxygen concentrations in the effluent water.

Other adverse effects would include the consumptive use of non-replenishable natural resources and the long-term commitment of other resources. These aspects of the Plant are discussed in Chapters VIII and IX and are not included in this Chapter.

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. 2 should not produce appreciable alterations in the public use of the general area beyond those caused by the operation of Unit No. 1. The site is to be developed for multiple public use, including a new visitors' center, a nature area, increased parking facilities, and a public marina. 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 fresh water lake should ultimately more than compensate for the loss of any wild-life habitat because of the land committed to the facility. Since the site was formerly an amusement park which was eventually 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 amount of land used for transmission line corridors to convert the Plant's electrical output to the switchyard and eventually to the applicant's power system involved a minimal use of land. No added right-of-way was required to convert a single 345-kV transmission line from Unit No. 2 to the Buchanan Substation located 200 feet from the Indian Point site boundary. The line from the Buchanan Substation is 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 guidelines for protection of aesthetic and other environmental values.

2. Air Use

The operation of Indian Point Unit No. 2 would not greatly increase the level of nonradioactive air pollutants in the area. It would, however, allow the applicant to reduce the number of fossil fueled plants in operation, thereby decreasing the pollution load of the air near the areas where the other plants are located. Only minor amounts of combustion products as listed in Table III-11 will be released from the Station during operation of diesel-powered engines for emergency use.

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 is related to the heat discharged into the Hudson River. 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. However, Plant operations should not interfere with present industrial or community utilization of the resource. Ground water 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-discharge structure along the river banks disturbed a minor amout 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 construction of Units Nos. 1 and 2 was just started.

As indicated in Tables III-1 and III-2 of Chapter III, operation of Units Nos. 1 and 2 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 fresh water flow rates in the lower Hudson range from 6,500 cfs in August to 38,000 cfs in April. The weekly average drought fresh water flow which may be anticipated one year out of ten is 3,000 cfs.

Salt water intrudes upriver to an extent determined by the existing rate of fresh water flow. At Indian Point, salt water will be present when the fresh water flow is less than approximately 19,000 to 20,000 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 fresh water flow. On the average, more saline water with its greater density moves landward in the deeper layers. Therefore, at any location within the salt intrusion zone, the average seaward flow in the upper layers is the sum of the fresh water flow and the landward lower layer flow at that point. This type of flow pattern is clearly established to exist in the Hudson; however, some questions remain as to the magnitudes involved. Evidence suggests that at low fresh water flows, the total upper layer flow at Indian Point greatly exceeds the fresh water flow. Further details of the characteristics of the river flow can be found in Appendices II-1 and V-2 of this Statement as well as Section III.E.1.

b. Water Withdrawal

Because of the estuarine nature of the Hudson River, the relative amount of the river water which is withdrawn through the once-through cooling system varies over the year. Seasonal variations of the river flow which includes the fresh water flow, the seaward flow at the upper level, the landward flow at the lower levels, and the net non-tidal flow affect the amount of the river water flowing past Indian Point Units Nos. 1 and 2. As discussed in Appendix V-2 as well as Appendix II-1, the use of river flow for the once-through cooling system in the spring thaws amounts to about 14% of river water. This is essentially all fresh water which flows past Indian Point during the spring time. Beyond Indian Point, as the salt front moves northward in the summer time, less fresh water flow is available but the salt water flow in addition to the low fresh water flow is necessary to assure that the Station will have a sufficient water supply to cool the once-through condensers. Imposed on the salt front are the tidal effects of the salt water, which complicate the flow patterns. The percentage of projected water use of the river by the 2 Units is about 13% during the summer time when the upper layer seaward flow is about 20,000 cfs (with 6,500 cfs fresh water flow and 13,500 cfs of landward flow) which can be withdrawn through the once-through cooling system. The freshwater flow used under these circumstances amounts to about 32% of Units Nos. 1 and 2. The applicant is planning to reduce the intake flow from a maximum of 840,000 gpm for a 6-pump operation to a minimum of 504,000 gpm throughrrecirculation by winter 1972-73. This will reduce the relative volume of water withdrawn but the temperature differential across the condenser will correspondingly increase. The intake velocity through the protective screens should proportionately decrease by a factor of 1.66.

c. Heat Dissipation

With pump flow reduction, thermal discharges will correspondingly increase because of the higher Δt°F across the condenser.

Based on a maximum flow of 840,000 gpm plus 30,000 gpm service water, the thermal discharge is about 15°F. The reduction of flow through the pumps to 504,000 gpm, would increase the thermal discharge from 15°F to a mean temperature of 32.5°F. With a change in the submerged discharge jet from 18 feet to 12 feet, the increased thermal discharge will be such that it may be very difficult to meet the Federal and New York State thermal criteria standards. The reduced flow operation may be done in the colder months of the year such as to take advantage of the colder Hudson River water.

The heated cooling water from Indian Point is discharged into the Hudson River in a multiport submerged discharge. Heat is dissipated initially by mixing and jet entrainment, then by dispersion into the receiving water, and finally by surface heat exchange into the atmosphere. The complex flow characteristics of the estuary make it difficult to predict the temperature distribution. The models presented by the applicant as discussed in Section III.E.1 have a number of deficiencies which make their conclusions uncertain. The near and far field models rely heavily on correction factors, based on inadequate observed data. The net nontidal flow phenomenon is certainly an important factor in diluting the warm discharged water, but its quantitative characteristics are not yet established. It appears that the isotherm criteria (4°F temperature rise) might be met with Indian Point Units Nos. 1 and 2 in operation. A greater concern also exists about satisfying the 90°F maximum surface temperature criteria during the summer, especially if the jet depth is changed from 18 feet to 12 feet. The applicant will have to demonstrate in actual practice that it can meet the thermal discharge regulations through the entire year.

4. Biological Impact

No important changes in the terrestrial biota are expected to result from Plant operation. The principal adverse effects will occur in the aquatic environment of the Hudson River. The operation of the Indian Point facility will subject aquatic organisms to stress through toxic properties of residual chlorine, thermal stresses associated with the discharges of waste heat to the river, and mortality resulting from the impingement of fishes and entrainment of phytoplankton, microcrustaceans, and larval stages of larger invertebrates and any of the estuarine fishes which use the area for spawning.

The use of sodium hypochlorite to prevent fouling of the circulating water system may result in toxic concentrations of chloramines in the Hudson River near Indian Point. The concentrations can be slightly lowered by limiting chlorination to periods of peak tidal flow. Also, the effects can be minimized by restricting chlorination to the daylight hours, when most of the larger zooplankton will be near the bottom, away from the highest concentrations, which initially will occur in the thermal plume. Neither of these alternatives will eliminate the problem. The chlorine demand of the river water could result in producing some chloramines which are also toxic to fish and biota. Other chemicals listed in Table III-9 of Chapter III are expected not to result in further degradation of the water quality of the Hudson River.

Drop in dissolved oxygen concentrations was measured between the intake and discharge of cooling water for Unit No. 1. Although these measurements made by the applicant may be in error, it is possible that Unit No. 2 may produce the same effect. A significant drop in dissolved oxygen concentration during passage of water through the Plant could be deleterious at times. For example, at a time when the demand for oxygen by the biota is high and unfavorable environmental conditions cause low ambient oxygen levels, an additional artificial drop in dissolved oxygen could have significant effects on the aquatic community. Thus, the dissolved oxygen levels in the discharge canal and plume should be routinely examined during the initial operation of the facility. If dissolved oxygen is significantly depressed in the canal or plume during periods of low dissolved oxygen in the summer, then steps such as use of aeration should be taken to alleviate this.

The relationship of Plant operations to entrainment of nonscreenable organisms and to impingement of larger organisms on the screens which filter debris from the cooling water is a problem of considerable magnitude. If both Units operate as they are presently constructed, then a substantial increase can be expected in the numbers of fish killed by impingement. Based on a larger withdrawal of water through the 3 condensers of the once-through cooling system of Unit No. 2 compared with one of Unit No. 1, an increase in fish kills totaling 2.5 to 3 times the number killed by Unit No. 1 may result from operation of Unit No. 2.

The entrainment of planktonic organisms appears to be the most serious threat to the aquatic community. Entrained organisms will be exposed to mechanical, thermal, and chemical damage. Most species of the aquatic organisms in the area will be subject to entrainment at some life stage. These include phytoplankton, planktonic crustaceans, and larval stages of benthic invertebrates and of many of the estuarine fishes which use the area for spawning. The species of fish which appear most likely to be affected include the striped bass, alewife, blueback herring, tomcod, smelt, and white perch.

The staff's assessment of the ecological impact indicates over the long-term the operation of this Plant has a significant potential for causing extensive damage to the biological community within the Hudson River. Of real concern are the populations of the anadromous fishes listed above and the food web which supports them. Changes in species composition and seasonal density will probably occur in the phytoplankton community from their natural seasonal cycles by temperature changes due to thermal discharges. Important changes may occur in planktonic and epibenthic invertebrates, which are the principal food organisms for the fish populations, thereby affecting the availability of the food for other fish populations.

The results of increased mortality or decreased reproductive success in the various species will reduce their ability to reproductively compensate for additional mortality from other causes. If their compensatory reserve is already low, the operation of the Indian Point complex may result in distinct reductions in the populations of these species. The area of the Hudson River estuary affected by such changes in local populations will extend throughout the area which depended on the affected population for recruitment.

Among the anadromous fishes, the alewife, blueback herring, smelt, tomcod, and striped bass may be significantly affected by Plant operation. For example, the striped bass populations which depend upon recruitment from the Hudson River include not only the Hudson itself, but much of Long Island Sound and the New York Bight, as well. The staff's analysis indicates that Plant operations will kill large numbers of larval striped bass, up to 25% of those in the water flowing past Indian Point, through entrainment. If their compensatory reserve is high, then no significant changes in recruitment to the various adult populations will occur. However, if their compensatory reserve is low and the adult mortality rates remain constant, there will be an initial drop in recruitment to the adult population and a subsequent decrease in the adult population. This situation could form a positive feed-back loop which would result in substantial reduction in the striped bass populations in areas dependent on recruitment from the Hudson River.

The applicant shall be responsible for acquiring and evaluating the data concerning the impact of the facility on the striped bass population which will include development of predictions of the impact upon the compen-satory population.

5. Radioactive Releases and Radiological Impact

The Plant, along with Unit No. 1, will release small quantities of radioactivity 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 gallons per day, over 60-to 45-day holdup of radio-active gases respectively, the estimated radioactive releases at Indian Point could result in doses to individuals of 1.3 mrem/year near the site boundary which is one-fourth of the 5-millirem guide proposed in Appendix I of 10 CFR 50. Furthermore, individual doses would be less than 1% of present limits set forth in 10 CFR 20. The man-rem dose to the population within 50 miles of the site will be about 4% of the suggested guideline of 400 man-rems per year for each 1000 MW(e) that should be achievable by conformance with the numerical values proposed in Appendix I of 10 CFR 50. These dose estimates are small fractions (0.001%) of the dose due to natural background. Individuals spending all of their time within 2 miles of the reactor would receive only about 0.09% of the typical background dose of 100 mrem per year. This is far below the normal variation in background dose. No discernible radiological impact on the population therefore is expected due to the normal operation of Units Nos. 1 and 2. Similar considerations for the liquid radwastes indicate that no discernible radiological impacts are expected.

The applicant in its Supplement No. 1 discusses improvement of some of the components of the radwaste system. Improvements including polish demineral-izers, improved waste evaporator and steam generator blowdown purification equip-ment for treating liquid radwastes, and charcoal traps for gaseous radwastes will reduce the radioactivity released by the Plant. Use of the modified radwaste system will assure that the radioactive releases to the environment will be as low as practicable, as defined in Appendix I of 10 CFR 50. Radioactive releases from neither the present nor the modified radwaste systems will have a significant adverse impact on man. In-plant monitoring and controls, as well as 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 non-irradiated 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 radioactivity 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 Plant 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 annual 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 radioactivity during operation of the Indian Point Unit No. 2 at full power are exceedingly small.

Although the radionuclides released into the environment will not cause important dose increases to man, the radionuclide concentrations which aquatic organisms will be exposed to, or which are internally digested, could result in increased radiation exposures above that which the aquatic organisms normally are exposed to from natural radiation. These increased radiation doses, however, are less than the levels which are needed to produce observable effects on organisms and thus will not produce observable effects. The increased radiation resulting from Plant operation to terrestrial and aquatic organisms will not result in any observable effects.

VIII. THE RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF MAN'S ENVIRONMENT AND MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

The purpose of this Chapter is to set forth the relationship between the proposed use of man's environment implicit in the proposed operation of Indian Point Unit No. 2 and the actions that could be taken to maintain and enhance the long-term productivity.* One must attempt to foresee the uses of the environment by succeeding generations and consider the extent to which this present use might limit, or on the contrary 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 Chapter X and XI. The use of the site for nuclear power plants will enhance the productive and beneficial uses of this region and its resources. The service area is highly developed and supports a center of commerce of great importance to the nation and to the world. Supplying adequate power to this area from a modern power plant is a step toward improving the beneficial services provided for the commercial activities. With the present state of technology, this site will continue indefinitely to be a good site for energy production, although the capacity of the Hudson River to absorb waste heat will limit total power production in plants dependent upon the river for cooling in the area of Indian Point.

As discussed in Chapter X, the production of electricity is directly related to meeting the needs of residential customers. The customers of the applicant are primarily residential, commercial and industrial users. The unavailability 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. Therefore, without

*The CEQ says that Section 102(2)(C)(iv) "in essence requires the agency to assess the action for cumulative and long-term effects from the perspective that each generation is trustee of the environment for succeeding generations." The "Declaration of National Policy" in NEPA sets the National objectives, related to this section of the detailed statement: "fulfill the responsibilities of each generation as trustee of the environment for succeeding generations" [Section 101(b)(1)]; "assure for all Americans...productive...surroundings" [Section 101(b)(2)]; "attain the widest range of beneficial uses of the environment without degradation, risk to health or safety, or other undesirable and unintended consequences." [Section 101(b)(3)]

Indian Point Unit No. 2 on line for summer 1972, the reserve margin of peak load for summer 1972 would be 10.5% resulting in a reserve deficiency of 812 MW(e).[1] With operation of Indian Point Unit No. 2 at 50% of full power (436 MW(e)) the reserve margin will be 15.6% with a 376 MW(e) reserve deficiency. With operation of Unit No. 2 at 100% of full power, the net dependable capability of the applicant's system would be 10,321 MW(e) and its reserve margin would be 1,771 MW(e) to give 20.6% reserve margin. This would meet the needed Federal Power Commission's reserve margin criteria of 20% of peak load. The applicant, however, would have only 61 MW(e) excess reserve. Any forced outages with the older fossil-fueled plants of the applicant's cripples the applicant in supplying needed power to the metropolitan New York area without having Indian Point Unit No. 2 on line to make up for any power losses.

As indicated in Chapter X, Indian Point Unit No. 2 is needed in the next year for the short-term needs of meeting the power demands of the applicant's service area but also for the long-term needs as the country's standard of living increases, particularly for the poor people living in the slum areas of New York City. Thus the increased electrical production by the applicant will enhance the well being of the people and communities it serves both in the near future and in the long-term.

The existence of a nuclear power plant will tend to attract some tourists' attention; the applicant has recognized this by building a visitors' center on the site for Unit No. 1. Educational benefits have already been gained by the exhibits, displays, and lectures on the subject of energy needs and principles of atomic power since the center was built in 1959. The applicant plans to build a larger visitors' center within the next year and to develop gardens and nature trails through the 80-acre forested woodland on the site. The applicant also plans to enhance the beauty of the site through landscaping and planting after construction of Unit No. 3 is completed.

B. USES ADVERSE TO PRODUCTIVITY

The local effects of construction and operation of a nuclear power plant might, in general, tend to 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 Plant. These types of impacts are relevant to any type of power plant, 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 Usage

About 35 acres of the 239-acre applicant-owned tract is used for the Indian Point facilities for 3 Units. Transmission lines for Unit No. 2 will use existing rights-of-way.[2] Land used for these purposes represents an insignificant expenditure in comparison with the value of 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*.

Utilization of the 239 acres of land within the applicant's boundaries for a power plant should have no impact on the growth of commerce, industry, agriculture, or population in Westchester County. This land has been zoned only for industrial purposes. It does not appear to have other potential uses that would be of equal or greater value to the local economy than will the increase in tax base resulting from operation of Unit No. 2. The assessed valuation of Unit No. 2 at present will yield about $2 million in taxes per year to the Town of Cortlandt, Village of Buchanan and the local school district.(3) If the increased availability of electricity or other factors were to stimulate more rapid economic growth in Westchester County, the unavailability of the land included in the Indian Point site would not be a retarding factor.

Although use of the site seems reasonable for the 40-year term of power Plant operation, the degree of usefulness of this land after operations are terminated and whether long-term productivity would be unduly curtailed should also be considered.** The Commission requires that, upon decommissioning, all source, special nuclear, and byproduct materials not exempt from licensing under Parts 30, 40, and 70 of Title 10, Code of Federal Regulations, have to be removed from the site or secured and kept under surveillance.(4) The applicant has not identified specific actions it would take for decommissioning the Plant but in Chapter V.G, the subject of decommissioning the Plant is discussed.

Decommissioning plans that have been made for other nuclear plants consist of removal of all nuclear fuel, radioactive wastes, and unbound radioactive contamination on Plant equipment. Further action may follow a variety of courses, depending upon the degree to which areas of the site will be held within a controlled zone. These alternatives have varying estimated costs, ranging from $5 to $10 million (in terms of present value for decommissioning 40 years hence, including maintenance of control and surveillance in perpetuity). In some cases, no visible structures would remain; in others, major structures would be left secured or converted for other uses. Costs of completely removing all Plant features and restoring the Indian Point site have not been estimated, but this degree of restoration could be attained if the value of the land were to justify it.

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*NEPA enjoins that the Nation "attain the widest range of beneficial use of the environment." [Section 101(b)(3)]

**A National objective declared by NEPA is to "maintain, wherever possible, an environment which supports diversity and variety of individual choice." [Section 101(b)(4)]

2. Water Usage

The range of ground and surface water use, in the long term, will not be curtailed in the least except for the possible degradation of the Hudson River in supporting aquatic organisms, as discussed in detail in Chapters V and VII. Commerce and industry that use the river, as well as the public for boating and recreation uses, should not be affected by the operation of Unit No. 2 except that discharge of heat from this Plant will limit the extent to which future industries in the immediate vicinity could further heat the water. So, the productivity of the river could suffer a loss in this respect for future generations. The value of such a future loss would be difficult, at best, to assess quantitatively.

An improved ecological monitoring program which will be conducted by the applicant over many years of Plant operation, will provide means for assessing the potential impacts that may occur over the long-term. From the ecological monitoring program, the applicant will be required to assess the long-term adverse effects of Plant operation and modify its Plant design and operation before serious degradation of the environment continues.

In consideration of the impacts and alternatives discussed in detail in Chapters IV, V, VI, VII, X and XI, the staff has concluded that the only effect of the operation possibly inimical to the objectives of NEPA with respect to productivity is the potential for further degradation of the Hudson River estuary, which is used as the spawning and nursery area in the life cycle of many marine aquatic organisms that spend much of their adult life in the coastal areas of northern New Jersey, New York, and Long Island. Such degradation would, indeed, over the long-term diminish the productivity of the area to an extent that cannot be stated in precise terms at present. Only the yearly cost of replacing the estimated number of fish that might be killed has been calculated (see Chapter XI). The ultimate impact on commercial and sport fishing has not been estimated, since the decline of the Hudson River fishery is problematical at this time.

The long-term effect of the chemical effluents that will be discharged from the Plant cannot be forecast with exactness. Some chemicals, such as phosphates, even in modest amounts tend to promote long-term growth of plankton and other algae and if continuously discharged into the Hudson River will partially cause eutrophication of the Hudson River. Thus, they are considered harmful to the future of the river. Similarly, some other chemicals are detrimental to either the short-term or long-term use of water for fish in the spawning and juvenile stages. The Plant will probably not discharge total amounts of chlorine or phosphate greater than from the sewage system 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 by limiting the concentration, frequency, and length of time of the intermittent chemical treatment during Plant operation. Proper restrictions on chemical discharges during the next 100 years are necessary to preserve and maintain the Hudson River as a valuable natural resource of the United States.

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 long-term effects of power plants of all types on the water quality and biota of the Hudson River. Coordinated effort to look at the overall effects of power plant operation on the well being of the Hudson River need greater emphasis before other new power plants are located on the river. Such an effort should be conducted in cooperation with the New York State Department of Environmental Conservation and Public Utilities Commission and with Federal agencies, including the commercial and sport fish and wildlife services. The applicant uses the advice of the Hudson River Policy and Technical Committees as well as the Fish Advisory Board to plan for fish protection and for types of environmental monitoring programs, to investigate the potential effects of Plant operation on the Hudson River. However, it appears that an improved coordinated effort should be carried out with industrial, government, and other organizations to assure that discharges into the river of all types are restricted and ecological studies conducted from which positive steps can be found to alleviate the degradation of the Hudson River.

C. CONCLUSION

In conclusion, it is considered that the major adverse impact of the existence and operation of the Plant will be ecological. The use of the site for a power Plant will be beneficial in serving both the economic and electrical needs of the county and State. Alternatives to this choice are now limited. Options that remain open are outlined in Chapter XI.

REFERENCES FOR CHAPTER VIII

1. Letter from T. A. Phillips, Bureau of Power, Federal Power Commission, to R. S. Boyd, Division of Reactor Licensing, U. S. Atomic Energy Commission, December 22, 1971.

2. Consolidated Edison Company of New York, Supplement No. 1 to Environmental Report, Indian Point Unit No. 2, Section 2.1.2(c), September 9, 1971.

3. Letter to P. A. Morris, U. S. Atomic Energy Commission from W. J. Cahill, Jr., Consolidated Edison, on Responses to Questions on Environmental Aspects of Indian Point Units Nos. 1 and 2, October 28, 1971.

4. Consolidated Edison Company of New York, Supplement No. 1 to Environmental Report, Indian Point Unit No. 2, Section 2.6, September 9, 1971.

IX. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

In this Chapter the commitments of resources involved in the construction of Unit No. 2 as well as commitments for Plant operation, are discussed, although only the latter would be affected by the proposed issuance of an operating license. Irreversible commitments generally concern changes that are set in motion by the proposed action and at some later time could not be altered so as to restore the present order of environmental resources. Irretrievable commitments are generally the use, consumption, or destruction of resources that are neither renewable nor recoverable for subsequent utilization.

The staff is concerned with the extent to which resource usage in this case either contributes to or impairs the attainment of the widest range of beneficial uses of the environment.* The staff is also concerned with the need to enhance the quality of renewable resources and fully utilize depletable resources.** Commitments inherent in environmental impacts are identified here, while the main discussions of the impacts are in Chapters IV, V, VI and VII. Also, commitments that involve local long-term effects on productivity are discussed in Chapter VIII.

A. COMMITMENTS CONSIDERED

A wide range of possible resource commitments must generally be considered for nuclear power plants. Many of these commitments will be similar for all plants of the same size and type. The types of resources of concern in this case can be identified as:

(1) material resources, materials of construction, renewable resource materials consumed in operation, and depletable resources consumed;

(2) nonmaterial resources, including a range of beneficial and non-beneficial uses of the environment.

Resources that would be irretrievably committed by the operation are:

(1) construction materials that cannot be recovered and recycled with present technology;

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* The national objectives stated in the NEPA include "attainment of the widest range of beneficial uses of the environment without degradation, risk to health or safety, or other undesirable and unintended consequences." [Section 101(b) (3)] The CEQ adds: "This requires the agency to identify the extent to which the action curtails the range of beneficial uses of the environment."

** A further NEPA objective is to "enhance the quality of renewable resources and approach the maximum attainable recycling of depletable resources." [Section 101(b) (6)]

(2) materials that are rendered radioactive and cannot be decontaminated;

(3) materials consumed or reduced to unrecoverable forms of waste, including uranium-235 and -238 consumed;

(4) space for long-term storage of radioactive materials;

(5) water used for disposal of heat and certain waste effluents;

(6) air used for disposal of minor quantities of wastes;

(7) capital investment of physical Plant facilities.

B. MATERIAL RESOURCES

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 Plant. Commitments are not being made at this time on whether these materials will be recycled when their present use terminates. Some are of such value that economics clearly favors recycling and others not favor recycling. Plant operation will result in radioactive contamination of only a small portion of the Plant to such a degree that decontamination would be needed to reclaim and recycle the constituents. The quantities of materials that could not be decontaminated for unlimited recycling represent very small fractions of the resources available in kind and in broad use in industry. If these quantities indeed become irretrievably lost to recycling, their expenditure is in the staff's judgment justified by the benefits of the electrical energy produced.*

Uranium is the principal material irretrievably consumed in Plant operation. Other materials that will, for practical purposes, be consumed 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 isotopes-235 and -238, the 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) Considering the reserves of all depletable fuels, consumption of uranium in the proposed

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* This is a qualitative judgment based upon a general knowledge of Plant design. One must go through a check-list of materials and, at least, determine the quantities of minerals listed for strategic stock piling that are used in the Plant.

operation is a reasonable productive use of this resource. Estimated resources of nuclear fissile fuel 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[3] show that the total recoverable resources, expressed as theoretically available equivalent energy, amount to 26 quintillion British thermal units for all forms of fossil fuels, 39 quintillion British thermal units for uranium, and 37 quintillion British thermal units for thorium. Electrical generation by utilities in 1968 accounted for only 23% of the total use of depletable energy resources, which attests to the significant demands for the fossil fuels, particularly petroleum and natural gas, in other industries.

About 40,000 kg of uranium-235 will be consumed in Unit No. 2 during its operating life,[4] along with 30,000 kg of uranium-238, converted into non-fissile products (that is, not useful for energy production). The nuclear fuel will be reprocessed after removal from the reactor to reclaim essentially all unconsumed uranium, namely, 96% of the total uranium introduced as new fuel.[4] About 10,000 kg of fissionable plutonium-239 will be produced and will be recovered in fuel processing and recovery facilities.

C. STORAGE SPACE

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 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 utilization of nuclear fuels expands, additional facilities in other portions of the fuel cycle system will be planned to provide the needed capacity for these supporting services. The licensing of privately owned facilities (such as the Midwest Fuel Recovery Plant) and the establishment of government-owned facilities (such as high-level waste repositories) are actions that will be the subject of detailed statements on environmental, resource, and other aspects of those facilities. It is appropriate here, however, to point out that onsite waste management programs for operation of Unit No. 2 will jointly affect commitments of resources for ultimate waste storage and commitment of the environs of this Plant to accept radioactive wastes routinely released during operation. It is the Commission's policy to keep the level of radioactivity of effluents from Unit No. 2 and similar plants as low as practicable, with the consequence that more storage space in repositories must be committed than would be required with more permissive policies. The volume of wastes expected to be shipped to repositories from Unit No. 2 is estimated to be 29,000 to 44,000 cubic feet for a 40-year period of operation.[5] These low-level solid wastes are described in Chapters III, V, and VI. 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. 2 wastes to be made at this time, so that a diversity of choice can be retained for the future.*

D. WATER AND AIR RESOURCES

The expected releases of chemicals, radioactive materials, and heat from Unit No. 2 and their consequences are discussed in Chapters III and V. It is necessary, in Plant operation, to use both air and water resources at Indian Point to disperse these discharges. There is, therefore, a commitment of these resources for this purpose.[6] It should be noted, however, that this use is not a matter of consumption; furthermore, the use does not curtail the range of beneficial uses of these environmental resources except as already mentioned in Chapters VB, VC, and VIII. The proposed action when taken has a potential of affecting the aquatic organisms essential to maintaining a fish population of the Hudson River as well as that along the Long Island Sound, New Jersey coast and the New York Bight so that the population could deteriorate beyond the point of rehabilitation. In this event, operation of the Plant could entail an irreversible commitment of the river as a resource. Details of the problem of biological impact have been described in Chapters V and VII.

E. FINANCIAL RESOURCES

The total investment of the applicant committed to the Plant is $178,250,000, as of February 1972,[7] which includes both costs of depletable and renewable resources and costs for non-resource-connected services. Another commitment is the time of over 6 years to build the physical Plant. Construction of Unit No. 2 started in December, 1965. Completion is expected by April 1972.

F. CONCLUSION

The staff concludes that the proposed operation, if carried out with the radiological and non-radiological ecological surveillance program we propose, will achieve the objectives of the National Environmental Policy Act with respect to use of resources. The environmental program will serve to provide a mean to assess any potential damage to the environment and to develop alternative techniques to minimize any damage. An evaluation of the monitoring program may be used to predict in advance any irreversible or irretrievable damage to the environment so as to take preventive steps to avoid degradation of the environment beyond repair and to optimize Plant operation with minimal damage to the environment.

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* NEPA instructs that the Nation should "maintain, wherever possible, an environment which supports diversity and variety of individual choice..." [Section 101(b)(4)]

REFERENCES FOR CHAPTER IX

1. Consolidated Edison Company of New York, Supplement No. 1 to Environmental Report for Indian Point Unit No. 2, September 9, 1971, Section 1.0.

2. Bureau of Mines, U. S. Department of the Interior, "Mineral Facts and Problems," 1970 Edition, p. 230.

3. Bureau of Mines, U. S. Department of the Interior, "Mineral Facts and Problems," 1970 Edition, p. 14.

4. Consolidated Edison Company of New York, Supplement No. 1 to Environmental Report for Indian Point Unit No. 2., September 9, 1971, Section 2.7.

5. Consolidated Edison Company of New York, Inc., Indian Point Generating Unit No. 2, Final Facility Description and Safety Analysis Report, Table 1.4.1.

6. Consolidated Edison Company of New York, Supplement No. 2 to Environmental Report for Indian Point Unit No. 2, October 15, 1971, Section 2.3.2.3.

7. Consolidated Edison Company of New York, Supplement No. 3 to Environmental Report for Indian Point Unit No. 2, February 15, 1972.

X. EFFECTS OF DELAY OF FACILITY OPERATION UPON THE PUBLIC INTEREST

A. THE NEED FOR POWER

The area serviced by the applicant consists of the five boroughs of New York City and most of Westchester County, New York, and encompasses a population of 8,760,000 (1970).(1) The power needs of this region have been well known, particularly since 1969 when the applicant has actively recommended to the public to reduce their usage of electricity through its campaign of "Save a Watt." The heaviest concentration of electric load occurs in Manhattan.

Figure X-1 shows the consumption of electricity by four major classes of users for the 1960-70 period in the applicant's service area. It can be seen that, during this decade, residential use of electricity increased about 95%, commercial and industrial use increased by 70%, and governmental use increased 96%. In general, the load requirements of the applicant's system differ from the national average, in that most of the energy is distributed to residential and commercial customers and relatively little goes to large industrial users. For example, in 1968, about 22% was for residential use, about 44% for commercial use, and only 7.2% for industrial use, as compared with national averages of 27.7, 18.0, and 41.1%, respectively. Thus the loading of the system tends to be closely related to the activities of individual residents and commercial establishments; loads are low during late night hours and on weekends and holidays and high during 8:00 a.m.-5:00 p.m. working hours. The ratio of the maximum to the minimum load during a 24-hr period may be as high as three to one, so that much of the capacity needed to meet the daytime peak sits idle or not loaded a good part of the time. The seasonal peak demand occurs in the summer, largely for air conditioning.

Another special characteristic of this area is the slow growth of the population. The population remained essentially constant between 1950 and 1960; from 1960 through 1968 it increased only about 0.5% per year. The demand increase shown in Fig. X-1 is attributable to the development of new commercial and residential facilities and to the modernization of older facilities.

According to the Federal Power Commission (FPC),(2) the following Table X-1 shows the loads to be served by the applicant and the New York Power Pool (see below) and the relationship of Indian Point Unit No. 2 to their available reserve capacities during the 1972 summer peak load period. The detailed analysis covers only the period indicated since it is of primary importance in relation to the initial operation of the Indian Point Unit No. 2. The life of this facility is expected to be 40 years, however, and it will be depended upon as a part of the system's dependable generating capacity to serve projected growing loads throughout that period.

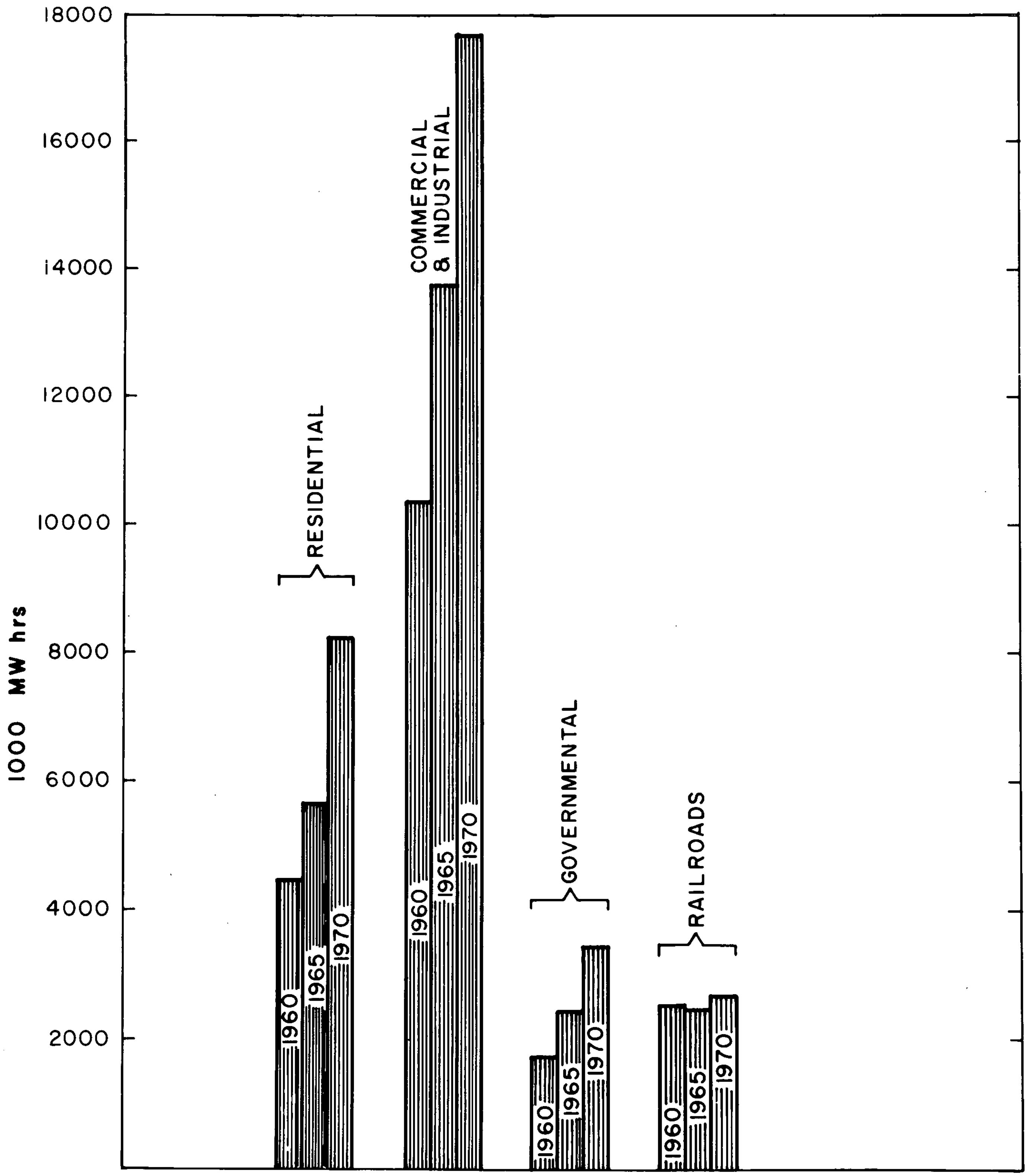

Fig. X-1
Consumption of Electricity by Classes of Customers in the Area Serviced by Consolidated Edison Company.

TABLE X-1 FORECASTED 1972 SUMMER PEAK SITUATION

	Consolidated Edison Company	New York Power Pool
Conditions without Indian Point Unit No. 2		
Net Dependable Capability - MW(e)	9,448 1/	24,026
Net Peak Load - MW(e)	8,550	20,040
Reserve Margin - MW(e)	898	3,986
Reserve Margin - Percent of Peak Load	10.5	19.6
Reserve Deficiency - MW(e)	812	22
Conditions with Indian Point Unit No. 2 (436 MW(e))*		
Net Dependable Capability - MW(e)	9,884 1/	24,462
Net Peak Load - MW(e)	8,550	20,040
Reserve Margin - MW(e)	1,334	4,422
Reserve Margin - Percent of Peak Load	15.6	22.1
Needed Reserve Margin Based on Criteria of 20 Percent of Peak Load - MW(e)	1,710	4,008
Indian Point Unit No. 2 (436 MW(e)) Capability as Percent of Needed Reserves	25.5	10.9
Reserve Deficiency - MW(e)	376	-
Indian Point Unit No. 2 (873 MW(e))		
Net Dependable Capability - MW(e)	10,321	24,899
Net Peak Load - MW(e)	8,550	20,040
Reserve Margin - MW(e)	1,771	4,859
Reserve Margin - Percent of Peak Load	20.7	23.8
Needed Reserve Margin Based on Criteria of 20 Percent of Peak Load - MW(e)	1,710	4,008
Indian Point Unit No. 2 (873 MW(e)) Capability as Percent of Needed Reserves	51.0	44.2
Reserve Deficiency - MW(e)	61	851

1/ Includes 325 MW(e) of firm power purchases.

* Even with operation of Indian Point Unit No. 2 at 50% power, a reserve deficiency of 376 MW(e) in the applicant's system results.

The applicant has been an early participant in intercompany agreements aimed at achieving maximum reliability and economy of service and is one of eight member utilities of the New York Power Pool. Table X-2 lists the members of the Pool.[3] Under this pooling agreement, each member continues to have full responsibility for maintaining adequate electric generating capacity and transmission facilities within its own service area. In particular, the applicant is required to maintain a reserve margin of at least 18% of peak load. The FPC has recommended that, as a general rule, a minimum of 20% reserve margin capacity be maintained for large power pools whose capacity is predominantly from thermal stations.[4] This includes allowances for scheduled maintenance, forced outages, errors in load forecasting, and spinning reserve requirements. In return, under the pooling arrangement, each member of the Pool and the customers it serves receive the benefits associated with fully coordinated planning and co-operation of the systems.

According to the FPC the applicant used a criterion for reserve margin of 20 percent of peak load, which includes allowances for scheduled maintenance, forced outages, errors in load forecasting, and spinning reserve requirements. The largest units now in service in the New York Power Pool are the applicant's 1,000 MW(e) Ravenswood Unit No. 3, followed in size by Niagara Mohawk Power Company's 625 MW(e) Nine Mile Point Nuclear Unit No. 1. Loss of large increments of generating capacity by forced outages of large units require similar large amounts of comparable capacity in system reserves to maintain system reliability. Recent experience with new large generating units indicate that frequent forced outages of such units may be expected during the initial months of their operation.

Although the reserves on the applicant's system under more normal circumstances would appear to be ample to meet the reserve margin needs, the applicant has suffered so many extensive outages of major equipment and delays in new facilities during recent years that major maintenance has necessarily been deferred. This has created an extensive backlog of needed maintenance to return much of the existing equipment to a normal state of dependability. A heavy maintenance program is planned by the applicant during the spring months in an effort to provide greater equipment reliability for the peak load season of the 1972 summer.

As seen in Table X-1, the analysis of the 1972 summer peak situation indicates that without the Indian Point Unit No. 2, the applicant will have a reserve margin of 898 MW(e) or 10.5%, or 812 MW(e) short of its stated 20% reserve criterion. The reserve of 898MW(e) is less than the capacity of the applicant's Ravenswood Unit No. 3 (1,000 MW(e)). The New York Power Pool, without Indian Point Unit No. 2, has reserves of 3,986 megawatts short of the 20% reserve criterion. With the Indian Point Unit No. 2 in service at 436 MW(e) output at 50% of rated power at the time of the summer peak, the applicant's system with a 15.6% reserve margin is still short of its reserve criterion by 376 MW(e) and at 873MW(e) (100% of rated power), the reserve margin is 20.7%. The New York Pool with 22.1% reserve margin will meet the criterion if Indian

TABLE X-2

NEW YORK POWER POOL MEMBERS

Consolidated Edison Company of New York, Inc.

Long Island Lighting Company

New York State Electric and Gas Corporation

Orange and Rockland Public Utilities, Inc.

Rochester Gas and Electric Company

Niagara Mohawk Power Corporation

Central Hudson Electric and Gas Corporation

Power Authority of the State of New York

*Jamestown Municipal Electric System

*Long Sault, Inc.

*Village of Freeport

* New York State Companies which are not members of the New York Power Pool but which report their Load and Capability as part of the New York State Interconnected Systems.

Point No. 2 is in service. Table X-3 depicts the projected peak loads and reserve capacity needed for the New York Power Pool to meet the power needs for summer 1972 and winter 1972-73.

In addition to being a member in the New York Power Pool, the applicant is also a member of a larger area agreement, the Northeast Power Coordinating Council (NPCC). The latter was formed out of an agreement in 1966 between the large electric utilities in New York, New England, and Ontario, aimed at further strengthening the service reliability of the interconnected company systems in this area. Table X-3 shows some recent projections, reported by the FPC, of the near-term gross generating capability and reserve conditions in the Northeast Power Coordinating Council area and in the New York Power Pool.[5] It should be noted, however, that the NPCC is primarily a council for planning, coordinating, and protection for the region and not a capacity resource pool for its member companies. The projections shown in Table X-3 include the full generating capability of Indian Point Unit No. 2, 873 MW(e), which represents some 20% of the anticipated reserve of the New York Power Pool for the summer 1972 peak-demand period. Without Indian Point Unit No. 2, the available peak load reserve of the New York Power Pool was projected to drop to 16.6%, which is short 674 MW(e) of the recommended minimum 20% margin for reliable service. Furthermore, this estimate was contingent on addition of 348 MW(e) of gas turbine capability scheduled for July 1972.

Analysis of the New York Power Pool reserves for the summers of 1969, 1970, and 1971 indicates actual operating reserves were experienced of only 6.0, 4.4 and 10.9 percent respectively, after accounting for maintenance, unscheduled outages, and forced unit capacity deratings. Such a low reserve margin is not adequate, and severely threatens system reliability. Further analysis indicates a concentration of the contributing factors in the applicant's system. No new base-load capacity has been added to this system since 1969, while load has continued to grow. Some 1,584 megawatts of gas-turbine peaking capacity has been added; however, extended operation of such units has resulted in extensive maintenance problems and reduced availability of the gas-turbine capacity.[2]

The Public Service Commission of the State of New York has recently issued a report describing the New York State plans for expansion of electric generation and transmission in the 1971-80 decade.[6] According to this source, expected growth in electric load in this period will be slightly over 12,800 MW(e), equivalent to an average compound growth of 6% per annum (see Table X-4). If all generation units are completed on schedule, projected reserves range between 21.8% and 33.1% of summer peak load; however, when account was taken of likely delays in startup of thermal base-load units,

TABLE X-3

PROJECTED ELECTRIC LOADS AND SUPPLY CONDITIONS
WITHIN THE NORTHEAST AREA AND THE NEW YORK POWER POOL
(WITH AND WITHOUT INDIAN POINT UNIT NO. 2)

		Summer 1972	Winter 1972-73
Northeast Power Coordinating Council*			
Planned Capability, MW(e)		54,763	57,488
Anticipated Reserves, MW(e)		13,334	12,062
% of Projected Peak Load		32	27
Planned Nuclear		2,824	2,835
% of Aniticpated Reserve		21	24
New York Power Pool**			
Planned Capability, MW(e) (Including net of transactions and 873 MW(e) from Unit No. 2)		24,247	25,733
Peak Load, MW(e)		20,040	20,040
Anticipated Reserves, MW(e)		4,207	6,683
% of Projected Peak Load		21	35
Necessary Reserve at 20%(1) MW(e)		4,008	3,810
Surplus (Deficiency) MW(e)		199	2,873
Without Indian Point Unit No. 2 (Nuclear, April 1972)		-873	-873
(Consolidated Edison Co. - Buchanan, New York)			
Net Capability	MW(e)	23,374	24,860
Peak Load	MW(e)	20,040	19,050
Reserve	MW(e)	3,334	5,810
Peak Load	%	16.6	30
Necessary Reserve at 20%1/	MW(e)	4,008	3,810
Surplus (Deficiency)	MW(e)	(674)	2,000

* Includes New York, New England, and Canadian members.
** Includes net of sale transactions.
1/ FPC Staff Estimate

Source: Letter to J. R. Schlesinger, Chairman of the Atomic Energy Commission, from J. N. Nassikas, Chairman of the Federal Power Commission, October 15, 1971.

TABLE X-4

EXPANSION PLANS FOR THE 1971-80 PERIOD FOR THE NEW YORK STATE POWER SYSTEM, AS OF DECEMBER, 1971. (CONDITIONS AT SUMMER PEAK DEMAND.)

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
New York Power Pool										
Total Available Capacity,* MW(e)	22,269	24,053	26,619	28,964	30,084	32,222	34,783	36,871	39,061	40,746
Estimated Reserves, MW(e)	4,200	4,303	5,592	6,607	6,359	7,153	8,337	8,989	9,706	9,846
% of Projected Peak Load	23.2	21.8	26.6	29.6	26.8	28.5	31.5	32.2	33.1	31.9
Consolidated Edison System										
Total Available Capacity,* MW(e)	9,509	10,031	10,585	12,050	12,050	12,459	13,544	14,180	14,095	15,105
Estimated Reserves, MW(e)	1,709	1,481	1,635	2,650	2,200	2,159	2,794	2,980	2,445	3,005
% of Projected Peak Load	21.9	17.3	18.3	28.2	22.3	21.0	26.0	26.6	21.0	24.8

*Assumes no schedule slippage in implementing plans.

Source: The New York Power System Generation and Transmission Plans 1971-1980, report prepared by the Power Division of the New York State Department of Public Service, December 1971.

particularly Indian Point Unit No. 2 and the 400-MW(e) Bowline Point No. 1 fossil-fueled unit (a project of joint-ownership between the applicant and Orange and Rockland Public Utilities and delayed because of labor difficulties), the Public Service Commission projected that the summer of 1972 is likely to be the most critical time during the decade, with probable reserves for the entire Pool dropping to 14.3% of peak load. In analyzing the supply-demand situation for individual utilities in the Pool, the applicant was found to have the most critical in the State, with estimated reserves possible as low as 2.4% of peak load if neither of the above-mentioned Units is available by the summer of 1972.*

The current generating capacity of the applicant's system is provided by 66 base-load generating units, supplemented by gas turbines for peaking capability. This base-load totals 8,258 MW(e). Of the base-load units, 36 units, representing about 2,104 MW(e) or 25% of the base-load capability, are over 30 years old. Many of these are considered obsolete from the standpoint of efficient use of fuel and operating reliability. Also, in recent years all of the coal-fired units have been converted to oil or gas in order to meet air pollution criteria for New York City. Continued dependence upon over-aged generating equipment, with no new base-load capacity additions, can only lead to the increased possibility of system catastrophe with attendant loss of supply to large portions of the service area and the consequent hazards which accompany such a condition. The applicant forecasts that lost capacity due to deratings and forced outages will total as much as 2,500 megawatts during the summer.

Toward the end of 1969, a 10-year plan(1) prepared by the applicant for the FPC called for the construction of new hydroelectric pumped storage, fossil fuel, and nuclear capacity; construction of new transmission lines and upgrading of existing lines; the purchase of power from other systems [total of 1,975 MW(e), 1969 through 1972]; and the retirement of selected units totaling about 2,300 MW(e). The schedule included addition of Indian Point Unit No. 2 in 1971 (delayed due to fire on November 4, 1971) and Unit No. 3 in 1973, together with 2,100 MW(e) of gas turbine capacity in 1970-72. No new base-load capacity has been added since 1969, while load has continued to grow.

The experiences and problems encountered by the applicant since 1969 are illustrative of the difficulties that operation of Indian Point Unit No. 2 is intended to help alleviate. For example, the applicant(3) experienced two severe power shortages during the 1969 summer season, one due to extreme weather conditions and the other to an abnormal amount of forced outages coupled with difficulties in purchasing power owing to schedule slippage elsewhere. As a result, the applicant requested customers using large

* This is somewhat more pessimistic than the FPC's more recent projections. See Table X-3

blocks of power to reduce their load voluntarily and the general public to conserve power. Even then the applicant was forced to institute voltage reductions on 8 different days, on 2 occasions to the maximum allowable reduction of 8%.

Voltage reductions were instituted on 15 days during the summer of 1970. On one occasion it was necessary to interrupt service to about 67,000 customers. During this occurrence, 425 MW(e) was gained by the voltage reduction, and an additional 390 MW(e) was gained by an appeal to the public to reduce power, but a disconnection of 57 MW(e) was still necessary - 13 MW(e) in Westchester, affecting 6,980 customers, and 44 MW(e) in Staten Island, affecting 59,953 customers.(7) As of September 9, 1971, the voltage on the system had been reduced 13 times during 1971.

The FPC reported that on August 28, 1970, the applicant's peak load was 7,041 MW(e) with an available capacity of only 7,415 MW(e) [including 1,253 MW(e) of firm power purchases], resulting in a reserve margin of 374 MW(e) (5.3% of the peak load).(4)

Approximately 1,500 MW(e) of gas turbine capacity, recently installed, for peak loads and emergencies and 920 MW(e) of firm power purchase raised the reserve margin to 21%; however, adjustments due to derating of the older steam units reduced the expected reserve to 17.3%, as of 1971.

Largely as a result of unusually favorable weather conditions and fewer forced outages during the summer of 1971, the reserve margins of the system at peak demand were improved over those of 1970. Without Indian Point Unit No. 2 available, the applicant's net capacity during the summer 1971 peak-demand period was 9,829 MW(e), which was 1,879 MW(e) in excess of the peak load and equal to a reserve margin of about 24%. Similar favorable conditions were experienced in the New York Power Pool area. It is to be noted, however, that this reserve margin included a disproportionate amount of gas turbine peaking capability. This is not an economical mode of generating substantial amounts of electric power, in terms of the cost of high-quality fuel oil, the thermal-electric efficiencies obtained from present units, and reliability for long periods of operation. For these reasons, it does not constitute a long-run solution to providing adequate reserve margins.

In the event of a power supply shortage during the 1972 peak load period, the New York Public Service Commission has ordered a 23-step emergency procedure to be implemented.(8) The most significant steps include an 8% voltage reduction and disconnecting power to some customers.

B. AVAILABLE ALTERNATE SOURCES

The possibility of purchase of power from outside the New York Power Pool to compensate for this shortage is limited and does not appear to be feasible because of load requirements and shortages in other regions such as Canada, New England, and the P. J. M. Interconnection. The applicant purchased 920 MW(e) and added 624 MW(e) gas-turbine capacity to its systems in 1971 to meet the shortages expected, particularly during the summer of 1971. In 1972 the applicant has contracted for 325 MW(e) of purchased capacity, which includes 125 MW(e) from Orange and Rockland's share of the Bowline Point Unit No. 1, scheduled to go on line in July 1972 and an additional 70 MW(e).

Thus the applicant needs to have Indian Point Unit No. 2 as a base load facility on line as soon as possible in order to meet the base load requirements for its own service area and to maintain needed reserve margins with respect to meeting the requirements of the New York Power Pool. The situation would be further complicated if the Bowline Point Unit No. 1 (525 MWe, including the 125 MWe purchase) and the new gas turbines (345 MWe) were delayed in completion of construction by the summer of 1972. Thus without these new plants available, a serious power shortage to the New York Metropolitan area would occur. Furthermore, the environmental impact of the air pollutants from the older fossil fuel plants which would have to operate to make up for the lack of availability of Indian Point Unit No. 2 should be added into the picture with the unavailability of Indian Point Unit No. 2. Details of the applicant's available alternate sources particularly for the long-term, are discussed in Chapter XI.A.

The applicant in its testimony of October 19, 1971, before the presiding Atomic Safety and Licensing Board, details the problems of power purchases to meet these shortages, particularly during spring and summer of 1972.

C. COST OF DELAY

The cost of delay to the applicant and its customers in placing this plant on line in time has been reported by the applicant to consist of about $3,500,000 per month, the estimated cost of incremental operation and maintenance and out-of-pocket cost of replacing energy which would otherwise have been produced by Indian Point Unit No. 2 plus about $1,000,000 per month, the amount of interest during construction which would occur during the period of delay.[9] Operation at 50% of power would essentially reduce these costs by one half and at 100% of power would not only completely reduce the costs of delay but would generate electricity for its customers so as to begin financial return on capital investment. Taxes are then paid by the applicant on the income obtained, some of which will be supporting beneficial activities in the local communities as well as providing needed services to its service area.(9)

Since the applicant's original decision to schedule the addition of Indian Point No. 2 to its system to meet the demand for electricity in the 1970's, voltage reductions and service interruptions have occurred; these events, taken together with new and more stringent air pollution restrictions and environmental protection concerns, have tended to increase the pressures on the existing capacity. In view of this, the staff believes that the need for the additional base-load capacity represented by Indian Point Unit No. 2 has been sufficiently demonstrated the availability of alternate sources is limited for short-term purchase commitments for base-load supply.

REFERENCES FOR CHAPTER X

1. Bureau of Power, Federal Power Commission, "A Review of Consolidated Edison Company 1969 Power Supply Problems and Ten-Year Expansion Plans," December 1969.

2. Letter from T. A. Phillips, Bureau of Power, Federal Power Commission, to R. S. Boyd, Division of Reactor Licensing, U.S. Atomic Energy Commission, December 22, 1971.

3. Consolidated Edison Company of New York, Inc., Supplement No. 1 to the Environmental Report for Indian Point Unit No. 2, September 9, 1971.

4. Letter from John N. Nassikas, Chairman of Federal Power Commission, to Glen T. Seaborg, Chairman of Atomic Energy Commission, September 24, 1970.

5. Letter from J. N. Nassikas, Chairman of the Federal Power Commission, to J. R. Schlesinger, Chairman of the Atomic Energy Commission, October 15, 1971.

6. Power Division of the New York State Department of Public Service, "The New York Power System Generation and Transmission Plans 1971-1980," December 1971.

7. Consolidated Edison Company of New York Service Interruption Report (Rendered in connection with Public Service Commission Order in Case 3729). Report for the week of September 20, 1970, to September 26, 1970, and Report for the week of September 27, 1970, to October 3, 1970.

8. New York Public Service Commission, Second Interim Report, August 9, 1971, Case 25937.

9. Consolidated Edison of New York, Inc., Testimony Supporting Motion to Test Up to 50% Power in the Hearing Before the Atomic Safety and Licensing Board, October 19, 1971, presented in the Hearing on Indian Point Unit No. 2, (Docket No. 50-247) on November 17, 1971.

XI. ALTERNATIVES TO PROPOSED ACTION AND COST-BENEFIT ANALYSIS OF ENVIRONMENTAL EFFECTS

A. DESCRIPTION OF ALTERNATIVES

The present and future demands for electrical energy in the metropolitan New York area have been described in Chapter X of this Statement. The generating capacity now available to the applicant to meet its commitments to the approximately 9 million customers in its service area and to the New York Power Pool is quite inadequate without operation of Indian Point Unit No. 2. Although the applicant, through its membership in the New York Power Pool, can arrange for distributing the needed power to the New York area in certain emergency situations, this arrangement in the long run will not satisfy the long-term projections of the applicant to meet the load demands of its own service area. It may also result in affecting other areas of the State where shortages may also exist. Furthermore, although the applicant and its partners in the New York Power Pool can exchange available power between each member, there is an increasing probability for the next year or two that sufficient power will not be available through the inter-ties to satisfy the needs of the Pool if forced outage of a major generating unit occurred in the period of peak demand. In this case the Pool would be forced to curtail energy to some part of its load or reduce voltage throughout its system. Operation of the Indian Point Unit No. 2 will lessen this probability, Furthermore, any forced outages of older fossil-fuel plants, many of which should have been retired years ago, would further hinder the applicant in providing the needed electricity to the New York area. A critical shortage of electricity in this area of the nation would have serious repercussions throughout the nation and the world since New York City is both a national and international center of commerce and industry. In addition, the lack of reliable power would cause hazards to the welfare and the health of the people of New York City. The alternative of load reduction as considered by the applicant, in terms of trying to reduce the shortage of electricity, has not been a satisfactory method to have sufficient reliable electrical power available in the long term for its service area, and certainly it would not be sufficient to replace the power that would be obtained from Indian Point Unit No. 2.[1] Failure to provide power is not considered a feasible alternative in view of the applicant's obligation under its charter from the State.

Permanent curtailment of the operation of the Plant would result in the irretrievable loss of most of the resources committed to the construction of the Plant without removing impacts already created by construction. In addition a large part of capital investment at the Indian Point site would be unrecoverable and probably be borne by the investor and the customer in higher rates. A replacement plant would cost at least twice as much as the abandoned facility[2] and would create an additional environmental impact at the same or other site.

Based on comparative costs and availability of nuclear fuel and oil or gas operation of the Indian Point Unit No. 2 should be financially preferred over the older oil-fired plants. The Indian Point Plant Unit No. 2 will result in lesser adverse,on air quality than older oil-fired plants which need to be retired or to be used to a lesser extent because of higher maintenance costs, low efficiency, and poor reliability. These later facilities which were constructed prior to availability of adequate smoke-abatement equipment produce and discharge to the environment considerable quantities of sulphur dioxide, nitrogen oxide, particulates, and other hazardous materials.[3] Although backfitting of these existing oil-fired power plants by installation of modern pollution control equipment can be done, it is not expected that the gaseous effluent of these plants will be as clean as that of a nuclear plant.

In choosing the site for the Indian Point Station, the applicant took into account the following types of alternatives. Location of the site with respect to load; type of fuel and costs; transportation, primarily·of both fuels; method of waste-heat dissipation; and other quantifiable variables of lesser significance. The applicant purchased the Indian Point site after abandonment of the amusement park in the mid-1950s and built Indian Point Unit No. 1 as an oil- and nuclear-fueled steam generator unit with once-through cooling of the steam condenser using the Hudson River as the source of the water coolant.

Furthermore, sites for thermal electric plants are also at a premium within this region. The applicant is attempting to overcome this deficiency by entering into joint construction ventures with adjacent facilities; for example, the construction of the Bowline Point Unit 1 with Orange and Rockland Public Utilities Company located about 5 river miles downstream from Indian Point.[1]

In consideration of other available locations, offshore sites were not considered as an alternative during the original site selection process back in the mid 1950s, since the technology for offshore nuclear power plants did not exist. During the mid-1960s a series of studies[9,10] were conducted to determine the advantages of offshore siting and the additional advantages when the power plant is coupled with the desalination plant.[11,12,13] These studies have devoted much effort to various designs for offshore sites,[14,15] but not much attention has been given to thermal discharge problems. Obviously, time would not permit construction of an offshore plant as an alternative to the Indian Point facilities in meeting the peak load requirements for 1972. However, as was pointed out earlier, sites for thermal electric plants are at a premium in the applicant's service area and, as technology permits, an offshore nuclear- or an oil-fired plant should be given serious consideration when an additional base load plant is required.

1. Alternative Fuels and Sources

A number of alternatives to the use of nuclear fuel can be considered in light of replacement of Indian Point Unit No. 2. They are natural gas, oil, coal, load reduction, disconnection, and no further expansion of the power generating capacity of the applicant's system.

a. Coal

Coal could be a primary alternative fuel source and could have been the fuel type chosen by the applicant to replace the nuclear fuel in Indian Point Unit No. 1. This is particulary true when a power plant existing at a site is committed to the use of coal since certain auxiliary features, such as coal yards, coal handling equipment, and the extensive railroad equipment necessary for handling large quantities of coal would already be available. However, for a site such as the Indian Point site, coal is not a reasonable alternative. From an economic point of view, the cost of coal used by utilities in the New York area would be excessive. This is primarily due to costs of transportation, since most of the coal is obtained from eastern Kentucky, West Virginia, and southwestern Virginia.(4) In addition, the use of coal requires additional capital investment for coal-handling equipment and for pollution abatement equipment. Even today the latter may prove inadequate to reduce particulate and gas emissions to the level required by increasingly restrictive air quality standards.

The use of coal as a fuel at the Indian Point site would have necessitated the commitment of a much larger area of land for coalyards and coal handling equipment and for flyash storage. This would have led to the destruction of a sizeable segment of the land used at this site. The environmental impact on the land would have been more severe. Also, the environmental impact on the Hudson River might also have increased because some of the large amount of flyash could fall from the river banks into the river. In terms of the radiological impact, recent studies indicate that coal-fired plants may lead to a radiation dose, exposures to the general population at a level similar to or greater than exposures derived from operation of power plants using pressurized water reactors.(5) This is due to the presence in the emissions of a coal-fired plant of the radioactive daughter products of uranium and thorium which occur naturally in coal. The environmental impact due to radiological considerations may therefore be as great for coal-fired power plants as for nuclear powered plants or greater depending upon the concentrations of radioactive elements in the coal and on the gaseous effluent control built in the coal-fired plant.

b. Oil and Gas

Because of the critical air quality in the New York metropolitan area, the applicant has converted the fossil plants located in New York City to oil-fired and gas-fired plants, thereby reducing the air pollutants from coal-fired plants. Of the applicant's 10 major facilities formerly burning coal up to 1970, only 2, the Arthur Kill and the Astoria Plants, generated an appreciable amount of energy from burning coal.(6) Since then, these plants have been converted to burning oil.

Fuel oil is not necessarily an economically competitive fuel in the New York area due to the long distance from the principal sources which are: the southcentral states of Texas, Louisiana, and Oklahoma; central Canada;

Venezuela; northern Africa; and the Arabian peninsula. Since the domestic consumption of oil far exceeds the combined United States and Canadian production,[7] imported oil from overseas is necessary. Evaluation of the use of oil as an energy source for proposed power plants must therefore include the shipping costs associated with ocean-going tankers and possibly more important the reliability of delivery from foreign sources in today's troubled world.

Developing shortages of domestic coal and foreign fuel oil has thus resulted in a difficult fuel supply problem. Furthermore, on October 1, 1969, New York City imposed restrictions on sulfur dioxide limits in which the sulfur content of fuels burned by utilities in the New York City area would be 1.%.[6] This restriction plus the shortage of natural gas limited the applicant as to the availability of energy sources to select. Because of the political situation influencing the foreign fuel oil market, the applicant is definitely limited as to obtaining dependable and reliable energy sources to meet both the short-term and the long-term power demands of its service area. The applicant also investigated the economics of importing liquified natural gas as a solution to the public controversy over the expansion of its Astoria Plant. This alternative to domestic natural gas appears to be economically prohibitive. Thus, from the above discussion, any plan to build a fossil-fueled plant in lieu of the Indian Point Unit No. 2 would fail to create the generating capacity which is needed to meet the 1972 summer peaking season. Any fossil-fueled plant would necessarily add to the particulate and gaseous pollutants entering the atmosphere of the applicant's service area. The use of Indian Point Unit No. 2, therefore, offers important environmental advantages with respect to air quality in the New York area.

Furthermore, other new plants are not feasible to meet the 1972 power needs. Fossil-fuel plants require an estimated 4-6 years to complete, and an alternative nuclear power plant would require an even longer time. Gas turbines, which are discussed below, are not technically reliable alternatives for base-load plants such as Indian Point Unit No. 2. The installation of gas turbines requires more than 1 year even on a crash basis, so that the earliest that gas turbines equivalent to the capacity of Indian Point Unit 2 could be installed would be after the summer of 1972.[1] Although the applicant has a number of gas turbine facilities in its system, such facilities are used primarily for peaking purposes. The availability of natural gas supply is also limited. Over 70% of the natural gas produced in the United States in 1968 came from sources in Louisiana and Texas, while the industries of the States of Louisiana, Texas, Arkansas, and Oklahoma accounted for the consumption of about one-third of the total nation-wide production. Small, gas-turbine generating units used for peaking purposes in local situations provide for flexibility of operation and dispersion of environmental impacts, but do not contribute to the base-load capability of the system. Therefore, natural gas is not a reasonable economic choice for large power plants that must depend on interstate delivery of the gas by long pipelines from the principal continental sources.

c. Hydroelectric Power

Hydroelectric power from natural sites is not a practicable alternative since the remaining available sites in the New York area would provide only small incremental increases in generating capability. In addition, environmental impact of man-made reservoirs on natural waters would be a poor tradeoff for the small increments of power made available. Pump storage hydroelectric generation facilities can be built in a way that natural waters are not unduly disturbed. However, this type of facility requires an off-peak capacity for the pumping phase which was not available when the Indian Point Unit No. 2 was undertaken. The Cornwall pump storage hydroelectric project rated at 2,000 MW(e) would reduce some of the pressure on the existing old fossil-fueled plants in the system but could not replace the Indian Point facilities as a base-load Plant. The fact that off-peak power is required for pumping river water to the reservoir is strictly limited to a peaking facility. The FPC[1, 8] has stated that there are no other suitable sites for conventional hydroelectric pump storage plants available within a radius of approximately 100 miles from New York City.

d. Purchase Power

In Chapter X.B, the subject of alternate sources of power through purchase was discussed. Purchase power is likewise not a feasible alternative for Indian Point Unit No. 2 for the year 1972. The applicant has commitments for purchase of 395 MW(e) of purchase power for the summer of 1972, which includes 325 MW(e) from Orange and Rockland's Bowline Point Unit No. 1 and 70 MW(e) additional purchases.[1] In terms of purchased power the applicant is planning to have available approximately 200 MW(e) of its share in the Bowline Point Unit No. 1 (525 MW(e) plus 125 MW(e) of purchased power to total 325 MW(e)). This will depend upon completion of the construction of this Unit which is not scheduled, at the earliest for service until the summer of 1972. The applicant is also depending on the availability of 348 MW(e) from new gas turbines. A large part of the capacity available on this contingent basis depends on the timely completion of fossil-fueled plants and licensing of nuclear facilities.

The applicant also has solicited offers from sources in the northeastern states and Canada, and there has been some indication that there may be some additional power available for purchase. However, purchase power as a short-term alternative for Indian Point Unit No. 2 would have to come from other utilities which must themselves maintain an adequate reserve over and above their peak load. Purchase of power is not considered to be a reliable source to meet load demands but may be suitable for emergency situations. The higher cost per kilowatt hour for purchase power is also a deterrent to this alternative. Purchase power as a long-term alternative for Indian Point Unit No. 2 is also not practical until the advent of a national power grid system.

e. Long-Term Alternatives of Power Sources to Meet the Need for Power

Long-term alternatives, to meet the need for power, as discussed in Chapter X, include not only the construction of Indian Point Units Nos. 2

and 3 but also the construction of 4 fossil-fuel generating units on the Hudson River at Bowline Point and Roseton. Bowline Point Unit No. 1 is scheduled to be in service by the summer of 1972. Roseton Unit Nos. 1 & 2 are scheduled for service prior to the summer of 1973 and Bowline Point Unit No. 2 is scheduled for the summer of 1974.[1]

Even with these additions, the applicant has plans for an additional base-load fossil-fuel plant that the applicant has proposed to build in New York City in 1974 at its Astoria Plant. Thus, if Indian Point Unit No. 2 were not available it would be necessary to replace that unit with other new resources. In order to replace Unit No. 2 with a new unit, a site better than the Indian Point site would have to be found; however, as stated above, there is a shortage of available sites to meet the projected load growth even with the Indian Point Units No. 2 and 3 in service. In order to obtain permission to construct a new fossil-fuel unit at its Astoria plant inside New York City, the applicant had to enter into an agreement with the City of New York in which the City of New York said that it was agreed that no more fossil-fuel boilers for electric generating plants would be located in New York City.[6]

Gas turbines are not a feasible alternative to supply base load power. Although the applicant has installed in its system about 2,300 MW(e) of gas turbines,[1] approximately only 200 MW(e) of this capacity was planned by the applicant to serve as an emergency startup and transit capacity. The remaining 2,100 MW(e) were planned to provide peak capacity for the early 1970s as compensation for delays incurred in constructing the Cornwall Pump Storage Plant and to replace capacity loss due to equipment deterioration at older plants which had been used for peaking purposes. Peaking capacities supplied by these gas turbines is electricity furnished for only a limited number of hours per year when demand for electricity is unusually high because of seasonal increases in demand. This is particularly true during the summertime when there is a shortage of electricity to meet the demand. Therefore, the gas turbine capacity that has already been planned for the system would be required to operate more hours than would normally be the case for gas turbines which were intended solely for peaking capacity. It is difficult to project the expected performance in using gas turbines in providing base-load capability for continuous reliable service.

The applicant also has begun to arrange for purchasing 1,000 MW(e) of power in 1977. This consists of 500 megawatts from the Breakabeen Pump Storage Project of the Power Authority of the State of New York and 500 MW(e) from Hydro Quebec.[1] This pumped storage project has not yet been licensed by the FPC and must be still considered as only a possible source of power. The transaction with Hydro Quebec may involve a seasonal exchange or a straight purchase and no contracts have yet been signed. The applicant is a participant in a study by the New York Power Pool, the Ontario Hydro and Hydro Quebec to determine the long-term feasibility of major interconnection with Canada to

New York to import power. Assuming these purchases are made, they will be necessary to meet the load growth of the applicant and are not available as a replacement for Indian Point Unit No. 2. Complications for transition of transmission from Hydro Quebec to the United States may develop in that a license has to be obtained to export power from Canada to the United States. Other possible sources for purchase are from the Canadian Hydroelectric Development at Churchill Falls in Labrador. From the study of the available capacity at Churchill Falls, the entire output at this plant would be required for anticipated load growth in Canada. The plans for major expansion of the Canadian hydro resources in the early 1980s have prompted the applicant to reinvestigate this possibility for long-range large purchases and preliminary discussions leading to such purchases have been held.[1] However, it cannot be assumed that any significant amounts of power resources will be available on a firm basis until the 1980s at the earliest.

2. Alternative Heat Dissipation Systems

a. Once-Through Cooling

The heat dissipation system as discussed in Chapter III.E.1 of this Statement is the once-through cooling system most likely to cause the most significant adverse impact to the environment. The heat dissipated by this system is about 6.35×10^9 Btu/hr, which results in thermal discharges of about 15°F at the outfall at the confluence with the Hudson River. During 28 of the first 100 months that Indian Point Unit No. 1 was in operation, fish kills on the intake screens were observed by the applicant. Indications are that several million fish were killed.[16-18] The applicant in Section 2.5 of the Supplement No. 1 and Appendix B in Supplement No. 3 to the Environmental Report outlines some of the alternatives for fish protection which have been considered and the results obtained, most of which have been unsatisfactory. However, the applicant has employed consultants from this country and abroad to look into the problems of fish kills and alternatives for the Plant condenser intake discharge structure to protect fish from damage due to the intake structure.

The primary cause of the impingement of fish on the screens has been excessive water intake velocities. The applicant[30] has proposed in the Supplement No. 3 a new screening structure for all three Units, at cost of $12-15 million, to be located offshore, with an intake channel closed by a sheet piling wall. The screening structure would be sized to maintain intake velocities below 0.3 fps during the winter season, when the fish kills have been most serious. Furthermore, the applicant plans to reduce the intake flow from 140,000 gpm per pump to 84,000 gpm per pump by recirculation during winter 1972-1973.[40]

Although the proposed modifications to the intake structure might eliminate or drastically reduce fish kills due to impingement, the problem of entrainment of small organisms in the water still remains. The absolute number of fish killed is not so important as the effect of any kill on the compensatory reserve of the species involved. Reduction of the flow of cooling water through the condensers when ambient river water temperatures permit would assist in reducing impingement losses and entrainment.

Indian Point Unit No. 2 will not have the sheet piling or the ice wall which presented a problem for Indian Point Unit No. 1. Indian Point Unit No. 2 will have a fixed screen of the type which the applicant believed proved satisfactory for Indian Point Unit No. 1 in reducing the mortality of larger fish. The extension of the discharge is also applicable to Indian Point Unit No. 2 because all the Indian Point Units use a common discharge canal and outfall structure. Furthermore, this extension avoided the problem of water recirculation through the cooling system.

In addition, an underwater hole in front of the Indian Point Unit No. 2 intake was filled in 1971, at a cost of approximately $90,000.[1] A newly designed air bubble curtain is being tested at the intake of Indian Point Unit No. 1.[30] The applicant is also studying the effectiveness of moving the travelling screens to the intake opening and running the screens continuously to reduce fish impingement. However, the intake velocity of the traveling screens is about 2 fps and this would result in greater fish impingement.

The applicant has made the statement in its Supplement No. 1 to Environmental Report for Unit No. 2[1, 16] that it would be willing to replace any loss of fish by replenishment from hatcheries it would construct and operate for this purpose. The staff believes that there is some question concerning the effectiveness and real value of transplanting juvenile fish at that site. Also, a more thorough evaluation needs to be made to determine if fish hatchery technology is adequate to rear the specific species of concern. The feasibility and advisability of such a fish rearing and transplant activity shall be evaluated.

The alternative of shutting down the Plant in the event of entrainment and fish impingement problems requires a balancing of competing factors. A shutdown of the Plant would produce a serious power shortage and increased emissions of air pollutants in New York City. If, for purposes of analysis, the power shortage problem can be ignored, environmental trade-off between air pollution in New York City and fish protection at Indian Point would need to be taken into account to determine whether such an action would be warranted.

b. Wet Cooling Towers

Among possible alternatives to the once-through condenser cooling water system are closed-loop systems that would utilize one or more cooling towers to dissipate the waste heat to the atmosphere.[20] At present, there are two major types of cooling towers in use, the wet (evaporative) and the dry, which operate on the same principle as the automobile radiator. The two types of wet cooling towers, mechanical-and natural-draft, 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 periodically 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. In general, mechanical-draft towers are relatively low structures, and the drift may cause fogging, misting, and icing that could be hazardous to motorists if highways, roads, or streets are within their reach. Natural-draft towers, on the other hand, are tall hyperbolic structures, about 400 feet high, which minimize the effects of drift at ground level. The principal objection to using evaporative cooling towers at the Indian Point site is the high range of salinity content of the Hudson River (100 to 7,000 ppm). The damaging effects of the salt-water drift on metallic objects and plant life could be detrimental. Until such a time as research can produce brackish water cooling towers with very low drift and environmental impact, their use is not practical. At present, brackish water cooling towers of the size required for Indian Point are not commercially available in the United States.

The size of the cooling tower will be dependent upon the amount of waste heat to be dissipated by evaporation. Evaporation of about 1 pound of water will transfer 1,000 Btu to the atmosphere.[21] Thus at least about 6,350 gpm would be evaporated from Indian Point Unit No. 2. 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 discusses both types of cooling towers, operating in either the open or closed cycle mode. The preferred method of an alternative is the closed-cycle natural draft cooling tower. See Section XI-B. for further details.

c. Dry Cooling Towers

Dry cooling towers have been used in Europe for fossil-fueled plants and chemical processing plants but have not gained widespread acceptance in the United States. Hence, the principal manufacturers of large-capacity dry cooling towers are located in Europe. 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. A disadvantage is that back-pressure turbines for pressures in the range of 8-inches Hg absolute above, which must be used with dry cooling towers, are not manufactured in the United States. Another disadvantage is that the thermal efficiency is lower, since it is governed by the dry-bulb rather than the wet-bulb temperature of the air. These dry cooling towers require much more heat transfer surface because of inefficiencies in heat transfer adding to the cost of installation and space requirements. 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[22] capacity for a nuclear plant, and in estimates of the increased cost to the consumer, which have ranged from 2% to 10%. Details on siting, performance, and economics of dry cooling towers are described by Smith and Larinoff,[22] who point the advantages and disadvantages of this cooling system for dissipating heat to the atmosphere. The applicant has estimated an additional cost of $45 million to the Plant if Unit No. 2 had been initially designed with dry cooling towers. Dry cooling towers may not be a practical short-term alternative for the Indian Point complex for the reasons stated above but with advances in technology, the applicant should give further thought for the long-term solution to potential environmental damage of the Hudson River using the present once-through system.

d. Cooling and Spray Ponds

Cooling ponds[23-26] and spray ponds are practical alternatives to once-through cooling systems or cooling towers for large nuclear reactors. However, the surface area required for cooling ponds is large (1 to 3 acres per megawatt of electricity)[27] and would be difficult and costly ($1 to $10 per kilowatt)[27] to obtain in the Indian Point area. A cooling pond for use at Indian Point would require about 2,700 acres. Since there are only 239 acres in the site, this alternative is not practical for this site. Spray ponds, though similar to cooling towers in operation, depend upon local temperature, humidity, and wind conditions, and thus their reliability is variable. The loss of land and the capital cost required for this alternative may not be justified for a benefit whose reliability is questionable, particularly during the summer months, when the peak electrical load is experienced. The applicant states in its Supplement No. 1 that a spray pond for use at Indian Point No. 2 would require about 30 acres at a design temperature rise of about 25°F. The costs of such a cooling pond was estimated to be $7-10 million for Indian Point Unit No. 2.[1]

There are adverse environmental effects associated with a spray pond at Indian Point. If the scenic wooded area to the north were to be used, the land would require defoliation and clearing. During winter operation, drift and spray would result in local icing. The effect of salt content of the spray is not known but it is likely that the local flora would be affected. Under adverse humidity conditions, local fogging can occur. See Section XI B. for further discussion of this alternative.

e. Waste Heat

An alternate to ambient heat sink cooling is to use the heat available in the turbine exhaust for low grade thermal requirements such as domestic and temperature process requirements. These uses require temperature levels generally corresponding to condensed pressures and temperatures not compatible with the design of the existing Indian Point Unit No. 2 turbine generator system. Furthermore, there are no potential users of waste heat in the quantity available within reasonable proximity of the Plant.

3. Alternative Chemical Discharge Techniques

a. Chemical Wastes

Chemical wastes resulting from treatment of the primary, secondary, and auxiliary systems of Units Nos. 1 and 2 are released to the discharge canal, where they are diluted by the cooling water before entering the Hudson River. The chemicals used are listed and discussed in Chapters III-E and III.E.3 and V.B and D of this Statement. The staff's assessment of the chemical waste disposal system shows that the releases to the Hudson River will meet the New York State water quality standards, which are written in general terms without specific limitations as to the concentrations of the various chemicals to be discharged. The applicant has established its own concentration criteria, based in part upon bioassay work performed by the Raytheon Company and New York University. Chemical discharges are also subject to regulation by the New York State Department of Environmental Conservation in accordance with Section 1230 of the Public Health Law.

Sodium hypochlorite is used for treatment of fouling organisms in the cooling and service water intake bays of the intake structures, the pumps, and the condenser tubing. The solution is pumped from storage tanks through flow control valves to the inlet bays in a cycle that doses 1/2 of the inlet water boxes of the cooling water bays for 30 minutes and then the remaining half for another 30 minutes and then the service water intake bay. These injections are initiated by an automatic programmed control system. The estimated maximum concentration of residual chlorine in the cooling water as it leaves the discharge structure and enters the Hudson River is 0.5 ppm; the residual chlorine concentration will exceed minimum toxic levels within the thermal plume and in the river during periods of low flow. This chlorine will react with substances in the water and undergo gradual decay. Chloramine compounds are a major by-product and have been found to be toxic to aquatic organisms in amounts greater than 0.003 ppm.[39] It is not known at this time what quantity of chloramines will be formed or the magnitude of the impact to the biota in the Hudson River. Alternatives to the sodium hypochlorite system as designed would be to reduce the amount of sodium hypochlorite per dose or to increase the time interval between doses, either of which would impair the effectiveness of the system but only delay the ultimate impact.

A more effective interim alternative would be to limit dosing cycles to daylight hours and periods of peak tidal flow. This modified operating procedure would reduce the impact of the chlorine on the aquatic biota in two ways. First, the highest concentration of toxic chlorine compounds will be in the thermal plume, which forms a layer at the surface . Thus the exposure of many planktonic crustaceans and larval fish will be reduced because of their vertical diurnal migration patterns. Second, peak tidal flows will permit maximum available dilution of the residual chlorine; when the peak tidal flow exceeds 390,000 cfs, the concentration will be reduced below the level that is toxic to sensitive organisms. Mechanical or thermal cleaning systems are also available[28,29] and would eliminate the need for the sodium hypochlorite biocide and the discharge of toxic chlorine compounds to the estuary.

b. Sanitary Sewage

The existing sanitary sewage disposal plant for Unit No. 1 has adequate capacity to serve Unit No. 2. It is described in Chapter III-E.3 of this Statement. At present, the percolation rate from the four 45-foot-square sand filter beds is such that the underdrains are not required. In the event that the influent to the sand filter beds exceeds the percolation rate, the applicant has stated that it will install an antomatic chlorination station and discharge the effluent to the Hudson River. An additional sand filter bed would be preferable to chlorination.

B. SUMMARY OF ALTERNATIVES

The applicant has provided a discussion of alternatives and a cost-benefit analysis in Supplement No. 3 to the Environmental Report. This discussion is summarized below. In many cases the staff did not agree with the applicant's estimates; these differences are discussed in Appendix XI-1 and below. The applicant in its Supplement No. 3 followed the Commission's draft guidelines (1/7/72) in preparing its analysis.

It should be noted that in following the draft guidelines, the monetized items (in present worth) calculated by the applicant differ from those calculated by the staff. The staff elected to use a discount rate of 8.75% which has been used in most recent draft environmental impact statements, although 8% was suggested in the original draft guidelines (12/29/71). The differences between the staff's calculated values and those of the applicant reflect this difference in procedure.

As discussed in the previous chapters of this Statement, the staff's independent evaluation of the environmental effects of the construction and operation of Indian Point Unit No. 2 disagrees in certain respects with the evaluation made by the applicant and presented primarily in its Environmental Report of August 6, 1970, and Supplements No. 1 of September 9, 1971, No. 2 of October 15, 1971, and No. 3 of February 15, 1972.

The important areas of disagreement between the applicant's analysis and that of the staff are the following:

(1) The staff's detailed review of the Quirk, Lawler, and Matusky heat dissipation and the Alden hydraulic models, developed for and used by the applicant, indicates a number of uncertainities which, the staff believes, might affect the applicant's conclusions. (These have been discussed in Chapter III.E.1.)

(2) Environmental effects from operation of the intake-discharge structure have a potential for long-term significant biological damage to aquatic biota not only in the localized area in the vicinity of Indian Point Unit No. 2, but also in the Hudson River estuary, New Jersey coast and New York Bight. (See Chapter V.D.3.)

(3) The discharge of residual chlorine may result in exposure of biota to toxic levels of residual chlorine or chloramines. (See Chapter V.D.2c.)

(4) There may be a reduction in the dissolved oxygen in the cooling water across the condenser. (See Chapter V.D.2b.)

There are other areas of difference which are relatively minor. The staff feels that there are insufficient data available to make a reasonably accurate estimate on long-term effects on biota. Of the major differences between the staff and the applicant in the analysis and evaluation of available information, the entrainment of nonscreenable fish eggs, larval, and fingerlings and the impingement of fish on the intake structure appear to be the major impacts on the aquatic ecosystem. Although the staff does not feel that the impacts can be quantified at this time, the staff does not agree with the small impact of about 2-3% damage to eggs larval made by the applicant. Details of the staff's disagreements are given in Chapters V.D, VII, and Appendices II-1, V-2, and XI-1.

The alternatives selected for compiling benefit-cost information are described in the following paragraphs:

1. Alternative 1, the existing Plant, has an 873 MW(e) capacity and construction is virtually completed. It is a pressurized water reactor utilizing once-through cooling in which the condenser discharge water from Unit No. 2 is being mixed with that from Unit No. 1 in the same discharge canal. The Alternative 1 design will limit doses from radioactive material in liquid and gaseous effluents to levels that are within the numerical guides for design objectives and limiting conditions of operation set forth in the proposed Appendix I (dated June 9, 1971) to 10 CFR 50.

2. Alternative 2, with a minimal water impact, was selected as the present facility with the addition of two natural-draft, closed-cycle cooling towers. It is believed that the water impact would be greater if closed-cycle, mechanical-draft cooling towers were used instead of natural-draft cooling towers because of the greater amounts of chemicals, biocides and corrosion inhibitors, that would be discharged in the cooling tower blowdown. The natural-draft cooling tower option was chosen because of a reduced environmental impact from fog, drift, salt deposition, and chemicals in blowdown. Six alternative cooling systems (in addition to Alternative 1) were evaluated. These are designated as Alternatives 2B, 2C,... 2G. These are mechanical-draft cooling towers, natural-draft cooling towers, and spray ponds, each operated in the open- and closed-cycle mode.

3. Alternative 3, as defined in the Commission's draft guidelines (1/7/72), is "the conceptual plant design which reduces to the minimum feasible level with available technology detrimental effects to ambient air and land." It is identical with Alternative 1 because Alternative 1 presents very minor interactions with air and land. Except for residual chlorine, the other chemical discharges are considered to be minor. Since the Indian Point site presently accommodates a nuclear power reactor (Unit No. 1) and has a total of 3 Units on the site, no additional community impact from a new industry will occur and no land acquisition is required.

4. Alternative 4, defined as "that design which results from the applicant's best effort to balance environmental cost reduction with plant modification costs," is also identical with Alternative 1. Therefore only Alternatives 1 and 2 will be discussed.

1. Description of Benefits of Alternative Plant Designs

a. Power Benefits

Alternative 1 The sum of the present worth of power benefits is estimated by the applicant to be $2,336,811,000. The following assumptions were made in the applicant's analysis:

(1) The Plant is assumed to be on scheduled maintenance for 8 weeks (1,344 hours) for each year.

(2) Immature forced outage rate used is assumed to be 15.0% the first 3 years.

(3) Mature outage rate is expected to 10.0% for all succeeding years.

These outage rates are considered to be conservatively representative based on past operating experience with nuclear plants by the applicant and other utilities. Since the capacity of Indian Point Unit No. 2 is 873 MW(e) during the Plant's lifetime, the applicant has stated that the capacity factor for the first 3 years will be 69.7% (6,107 hours) with an annual energy output of 5,331,400 MW(e) hrs. The capacity factor for all succeeding years is assumed to be 74.7% (6,540 hours) with an annual energy output 5,709,400 MW(e) hrs. The life of the Plant for economic purposes is considered to be 30 years. The applicant's discount factor is 8% based on the imbedded cost of debt and current earnings requirements on common equity.

The percentage of load by class of customers is given by the applicant as follows:

Commercial and Industrial	53.6%
Residential	30.0%
Other (Railroad and Governmental)	16.4%

These are based on long-range forecasts of sales by classification of customers. The applicant does not keep separate statistics on commercial customers and industrial customers because they are commingled in several of the rate schedules.

Power benefits are based on current rate schedules for 1972. Based on estimates of 1972 revenue and sales, the cost factors are:

	Cents/kwhr
Commercial and Industrial	3.69¢
Residential	4.36¢
Other (Railroad and Governmental)	2.46¢

Alternative 2. The minimum-water impact alternative has two natural-draft, closed-cycle cooling towers. The assumptions include:

(a) Construction time for all cooling alternatives is estimated to be about 3 years.
(b) Indian Point Unit No. 2 is unchanged during these 3 years and its power output is the same as Alternative 1.
(c) Cutover to the alternative cooling system is assumed to be coincident with the annual scheduled maintenance period on the Unit with no additional downtime required. This assumption is probably optimistic. Should a longer time actually be required for cutover, then the power benefits for the natural-draft alternative are slightly overstated and the incremental generating costs for all cooling alternatives are slightly understated.
(d) For the remaining 27 years the capacity factor is the same as the base Plant, that is 74.7% (6,540 hours). However, the net output capacity is reduced to 836 MW(e) and the annual energy output is reduced to 5,467,450 MW(e)-hr. All other parameters for the power benefits are the same. The total power benefits for the minimum water impact alternate is $2,259,287,000.

The power benefits stated for Alternative 2 are for Indian Point Unit No. 2 with the closed-cycle, natural-draft towers only. The generating costs include the cost of replacement energy produced on the other units of the applicant's system. If the replacement energy produced on the other units of the applicant's system were to be included in the power benefits, they would then be identical to the power benefits of the base Plant.

The applicant stated by footnote: "Per AEC Guidelines, this does not represent Con Edison's position as to the benefit of the Plant." The staff agrees that other indices are as or more appropriate.

b. Reliability Index

The applicant normally performs reliability calculations with a loss-of-load analysis confined to the times of maximum exposure to the peak load. This is the hour of maximum load for each weekday from June 15 to September 15th.If the capacity available is less than the load at the peak hour it is counted as a day of loss-of-load. A loss-of-load day is one on which the applicant cannot meet its peak load with its own generation plus firm purchases. Thus, a loss-of-load day would occur on any day the applicant was forced to use emergency or supplemental purchases or forced to reduce voltage or to actually disconnect customer load. The applicant does not schedule any maintenance during this peak summer period. Although supplemental purchases or load curtailment measures may be required to meet operating reserve requirements, these are not determined by the loss-of-load calculation.

For 1972, with all units scheduled for the summer of 1972 including Indian Point Unit No. 2 in service, and with scheduled retirements completed, the loss-of-load expected would be 2.0 days per summer. If Indian Point Unit No. 2 is not in service during the summer of 1972, the expected number of loss-of-load days will increase to 9.2 days assuming that all other planned new units are available as scheduled, but that planned retirements are deferred. Since the reliability index is based on 65 summer days, this represents 14.2% of the summer days. Thus, there would be a 7-day increase in the expected number of loss-of-load days without Indian Point Unit No. 2 in the summer of 1972, even if retirement of older plants were deferred. Expressed another way, this means a 350% increase in the expected exposure of the system to emergency conditions.

Over the long range the reliability index will vary as a function of the applicant's overall program of capacity additions and retirements, but the exclusion of Indian Point Unit No. 2 would have a similar impact on the actual reliability index in any given year. A unit or group of units would have to be added to the applicant's current construction program over the long range to replace Indian Point Unit No. 2 if it were not available.

c. Recreation

As stated in Chapters V and VIII, 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. After construction of Unit No. 3 is completed, a new $7 million visitors' center will be built to replace the first one. This will enhance the educational productivity of the site through exhibits and lectures on peaceful uses of atomic energy and development of nuclear power.

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. It is anticipated that boat launching ramps will be available at the marina; however, plans are not definite enough to estimate capacities and expected annual user days. There is no doubt, however, that construction of a public marina will enhance water-related activities of the area.

d. Air Quality

An analysis for 1972, with Indian Point in service all year, was performed to determine the annual production of all the units on the applicant's system. An identical analysis was performed without Indian Point No. 2 in service. The increase in generation at each station was converted into expected additional emissions. Thus, without Indian Point Unit No. 2 in service in 1972, an incremental amount of emissions of 29,000 tons of SO_2, 16,000 tons of NO_x, and 1,245 tons of particulate matter would be emitted into the New York City atmosphere above those emissions expected from those same generating stations if Indian Point Unit No. 2 were in service. This analysis was based on all units burning only oil, or gas when available. The oil which would be burned would be of the lowest sulphur content for which contracts could be obtained. The applicant's last coal burning unit is scheduled to be taken out of service for conversion to oil in the early part of 1972.

e. Education

Educational benefits will be provided by the new visitor's center to be constructed on the site. Construction of the center is expected to begin in 1973 and to be completed in 1974. 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. The estimated cost of the facility is $7 million.

It is anticipated that large usage of the facility will be made by school children on educational field trips. Since the new center will have facilities much expanded over those of the present center, visitations are expected to increase accordingly. The applicant expects approximately 100,000 visitors a year at the new center. This estimate is based on visitations to the previous center that was in operation between September 1959 and November 1970.

f. Research

A total of approximately $10.0 million is planned to be spent by the applicant on research for environmental studies relating to the Indian Point site. These studies are all directed toward environmental protection in the Indian Point areas. They are directed toward the entire Indian Point site rather than Indian Point Unit No. 2 specifically. About $1,700,000 has been spent in contract research to date.

Other studies, that are either completed or scheduled to be completed, that relate to environmental protection at the Indian Point site include radiological studies--$30,000; fathometer studies--#13,000; and Plant intake studies--$210,000. All of these studies affect in some manner the environmental protection of the Indian Point site.

g. Employment

Construction wages were estimated by the Staff to be about $100 million. It is estimated that an incremental increase of 100 permanent employees will result because of the existence of Indian Point Unit No. 2. This is based on projected employment for the fully developed Indian Point site and employment patterns at other multi-plant nuclear generating facilities.

The applicant has estimated that 399 full-time employees will be maintained at the Indian Point site on the completion of Units Nos. 1, 2, and 3. Some 112 of these are expected to be management personnel with the remainder being operational and maintenance personnel. The average payroll per employee is estimated at $12,000 per year. Thus, the 100 employees attributed to Indian Point Unit No. 2 will have a substantial economic impact on the local area with an approximate annual payroll of $1,200,000. Over the life of the Plant, this amounts to $36,000,000. This does not include the impact of construction personnel and their payrolls, nor the extra maintenance personnel that will be required during down times for maintenance.

h. Taxes - Community Benefits

The applicant estimated annual local taxes of $4,100,100 for Alternative 1 and $6,300,000 for subalternative 2E.

Local taxes for the alternatives not listed by the applicant in Supplement No. 3 to the Environmental Report were calculated using the figures given for Alternative 1, Plant As Is and the Alternative 2, Minimun Water Impact[32] for 6 alternative cooling systems described below plus the taxes available.

Alternative	Open-Cycle Cooling System	Local Taxes
2B	Natural-Draft	$6,355,000
2C	Mechanical-Draft	$5,740,000
2D	Spray Pond	$5,960,000
	Closed-Cycle Cooling System	
2E	Natural-Draft	$6,300,000
2F	Mechanical-Draft	$5,806,000
2G	Spray Pond	$6,127,000

2. Environmental Costs

The numbered items discussed below correspond to the Commission's draft cost-benefit guidelines.

1. Heat Discharge to Natural Water Body

As mentioned above the staff does not concur in the applicant's analysis of Item 1 which follows. This difference is detailed in Chapter III.E.1.

1.1 Cooling Capacity of Water Body

Alternative 1. Plant As Is

Environmental Cost: 6,350 x 10^6 Btu/hr, 42 acre-ft (applicant's estimate)

The values chosen from Table 1.1-1 of the applicant's Supplement No. 3 to represent the environmental costs under Item 1.1 were selected with the consideration that Unit No. 1 is presently operating with once-through cooling and will continue to operate in that manner regardless of the method of operating Unit No. 2. Therefore, the values selected correspond to the difference of the combined effects of operating both Units No. 1 and 2 less the effects of operating Unit No. 1 alone. Since the 4°F temperature rise is the standard which applies, these volumes were also selected to represent the environmental costs. Thus, 6350 x 10^6 Btu/hr would be discharged to the present discharge canal from Alternative 1 for Indian Point Unit No. 2. Unit No. 1 also uses this canal, discharging another 1,880 x 10^6 Btu/hr. The total volume encompassed within the 4°F rise is 47 acre-ft of which 42 acre-ft is attributed to Unit No. 2.

Alternative 2. Minimum Water Impact

Environmental Cost: 203 x 10^6 Btu/hr, ~0 acre-ft (applicant's estimate)

The procedures employed were as described for Alternative 1 and these were repeated six times for the various subalternates: 2B--Natural-Draft Cooling Towers, Open-Cycle; 2C--Mechanical-Draft Cooling Towers, Open-Cycle; 2D--Spray Pond, Open-Cycle; 2E--Natural-Draft Cooling Towers, Closed-Cycle; 2F--Mechanical-Draft Cooling Towers, Closed-Cycle; and 2G--Spray Pond, Closed-Cycle. The values chosen to represent the environmental cost for Alternative 2 are those for subalternative 2E and 2F, although the amount of heat to be introduced from subalternate 2G would be less. In either case, the quantity to be introduced is almost negligible when compared to the heat being dissipated from Unit No. 1. The volume within the 4°F temperature rise that could be attributed to Unit No. 2 is near zero for all closed-cycle subalternatives (2E, 2F, and 2G).

The selection of a closed-cycle cooling tower suboption rather than the closed-cycle spray pond to represent Alternate 2 was based on the significantly higher consumption of water caused by excessive drift from the spray pond. The total water consumption, drift plus evaporation, of closed-cycle cooling tower arrangements is estimated to be 15,000 gpm (0.1% drift) for mechanical-draft and 14,000 gpm (0.0025% drift) for natural-draft cooling towers while that from a closed-cycle spray pond would be between 23,000 gpm (1% drift) and 58,000 gpm (5% drift). This extra water consumption, 9,000 gpm to 44,000 gpm, from spray ponds represents a significant loss of water. The choice between the mechanical-draft and natural-draft towers for the minimum-water-impact alternative was then made, as described previously. None of the open-cycle subalternatives were selected because each would discharge substantial quantities of heat (see Table 1.1-1 of the applicant's Supplement No. 3) into the water body.

The staff estimated that the volume enclosing the 4°F isotherm for Alternative 1 would be 1,550 acre-feet rather than 42 acre-feet estimated by the applicant. Also, for open-cycle cooling towers the staff estimated that 1.27×10^9 Btu/hr would be released to the river rather than 5.08×10^9 Btu/hr estimated by the applicant. For closed-cycle towers the staff's estimate of drift and evaporation losses are given in Appendix XI-1.

1.2 Aquatic Biota

Alternative 1. Plant As Is

Environmental Cost: 0.24 lb Alewife/year, 0.03 lb Bay Anchovy/year, 1.00 lb American Shad/year, 0.03 lb Carp/year, 0.47 lb American Eel/year, 0.10 lb Hogchoker/year, 0.04 lb Blueback Herring/year, 0.01 lb Atlantic Sturgeon/year, 0.31 lb Striped Bass/year, 0.57 lb Atlantic Tomcod/year, 0.19 lb White Catfish/year, 2.9 lb White Perch/year. The applicant has supplied this estimate.

The applicant's estimate is based on the following considerations (quoted from pp. S3-25 to S3-31 of Supplement No. 3):

"The productivity as reflected by the standing crop of the Hudson River fishery from Croton Point to the Bear Mountain Bridge, which includes the Indian Point area, was estimated using fish catch data from ecological surveys[(1e)] and from commercial catch data.[(1f)] Bottom trawling, surface trawling, and beach seining were utilized to obtain fish in the ecological surveys. Fish in these collections were predominantly young of the year and yearlings. These collections were made throughout the year. The monthly catches by these various methods were averaged for the 12-month period of August 1969 through July 1970. The number of fish per unit of area was obtained by dividing the catch data by the area trawled (about one acre) or seined (0.017 acres).[(1g)] The average weight of fish species was calculated from the raw catch data from July 1970. By multiplication, pounds of fish per acre by species was obtained. These data are presented in Table 1.2-1. (See Supplement No. 3, p. S3-27.) The total surface area of the region from Croton Point to Bear Mountain Bridge is 13,140 acres[(1h)] and the surface area of a depth less than six feet is 2,380. The difference, 10,760 acres, is considered to be the area of the open water fishery while the near shore fishery of the area is considered to be approximated by the 2,380 acres. Data on average weight of fish species, number of fish/acre, pounds of fish/acre, and total pounds of fish in the region is presented for the near shore fishery in Table 1.2-2. (See Supplement No. 3, p. S3-29.)

(1e) Information supplied to consultants by Consolidated Edison.

(1f) Clark, J.R. and S. E. Smith, 1969. Migratory Fish of the Hudson River Estuary. In Hudson River Ecology, Proc. of Second Symposium on Hudson River Ecology, Sterling Forest, Tuxedo, New York, October, 1969. pp. 293-319.

(1g) Reference (1e) used a 75-foot seine initially and then switched to a 100-foot seine. They seined out to about 10 feet offshore so that initially 750 ft^2 (0.017 acres) and finally 100 ft^2 (0.023 acres) were covered. The lower number is used throughout to overestimate the fishery.

(1h) Areas determined by planimeter on a U.S. Geological Survey Map, scale 1 inch = 2,000 ft.

"Since the data from the ecological surveys were on predominantly young fish, data on the commercial catch of the Hudson River were considered.(1f) The four-year average catch of commercial species between 1965 and 1968 was considered to come from the Hudson River south of the Troy Dam. To estimate fish/unit area, this total area (78,044 acres) was considered to have a homogeneous fishery. From the data on pounds per species in the commercial catch, the area of the fishery, and the area near Indian Point (13,140 acres), estimates were obtained by species on commercial catch in pounds/acre and in pounds in the Indian Point area. This data is summarized in Table 1.2-3. In this table, the estimates on pounds of fish/acre obtained from the ecological surveys and from the commercial catch data were combined to obtain the total weight of fish/acre by species. These numbers are considered representative of the open water fishery in the Indian Point area of the Hudson River as estimated from the best available data.

"Two environmental costs are estimated: (1) that portion of the bottom and surface fishery within the 89°F isotherm, and (2) that portion of the fishery within the 4°F rise. Consideration is restricted to the open water fishery. The discharge occurs at a depth well in excess of six feet* through the existing Unit No. 1 canal and is directed toward midstream. Since the thermal plume does not approach the shore, it will not affect the near shore waters or the near shore fishery. The pounds of fish for each species within the two selected isotherms are calculated assuming a uniformly distributed fishery. These data are presented in Table 1.2-4. (See Supplement No. 3, p. S3-32.) It is assumed that the entire water column from surface to bottom is encompassed by the isotherms which overestimate the effect. Temperature of 89°F is selected as a conservative maximum for these fish, while the 4°F temperature rise isotherm corresponds to state standards during most of the year. The numbers within the 89°F isotherm are considered to be the potential environmental costs."

While the applicant made these estimates, according to Supplement No. 3, it stated that studies indicate zero costs. The staff agrees that the environmental cost would be small for aquatic biota from thermal discharges alone. However the combination of thermal and chemical discharges could cause more of an impact (see introduction to Section XI.B).

Alternative 2. Minimum Water Impact

Environmental Cost: $\sim$0 (Applicant's and staff's estimate)

The procedural details for the calculations are as described in the section for Alternative 1. The environmental cost of approximately zero is appropriate to the subalternative cooling system chosen, 2E natural-draft cooling towers, to minimize water impact.

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* The discharge port is being changed such as to discharge the cooling water at a depth of 12 feet rather than 18 feet below mean-low water level.

1.3 Migratory Fish

All Alternatives

Environmental Cost: 0 (The applicant's value)

In all cases under consideration, the applicant does not anticipate plumes of a 4°F isotherm, to extend across the Hudson River. According to the applicant, the maximum situation for the once-through cooling system (Alternative 1) would have the 4°F isotherm extending 590 feet, or less than 1/5 of the way across the Hudson River. The staff believes that only actual operating experience in which an adequate monitoring program is carried out in cooperation with the State and Federal agencies will determine whether Alternative 1 - Plant As Is - will be able to meet the New York State criteria of 4°F and 90°F, particularly during the summer time when the plume will spread on the surface and the ambient river temperature may be greater than the 79°F temperature which the applicant has used as the average summer temperature. This also will have to be verified, particularly with a change in the submerged jet from 18 feet to 12 feet. Subalternative 2E results in the 4°F isotherm reaching only 290 feet from the east shore. These numbers were obtained by scaling as described in Item 1.1. The scaling law obtained was proportional to the square root of the ratio of initial rise to the temperature rise of interest.

2. Effects on Water Body of Intake Structure and Condenser Cooling System

2.1 Primary Producers and Consumers

Alternative 1. Plant As Is

Environmental Cost: 3.7×10^5 lb microzooplankton/year (Applicant's estimate)

Experimental data for phytoplankton and microzooplankton relative to this effect have been obtained and projections made for cases of interest. The applicant has assumed that phytoplanktonic organisms are anticipated to be killed only as a result of chlorination and in make-up water for other alternatives. Based on this information, the applicant estimates that no environmental cost of phytoplankton will result from Alternative 1.

In Chapter V.D.3, the staff's analyses indicates that significant changes could occur in the phytoplankton community as a result of Plant operations. However, the staff has not quantitatively assessed the magnitude of the possible changes or the probability of their occurrence based on available information. The staff has estimated the maximum possible consequence which would result from a yearly reduction of 17% of phytoplankton productivity at Indian Point. Similarly the staff's analyses shows that significant damage to zooplankton from effects of chlorination, entrainment, and exposure to the thermal plume. Samples of microzooplankton consisting of 84% adult Copepods, 12.2% cladocerans, 2.7% barnacle larvae, and 1.1% copepod nauplii were air dried at 50°C and weighed to estimate the weight of an individual microzooplankter. This estimate (1.14×10^{-5}) was used to calculate the approximate microzooplankton kills per year resulting from Alternative 1. The number of organisms per year estimated to be killed is 1.48×10^{13}. The estimated kill is 3.7×10^{5} lb/yr of microzooplankton. The applicant believes that such minor impacts would not be expected to cause any significant shifting in the species present. However, the staff feels a shifting in species may be significant, and, again, that only from actual operating experience and study can this be determined.

Alternative 2. Minimum Water Impact

Environmental Cost: 1,570 lb phytoplankton/year, 3.1×10^{4} lb microzooplankton/year. (Applicant's estimate)

The environmental cost selected for this Alternative is that attributed to Subalternative 2E, natural-draft, closed-cycle cooling towers. The weight 3.1×10^{4} lb microzooplankton/year was estimated as described for Alternative 1. The weight of 1,570 lb/year of phytoplankton was estimated by considering the weight of an individual phytoplankton to be 1 nanogram. Calculations on single cells of blue-green algae resulted in an average cell weight of 10^{-11} g. A nanogram per phytoplankton kill under Subalternative 2E is in the use of make-up water for the cooling tower.

2.2 Fisheries

Alternative 1. Plant As Is

Environmental Cost: 0 fish/year (the applicant's)

As discussed in Chapter V.D. of this Statement, the staff disagrees with the above estimate. The major adverse impact of the operation of Indian Point Unit No. 2 from the intake and discharge structure will result in significant damage to anadromous and catadromous species from entrainment and impingement. The fish kill of February 29, 1972 when only 2 pumps of Indian Point Unit No. 2 were being tested plus experience with fish kills of Indian Point Unit No. 1 are indicative of the potentially serious effect of Plant operation to aquatic biota from Unit No. 2. Furthermore, the effect of Unit No. 2 operations from entrainment of fish eggs and larvae from spawning is an order of magnitude greater than that predicted by the applicant. See p. XI-13, item 2 for the staff's position regarding damage to biota from impingement and entrainment. Details of the staff's analysis are presented in Chapters V.D., Appendix V-1 on chlorination effects and Appendix V-2 on entrainment effects of operation of Indian Point Unit No. 2.

The applicant's estimate is based on the following considerations (quoted from pp. S3-25 to S3-31 of Supplement No. 3):

"While data has been collected daily since April 1970 on the small fingerling fish impinged on the screens at Indian Point 1 (see table 2.2-1 for total annual impingement) and there is limited data on the operation of pumps for Indian Point 2, this data is insufficient to predict impingement on the screens at Indian Point 2 during steady-state operation. Records of fish impingement at Indian Point clearly indicates that there is a relationship between the numbers of fish impinged on the screens, the velocity and volumes of cooling water flow, the fish density in front of the screens, the water temperature, perhaps the season of the year and the physiological condition of the fish. There are also indications that at low water temperatures, the slight rise in ambient river temperatures in the immediate vicinity of the plant due to the thermal discharge from Indian Point No. 1 may attract fish to the vicinity of the plant. Thus far we have been unable to quantify the interrelationship of these variables. Relating fish impingement at Indian Point No. 2 to the relative volumes of cooling water flow at Indian Point Nos. 1 and 2 is reasonable only if assumptions are made that the supply of fingerlings is infinite and the densities and condition of the fish in the vicinity of the plant are unaffected by plant operations. Such assumptions are invalid for this purpose. For example, it is unreasonable to assume that three times as many fish will be impinged on the screens of Indian Point 2 because the school will have been depleted before it arrives there.

"The experience during the winter of 1971-72 with impingement at I.P. No. 1 is substantially improved over last year reflecting in part an improved discharge structure (which is in the process of further improvement) and improved screen cleaning methods. Less ice cover may also have some bearing on this experience. An air curtain currently being tested also gives preliminary indications of further reduction in fish impingement.

"The impingement at the intakes of Indian Point No. 2 operating alone at Indian Point No. 1 rates of circulation can be expected to be less

Table 2.2-1. Total Annual Impingement of Fish (estimated) at Indian Point Unit 1

Species	Total Number of Fish
White Perch	454859
Striped Bass	20367
Tomcod	29419
Herrings (blueback & alewife)	15841
Bay Anchovy	11881
Other	33943
	566310

Notes:

1. Estimate based on days with complete counts and assumes that plant operates 365 days/year. Operation of plant in December, January, February and March was at reduced flow (60% of full flow).

2. Total number of each species was obtained by applying data on per cent compositions of catch from samples taken throughout the year to the total estimated impingement.

3. The actual total impingement is considerably less than the estimated because there are many days when the plant is not operating or is operating only a single main pump.

4. These fish average approximately 2 inches in length and 0.4 ounces in weight.

than the impingement rates at Indian Point No. 1. The intakes at Indian Point No. 2 are further removed from the thermal influence from the discharge canal, and the control gates being installed on the discharge ports to permit maintaining a 10 foot per second discharge velocity will improve mixing and reduce temperature differentials in the plume. There is no dock in front of Indian Point No. 2 that may shelter and attract fish. The screen cleaning mechanism at Indian Point No. 2 will be greatly improved over the mechanism at Indian Point No. 1 during the period in which the data was collected. Other improvements to the Indian Point No. 2 design are discussed in the Environmental Report Supplement No. 1. Accordingly, it is reasonable to expect a lower total impingement at Indian Point No. 2 per unit of cooling water than at Indian Point No. 1. However, it is reasonably anticipated that there will be fishes impinged at the intake screen of Indian Point No. 2, perhaps in numbers greater than experienced in the recent past at Indian Point No. 1. The data being collected at Indian Point No. 1 will be similarly collected at Indian Point No. 2 as a part of the Hudson River ecology study to provide a better understanding of the interrelationships of the many variables.

"The methodology by which the data available can be used to quantify or even demonstrate the relationship between the fish impingement at Indian Point 1 and 2 and the fishery resources is not yet complete. Again there are many variables which affect fish population: fecundity, sex ratio, maturation, mortality as influenced by food, temperature, rainfall and runoff, salinity and water quality. A very high mortality occurs naturally to young fishes. A great abundance of striped bass has been reported in the Hudson River throughout the last decade. To attribute this great abundance to the operation of Indian Point No. 1 since 1962 would be presumptuous. It would be equally presumptuous to attribute to Indian Point No. 1 operation in an opposite trend were such to be identified. Further there is clear evidence that the operation of Connecticut Yankee has not had any discernible effect on the Connecticut River Fishery. Our best judgment is that we can expect that the operation of Indian Point No. 2 will similarly have no adverse effect on the Hudson River Fishery. In order to confirm this expectation the Company has asked the Hudson River Policy Committee to conduct a ten million dollar five-year study of the effect of Indian Point operations on the Hudson River fisheries to supplement the data earlier collected under the direction of Raytheon. This study is currently underway.

"The Company has sought the advice of leading aquatic biologists and engineers in an attempt to evaluate the impact of its operations on the Hudson River Fishery and to devise methods to minimize that effect[2b]. They have helped guide the Company in the development of the plan of study referred to above and have continuously monitored data as it was collected. It is their professional view as expressed by Dr. Gerald Lauer at the Indian Point No. 2 Atomic Energy Commission hearings on 12 January 1972[2c], that: 'I personally and the members individually and collectively, based on their professional experience, feel that the operation of units 1, 2 and even 3 at Indian Point would have no significant effect on thy fisheries -- on the fish populations in the Hudson River.' On the basis of the best scientific information and advice, we anticipate no significant environmental costs arising out of fish impingement on the screens at Indian Point No. 2."

Alternative 2. Minimum Water Impact

Environmental Cost: 0 fish/year (the applicant's)

As stated above (Alternate 1) there is no scientific basis with which to predict the impingement of fish. Alternative 2E, natural-draft, closed-cycle cooling towers will result in a substantial reduction in numbers of fish impinged annually due to a reduction in withdrawal of cooling water. The net effect will be no change in environmental costs which will remain at zero.

The staff's analysis (see Chapter V and Appendix XI-1) of Alternative 1 indicates that entrained organisms, including fish eggs and larvae, would be subjected to mechanical, thermal, and chemical shock which would have a serious effect. Also, impingement of fish on the present intake structures is considerable, although the applicant is studying means of alleviating the impact. The staff agrees that for Alternative 2 the impact would be quite small.

The following is a summary with the staff's comments of possible alternatives suggested by the applicant to minimize the damage of fishkills from impingement.

1. Vertical traveling screens straight line in the river.
   Cost: $11,500,000.

   The proposal calls for use of a common intake structure farther out in the river with a single row of vertical traveling screens parallel to the river flow. This would reduce intake velocities to below 0.3 fps during colder parts of the year and to 0.5 fps during the summer.

2. Horizontal traveling screens straight line in the river.
   Cost more than $11,500,000.

   Will result in lower intake velocity as with 1. The operation of the screens will move impinging fish to the side of the intake rather than toward the surface of the water.

3. Vertical traveling screens VV shape with bypass in the river.
   Cost: $14,600,000.

   Will allow fish to be withdrawn through the bypass where they are returned to the river by pumping (fish pumps) or by lifting. Testing has indicated fish mortality of 5 to 50%.

4. <u>Vertical traveling screens relocated to the front of the forebays at Units Nos. 1 & 2.</u> Cost $1,000,000 for Unit No. 2, Unit No. 1 has higher costs.

   The relocation will allow lateral movement along the screen surface to avoid impingement. Continual operation of the screens instead of periodic operation will result in a lowered mortality rate for impinged fish.

5. <u>Vertical traveling fish basket.</u> The cost is unknown. Neither effectiveness nor practability for Indian Point has been demonstrated.

6. <u>Air bubble screen.</u> Cost: $12,000/bay.

   The effectiveness in preventing fish from moving toward the screen is uncertain. This device is presently being tested at Unit No. 1.

   Closed-cycle alternatives would be expected to have a reduced impact proportional to the reduced water intake:

Natural-draft towers	2.5% as great
Mechanical-draft towers	2.6% as great
Spray ponds	3.3% as great.

3. <u>Chemical Discharges to Water Body</u>

The chemicals which will be discharged from Indian Point Unit No. 2 are identified and the amounts to be released are described in Chapters III and V, and Appendix V-1.

3.1 <u>People</u>

<u>All Alternatives</u>

The discharge of chemicals to the river is not expected to have any effect on human use of the river. The staff agrees with the applicant on that point.

3.2 <u>Aquatic Biota</u>

<u>All Alternatives</u>

<u>Environmental Cost</u>: Small

Chemicals expected to be released into the discharge canal will have sufficiently low concentrations (after dilution by the discharge water) so as to protect aquatic biota from lethal or sublethal effects due to long-term or chronic exposure. An exception, however, is the discharge of residual chlorine combined with increased temperature. According to the applicant, the effect will probably not be great. The staff's analysis indicates that the effect may not be great except for entrained organisms. (See Item 3 for staff's discussion of entrained biota.)

3.3 Water Quality - Chemical

All Alternatives

Environmental Cost: 0 (see discussion of 3.1 above).

4. Consumption of Water

4.1 People

All Alternatives

Environmental Cost: 0 gal/year

The Hudson River near and below Indian Point is not used for drinking water purposes.

4.2 Property

All Alternatives

Environmental Cost: 0 acre-ft/year

The Hudson River near and below Indian Point is not used for irrigation purposes.

5. Chemical Discharges to Ambient Air

5.1 Air Quality - Chemical

All Alternatives

Environmental Cost: 2.7%

The Plant will release no combustion products to the atmosphere as a result of reactor operation. It will, however, have two "package boilers" fueled by #6 fuel oil (0.3% sulfur) to produce auxiliary service steam for startup and service heating. The exhaust from these boilers will be discharged through the Unit No. 1 superheater stack. Taking into account the planned reduction in the stack height, the annual average ground level concentrations of sulfur dioxide, nitrogen oxides, and particulates were calculated for the emission source based on 6,500 hours operation per year. The concentration values obtained were 8.1×10^{-4} ppm for SO_2, 3.4×10^{-4} ppm for NO_x, and 0.35 micrograms/m^3 for particulates. The Federal Air Quality Standards to be achieved by 1975 for these three pollutants are: 3×10^{-2} ppm for SO_2, 5×10^{-2} ppm for NO_x, and

75 micrograms/m^3 for particulates. The annual average concentrations estimated for Unit No. 2 emissions are, respectively, 2.7%, 0.68%, and 0.4% of these standard values. (These data are from the applicant's Supplement No. 3, p. S3-50.)

5.2 Air Quality - Odor

All Alternatives

Environmental Cost: None

Although a few chemicals of an organic nature are anticipated for use in the Plant, the amounts will be so small and their concentrations in the atmosphere and in discharge waters will be so low that no perceptible odors will be experienced at offsite locations.

6. Salts Discharged from Cooling Towers

6.1 People

Alternative 2. Minimum Water Impact Design

In order to assess this impact, it is necessary first to have estimates of the salt deposition resulting from the cooling alternatives. These values are tabulated in Table 6.1-1 for the sector having the highest deposition and for the entire area between radii of 0-1, 1-2, 2-3, 3-4, 4-5, and 5-10 miles of the site. These values were calculated using (1) estimates of salt deposition already obtained for natural-draft cooling towers calculated for Indian Point and (2) the factors employed to estimate the dispersion of airborne radioactivity from the site. (See p. S3-54, Supplement No. 3.)

The theoretical equations used to estimate salt deposition are based on equations developed for estimating the dispersion and deposition of radioactivity from elevated stacks[(2)]. The important parameters in these equations are (1) the salt discharge rate into the atmosphere, (2) the effective height of the plume, (3) the distance from the source, and (4) the average ambient weather conditions which include the stability, the wind velocity, and the wind direction. The factors for estimating the dispersion of airborne radioactivity are ratios of the groundlevel concentration of atmospheric radioactivity at a given point to the rate of radioactivity discharge from the site. Deposition is assumed to be proportional to groundlevel concentration so these factors are also applicable to estimating salt deposition. However, the factors were calculated for a groundlevel release and for an effective plume height of about 290 feet. These effective heights for radioactivity are, of course, not applicable to the cooling towers. The theoretical equations indicate that the logarithm of the radioactivity factor at a given location should be proportional to the square of the effective plume height, and this scaling was used to correct the radioactivity factors for the effective plume heights corresponding to the mechanical-draft cooling towers (about 400 feet). The spray ponds are essentially groundlevel releases while the effective plume heights for natural-draft towers are in excess of 1,000 feet so that this would require extrapolation beyond the confidence of the scaling.

According to the applicant, because of the difficulties in extrapolating the radioactivity factors to the plume heights of natural-draft towers, these factors could not be used with confidence to calculate the salt deposition from the towers. The earlier estimates of salt deposition were for natural-draft towers but these estimates were only for the sector showing the maximum deposition rates and were based on different salt discharge rates from the tower. These earlier estimates were scaled with the salt discharge rates of the applicant's Supplement No. 3 for natural-draft towers in order to obtain the depositions for the maximum sector. The scaling was directly proportional to the discharge rate. In order to estimate the average deposition rate for the entire area within given radii, the radioactivity factors were scaled to the effective plume height corresponding to the natural-draft towers. The average factor for all the sectors within the given radii was calculated and the ratio of this average factor to the factor for the maximum sector within the given radii was determined. This ratio was then multiplied by the salt deposition rate for the maximum sector to provide the estimate of the average deposition rate. The calculation of this ratio did not require as much confidence as the direct calculation of the deposition rate so that the scaling with plume height was satisfactory for this purpose.

The salt deposition values for the mechanical-draft towers and the spray ponds were calculated as the product of a salt discharge rate, a deposition velocity equivalent to 5 cm/sec, and the radioactivity factor for the given sector and distance from the site. The salt discharge rate used for the 0-1 mile distance was the value at the tower or pond. The total amount of salt deposited within 1 mile was then subtracted from the tower or pond discharge and this difference was used as the salt discharge rate for calculating the deposition within the 1 to 2 mile radii. This process of reducing the discharge rate was continued until the rate became zero. The results of these calculations indicated that about 5% of the salt discharged from mechanical-draft towers would be deposited within 10 miles while all of the salt discharged from spray ponds would be deposited within 1 mile. The definition of the radioactivity factors was not fine enough to calculate the exact radius within which all of the salt from the spray ponds would be deposited. Therefore, the average deposition rates for spray ponds were calculated with the assumption that all of the salt would be uniformly deposited on the area enclosed by the 1-mile radius.

<u>Cooling Subalternative 2E</u> (Natural-Draft, Closed-Cycle Cooling Towers)

<u>Environmental Cost</u>: 0 gal/year

Intrusion of salts from cooling tower drift into ground-water is considered improbable. The only public water supply served by wells averages about 550 gpm. A few wells, serving private homes, are still in use along the fringes of the area. Both the Stony Point System wells and the private wells are in unconsolidated deposits with depths ranging from 35 to 50 feet. However, on both sides of the river the ground elevations are considerably higher than at the Plant site, and water should flow to the river.

The data indicate that the maximum rate of salt deposition from the cooling towers under this subalternative will occur 3 to 4 miles from the Plant. The rate was calculated to be about 3 pounds salt per acre per year. Percolation of this material into the ground will depend upon rainfall. The annual rainfall in this region averages about 36 inches, and so the average salt concentration in percolating groundwater would be about 0.36 ppm. Since this is a factor of 700 below permissible water quality criteria for chloride and sulfate (250 ppm) as recommended for public water supplies, any salts from the natural-draft cooling towers that might reach underground wells will have negligible effect on the water supply.

Cooling Subalternative 2B (Natural-Draft Cooling Towers, Open-Cycle)

Environmental Cost: 0 gal/yr

This subalternative cooling method will discharge less salt than Subalternative 2E. Therefore, it will not affect local groundwater supplies.

Cooling Subalternatives 2C (Mechanical-Draft Cooling Towers, Open-Cycle) and 2F (Mechanical-Draft Cooling Towers, Closed-Cycle

Environmental Cost: 0 gal/yr

Most of the salt deposition from these mechanical-draft cooling tower subalternatives will occur within 2 miles of the Plant. The calculated deposition rates, while appreciably higher than for natural-draft cooling towers, would still result in peak average salt concentrations in percolating groundwater at 2 miles of 25 ppm. On the basis of the discussion presented for cooling Subalternative 2E, no effect on local groundwater supplies would occur.

Cooling Subalternatives 2D (Spray Pond, Open Cycle) and 2G (Spray Pond, Closed Cycle)

Environmental Cost: 0 gal/yr

Much more salt is available for deposition from these subalternatives than from the cooling tower subalternatives because of the higher drift values. However, the rate calculations indicate that the deposition will be confined to an area within 1 mile of the site. Since there is no use of well water in this area, no loss of water supply will occur.

6.2 Plants

Alternative 2. Minimum Water Impact Design

Environmental Cost: 0 acres

Although it was possible to obtain estimates of the magnitude of salt deposition for the various cooling alternatives, it was not possible to obtain enough specific data to allow a detailed assessment of the potential effects of the salt deposited on the vegetation within the Plant's sphere of influence. However, data from highway salting research indicates that salt deposition rates of 500 lb/acre/year could be detrimental to roadside vegetation and deposition rates of 1,000 lb/acre/year would cause damage to roadside vegetation. Using this range of deposition rates and the data for the various cooling alternatives, estimates were made for the acreage which could suffer potential detrimental effects from salt deposition.

Cooling Subalternatives 2B, 2C, 2E, and 2F

Environmental Cost: 0 acres

Since the data show no salt deposition rates in excess of 500-1,000 lbs/acre/year, there will be no environmental costs to plant life in the area associated with these alternatives.

Cooling Subalternatives 2D and 2G

Environmental Cost: 1,200 acres

The predicted salt deposition rates from the spray pond alternatives greatly exceed the 500-1,000 lbs/acre/year. Furthermore, the calculations predict that all the salt would be deposited within a 0-1 mile radius of the spray ponds. Consequently, either of these two alternatives could be expected to present an extreme hazard to terrestrial plant life particularly in the immediate Plant site environs, and to a lesser extent, up to 1 mile from the spray ponds.

Within the 0-1 mile radius from the spray ponds are some 1,206 acres of land with approximately equal utilization by industrial activities and residential usage. The environmental cost to the plant life on these 1,206 acres from either spray pond alternative could be potentially substantial.

6.3 Property Resources

Alternative 2. Minimum Water Impact Design

Through a review of the literature and contacts with a number of local real estate appraisal and consulting firms, efforts were made by the applicant to obtain data for comparable coastal and inland communities which could possibly provide guidance in the assessment of the impact of salt deposition on property resources within the sphere of influence of the Indian Point site. These efforts did not reveal any data which would enable a reasonable assessment of the detrimental effects on property resources.

Cooling Subalternative 2B and 2E

Environmental Cost: 0 dollars

From the standpoint of the Subalternative 2E, salt deposition rates are relatively low. The highest deposition rate occurs in the maximum sector of the 3 to 4 mile radius, which is almost entirely over the Hudson River proper. Consequently, there would be very little, if any, property resources in this sector to be exposed to the deposited salt.

The highest salt deposition rates from Subalternative 2B also occur in the maximum sector of the 3 to 4 mile radius, and deposition rates are essentially one-half those of Subalternative 2E.

Cooling Subalternatives 2C, Mechanical-Draft Cooling Towers, Open-Cycle; 2D, Spray Pond, Open-Cycle; 2F, Mechanical-Draft Cooling Towers, Closed Cycle; 2G, Spray Pond, Closed-Cycle

Environmental Cost: Moderate

Of the other cooling alternatives evaluated for minimum water impact, the spray pond alternatives (2D and 2G) represent the greatest potential threat to property resources in the area. It is predicted that all the salt will be deposited in a 1-mile radius from the Plant site. While most of the salt should be deposited near the ponds, the town of Verplanck is located within the 1-mile radius and would be expected to receive some of the deposited salts. Thus, the potential for damage to property resources in the area would be greatest from the spray ponds.

The mechanical-draft cooling tower alternatives (2C and 2F) would have the next greatest potential for damage to surrounding property resources. The highest salt deposition rates occur in the maximum sectors of the 0-1 mile radius which includes the town of Verplanck and the 1-2 mile radius. Consequently, some damage to property resources in this area could occur from the salts deposited by the mechanical-draft cooling towers.

7. Chemical Contamination of Groundwater

7.1 People

All Alternatives

Environmental Cost: 0 gal/year

No environmental cost will occur from any of the alternatives for this category because the few wells that may provide drinking water to nearby residents are shallow and at ground elevations that are considerably higher than the Plant site. Thus groundwater at the site flows to the Hudson River.

7.2 Plants

All Alternatives

Environmental Cost: 0 acres

Chemical discharges from the Plant, for each of the alternatives, are made at the beginning of the Station cooling water discharge canal and consequently travel with dilution directly into the Hudson River. Under Alternative 2, residual chlorine, following condenser chlorination treatment at levels of 0.1 to 0.5 ppm might be realized during passage of the cooling water through each of the alternative systems. A chemical reaction will form chloramines which, with residual chlorine, result in damage both lethal and sublethal to phytoplankton.

8. Radionuclides Discharged to Water Body

The following are estimates provided by the applicant in its Supplement No. 3 The staff's estimates are summarized in Chapter V.D. on doses to biota and Chapter V.E. on doses to man which differ because of different source term from that of the applicant's.

8.1 People-External

Alternative 1. Plant As Is

Environmental Cost: (applicant's estimate)

[Table on next page]

Individual Radiation Dose

Emission Source	Rem/year/person		
	Swimming	Boating, Fishing, Skiing	Sunbathing
Unit No. 2	1.1×10^{-8}	1.1×10^{-8}	4.6×10^{-7}
Units Nos. 1&2	4.3×10^{-8}	4.3×10^{-8}	4.1×10^{-6}

Integrated Population Dose

	Man-rem/year		
Population	114,000 Swimming	335,000 Boating, Fishing, Skiing	114,000 Sunbathing
Unit No. 2	1.3×10^{-3}	3.7×10^{-3}	5.3×10^{-2}
Unit Nos. 1&2	4.9×10^{-3}	1.4×10^{-2}	4.7×10^{-1}

The individual radiation dose estimates are based on (1) measured river concentrations, (2) known and anticipated liquid releases from Units Nos. 1 and 2, (3) 250 hours per year in-water activity for a swimmer, and (4) 500 hours per year above-water activity for boaters, skiers, or anglers. The values assume no credit for river dilution beyond the point of Plant discharge.

Alternative 2. Minimum Water Impact

Cooling Subalternatives 2E, 2F, and 2G.

The cost values for this alternative would be 3.75 times each of the numerical values given in the cost tabulation under Alternative 1. This is because the discharge dilution flow for liquid wastes would be reduced from about 1.2 million gpm to about 0.32 million gpm, and because no credit is taken for river dilution in the calculations.

Cooling Subalternatives 2B, 2C, and 2D

The cost values for these three subalternatives are the same as the cost tabulation given above for Alternative 1 because each of the subalternatives incorporates open-cycle operation which will provide essentially the same discharge dilution flow as is available for once-through cooling.

8.2 People - Ingestion

Alternative 1. Plant As Is

Environmental Cost: (applicant's estimates)

Drinking River Water

	Individual Radiation Dose Rem/year/person			
	Whole Body**	G.I.	Thyroid*	Bone
Unit Nos. 2	5.5×10^{-6}	6×10^{-9}	2.5×10^{-7}	7.4×10^{-11}
Units Nos. 1 & 2	6.3×10^{-6}	1.9×10^{-8}	7×10^{-7}	1.1×10^{-9}

(1.11×10^{6} persons)	Population Radiation Dose Man-rem/year
	Whole Body
Unit Nos. 2	6.1
Units Nos. 1 & 2	7.0

* Dose for child thyroid.
**Dose to whole body due almost entirely to tritium.

Eating Fish From River

	Individual Radiation Dose Rem/year/person			
	Whole Body**	G.I.	Thyroid*	Bone
Unit No. 2	4×10^{-7}	2×10^{-8}	1.2×10^{-8}	1.8×10^{-10}
Units Nos. 1 & 2	6×10^{-7}	8×10^{-8}	5.2×10^{-8}	4.8×10^{-9}

(7.90×10^{5} persons)	Population Radiation Dose Man-rem/year
	Whole Body
Unit No. 2	0.32
Units Nos. 1 & 2	0.47

* Dose for thyroid of adult.
**Dose to whole body due almost entirely to tritium.

Alternative 2. Minimum Water Impact Design

Environmental Cost: Same ratios as for Item 8.1.

8.3 Primary Producers and Consumers

Alternative 1. Plant As Is

Environmental Cost: (applicant's estimates)

Dose to Benthic Organisms

Emission Source	Rads/year*
Unit No. 2	2×10^{-4}
Units Nos. 1 & 2	1.4×10^{-3}

*After 40 years of Plant operation

The above dose rates are based on (1) results of radiological monitoring studies, (2) known radionuclide releases from Unit No. 1, and (3) expected discharge rates from Units Nos. 1 and 2 in the future. For comparison the natural dose rate from ^{40}K in the water is calculated to be 0.1 to 0.15 rads per year. Therefore, Plant operation would add less than 0.2% to the natural background.

Alternative 2. Minimum Water Impact Design

Environmental Cost: Same ratios as for Item 8.1.

8.4 Fish

Alternative 1. Plant As Is

Environmental Cost: (applicant's estimates)

Dose to Fish

Emission Source	Rads/year
Unit No. 2	2.0×10^{-5}
Units Nos. 1 & 2	3.4×10^{-5}

These results are for fish residing in the immediate vicinity of the design basis effluent from Indian Point Units Nos. 1 and 2. The values are based on measured accumulations of the longer-lived radionuclides in fish taken from the river near Indian Point and on reconcentration factors available from the literature for other radionulcides. The dose rates also are based on a standard fish weight of 1 kg. The dose from tritium accounts for more than 99% of the total. Recent surveillance studies of the Hudson River (at locations above Indian Point) conducted by the New York State Department of Environmental Conservation indicate ambient tritium concentrations of about 1,000 pCi/liter. The tritium concentrations of Plant origin in the river near the Station discharge, which contribute to the dose rates given above, are about 700 pCi/liter (Unit No. 2) and 1,100 pCi/liter (Units Nos. 1 and 2). At more distant points the concentrations will be lower and so the environmental impact on migratory species may be considered negligible.

Alternative 2. Minimum Water Impact Design

Environmental Cost: Same ratios as for Item 8.1.

9. Radionuclides Discharged to Ambient Air

The following estimates were provided by the applicant. See Chapter V.E for the staff's estimates.

9.1 People - External

All Alternatives

Environmental Cost: (applicant' estimates)

Individual Radiation Dose

Distance from IP-2	Rem/year/person* Whole Body	Skin
500 meters	5×10^{-4}	4×10^{-3}
1000	3×10^{-4}	1.2×10^{-3}
2000	1.7×10^{-4}	3.4×10^{-4}
5000	8×10^{-5}	7×10^{-5}

*In critical wind sector which is S-SW of the site.

Population Radiation Dose

Distance from IP-2	Cumulative Population	Cumulative Man-rem/year Whole Body
1 mile	2,010	0.23
2	20,810	0.79
5	107,960	1.6
10	312,540	2.1
15	670,120	2.4

9.2 People - Ingestion

All Alternatives

Environmental Cost:

Thyroid Dose

	Rem/year/person Adult	Child
Unit No. 2	4.3×10^{-4}	4.3×10^{-3}
Units Nos. 1 & 2	4.7×10^{-4}	4.7×10^{-3}

Thyroid Dose

Man-rem/year

	Adult	Child
Unit No. 2	16	160
Units Nos. 1 & 2	18	180

9.3 Plants and Animals

All Alternatives

Environmental Cost: (applicant's estimates)

	Dose to Cow Thyroid
	Rads/Year
Unit No. 2	4×10^{-4}

10. Radionuclide Contamination of Groundwater

10.1 People

All Alternatives (applicant's estimate)

Environmental Cost: 0 Rem/yr

The absence of an environmental effect on groundwater supplies is based on the known hydrology of the Indian Point site area. The ground surface elevations of the adjacent land are considerably higher than the Plant site. Thus, the direction of groundwater flow is towards the river, and this precludes the possibility of contamination of these supplies through groundwater flow.

The following is a summary of the staff's dose estimates.

Annual Integrated Whole-Body Dose to the General Population (1970) from the Operation of the Indian Point Station

Source	Population	Dose (man-rem)
Cloud (immersion)	16,000,000	15
Fish	1,600,000	3.2
Swimming	1,600,000	0.47

The doses to plants, invertebrates, and fish were estimated to be about 480, 135, and 65 mrad/yr, respectively. For closed-cycle alternatives, the values are estimated to be about 3.75 times those for the present design.

11. Fogging and Icing

11.1 Ground Transportation

Alternative 1. Plant As Is

Environmental Cost: 0 hours of increased driving hazard per year

Since once-through cooling discharges heated water onto the river surface in which the heat is transferred into the air, whispy fog may form, but as discussed in Chapter V, it is not expected to persist and thus no increase in the annual occurrence of fog or ice on roads is anticipated.

Alternative 2. Minimum Water Impact

Environmental Cost: 0 hours of increased driving hazard per year

In order to assess this impact and the impacts listed under Items 11.2, 11.3, and 11.4, it is necessary to estimate the increase in the annual number of hours of fog due to the cooling alternatives at locations surrounding the Indian Point site. In Table II.1-1 of the applicant's Supplement No. 3 values were calculated using (1) the annual frequency of saturation deficits over Poughkeepsie and (2) the radioactivity dispersion factors used to estimate salt deposition (see Item 6.2) and radiation doses (see Item 9). The confidence in the radioactivity factors for natural-draft towers is not good because of difficulties in scaling the radioactivity factors to the effective plume heights of the towers. These difficulties were discussed in Item 6.2. However, because the effective plume heights are so large (in excess of 1,000 feet), the estimates for fog at river level due to natural-draft towers are essentially zero so that the inaccuracies in the factors do not effect the conclusion that there is no river-level fog from natural-draft towers.

The theoretical equations used to calculate the increase in annual hours of fog are similar to the equations for estimating dispersion of radioactivity as discussed in Item 6.2. The excess humidity (above ambient) at a given location was calculated as the product of the rate at which water is discharged into the air and the radioactivity factor corresponding to the location's sector and distance from the site. The cumulative frequency for which the saturation deficit is less than or equal to this excess humidity was then determined from the Poughkeepsie data. The water in the plume would tend to evaporate if the saturation deficit was greater than the excess humidity. Therefore, the cumulative frequency for which the deficit is at or below the excess humidity is a measure of the cumulative frequency of fog (condensed water). Part of this fog would coincide with periods of natural fog. The occurrence of natural fog was assumed to be the frequency of zero deficit (when the air is saturated with water vapor). This frequency of zero deficit was therefore subtracted from the cumulative frequency corresponding to the excess humidity in order to arrive at the frequency of increased fog due to the cooling alternatives. The product of this latter frequency and the number of hours in a year (8,760) is the estimate of the increased hours of fog due to the cooling alternative.

As already mentioned, the confidence in the calculations is not good for natural-draft towers but the fog estimates are essentially zero so that possible errors in the calculations are not significant. The confidence in the calculations for spray ponds is also not good for distances greater than 1 mile because the calculations do not account for rainout of the condensed water. The calculated values of excess humidity would indicate that large amounts of rainout could occur within 1 mile during most of the time. This rainout would remove excess water from the plume so that locations beyond 1 mile would have a much lower frequency of fog than was calculated (see Table II.1-1, Ref. 1). However, those values can be considered as upper-limit estimates of fog beyond 1 mile while the lower-limit estimates would be zero fog beyond 1 mile.

In assessing the environmental cost, it was noted that a major highway runs within 1 mile of the site, but not necessarily in the direction of the maximum sector. Therefore, the environmental cost was taken as the average increase in the annual hours of fog within 1 mile of the site, and this was also taken as the hours of increased driving hazard. For reasons discussed in the introductory section on alternatives, the natural-draft cooling tower operating in a closed cycle, Subalternative 2E, was chosen as Alternative 2. The increase in the annual occurrence of fog within 1 mile of the site for this alternative is 0 hours. The increase is also zero for Subalternatives 2B and 2C, 88 hours for Subalternative 2F, 4,030 hours for Subalternative 2D, and 5,340 hours (60% of the time) for Subalternative 2G.

It should be noted that fog at the river level may not be the maximum. In fact, the maximum increase in fog would occur at about the plume height. Since the terrain is hilly in the area and the effective plume height for mechanical-draft towers is only about 400 feet, it is possible that some locations could receive increases in the occurrence of fog that are greater than the values calculated. For elevations approaching 400 feet above the river, the increase in annual hours of fog from mechanical-draft towers could approach the values for spray ponds. However, the increases in fog at the river level were felt to be the best representation of the environmental cost of the alternatives.

11.2 Air Transportation

Alternative 1. Plant As Is

Environmental Cost: Airport closed 0 hours per year

Since once-through cooling does not discharge any water into the air, there will be no increase in the annual occurrence of fog at airports and, thus, no closing of airports due to Alternative 1.

Alternative 2. Minimum Water Impact

Environmental Cost: Airport closed 0 hours per year

In assessing this environmental cost, it was noted that there is a seaplane base at Verplanck, approximately 1.57 miles south of the site. The sector having the maximum frequency of fog is also toward the south. Therefore, the environmental cost was taken as the maximum increase in the annual hours of fog between 1 to 2 miles of the site, and this was assumed to equal the hours during which the airport would close. The increase in the annual occurrence of fog within 1 to 2 miles of the site for Subalternatives 2B, 2C, and 2E is 0 hours, 88 hours for Subalternative 2F, 3,150 hours for Subalternative 2D, and 4,820 hours for Subalternative 2G. The spray pond values are upper-limit estimates beyond 1 mile. Also, as previously mentioned in Item 11.1, the effect of elevation may be significant in that there may be an increase in occurrence of clouds at the 400-foot level for mechanical-draft towers and at the 1,000-foot level for natural-draft towers. These increases could approach the values for spray ponds.

11.3 Water Transportation

Alternative 1. Plant As Is

Environmental Cost: Ships reduce speed 0 hours per year

Alternative 2. Minimum Water Impact

Environmental Cost: Ships reduce speed 0 hours per year

In assessing this environmental cost, it is significant that the site is located on the Hudson River which is navigable. Also, the sector having the maximum frequency of fog tends to be in a southerly direction over the river. Therefore, the environmental cost was taken as the maximum increase in the annual hours of fog within 1 mile of the site, and this value was assumed to equal the hours during which ships on the river must reduce speed. The increase in the maximum annual occurrence of fog within 1 mile of the site is zero hours for Sublternatives 2B, 2C, and 2E, 175 hours for Sublternative 2F, 5,610 hours for Sublternative 2D, and 6,570 hours for Sublternative 2G.

11.4 Plants

Alternative 1. Plant As Is

Environmental Cost: 0 acres

Alternative 2. Minimum Water Impact Design

Environmental Cost: 0 acres

While there is very little experimental evidence on which to base an accurate assessment of the potential effects on plant life from the fogging and icing conditions produced by the various cooling alternatives, some general statements can be made concerning the nature of some of these effects. For instance, evaporation and drift losses from the cooling towers and/or spray ponds could result in an increase in the relative humidity of the area. Since the vapor pressure gradient between the atmosphere and the moist plant surfaces would be lowered, a reduction in the rate of evaporation and transpiration could possibly occur. Also, the increased moist air conditions could favor certain fungi which might become serious pests on higher plants in the area.

The estimated environmental cost for each cooling subalternative is given below and expresses the number of acres exposed to increased fog frequencies and hence some possible detrimental effects on plant life. Concerning icing phenomena, ice formation on vegetation could occur during those periods when ambient temperatures are below freezing. Temperature statistics for New York City indicate that the monthly mean low temperature is below freezing for only 3 months of the year -- December, January, and February. However, the monthly mean high temperature for these same months is above freezing. Therefore, as an approximation, it may be assumed that the potential for icing occurs only about 12.5% of the time on an annual basis.

Cooling Subalternative 2B, 2C, 2E, and 2F

Environmental Cost: 0 acres

Since there are no increases in groundlevel fog frequencies predicted for Subalternatives 2B, 2C, and 2E, there would be no environmental costs to surrounding vegetation. Very little, if any, damage to plant life would be expected to result from the increases in the frequency of ground fog predicted for Subalternative 2F.

Cooling Subalternatives 2D and 2G

Environmental Cost: Moderate

These subalternatives would produce the greatest potential for damage to surrounding plant life resulting from fogging and icing. From the fog frequency data, it can be seen that the area encompassed by the 0-1, 1-2, and 2-3 mile radii would be subjected to significant increases in fogging conditions.

Within this 3-mile radius of the Plant site are some 11,762 acres of land with approximately the following utilization:

Residential - 7,238 acres
Recreational - 3,619 acres
Industrial - 905 acres.

The plant life on these 11,762 acres could suffer potential detrimental effects from the fogging conditions attributed to these two cooling alternatives.

12. Raising Lowering of Groundwater Levels

12.1 People

All Alternatives

Environmental Cost: 0 gal/year
For each of these alternatives the Plant condenser cooling water and service water supply is taken from the Hudson River. The Plant uses no well water. Therefore, Plant operations under all of these alternatives will not affect local groundwater levels.

12.1 Plants

Alternative 1. Plant As Is

Environmental Cost: 0 acres (see above)

13. Ambient Noise

13.1 People

Alternative 1. Plant As Is

Environmental Cost: No residents, schools, or hospital beds within area having noise increased above present levels.

The ambient noise levels now existing in the area were measured by the Applicant at locations which were chosen to document noise levels at his property line and also at locations in the surrounding area where noise might affect the residents or where other noise sources exist. However, the design of the Indian Point Unit No. 2 facility is such that no significant noise sources are expected to be introduced by its operation so that the existing noise levels in the surrounding areas are expected to be virtually the same with Indian Point Unit No. 2 in operation.

Alternative 2. Minimum Water Impact Design

Each of the six cooling subalternatives which were considered in determining the minimum water impact design are examined separately.

Subalternatives 2B and 2E

Environmental Cost: About 300 residents subjected to noise levels in the normally unacceptable range.

This alternative involves construction and operation of 2 natural-draft cooling towers--open-cycle, each 515 feet in diameter and 500 feet high. It is expected that the noise generated by these towers would be almost white (broad-band) in character, and--because the natural-draft cooling towers do not employ powered fans to move air--that the noise levels generated will be relatively low. Estimates of the noise emitted from the natural-draft cooling towers have been made and the results indicate that the noise levels will be in the unacceptable region for a distance of 2,500 feet from the center of the tower complex. Thus, an area of about 0.7 square miles would experience noise levels in the unacceptable range, and about 300 residents would be involved.

The following was stated by the applicant:
Note: "These costs are in conformance with assumptions made in the guidelines. Our studies indicate that the estimated noise at the Broadway property line is 58 dB(A)* and the costs will be zero, in that the expected noise from the two hyperbolic cooling towers will:

(a) not exceed the local noise ordinance of the Village of Buchanan along the Broadway property line.

(b) be less than the existing background noise level along Broadway due to vehicular traffic which exceeds 60 dB(A) for more than 50% of the time. Refer to Figure 13.1-2 of the applicant's Supplement No. 2.

(c) be within the 65 dB(A) limit for "Discretionary-Normally Acceptable" category for external noise exposure standards for new construction sites as outlined in the U.S. Housing and Urban Development (HUD) Transmittal Noise 1390.2, (subject: "Noise Abatement and Control: Departmental Policy, Implementation Responsibility, and Standards." Reference 13a is a contractor's report to HUD and does not represent official policy.)

(d) produce broadband white noise (similar to the noise generated by falling rain) that will serve to mask the intrusion of transient environmental noise."

In addition, the noise radiated from the two hyperbolic cooling towers will be limited within the boundary lines of the site with the exception of the Broadway boundary line.

The staff agrees that the noise in this case is probably negligible.

Subalternative 2C

Environmental Cost: About 4,500 residents subjected to unacceptable noise levels.

Alternative 2C would involve 67 mechanical draft cooling cells operating in the open cycle mode. Each cell is expected to have an electric motor-driven fan rated at 200 horsepower, a total of 13,400 horsepower. Of all alternatives, this will be the noisiest. Ignoring the directional effects of the cell layout, the predicted noise generated by the mechanical-draft cooling towers will produce a sound level of 50 dB(A) at a distance of 6,200 feet from the cooling cell complex. This means that an area of approximately 4.3 square miles will be in the unacceptable zones as defined by the Department of Housing and Urban Development. Approximately 4,500 residents are in this area.

Of this area, approximately 0.1 square mile in the immediate vicinity of the cells will be in the "clearly unacceptable" classification, with the remainder of the unacceptable area falling in the "normally unacceptable"

* dB(A) = noise levels in air expressed as decibels.

classification. The latter would constitute approximately 4.2 square miles, and encompasses portions of Peekskill, Buchanan, and Verplanck.

These predicted acoustic levels are those which are emitted from the louvered face of the cells. The sound level on the cased face of the cooling cell is expected to be from 5 to 10 dB(A) lower, so the corresponding areas will experience lower noise levels. Therefore, the noise levels are conservatively high.

<u>Subalternative 2D</u>

<u>Environmental Cost:</u> Minor

This subalternative requires the use of an open-cycle spray pond. This subalternative will probably generate less noise than the mechanical-draft cooling towers because of the absence of the large outside fans. The acoustic power generated by the spray pond should be proportional to the hydraulic power dissipated, but insufficient information is available to enable the noise level to be predicted accurately. The character of the noise generated will be almost white (broad-band) in nature.

<u>Subalternative 2F</u>

<u>Environmental Cost:</u> About 3,000 residents subjected to unacceptable noise levels.

This subalternative involves the use of 38 mechanical-draft cooling cells operating closed cycle. Each cell will have an electric motor-driven fan rated at 200 horsepower, giving a total of 7,600 horsepower. The noise generated by these cooling towers is predicted to produce a sound level of 50 dB(A) at a distance of 5,000 feet. Consequently, an area of approximately 2.8 square miles will be in the unacceptable zones as defined by HUD. Of this area, about 0.1 square mile in the immediate vicinity of the cells will be in the "clearly unacceptable" classification. This unacceptable zone encompasses portions of Peekskill, Verplanck, and Buchanan, and it is expected that about 3,000 residents would be subjected to noise levels in the unacceptable category.

As mentioned under Alternative 2C, the predicted acoustic level is that emitted from the louvered face of the cell. The levels would be 5 to 10 dBA less from the cased side of the cooling cell, so the noise levels are conservatively high.

<u>Subalternative 2G</u>

<u>Environmental Cost:</u> Minor

This subalternative requires the use of a closed-cycle spray pond. Comments under Subalternative 2D apply.

14. Aesthetics

14.1 Appearance

The aesthetic appearance or quality of the environment is determined by value judgments made by members of society. Because individuals vary in their perception of the environment, it is often difficult to quantify and reach a consensus of their views. In this report certain aesthetic standards were used that have a sensitivity toward the environment and social values, so that it was possible to analyze aesthetic considerations on a relative basis.

Aesthetic impacts from Indian Point Unit No. 2 were determined by considering the overall aesthetic composition of the area and four elements which define this composition: water, air, fauna and flora, and man-made objects. Each of these considerations was systematically analyzed to determine any aesthetic changes either favorable or adverse.

Alternative 1 - Plant As Is

Environmental Cost: Minor

The overall aesthetic impact of Unit No. 2 of Indian Point is negative in direction, but minor in magnitude. (See Section III.)

Alternative 2 - Minimum Water Impact Design

Subalternatives 2B and 2E

Environmental Cost: Major

It is expected that the overall impact from the natural-draft towers on the aesthetic composition of the Hudson Valley would be negative in nature and major in magnitude.

Two natural-draft cooling towers between 400-500 feet high are proposed for Indian Point. These towers would be located in an area immediately to the southeast of the structures for Units Nos. 1 and 2. Some of the natural vegetation in this area would be eliminated with the construction of these towers.

Natural draft towers would dominate the landscape of the valley and the towns in the immediate vicinity of the site. The towers and their plume would be visible for many miles in all directions from Indian Point. Because many individuals use the Hudson Valley for recreation, these conditions would pose a major conflict with the natural environment and would produce an aesthetically displeasing situation.

Subalternative 2C and 2F

Environmental Cost: Moderate

The net impact on the aesthetics of the area is negative in direction and moderate in magnitude.

The mechanical-draft cooling towers for the nuclear power plant would be located in an area immediately to the southeast of Units Nos. 1 and 2. Because this area is elevated and only partially buffered with natural vegetation, these towers would be visible to individuals near the site. In the placement of these towers, some of the natural vegetation in the area would be removed.

The water vapor emissions from these towers and the resulting ground fog would be noticeable from many locations in the valley. On some days the ground fog would probably cover most of the plant site.

Subalternative 2D and 2G

Environmental Cost: Moderate

It is expected that the overall impact of the spray pond and the relevant impacts from Alternative 1 would be negative in direction and moderate in nature.

The spray pond would be located in an area southeast of Units Nos. 1 and 2. Because this area is elevated and only partially buffered with natural vegetation, it is expected that some of the pond and the pipes would be visible to individuals near the site.

The fogging conditions created by the pond would call attention to its location and interaction with the natural environment. These fogging conditions are also expected to be visible to individuals in the town of Verplanck which is adjacent to the pond.

15. Permanent Residuals of Construction Activity

15.1 Accessibility of Historical Sites

All Alternatives

Environmental Cost: 0 visitors per year

Although several historical sites are located in the vicinity of the Indian Point Station, no access routes to these sites use any portion of Station land. Power transmission lines associated with the Station do not interfere with public land use and cross only one public road immediately east of the Station.

15.2 Accessibility of Archaeological Sites

All Alternatives

Environmental Cost: None

Construction activity at the Indian Point site has revealed no evidence of items having archaeological value. No other indication of important archaeological activity in the general area could be located. Thus, the plant site probably contains no valuable archaeological deposits.

15.3 Setting of Historical Sites

Alternative 1. Plant As Is

Environmental Cost: 0 visitors per year

The nearest designated historical site is Stony Point Battlefield, located 2 to 3 miles from Indian Point on the opposite side of the Hudson River. It is doubtful that the existing plant can be seen from this location, but if such is the case the most noticable feature would be the stack for Unit No. 1. Thus, Unit No. 2 structures have very little if any additional impact, and no effect on visitations to this historical site or to others which are more distant should occur.

Alternative 2. Minimum Water Impact Design

Environmental Cost: Minor

The tall natural-draft cooling towers associated with cooling Subalternatives 2B and 2E should be visible from the Stony Point Battlefield site and perhaps from the U. S. Military Academy and the Van Cortlandt Manor which are both approximately 6 miles from Indian Point. No visitation figures have been obtained for these three sites, so it can only be stated that the environmental effect will be negative.

The mechanical-draft cooling towers associated with Subalternatives 2C and 2F are low profile structures which should be no more visible from the nearest historical site than the Plant itself. The environmental cost value for these subalternatives should be zero. This impact would also apply to Subalternatives 2D and 2G which utilize a spray pond.

15.4 Land Use

All Alternatives

Environmental Cost: 0 acres

None of the alternatives would require additional land since the Indian Point Unit No. 2 with its associated transmission facilities are essentially complete and additional land on the site is available. Transmission lines for Unit 2 were constructed on existing rights-of-way.

15.5 Property

Alternative 1. Plant As Is

Environmental Cost: 0

Most of the land use in the vicinity of Indian Point Station is for residential or industrial purposes and no significant change in property values are expected from Unit No. 2 itself. This is because Unit No. 1 has been operating at the site for about 10 years. The Unit No. 2 is situated on the same property and transmission lines for this Plant have utilized existing rights-of-way.

Alternative 2. Minimum Water Impact Design

Each of the cooling subalternatives from which Alternative 2 was selected produce some adverse effects which could affect property values in the vicinity. The natural-draft towers are large and present a major aesthetic impact. Mechanical-draft cooling towers cause higher noise levels and lead to increased fogging and icing frequencies. The spray pond may cause excessive fogging and icing and high localized salt deposition. It is very difficult to predict property value losses for these situations on a monetary basis since the impacts of the adverse effects are not uniformly quantified. Therefore, a qualitative ranking of potential losses will be made which takes into account the area or population affected and the type of effect. Three types of effects to be considered in their order of importance are: (1) health and safety, (2) damage to real property, and (3) landscape deterioration.

Cooling Subalternatives 2B and 2E

Environmental Cost: Minor

Both salt deposition and fogging potential exists from these two subalternatives is quite low compared to the other cooling methods. Noise levels (Section 13.1) apparently would be relatively low. Thus, probable effects on health and safety and property damage would be minimal, even near the Plant. Aesthetically the natural-draft towers have a major impact, but since this is considered third in relative importance, the overall ranking is classified as minor for each subalternative.

Cooling Subalternatives 2C and 2F

Environmental Cost: Major

These two subalternatives are intermediate in their salt deposition rates and fogging (icing) frequencies. Open-cycle operation (2C) would yield less salt and less fog. However, the noise levels for this subalternative would be more severe and noise from both these subalternatives apparently would reach normally unacceptable levels at populated locations offsite. Thus definite effects on health and safety and on property damage could result in the vicinity of the Plant site. The moderate asethetic impact would be of little importance compared to these major effects.

Cooling Subalternatives 2D and 2G.

Environmental Cost: Major

These two subalternatives offer considerable more potential for extensive salt deposition and fogging (icing) frequency than any of the others. Although salt deposition should be localized, the wide area affected by fog and the implication of this to health and safety and to property damage suggests a major effect on property in the region would occur. The minimal expected effects of noise and the moderate aesthetic impact are insufficient to reduce the projected cost.

15.6 Flood Control

All Alternatives

Environmental Cost: None

Flooding at the site is nonexistent. Therefore, the Plant has no implications regarding flood control.

15.7 Erosion Control

All Alternatives

Environmental Cost: 0 tons per year

Relatively little dredging and filling were required for the construction of the Plant intake and discharge structures. With Unit No. 2 construction nearly complete site restoration has begun. Landscaping and planting activities will remove and control erosion effects.

16. Temporary Impacts of Plant Construction

See Appendix XI-1 for details regarding the different impacts which are considered by the staff to be temporary.

17. Transportation (Staff's Analysis)

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 station, 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. The estimated dose due to transportation of irradiated fuel is 1.8 man-rem if transport is by rail and 3.4 man-rem if by truck. The estimate for transportation of waste is 0.9 man-rem.

18. Waste Products

See Appendix XI-1 on solid nonradioactive waste products.

Alternative 1. Plant As Is

C. SUMMARY OF BENEFIT-COST ANALYSES

The monetized benefits and costs and environmental costs of the present plant and the least-impact alternative are summarized in Tables XI-1 and XI-2. In Table XI-3 the various subalternative cooling systems are compared with the present once-through cooling system. It should be noted that the tables are not complete without the discussion in Chapter XIB above, Appendix XI-1, and elsewhere in this Statement. Again it is pointed out that the applicant used a discount rate of 8% and carrying charges of 13% that were interpreted as consistent with the draft guidelines. More recent drafts of the guidelines provide a more clear interpretation of common economic practices in which a discount factor of 8.75% for a 30-year lifetime of the Plant is taken into account.

In the case of the closed-cycle, natural-draft cooling tower system, the generating costs will be increased by about $104,000,000 over the 30-year period. This incremental cost would be added to the applicant's customers bills. This incremental cost should be weighed against the differential environmental costs of the different cooling modes of operation.

In regards to benefits for the community, a larger amount of local taxes could be available. However, the overall generating costs which would be paid out of the customers' pockets would more than compensate for the added advantage of increased taxes paid to the community.

Environmentally, the cooling towers offer advantages of reduced waste heat input discharged into the Hudson River, thereby minimizing the influence of the thermal plume on fish and other aquatic biota. Cooling towers also offer the advantage of reduction of volume intake for makeup use as compared to the volume of once-through cooling. Thus the biological impact from entrainment will be correspondingly reduced. If the intake velocity is also reduced, then less damage is done by fish impingement on the screens. However, cooling towers may have distinct disadvantages as discussed in Chapter XI.A and B if the blowdown has chemicals such as zinc, phosphate, and chromates. These are very toxic to aquatic biota and may cause far more damage than that from thermal discharges. Added to the cost of the cooling towers would have to be the costs of water treatment of the blowdown. The salty-brackish water of the Hudson River also causes difficulties in operation of cooling towers and could cause salt deposits on the terrain through drift. Furthermore, cooling towers result in the higher in-Plant power needs, thereby resulting in less energy available from the Plant. Dry cooling towers have certain distinct advantages and disadvantages compared with wet cooling towers, as discussed in Chapter XIA. The applicant, however, did not include this alternative in its cost-benefit analysis.

The applicant also has under consideration a number of fish protection alternatives, as discussed in Section XIA and XIB, which can be used to minimize the biological impact of the Plant operation.

As discussed in Chapter X, the need for power in the applicant's service region is so urgent that benefits from the operation of Unit No. 2 to provide an immediate increase in the regional power supply are overwhelming. The short-term power benefits (2 to 4 years) from operation of Unit No. 2 would not be expected to cause an irreversible environmental damage to the aquatic biota of the Hudson River. The long-term situation is much less clear. The staff's analysis of the effects of the present cooling system on the Hudson River indicates that the complex estuarine environment could be irreversibly damaged from long-term operation of Unit No. 2. The staff's analysis was appropriately conservative, in accord with the nature of the environmental risk, and may therefore overestimate the long-term cost. Nevertheless, it is essential that operation of the Plant guarantee an acceptable limit to this cost by some contingent arrangement that will assure that the impact can be reduced should the effects prove to be unacceptably severe.

An operating license would permit the applicant to allow for this environmental contingency by establishing an effective environmental monitoring program in conjunction with an alternative plan to limit the effects on the aquatic system. The applicant shall be required to evaluate and assess the data collected from the monitoring program in order to design and implement an alternative plan or plans to minimize the long-term potential damage to the aquatic biota in the Hudson River. The applicant shall be required to submit to the Commission within the next 6 months a plan or plans of specific detailed design of the best alternative system that it can determine which will result in an optimization of Plant operation and minimal environmental damage. With this provision, the benefits from short-term operation of the Indian Point Station will outweigh the environmental costs, and the long-term benefits can be realized by suitable environmental control measures which the applicant shall be required to exercise. The Technical Specifications to be provided with an operating license will specify the limitations of specific effluent discharges and the ecological monitoring surveillance program required with the necessary administrative controls, to assure adequate data will be collected for use to assess the biological impact of operation of Indian Point Unit No. 2 on the environment.

The applicant's commitment to meet Federal and New York State water quality standards; to conduct extensive ecological studies in cooperation with the State and Federal Fish and Wildlife Service; the capability of some of aquatic biota of the Hudson River to recover; and to implement those changes in the operation and design of the Indian Point Unit No. 2 that will minimize damage to aquatic biota could assure that the overall ecosystem of the Hudson River will be preserved for future generations.

FORM AEC–
(1/7/72)

TABLE XI-1. BENEFIT DESCRIPTION OF ALTERNATIVE PLANT DESIGNS

(All monetized benefits expressed in terms of present value)

1. NAME OF FACILITY: Indian Point Unit 2

2. DATE OF REPORT: March 1972

BENEFITS [1+2+3]		1 Plant As Is	2 Minimum Water Impact *	3 Minimum Land/Air Impact	4 Plant License Request
Electric Power Produced and Sold:	Total (millions MWhr)	170,000	164,000		
	(30-yr period)				
Reliability Index	Increased days per summer loss of load without IP2 (1972)	7	-		
Process Steam Sold		None	Same		
Environmental Enhancement:	Recreation: Acres	80	Same		
	Navigation	No Benefit	Same		
Increased 1972 Emissions (Tons) if Indian Point No. 2 is not in Service	Air Quality: SO_2	29,000	-		
	NO_x	16,000	-		
	Particulates	1,245	-		
	Others				
Education	Visitors/yr (visitors center)	100,000	Same		
Research	$ Million presently planned (total Indian Point site)	10	Same		
Regional Gross Product		no benefit	claimed, not	poverty	area
Local Taxes	($ millions/yr)	4.1	6.3		
Employment	($ millions) Estimated Incremental Payroll/yr	1.2	Same		
Other Benefits					

[1] Where a row is not relevant to a particular alternative, insert n.a. for not applicable.
[2] See Section III.A. of the guideline for suggested units of measure of benefits. Applicants should specify the units they use on the form.
[3] Where benefits are the same for each alternative, put same in columns 2, 3 and 4.

* Alternative 2E - Natural-Draft, Closed-Cycle Cooling Tower

FORM AEC–
(1/7/72)

TABLE XI-2

COST DESCRIPTION OF ALTERNATIVE PLANT DESIGNS

(All monetized benefits expressed in terms of present value)

1. NAME OF FACILITY

Indian Point Unit 2

2. DATE OF REPORT

March 1972

			ALTERNATIVES		
		1	2	3	4
		Plant As Is	Minimum Water Impact	Minimum Land/Air Impact	Plant License Request
SUBSYSTEMS	Alternative Cooling Systems (I)	A[4]	E		
	Alternative Rad Waste Systems (II)	A	A		
	Alternative Chemical Effluent Systems (III)	A	A		
	Alternative ______ System (IV)	A			
	Alternative ______ System (V)	A			
GENERATING COSTS	($ millions)	$286,000	390,000		
ENVIRONMENTAL COSTS[1+2+3]					
Primary Impact 1. Heat Discharged to Water Body	Population or Resource Affected Btu/hr x 10[9] 1.1 Cooling Capacity Acre-ft x 10^3	6.4 1.6	1.3 <1		
	1.2 Aquatic Biota	small	∿0		
	1.3 Migratory Fish	small	∿0		
2. Effects on Water Body of Intake Structure and Condenser Cooling Systems *	2.1 Primary Producers and Consumers	small	small		
	2.2 Fisheries	large	2.4% Alt.1		
3. Chemical Discharge to Water Body	3.1 People	0	0		
	3.2 Aquatic Biota	small	small		
	3.3 Water Quality–Chemical (chlorine) maximum % of std.	100	100		
4. Consumption of Water	4.1 People gal/yr	0	0		
	4.2 Property Acre ft/year	0	0		
5. Chemical Discharge to Ambient Air	5.1 Air Quality-Chemical % of standard	2.7	2.7		
	5.2 Air Quality–Odor	none	none		

[1] Where a row is not relevant to a particular alternative, insert n.a. for not applicable.
[2] See Table 3 for units of measure and methods of computation, units should be specified by the applicant on the form.
[3] Where items are the same for each alternative, put same in columns 2, 3 and 4.
[4] A refers to alternative in the Supplementary Forms.

* Includes impingement and mechanical, thermal, and chemical effects on entrained biota.

(1/7/72)

6. Salts Discharged from Cooling Towers	6.1 People gal/yr	0	0			
	6.2 Plants Acres affected	0	0			
	6.3 Property Resources $	0	0			
7. Chemical Contamination of Ground Water (excluding Salt)	7.1 People gal/yr	0	0			
	7.2 Plants Acres affected	0	0			
8. Radionuclides Discharged to Water Body	8.1 People—External Contact Man Rem/yr	0.47	same			
	8.2 People—Ingestion Man Rem/yr	3.2	same			
	8.3 Invertebrates Plants mRad/yr	135 480	3.75 x Alt. 1 "			
	8.4 Fish	35	"			
9. Radionuclides Discharged to Ambient Air	9.1 People—External Contact	15	same			
	9.2 People—Ingestion	1	same			
	9.3 Plants and Animals					
10. Radionuclide Contamination of Ground Water	10.1 People	0	0			
	10.2 Plants and Animals Rad/yr	0	0			
11. Fogging and Icing	11.1 Ground Transportation hrs of increased driving hazard/yr	0	0			
	11.2 Air Transportation hrs of airport closing/yr	0	0			
	11.3 Water Transportation hrs which ships reduce speed/yr	0	0			
	11.4 Plants Acres affected	0	0			
12. Raising Lowering of Ground Water Levels	12.1 People gal/yr	0	0			
	12.2 Plants Acres	0	0			
13. Ambient Noise	13.1 People Residents affected	0	300			
14. Aesthetics	14.1 Appearance	Minor	Major			
15. Permanent Residuals of Construction Activity	15.1 Accessibility of Historical Sites visitors/yr	0	0			
	15.2 Accessibility of Archeological Sites	0	0			
	15.3 Setting of Historical Sites visitors/yr	0	Minor			
	15.4 Land Use Acres	0	0			
	15.5 Property $	0	Minor			
	15.6 Flood Control	None	None			
	15.7 Erosion Control tons/yr	0	0			

COMMENTS

SUPPLEMENTARY FORM - 1

TABLE XI-3 COST DESCRIPTION - ALTERNATIVE COOLING SYSTEMS
(Include Associated Coolant Water Treatment Systems)

1. Name of Facility	2. Date of Report
Indian Point Unit No. 2	March 1972

			ALTERNATIVES						
				Open Cycle			Closed Cycle		
			Once-thru 1	Nat. Draft 2B	Mech. Draft 2C	Spray Pond 2D	Nat. Draft 2E	Mech. Draft 2F	Spray Pond 2G
INCREMENTAL GENERATING COST		$ x 10^6	XXXX	93	88	88	104	89	102
ENVIRONMENTAL COSTS									
Primary Impact	Population or Resource Affected								
1. Heat Discharged to Water Body	1.1 Cooling Capacity	Btu/hr x 10^9	6.35	1.27	1.27	1.27	0.13	0.113	0.053
		Acre-ft	1.6 x 10^3	<1	0	0	0	0	0
	1.2 Aquatic Biota		Small	0	0	0	0	0	0
	1.3 Migratory Fish		Small	0	0	0	0	0	0
2. Effects on Water Body of Intake Structure & Condenser Cooling System*	2.1 Primary Producers Consumers		Potentially Large	0	0	0	2.5% of Open Cycle	2.6% of Open Cycle	3.3% of Open Cycle
	2.2 Fisheries		Potentially Large	0	0	0	2.5% of Open Cycle	2.6% of Open Cycle	3.3% of Open Cycle
3. Chemical Discharge to Water Body	3.1 People	days	0	0	0	0	0	0	0
	3.2 Aquatic Biota		Small	---- Same ----					
	3.3 Water Quality - Chemical Max. 100% of Standard		Chlorine 100%	100	100	100	No effect	No effect	No effect

* Includes impingement and mechanical, thermal, and chemical effects on entrained biota.

SUPPLEMENTARY FORM - 1

COST DESCRIPTION - ALTERNATIVE COOLING SYSTEMS
(Include Associated Coolant Water Treatment Systems)

1. Name of Facility
Indian Point Unit No. 2

2. Date of Report
March 1972

		ALTERNATIVES						
		Open Cycle				Closed Cycle		
		Once-thru 1	Nat. Draft 2B	Mech. Draft 2C	Spray Pond 2D	Nat. Draft 2E	Mech. Draft 2F	Spray Pond 2G
ENVIRONMENTAL COSTS (cont'd)								
4. Consumption of Water	4.1 People gal/yr	0	0	0	0	0	0	0
	4.2 Amount Used cfs	14	23	25	36	28	30.2	41.3
	mgd	8.9	14.6	16	23.6	18.3	19.2	26.6
5. Chemical Discharge to Ambient Air	5.1 Air Quality - Chemical % of Std SO_2	2.7%		---- Same ----				
	NO_x	0.68%		---- Same ----				
	5.2 Air Quality -	0.47%		---- Same ----				
	Particulates	None		---- Same ----				
6. Salts Discharged from Cooling Towers	6.1 People gal/yr	None		---- Same ----				
	6.2 Plants Deposition on Land - acres	0	0	0	1200	0	0	1200
	6.3 Property Resources $	0		---- Same ----				
7. Chemical Contamination of Ground Water (excluding Salt)	7.1 People gal/yr	0		---- Same ----				

SUPPLEMENTARY FORM - 1

COST DESCRIPTION - ALTERNATIVE COOLING SYSTEMS
(Include Associated Coolant Water Treatment Systems)

1. Name of Facility
Indian Point Unit No. 2

2. Date of Report
March 1972

		ALTERNATIVES						
			Open Cycle			Closed Cycle		
		Once-thru 1	Nat. Draft 2B	Mech. Draft 2C	Spray Pond 2D	Nat. Draft 2E	Mech. Draft 2F	Spray Pond 2G
ENVIRONMENTAL COSTS (cont'd)								
	7.2 Plants Acres affected	No Effect			---- Same ----			
8. Radionuclides Discharged to Water Body	8.1 People - External Contact Man-Rem/yr	0.47			---- Same ----			
	8.2 People - Ingestion Man-Rem/yr	3.2			---- Same ----			
	8.3 Invertebrates Rad/yr	0.135					3.75 x Alt. 1	
	Plants Rad/yr	0.480					3.75 x Alt. 1	
	8.4 Fish Rad/yr	0.064					3.75 x Alt. 1	
9. Radionuclides Discharged to Ambient Air	9.1 People - External Contact Man Rem/yr	15			---- Same ----			
	9.2 People - Ingestion Man Rem/yr	1			---- Same ----			
	9.3 Plants and Animals Rad/yr	Unknown			---- Same ----			

SUPPLEMENTARY FORM - 1

COST DESCRIPTION - ALTERNATIVE COOLING SYSTEMS
(Include Associated Coolant Water Treatment Systems)

1. Name of Facility
Indian Point Unit No. 2

2. Date of Report
March 1972

		ALTERNATIVES: Open Cycle: Once-thru 1	Open Cycle: Nat. Draft 2B	Open Cycle: Mech. Draft 2C	Open Cycle: Spray Pond 2D	Closed Cycle: Nat. Draft 2E	Closed Cycle: Mech. Draft 2F	Closed Cycle: Spray Pond 2G
ENVIRONMENTAL COSTS (cont'd)								
10. Radionuclide Contamination of Ground Water	10.1 People Man Rem/yr	No effect		----	Same	----		
	10.2 Plants			----	Same	----		
	Invertebrates Rad/yr	No effect		----	Same	----		
	Fish			----	Same	----		
11. Fogging and Icing	11.1 Ground Transportation Hrs of increased driving hazard/yr	0	0	0	4,030	0	88	5,340
	11.2 Air Transportation Hrs of airport closing	0	0	0	3,150	0	88	4,820
	11.3 Water Transportation Hrs of reduced speed/yr	0	0	0	5,610	0	88	6,570
	11.4 Plants acres affected	0		----	Same	----		
12. Raising/Lowering of Ground Water Levels	12.1 People gal/yr	No Effect		----	Same	----		
	12.2 Plants acres	0		----	Same	----		

SUPPLEMENTARY FORM - 1

COST DESCRIPTION - ALTERNATIVE COOLING SYSTEMS
(Include Associated Coolant Water Treatment Systems)

1. Name of Facility	2. Date of Report
Indian Point Unit No. 2	March 1972

			ALTERNATIVES						
			Open Cycle				Closed Cycle		
			Once-thru 1	Nat. Draft 2B	Mech. Draft 2C	Spray Pond 2D	Nat. Draft 2E	Mech. Draft 2F	Spray Pond 2G
ENVIRONMENTAL COSTS (cont'd)									
13. Ambient Noise	13.1	People Residents affected	0	300	4500	Minor	300	3000	Minor
14. Aesthetics	14.1	Appearance Transmission Facilities	Minor Minor	Major Minor	Moderate Minor	Moderate Minor	Major Minor	Moderate Minor	Moderate Minor
15. Permanent Residuals of Construction Activity	15.1	Accessibility of Historical Sites Visitors per yr.	0			- - - - Same - - - -			
	15.2	Acessibility of Archeological Sites	No Known Deposits			- - - - Same - - - -			
	15.3	Setting of Historical Sites Visitors per yr.	0	Minor	0	0	Minor	0	0
	15.4	Land Use - Acres	0			- - - - Same - - - -			
	15.5	Property $	0			- - - - Same - - - -			
	15.6	Flood Control	None	None		- - - - Same - - - -			
	15.7	Erosion Control tons/yr	0	0	0	0	0	0	0

SUPPLEMENTARY FORM - 1

COST DESCRIPTION - ALTERNATIVE COOLING SYSTEMS
(Include Associated Coolant Water Treatment Systems)

1. Name of Facility	2. Date of Report
Indian Point Unit No. 2	March 1972

		ALTERNATIVES						
		Open Cycle				Closed Cycle		
		Once-thru 1	Nat. Draft 2B	Mech. Draft 2C	Spray Pond 2D	Nat. Draft 2E	Mech. Draft 2F	Spray Pond 2G
ENVIRONMENTAL COSTS (cont'd)								
16. Temporary Impacts of Plant Construction	16.1 Land Disturbance Acres	35	23	20	30	18	19	38
	16.2 Air Quality	Negligible		- - - -	Same - - - -			
	16.3 Water Quality	Minor Turbidity	Negligible	Same	Minor Turbidity	Negligible	- - - Same - - -	
	16.4 Water Diversion	None	Negligible	- - - -	Same - - - -			
	16.5 Waterways Effects	None		- - - -	Same - - - -			
	16.6 Spoilage cu. yds.	Negligible		- - - -	Same - - - -			
	16.7 Housing	No Known Impact		- - - -	Same - - - -			
	16.8 Schools	Negligible		- - - -	Same - - - -			

SUPPLEMENTARY FORM - 1

COST DESCRIPTION - ALTERNATIVE COOLING SYSTEMS
(Include Associated Coolant Water Treatment Systems)

1. Name of Facility
Indian Point No. 2

2. Date of Report
March 1972

			ALTERNATIVES						
			Open Cycle				Closed Cycle		
			Once-thru 1	Nat. Draft 2B	Mech. Draft 2C	Spray Pond 2D	Nat. Draft 2E	Mech. Draft 2F	Spray Pond 2G
ENVIRONMENTAL COSTS (cont'd)									
16. Temporary Impacts of Plant Construction	16.9	Traffic	Moderate Increase	---- Same ----					
	16.10	Community Services	Negligible	---- Same ----					
17. Transportation (Units/yr)	17.1	Fuel Transport Man-Rem/yr	64 Fuel Assemblies 1.8 (rail) - 3.4 (truck)	---- Same ----					
	17.2	Fuel Storage	64 Fuel Assemblies	---- Same ----					
	17.3	Waste Products - Man-Rem/yr	90 - 150 Drums 0.9	---- Same ----					
18. Solid Wastes	18.1	Non-Fuel Solid Wastes	100 - 200 Drums	---- Same ----					

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APPENDICES FOR CHAPTER II

APPENDIX II-1

CHARACTERISTICS OF HUDSON RIVER CIRCULATION AT INDIAN POINT, IN RELATION TO DILUTION

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. The flow of fresh water through the river is the result of gravitation, whereas the flow of ocean water is mainly caused by tidal movement. While the salt concentration of the fresh water is very low, the ocean water contains about 31 or 32 parts per thousand (ppt) of salt.[1] As a result, it is possible to determine the relative proportions of ocean and runoff water in the estuary. The runoff of fresh water supplies all the water in the estuary downstream as far as the salt water front. Below this point, the upstream flow of saline ocean water becomes a progressively more important source of water within the estuarine system.

That ocean water moves upstream against the flow of fresh water is demonstrated by the presence of salt upstream from the mouth of the estuary in amounts far greater than could be accounted for by molecular diffusion. However, the amount of ocean water moving upstream has to be equal to the amount of ocean water moving downstream (steady state) when averaged over several tidal cycles. Thus, the flow of salt water in the estuary is a dynamic process which results in no net change in the discharge of water from the Hudson River to the ocean. Two factors are responsible for the upstream movement of salt water, turbulent diffusion (mixing) and density flow.[1,2] The magnitude of each of these factors is dependent upon high tidal flows.[3]

Ocean water moves back and forth in the estuary in response to the tides. Two high tides and two low tides occur every 24 hr 50 min.[2]* These tidal movements are the result of interaction of the gravity forces between the sun, moon, and earth. Since the relative positions of these bodies are not constant, the amplitude of the tide changes from tidal cycle to tidal cycle. The most important components of the tide-producing forces are given in Table A-II-1. These factors can change the tidal amplitude 20 to 40%.[4]

Investigations of tidal flows in the Hudson in 1966 indicated that at the Battery, maximum tidal discharges of 300,000 to 400,000 cubic feet per second (cfs) were not uncommon, with a few maximum tidal discharges of 500,000 cfs.[3] The tidal flow as measured at Poughkeepsie on May 24-25, 1966, is presented in Fig. A-II-1.[3] Both the water velocity and direction

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* A tidal cycle at Indian Point comprises a flood period with an average duration of about 6 hours and an ebb period of about 6.5 hours, flood plus ebb thus making a tidal cycle duration of approximately 12.5 hours.[4]

TABLE A-II-1

THE MOST IMPORTANT COMPONENTS OF THE PREDICTABLE TIDE-PRODUCING FORCES AND THEIR PERIODS. THE COEFFICIENT RELATES TO THE INTENSITY OF EACH TIDE-PRODUCING FORCE, SO THAT THE GREATER THE COEFFICIENT THE GREATER THE FORCE.[2]

Name of Corresponding Partial Tide	Period in hours	Coefficient
Semi-diurnal:		
Principal lunar	12.42	0.4543
Principal solar	12.00	.2120
Larger lunar elliptic	12.66	.0880
Luni-solar	11.97	.0576
Diurnal:		
Luni-solar	23.93	.2655
Principal lunar	25.82	.1886
Principal solar	24.07	.0880
Long-period		
Lunar fortnightly	327.86	.0783
Lunar monthly	661.30	.0414
Solar semi-annual	2191.43	.0365

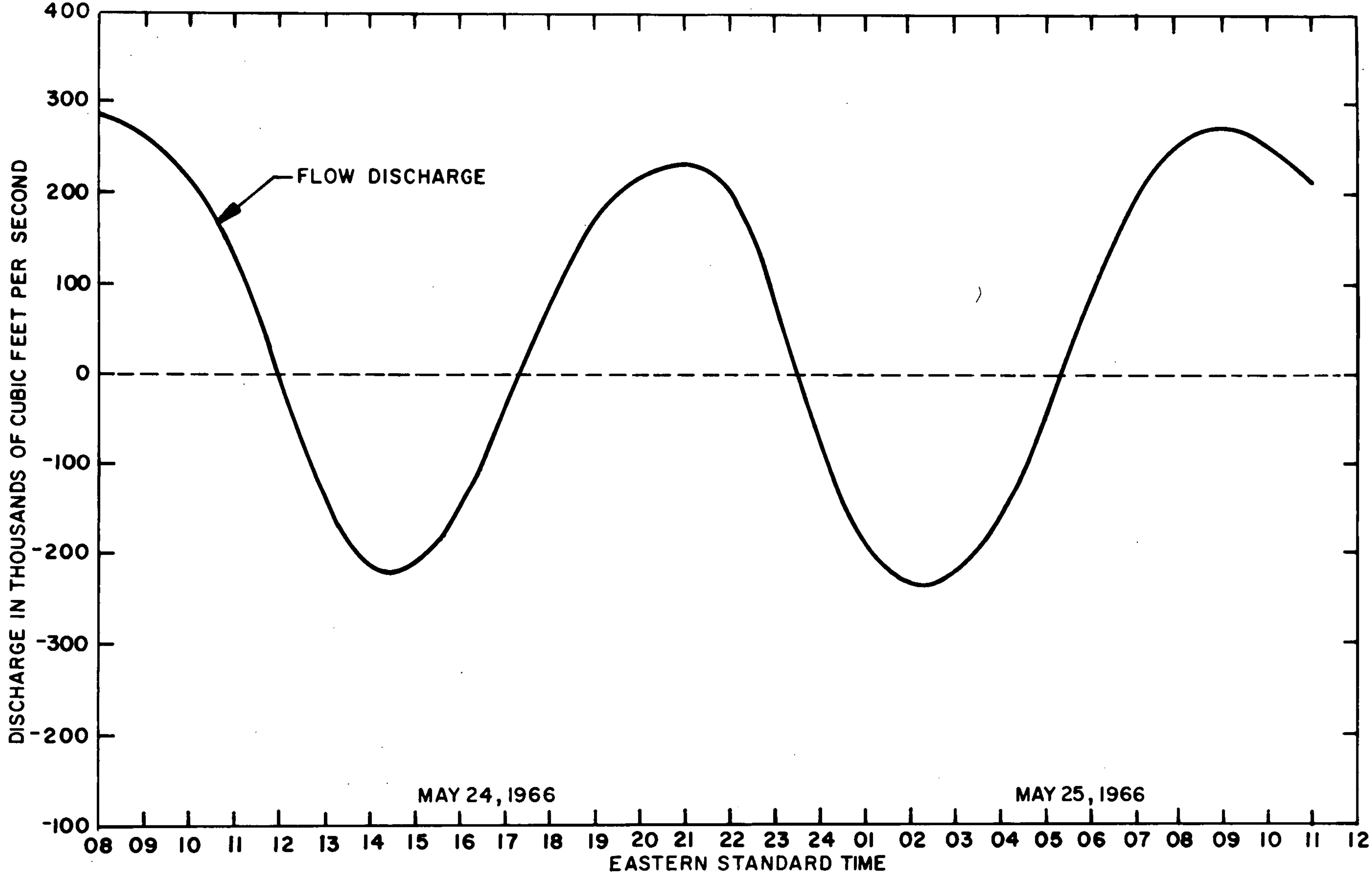


Fig. A-II-1
Flow Discharge During Tidal Measurement on May 24-25, 1966-Hudson River Near Poughkeepsie, N.Y.

change through time. In addition, changes in barometric pressure[2] and winds associated with storms[4] may cause changes in the flow characteristics of the water in the Hudson River. However, in all cases the tidal flows are much larger than the flow of fresh water resulting from runoff (Fig. A-II-2).[5]

The relative amounts of fresh and salt water at any point in the river can be determined by the salt concentration at that point.[1] Thus, at Indian Point when the salt concentration is 2 ppt, the water is composed of 1/16 seawater and 15/16 fresh water. To maintain this concentration, a particular volume of seawater must move up through the Hudson River to Indian Point to provide sufficient salt to change the salt concentration of the fresh water to the observed concentration (2ppt). This volume may be calculated by the following formula:

$$V_s = \frac{(V_f)(\Delta C_f)}{\Delta C_s}, \qquad \text{(Eq. 1)}$$

where

V_s = volume of the source water (ocean water containing 32 ppt of salt),

V_f = volume of fresh water discharge,

ΔC_f = change in salinity of fresh water at sample point, and

ΔC_s = change in salinity of source (ocean) water at sample point.

Since the water derived from the ocean is diluted with the fresh water flow, the amount of water containing 2 ppt of salt that is generated by the dilution is equal to the sum of the volume of fresh water moving downstream and the volume of salt water that must move upstream to change the salinity of the fresh water to 2 ppt:

$$V_T = V_f + \frac{(V_f)(\Delta C_f)}{\Delta C_s}, \qquad \text{(Eq. 2)}$$

where:

V_T= total volume of water of particular salinity.

The high tidal flows cause a large amount of turbulent mixing, which is primarily responsible for the upstream movement of salt and consequently the ocean water.[2] This upstream movement of salt water may be greater in certain regions of a cross sectional area than in others. The most common such occurrence is for there to be greater upstream movement of salt along the bottom, less upstream movement on the surface, and no net flow at middepth.[1,6] As a consequence, the downstream movement of fresh water is often described as occurring on the surface.[6] Again, turbulent mixing is still involved in the upstream salt movement, but the net flows are spatially distributed vertically.

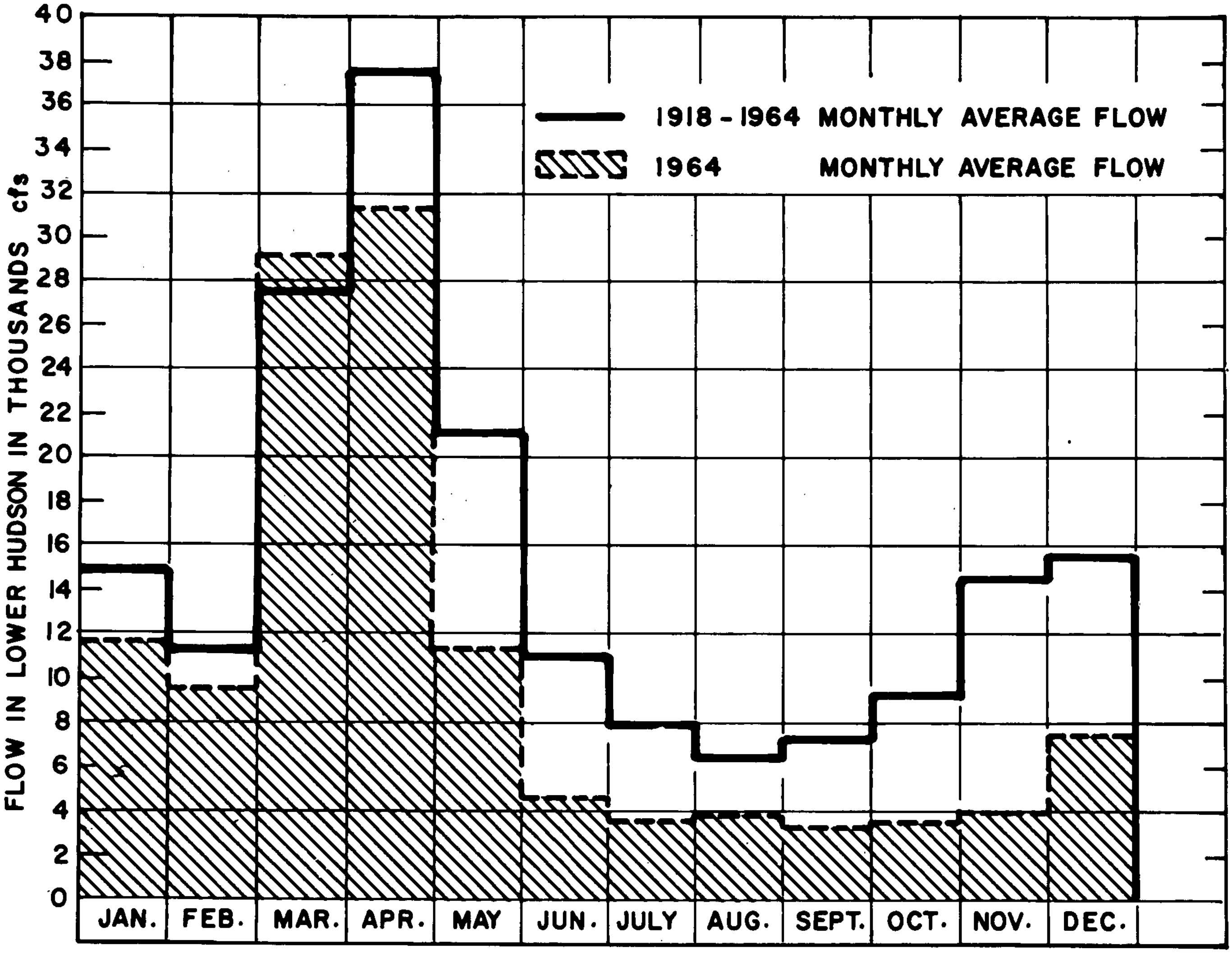


Fig. A-II-2
Fresh Water Flow in Lower Hudson at Indian Point.

The density flow concept is misleading when related to the dilution of Plant effluents. The actual seaward flow of water at Indian Point, which is available for removal of continuous discharges of conservative (nondegrading) effluents, is equal to the sum of the fresh water flow and the ocean water flow that is required to move sufficient salt up to Indian Point to result in the observed salinity. The surface flow may be many times the sum of the fresh and ocean water flows, and the lower layer flow may be much greater than the upstream flow of ocean water. It is explained[7] that the downstream movement of the fresh water flow is in the surface layers and that the upstream flow of salt water occurs in the lower layer. This statement gives the impression that the net downstream velocity of fresh water through the system is equal to the upper layer flow.

The actual situation is more complex. The downstream flow is at the surface; however, much of this flow is made up by upstream movement of (fresh) water in the lower layer, so that the net downstream flow in the upper layer, which is lost from the region, is equal to the sum of the fresh water flow and the flow of salt water to Indian Point. The net increase in downstream velocity of the fresh water due to density currents is equal only to the fraction of additional ocean water present. At Indian Point, the maximum salinity was about 7 ppt during drought conditions with a fresh water flow of approximately 4,000 cfs.[57] Under these conditions, the net lower layer upstream flow would equal only 1,120 cfs, and the downstream layer on the surface would flow at 5,120 cfs if in fact the two zones were completely isolated from each other. Apparently, much greater flow rates than these have been measured;[6,7] they must be the result of circulation within the estuary and are not representative of an increased net seaward velocity of the fresh water (see Fig. A-II-3).[8,9,10]

The actual spatial distributions of movement of salt water cannot be based solely on salinity data. The applicant reports on page 16 of Appendix K of the Supplement No. 1 to the Environmental Report that "Extensive field current measurements, at vario depths throughout cross-sections within the salt intruded reach, and over a full tidal cycle, are necessary to obtain this quantity. Measurements meeting these requirements are not available for the Hudson."[10]

On the basis of the evidence examined, the staff agrees with the preceding statement, although attempts were made to quantify the nontidal flow velocities in a later document.[6] In the Supplement No. 1 to the Environmental Report, the applicant contends that at Indian Point when the fresh water flow is 8,000 cfs, the upper layer flow would be about 21,500 cfs and the lower layer flow would be 13,500 cfs.[6] Thus, although the net flow of fresh water past Indian Point is only 8,000 cfs, the downstream flow in the upper layer would be 21,500 cfs.[6] This gives a

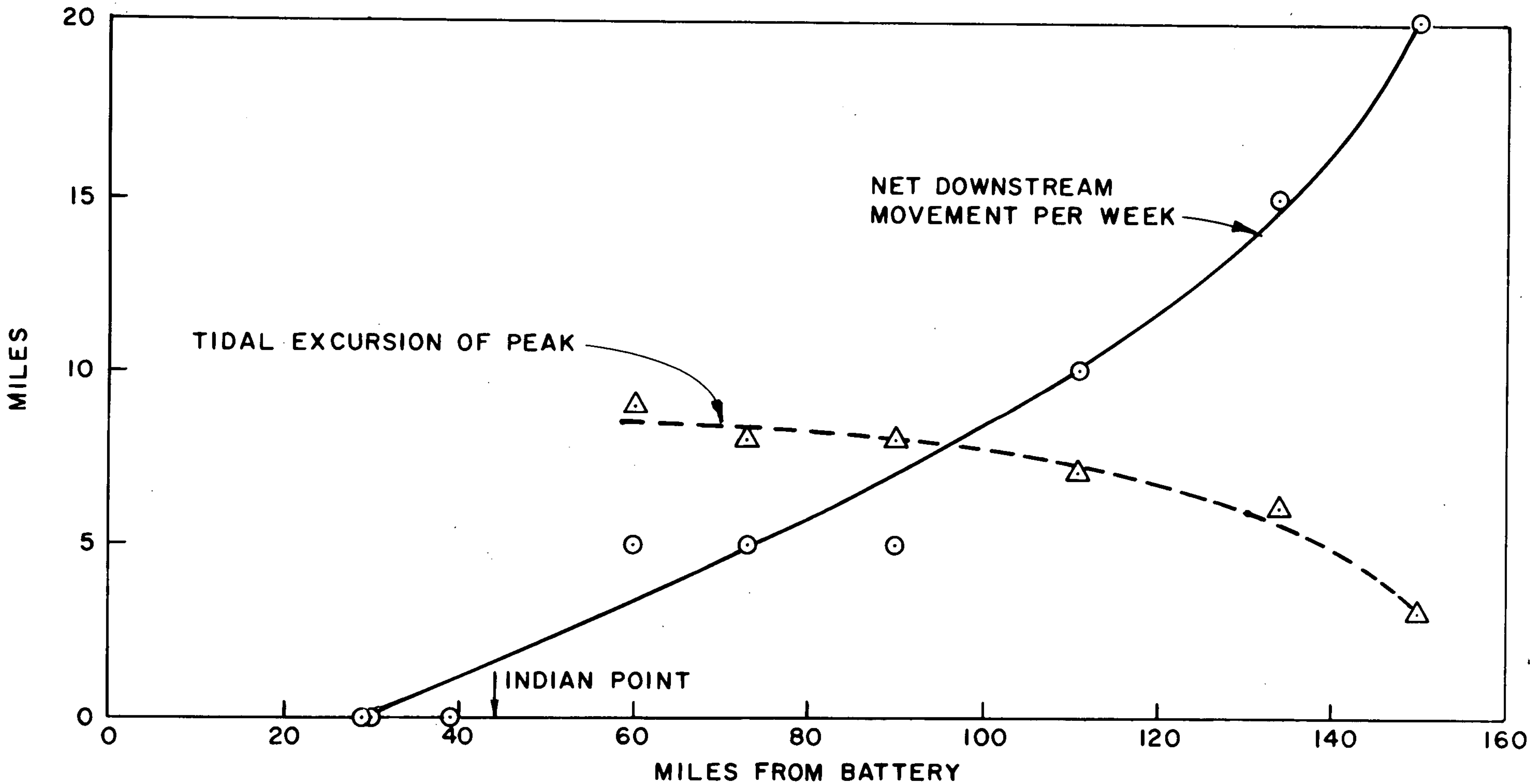


Fig. A-II-3
Transport of a Conservative Dye Downstream Past the Intake of Indian Point Unit 1 and 2.

total dilution flow available for dilution of 36,700 cfs. The total dilution flow at Indian Point is always greater than 20,000 cfs and this value is equivalent to the minimum total dilution flow. Unfortunately, field data that quantify these predictions are not convincing. Investigators from Alden Research Laboratories and Raytheon Company took temperature, salinity, and flow data on October 1 and 7, 1969, for one half of the tidal cycle on each day.[9] Since the amplitude and periodicity of the tidal movements are regulated by the relative positions of the sun and moon (Table A-II-1), an elapsed period of 7 days between sampling the two halves of the tidal cycle would be expected to introduce considerable variation into the measurements The second sampling period included only the first portion of the tidal change and was cut short by stormy weather, which itself would be expected to introduce significan changes in flow patterns. In addition, these measurements were not made at Indian Point but downstream in the area of upper Haverstraw Bay.

The importance of the density flow is related to the rate of dispersal of material released by the Indian Point facility. High-velocity density flows would tend to distribute the effluent more rapidly in a downstream direction, since the effluent will be thermally stratified at the top of the most rapidly moving layer. Thus, under such conditions, any effluent would have less chance of re-entering the area (via mixing with the upstream-moving lower layer) than it would if density flows were not significant or if the effluent were not stratified.

The mixing caused by tidal movements obviously causes water exchanges between adjacent areas at rates greater than the rates between distant areas. For example, the water between Indian Point and 5 miles downstream mixes at a greater rate than water between Indian Point and the ocean. However, such mixing exchanges occur in both directions, with the downstream loss (i.e., decrease of concentrated effluent by dilution) equal to the upstream gain less the dilution flow. Thus, as indicated by dye studies in the Hudson[11] (Fig. A-II-3) and in the Hudson River model at Vicksburg, Mississippi,[10] the rate of downstream loss of an effluent is very slow (Fig. A-II-4). As a result, effluents tend to dissipate slowly from the area of discharge.

The concentration of plant effluents in the Hudson River at Indian Point can be calculated from the following equation:

$$C(t) = \frac{R}{V\Lambda}\left(1 - e^{-\Lambda t}\right) , \qquad \text{(Eq. 3)}$$

where:

C = concentration of effluent in the Hudson,

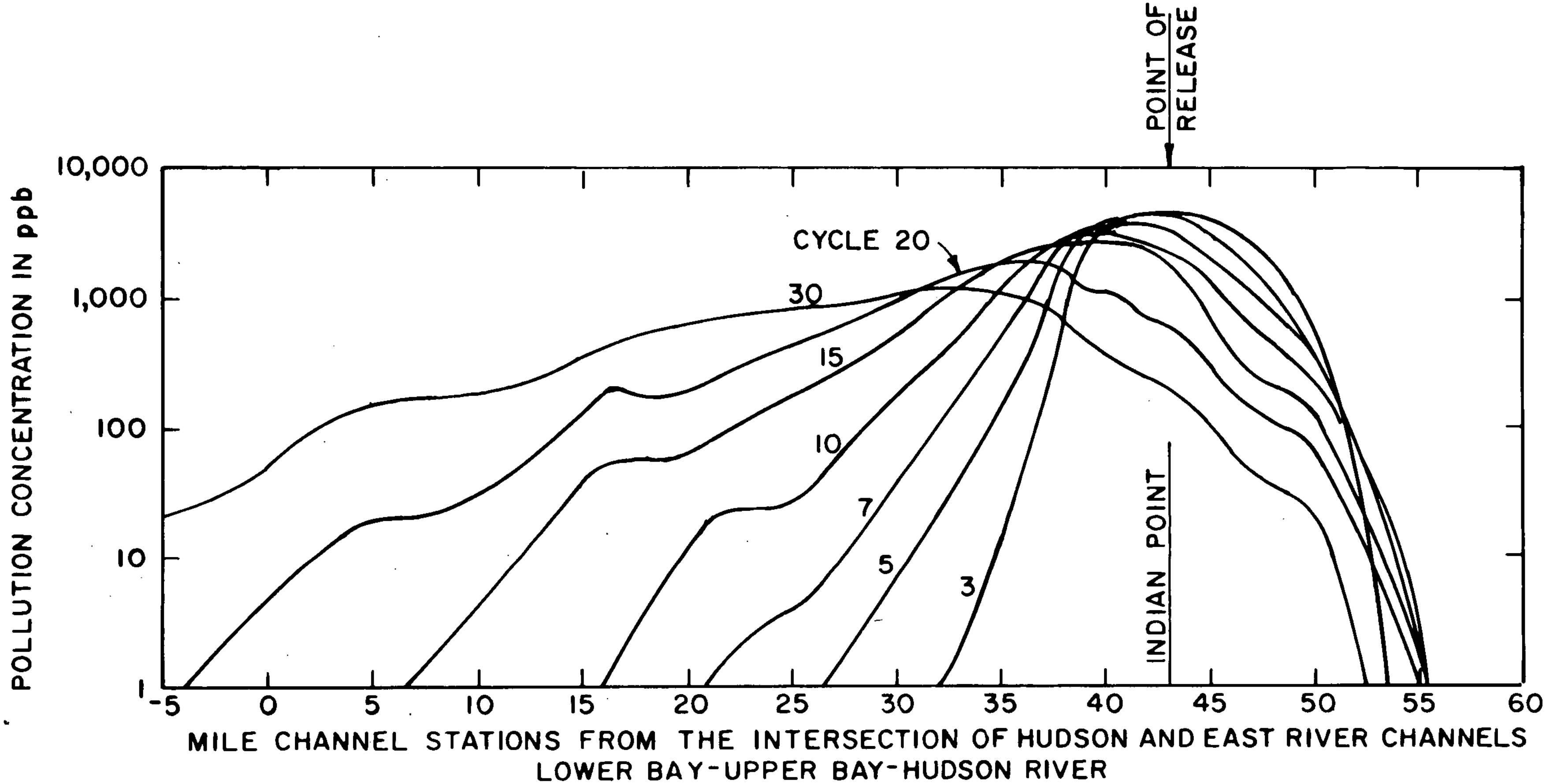
R = rate of discharge of effluent,

V = volume of river affected,

Λ = rate of removal from the affected volume = $\lambda + r/V$,

r = rate of water loss from the volume of river affected, and

λ = decay rate.



NOTE:

A TOTAL OF 6 LITERS OF DYE WAS RELEASED AT A UNIFORM RATE DURING 1 TIDAL CYCLE.

THE INITIAL DYE CONCENTRATION WAS 1,000,000 ppb

HUDSON RIVER AND RARITAN RIVER INFLOWS =12,000 cfs AND 1770 cfs RESPECTIVELY.

Fig. A-II-4

Change in Concentration of a Conservative Dye Released at Indian Point over One Tidal Cycle. Results are for Hudson River Model at Vicksburg, Miss.

Unfortunately the effective r in the above equation changes not only with variations of the combined fresh and salt water flows but also with the volume of the river affected. This latter factor makes implementation of the equation difficult since empirical data on the flow characteristics near Indian Point are sparse. This is particularly important in determining the dispersion characteristics of Haverstraw Bay in relation to the effective proportion of the Bay that is hydraulically active in the transport of salt. This factor could be especially important since much of the Bay is shallow (12 feet or less in depth at mean low water) and may act more for storage than transport, whereas the greatest proportion of the material transport both in upstream and downstream directions may occur in the channel, where hydraulic properties are superior. This is important because for substances that undergo decay of degradation the magnitude of the upstream return of effluents previously transported downstream is time-dependent. High rates of a concentration flux in smaller effective volumes would maximize the concentration of the effluent at Indian Point and vice versa.

That salinity data cannot be used to calculate density currents was amply demonstrated in the Mersey Estuary, where extensive current velocity and salinity data were taken in an effort to quantify the density current.[13] The density flows in this estuary at several locations could account for a maximum of 75% of the upstream transport of salt but only 15% of the upstream salt transport at other locations. The additional upstream salt transport was provided by turbulent mixing acting at all depths.[13] Thus the upstream movement of salt was only partly dependent on density flows.

This same type of data is needed to quantify the water movement at Indian Point in order to completely understand the dilution flow characteristics of the Hudson River at this point. The data presented by Quirk, Lawler, and Matusky Engineers[5,6,10] concerning the nontidal flow are not adequate to predict flow characteristics at Indian Point through seasonal changes in fresh water discharges. Data on the salinity of the lower Hudson River is shown in Fig. A-II-5 in which the salinity at the Indian Point site (Mile Point 43) ranges from about 0.1 to 8 ppm as a function of the flow corresponding to about 17,000 cfs to 3,000 cfs (drought conditions).

Although the spatial distributions of flows are uncertain, the quantities of water movement via combined density currents and turbulent diffusion can be calculated from Equation 2. At equilibrium, the concentration of a conservative Plant effluent would be regulated by the dilution flow, which is the sum of the fresh and ocean water flows at Indian Point during the time in question. This dilution flow varies with the fresh water flow as indicated in Fig. A-II-6.

Larson presents a lucid explanation of the initial fate of plant effluents:

> "A constant release of a conservative substance at Indian Point would produce the following, somewhat simplified, but yet pertinent, picture. Starting at slack before flood, accumulation would occur in an area outside the outfall. The 'island' of substance-containing water would start moving upstream with the flood flow. The continuously released substance would

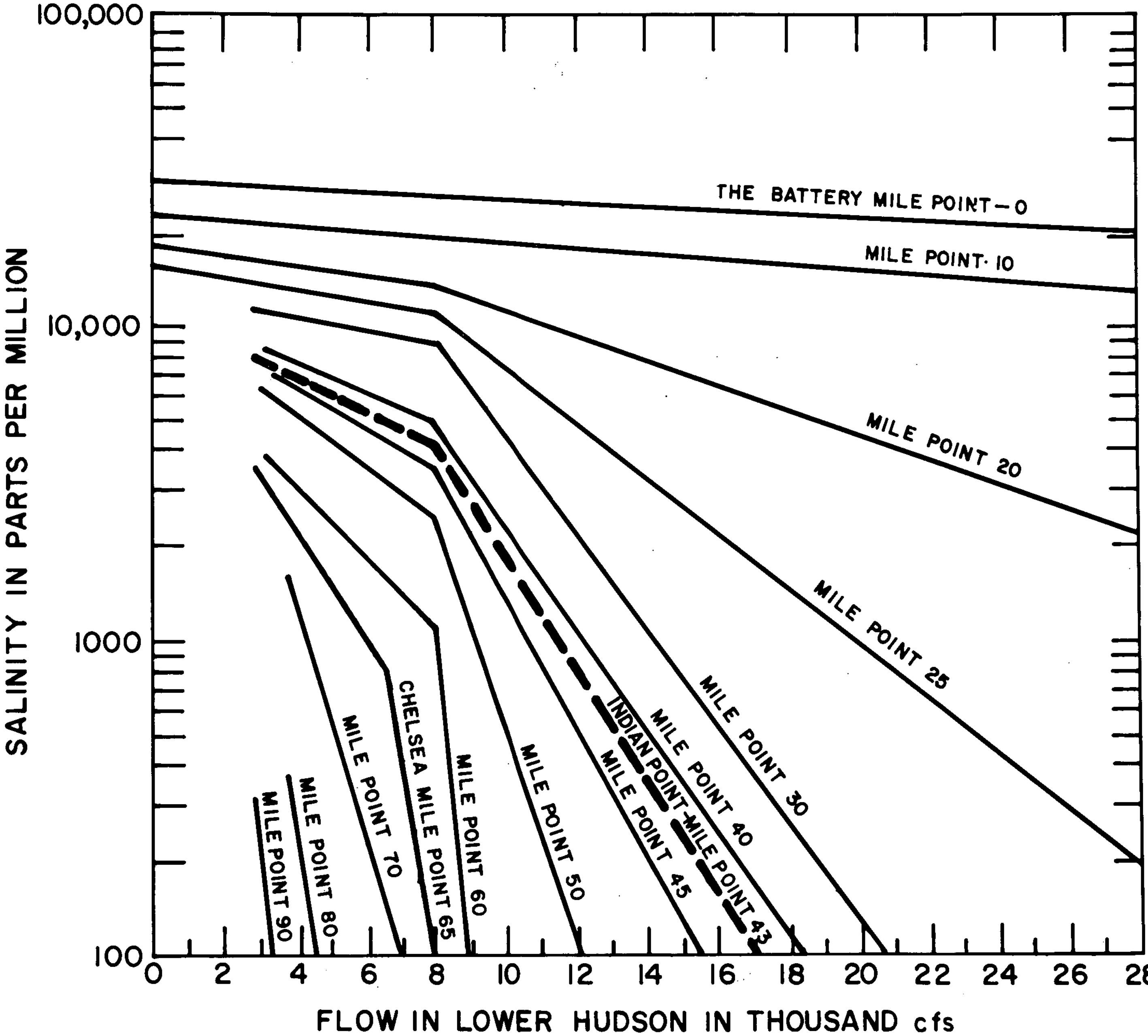


Fig. A-II-5
Hudson River Salt Intrusion Curves-Salinity Averaged Over Tidal Cycle and Channel Cross-Section.

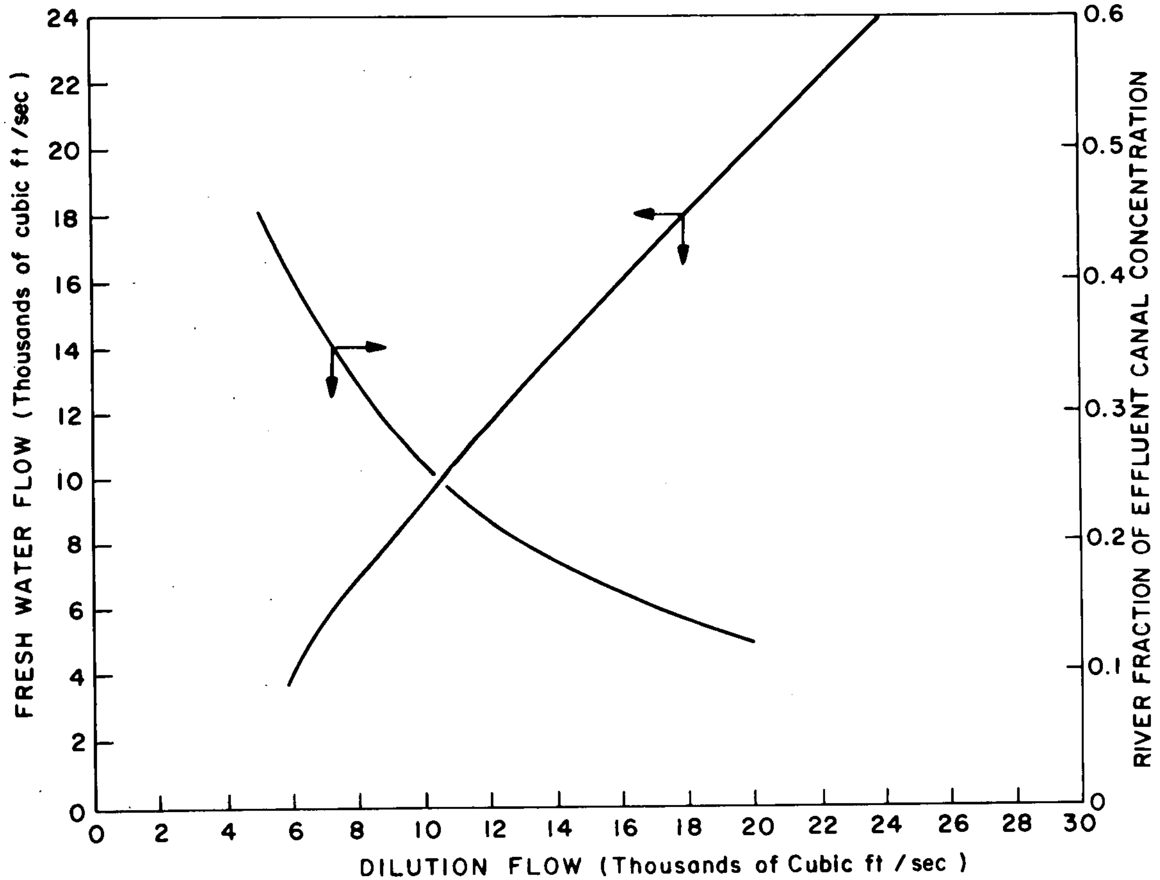


Fig. A-II-6

Equilibrium Concentration of Conservative Effluent after Long Duration Releases from the Indian Point Facility.

immediately be carried with the flow in the upstream direction, occupying an area mainly determined by the flow pattern of the river flow. At slack before ebb the original 'island' would be upstream, and a new island would form at Indian Point. Thus three 'islands' would be moving upstream during the second tide cycle, two of which were separated by the distance of the net downstream movement. At slack before ebb the third 'island' would miss Indian Point by this distance. Theoretically after a number of tide cycles a 'necklace' of 'islands,' chained together by substance containing water of varying concentration and with equidistance spacing equal to the net downstream movement would occur in the River. Longitudinal and lateral dispersion would have changed the initial boundaries and reduced the concentration tending to produce a more uniform distribution of the substance."(14)

For long duration releases of a conservative substance, Equation 3 reduces to:

$$C_{equil} = \frac{R}{r} \qquad \text{(Eq. 4)}$$

where:

r = dilution flow (Eq. 2).

Implementation of the equation to determine the fraction of the Hudson River water at Indian Point which would have passed through Indian Point Unit No. 1 and Unit No. 2 once-through condenser system showed that at low fresh water flow conditions a large proportion of the water at Indian Point had already passed through the once-through cooling system (Fig. A-II-6). These values can be used to predict concentrations of conservative materials released into the discharge water during Plant operation but cannot be used to predict entrainment, which is discussed in Appendix V-2. In calculations of the concentrations of chemicals in the Hudson River resulting from discharge during Plant operations, the staff assumed that the chemicals were continuously discharged and that they were conservative substances.

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APPENDIX II-2

AQUATIC ORGANISMS WHICH OCCUR IN THE HUDSON RIVER NEAR INDIAN POINT

TABLE A-II-2

AQUATIC PLANTS WHICH HAVE BEEN IDENTIFIED IN COLLECTIONS FROM THE HUDSON RIVER NEAR INDIAN POINT

Chrysophyta (yellow-green algae)

- *Acnanthes*
- *Asterionella*
- *Bacillaria paradoxa*
- *Campylodiscus*
- *Cocconeis*
- *Coscinodiscus*
- *Cyclotella*
- *Cymbella*
- *Diatoma*
- *Diploneis*
- *Eunotia*
- *Fragilaria*
- *Gomphonema*
- *Melosira ambigua*
- *M. borreri*
- *M. granulata*
- *M. italica*
- *M. varians*
- *Meridion*
- *Navicula*
- *Nitzschia iridula*
- *N. paradoxa*
- *N. sigmoidea*
- *Pinnularia*
- *Pleurosigma* (*Gyrosigma*)
- *Skeletonema*
- *Stephanodiscus*
- *Surirella*
- *Synedra*
- *Tabellaria*

Chlorophyta (green algae)

- *Characium*
- *Cladophora*
- *Closterium*
- *Coelastrum*
- *Eudorina*
- *Mougeotia*
- *Oedogonium*
- *Pediastrum*
- *Phormidium* (*Sphaerotilus*)
- *Scenedesmus*
- *Spirogyra*
- *Tetraspora*
- *Thallassiothrix*
- *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.*
- *Potomogeton crispus*
- *P. pectinatus*
- *P. perfoliatus*

TABLE A-II-2
(continued)

Myriophyllum sp.
Najas flexilis
Nitella sp.
Pontederia cordata (pickerel weed)
Potomogeton sp.
Spartina sp.
Trapa natans (water chestnut)
Vallisneria americana

TABLE A-II-3

AQUATIC ANIMALS WHICH HAVE BEEN IDIENTIFIED 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 sp.*
- *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 quadridentata*
  - *Filinia sp.*
  - *Hydratina sp.*
  - *Notholca*
  - *Philodina sp.*
  - *Platyias sp.*
  - *Rotoria sp.*

TABLE A-II-3
(continued)

Kellicottia longispina	Seison
Keratella cochlearis	Trichocerca sp.
K. quadrata	
Gastrotricha	
Nematoda	
Ectoprocta	
Ectoprocta crustulenta	
Hyalinella	
Tardigrada	
Annelida	
Hirudinea	
Piscicola punctata	
P. milneri	
Oligochaeta	
Aeolosoma sp.	
Tubifex tubifex	
Polychaeta	
Hypaniola grayi	Prionospio sp.
Nectochaete	Spio setosa
Nereis succinea	
Mollusca	
Gastropoda	
Amnicola limosa	Lymnaea
Bithinia tentaculata	Physa sp.
Pelecypoda	
Congeria leucophaeta (mussel)	Mya arenaria
Crassostrea virginica	Pisidium
Elliptio complana	Sphaerium sp.
Macoma balthica	
Arthropoda	
Crustacea	
Cladocera	
Bosmina longirostris	Ephippium sp.
Daphnia pulex	Leptodora kindti
Diaphanosoma	Sida crystallina
Copepoda	
Acartia discaudata	Ectinosoma curticorne
A. tonsa	Epischura sp.
Calanoid sp.	Eurytemora copepodid V.
Canuella elongata	E. hirundoides
Cyclops bicuspedatus	E. lacustris

TABLE A-II-3
(continued)

- *C. vernalis*
- *Diaptomus ashlandi*
- *D. pallidus*
- *Harpactocoid sp.*
- *Laophonte sp.*
- *Microarthridion littorale*

Amphipoda
- *Corophium volutator*
- *Gammarus fasciatus*
- *Leptocherius pinguis*
- *Monoculoides sp.*
- *Pontocrates norvegicus*

Isopoda
- *Ancinus depressus*
- *Cyathura carinata*
- *C. polita*
- *Edotea montosa*
- *Livoneca ovalis* (fantail sowbug)

Mysidacea
- *Mysis sp.*
- *Neomysis americana*
- *N. mercedes*

Ostracoda
- *Cypris sp.*

Decapoda
- *Callinectes sapidus* (blue crab)
- *Crangon septemspinosa* (brown crab)
- *Orconectes limosus*
- *Palaemonetes intermedius* ("shrimp")
- *P. paludosus* ("shrimp")
- *Rithropanopeus harrisii* (mud crab)

Cirrepedia (barnacles)
- *Balanus improvisus*

Chordata
- Cyclostomata
  - Petromyzontidae
    - *Petromyzon marinus* (sea lamprey)
- Osteichthyes
  - Acipenseridae
    - *Acipenser brevirostrum* (shortnose sturgeon)
    - *A. oxyrhynchus* (Atlantic sturgeon)
  - Anguillidae
    - *Anguilla rostrata* (American eel)
  - Atherinidae
    - *Menidia beryllina* (tidewater silverside)
    - *M. menidia* (Atlantic silverside)
  - Belonidae
    - *Strongylura marina* (Atlantic needlefish)
  - Carangidae
    - *Caranx hippos* (crevalle jack)

TABLE A-II-3
(continued)

Catostomidae
- Catostomus commersoni (white sucker)

Centrarchidae
- Lepomis auritus (redbreast sunfish)
- L. gibbosus (pumpkinseed)
- L. macrochirus (bluegill)
- Micropterus salmoides (largemouth bass)
- Pomoxis nigromaculatus (black crappie)

Clupeidae
- Alosa aestivalis (blueback herring)
- A. pseudoharengus (alewife)
- A. 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)
- N. cornutus (common shiner)
- N. hudsonius (spottail shiner)

Cyprinodontidae
- Fundulus diaphanus (banded killifish)
- F. heteroclitus (mummichog)

Engraulidae
- Anchoa mitchilli (bay anchovy)

Esocidae
- Esox niger (chain 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)
- I. nebulosus (brown bullhead)

Mugilidae
- Mugil cephalus (striped mullet)
- M. curema (mullet)

Osmeridae
- Osmerus mordax (rainbow smelt)

Percidae
- Etheostoma nigrum (Johnny darter)

TABLE A-II-3
(continued)

    E. olmstedi (tessellated darter)
    Perca flavescens (yellow darter)
Pleuronectidae
    Pseudopleuronectes americanus (winter flounder)
Pomatomidae
    Pomatomus saltatrix (bluefish)
Salmonidae
    Salma trutta (brown trout)
Sciaenidae
    Cynoscion regalis (weakfish)
Serranidae
    Morone americana (white perch)
    M. saxatilis (striped bass)
Soleidae
    Trinectes maculatus (hogchoker)
Sparidae
    Stenotomus chrysops (scup)
Syngnathidae
    Syngnathus fuscus (northern pipefish)

TABLE A-II-4

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)

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APPENDIX II-3

LIFE HISTORY INFORMATION OF IMPORTANT FISH SPECIES IN THE HUDSON RIVER NEAR INDIAN POINT

From an ecological standpoint the most important fish species that occur near Indian Point are the estuarine and marine forms which migrate through the area to spawn and those which require the estuarine environment for a nursery area. Fresh water and marine fishes which occur in the area from time to time through random wandering are less important to the area and will not be discussed in detail.

Shortnose Sturgeon (*Acipenser brevirostris*)

This, the smallest species of sturgeon, is classified as an endangered species.[1] Apparently it never grows to more than about 3 feet.

The early life history is unknown. Few small specimens have been recorded; probably the smallest fish is one of 7.3 inches (about 185 mm), from North Carolina. The smallest specimens taken in the Hudson River were two females; both a little less than 18 inches; one weighed 15 ounces and the other 19 ounces. The sizes of five specimens from the Delaware River observed by Ryder ranged between 18 and 23 inches. Age determinations based on otolith readings[2] have shown that *A. brevirostris* is a very slow-growing species. Specimens of *brevirostris* from the Hudson River that measured 17 to 35 inches (about 430 to 890 mm), total length, were 4 to 15 years old.

Males may mature when they are only about 20 inches total length, and most of them do so by the time they pass 21 inches; most of the females mature at about 24 inches. The ripe eggs are dark brown. The number of eggs is not known. Spawning takes place in rivers early in the spring. For Hudson River fish, the spawning season evidently includes late April.

On account of its small size, *A. brevirostris* has attracted little attention except when taken in nets in fresh, brackish, or salt water. It is found most often in tidal rivers. But the capture of specimens in the Gulf of Maine shows that some certainly go out into the open sea and wander for some distance from the parent stream.

Studies of stomach contents from Hudson River specimens showed that *A. brevirostris* feeds upon the bottom, eating small animals and plants intermingled with mud. The organisms consumed were sludgeworms, chironomid larvae, small crustaceans, etc.[3] Judging from the stomach contents of fish taken from the area between Rhinebach and Nyack, they seem to feed mostly on the bottom at a depth of 12 to 30 feet.[4] Snails, clams, crustaceans, and other bottom organisms are the main diet.

The breeding range of A. brevirostris is not clearly defined, but it is known to include the Hudson River, where the spawning areas appear to be very restricted.[2] The Delaware River may still maintain a small local population, and it seems likely that the Saint John River, in New Brunswick, has a spawning population, judging by the near-spawning condition of a male and female taken at Gagetown. If, through increased pollution or habitat changes, the population is no longer able to persist in these northern rivers; the species may become dangerously reduced.[2]

Atlantic Sturgeon (Acipenser oxyrhynchus)

The Atlantic sturgeon is an anadromous fish distributed on the Atlantic coast from the Saint Lawrence River, Canada, to northern Florida. This sturgeon is found in both fresh and brackish waters of the Hudson. Adults enter the river in spring to deposit their eggs in fresh or brackish water, possibly preferring brackish.[5] They then spend the remainder of the summer in the river before returning to the sea in the fall.

Sturgeon are bottom feeders and are usually found over sand or mud. Their diet consists mainly of worms, insect larvae, crustaceans, molluscs, and small fish.[6]

Female Atlantic sturgeons produce from 1 to 2-1/2 million eggs for each year's spawning. The eggs are heavy and strongly adhesive, sticking to each other and to the river bed, where they lie in large masses.[2,6] The eggs, 2.5 mm in diameter, hatch in about 6 days. At hatching, the larvae are about 11 mm long, but they gain a length of about 4 inches (10 cm) in a month's time.[2,6] Sturgeon young live on their yolk sac until about 20 mm long, then begin to feed on planktonic crustaceans. At a length of about 9 inches (23 cm) they become bottom feeders, rooting in the sand or mud with their snouts for amphipod and isopod crustaceans.[6] Their juvenile distribution is not well known, because, unlike striped bass and other species, the young are not taken by seines along the river's edge. Young sturgeon may remain in rivers until they reach 30 to 36 inches (76 to 91 cm) in length.[5] In March of 1968, 500 Atlantic sturgeon were captured in Haverstraw Bay with the 40-foot otter trawl. Of these, a sample of 71 fish ranged from 10 to 34 inches (26 to 87 cm).[3]

The Atlantic sturgeon is an anadromous species, invariably spawning in fresh or brackish water but making its growth in salt water. The adults migrate from the sea to fresh water in advance of the spawning season. The spawning migration begins at the end of April and in May in the Hudson River.

The eggs when laid are light to dark brown. The outside membrane of ripe eggs readily imbibes water and becomes attached to weeds, stones, and so forth, and it is believed that the eggs are scattered over a wide area. There is no evidence of prenatal care, such as preparation of a nest area.[2,5]

Sturgeon are bottom fish and are seldom seen except when taken in nets or when jumping. It is of interest that this relatively sluggish species is capable of making powerful jumps.[2]

Very little appears to be known about the behavior of the sturgeon in salt water. These fish can adapt to a sudden change from salt to fresh water, or vice versa. Some tagged specimens were forced to abruptly change salinity habitats at least twice during the same season, apparently without harmful results, because they were recaptured again alive.[2]

The large sturgeon feeds on molluscs and other bottom organisms. The fish roots in the sand or mud with its snout, as it noses up the worms and molluscs on which it feeds and which it sucks into its mouth with considerable amounts of mud.[2,6] The sturgeon also eats small fishes, particularly launce (Ammodytes).[2] The mature sturgeon, like the salmon, eats little or nothing while it travels up the river to spawn.

The digestive tracts of 26 young A. oxyrhynchus weighing 1 to 7 pounds from the Hudson River contained bottom mud along with plant and animal matter, including sludgeworms (Limnodrilus), chironomid larvae, isopods, amphipods, and small bivalve molluscs (Pisidium).[2] The food of A. oxyrhynchus varies with the type of habitat, as in the Saint Lawrence River, Quebec. Polychaete worms (Nereis virens) were found (265 on the average; the maximum number in a single stomach was 1,221) in 27 half-grown sturgeon taken in salt water. In addition, the sturgeon fed on marine gastropods, shrimps (Crago), amphipods, and isopods, in that order. In fresh water, the bulk of the food consisted of aquatic insects, amphipods, and oligochaete worms; in 88% of 178 sturgeon examined, larvae of the burrowing mayfly (Hexagenia) were present.[2]

Bluefish (Pomatomus saltatrix)

The bluefish occurs on the Atlantic coast seasonally from the Florida Keys to southern New England.[3] Throughout this range, it is particularly abundant in southern Florida, in North Carolina and Virginia, and from New Jersey to southern Massachusetts.

In the north, bluefish spawn in July and August between the 15-fathom (27-m) isobath and the edge of the shelf from northern North Carolina to Long Island.

After spawning, young bluefish lead a pelagic life for one month or longer, depending on the distance they must travel to the coast from the spawning areas and upon water temperature and other unknown environmental variables. In the New York area, the young arrive in two waves. The first reaches the coast from late June to early July, when most juveniles range from 3 to 5 inches (7.5 to 12.5 cm) in length. These juveniles are probably recruits from the spring spawning south of Cape Hatteras, having been carried north by the Gulf Stream system. The second wave, which reaches Middle Atlantic coasts in mid-August, when the young range from 1 to 4 inches (3 to 10 cm), are probably recruits from the northern spawnings in summer. Those of the first wave change from a diet largely of planktonic forms (crustaceans and fish eggs) to one of small fish when they are 2.4 to 3.5 inches (6 to 9 cm) long. This is about the time they become abundant along the coast and move into the Hudson estuary. They grow very fast during the course of their first summer, those of the first wave reaching around 10 inches or more before the end of the summer. They leave the estuaries in the early part of autumn and disappear into the sea for winter. According to Greeley,(7) bluefish were moderately common in the Hudson in August and September in 1937, with considerable numbers of young fish inhabiting the lower areas of the river. However, recent surveys have not indicated so great an abundance in the area.

Menhaden (Brevoortia tyrannus)

The menhaden is a very abundant and economically important oceanic member of the herring family.(3) Its range extends from Nova Scotia to Florida. Adults undertake extensive migrations, moving northward along the coast in spring and southward in fall. During the summer, they tend to be found in inshore areas, while in winter they move to deeper water. They spawn at sea over a wide geographical range throughout much of the year.(8) The larvae move inshore to enter the estuaries along the coast and usually congregate near the upstream limits of the tidal zone. These areas are rich in plankton organisms such as diatoms and holophytic flagellates which provide the food necessary for the survival of the young. As they increase in size, they tend to move farther downstream, and as fall approaches, they congregate near the mouth of the river before moving out to sea.(8)

In 1936, Greeley reported that young menhaden were common in the Hudson and were numerous at the mouth of the Mamroneck River in mid-July.(7) In recent surveys the menhaden have not been abundant. However, this species may once again become abundant as pollution abatement measures reduce the pollution level of the lower Hudson.(3)

Menhaden feed on small organisms strained from the water by their numerous long, slender, close-set gill rakers, which form an effective strainer. While feeding, the fish generally swim near the surface and often "break water"; they whirl around, sound a short distance, come out of the whirl, and swim up and straight ahead at a considerable speed for a rather short distance. During this time the mouth is wide open and the gill covers are lifted, thus making it possible for a fish to filter a great amount of water with minimum effort. The food that is ingested depends in large measure upon the organisms that are present where the fish is feeding. Even a considerable amount of mud and general debris is often swallowed. Included in the stomach contents examined by various investigators were numerous small crustaceans, especially copepods; small annelid worms; rotifers; and unicellular plants, particularly diatoms and peridinians. The plant organisms, as a rule, constitute the chief food.[9]

Most predatory animals associated with the sea feed on Atlantic menhaden - an easy prey because of their habit of schooling. Their fiercest enemy probably is the bluefish (Pomatomus), which, it is said, kills many more than it eats. Among the other fish that feed on them extensively are the cod, pollock, hakes, weakfish, swordfish, tuna, dolphin, amberjacks, and sharks. Whales and porpoises, as well as birds, also devour many of them.[9]

Large commercial fisheries exist for this species. Two products are obtained, oil and fish meal. The fish meal is used for poultry and livestock feed. These fish, though exceedingly valuable, are not used very extensively as food by man, mainly because of their bony nature and oiliness. However, some find the flesh delicious, and many people living along the coast, especially the fishermen, eat them in season as a common article of diet. Considerable quantities are often "corned" (salted) for home use during winter, and they are said to be delicious when smoked. They were canned to a limited extent for export during the last war, and a small quantity is still canned for home consumption.[9]

American Shad (Alosa sapidissima)

The American shad is an anadromous fish of the herring family, Clupeidae. Its range includes offshore, coastal, and river waters from Newfoundland to the Saint John's River, Florida. Shad are most abundant from Connecticut south to North Carolina. They spend their adult lives in the ocean, except in spring, when they ascend rivers along the coast to spawn. Hudson fish, like others that spawn in rivers north of the Chesapeake Bay, are said to return to the sea and migrate north to Gulf of Maine waters.[5] In winter they are presumed to remain in the deeper offshore waters of the Middle Atlantic coast, moving inshore again as the spawning season approaches.[10]

Shad begin their spawning run into the Hudson in late March and early April, and the run continues until the end of June. Although much of the river below the Troy Dam is used for spawning, the major breeding area appears to be just below the town of Catskill.[11] The average number of eggs produced by a single fish varies between 25,000 and 30,000, with larger fish producing more eggs than small ones.[12] The eggs are deposited free in the water and sink, to be carried along near the bottom by the current. They were reported[12] to hatch in 52 hours at an average temperature of 57.2°F, and in less than 36 hours at an average of 74°F. However, a longer incubation period has been reported.[12] Eggs held under artificial conditions hatched in 12 to 15 days at 53.6°F (12°C) and in 6 to 8 days at 62.6°F (17°C). The yolk is absorbed in 4 to 5 days at 62.5°F.[12]

Newly hatched larval shad average 0.40 inches in length and are transported by water currents.[12] They were most abundant near river mile 110 during the 1940-1942 surveys (New York State Conservation Department, 1943).

The young, as they grow, tend to disperse from the upstream spawning grounds down into the lower brackish parts of the river. The larvae appear to feed on plankton; the principal diet of juveniles consists of small crustaceans and insect larvae.[13] Those found in the lower estuarine parts of the river are reported to grow faster than those further upstream.[14] In the autumn, the young migrate to the sea to stay until they mature and join the annual spring migrations into the river for spawning.

Working with young specimens from the Shubenacadie River, a tributary to the Bay of Fundy, and its estuary, Leim found that the first food taken by larvae 11 mm long consisted of midge larvae (Chironomidae), while the somewhat larger larvae had fed principally on mature and immature copepods.[15] In fact, these organisms constituted the chief food of the young up to the time of transformation, with the relative abundance of these forms in a particular locality determining which food predominated. These data show also that young adults taken in the same vicinity ccontinued to subsist principally on these same organisms. Other foods ingested consisted of ostracods, insects, and fish.[12]

Little or no food has been found in the stomachs of shad caught while in fresh water en route to their spawning grounds, indicating that these fish, like salmon, do not ordinarily feed then. However, there are some records showing that adults occasionally do take food while in fresh water, at least late during the spawning season. They will often take a live minnow or an artificial fly when working upstream on their spawning run.[12]

From an examination of about 350 stomachs of both mature and immature fish caught in the salt water of Scotsman Bay (Bay of Fundy), Leim found that, while copepods constituted the chief food of the smaller ones, as in fresh water, these crustaceans were unimportant in fish 400 mm and more in length.[15] Mysids, which were sparingly eaten by small fish, were the chief food of adult fish. In general, about 90% of the specimens of all sizes from that area had eaten copepods and mysids, with ostracods, amphipods, isopods, decapod larvae, insects, molluscs, algae, fish eggs, and fish making up the remainder. After examining many stomachs of specimens taken in the Bay of Fundy, Willey also concluded that the chief foods consisted of copepods and mysids, with a few shrimp and larval stages of barnacles.[12] Stomach samples from Hudson River fish support his conclusions.[13]

The shad is still an important contributor to the Hudson River commercial fishery. The catch was 238,000 pounds in 1965 and 245,000 pounds in 1968. The peak catch during the past 50 years was 3,800,000 pounds in 1944. Sport fishing for shad in the Hudson is presently unimportant.[3]

Although there is no sport fishing for shad in the Hudson, more than 100,000 sport fishermen fished for shad in other Atlantic coastal rivers, estuaries, and bays in 1965 and took an estimated 4,700,000 pounds of them.

From Maine to North Carolina, commercial fishermen took 6,372,000 pounds of shad in 1965. The part of this catch that depends upon Hudson stock is not certain. However, it is known, from tagging experiments in the river, that Hudson shad migrate as far north as Maine and as far south as North Carolina, and thus contribute to coastal fisheries far from New York.[11] Tagging shad from pound nets on the New Jersey and New York coasts in 1956 indicated that Hudson River stock made up 76% of the catches of these nets; therefore these catches were dependent on the size of the Hudson River shad population.[16]

Bay Anchovy (<u>Anchoa mitchilli</u>)

The bay anchovy is a schooling species found in coastal salt and brackish waters, ranging from Mexico to Maine. This species has a long spawning season from late spring to September in the New York area and is a major component of the fish fauna at Indian Point.

A total length of 4 inches (100 mm) is seldom exceeded, with a usual length of about 3 inches (75 mm). The largest specimens have been taken in New York, where this species evidently grows larger than in the southern part of its range.[17]

The anchovy numerically is the most abundant fish caught by trawls within the study area near Indian Point. This species constituted 43% of the bottom trawl and 68% of the surface trawl catches. However, it made up less than a percent of the beach seine populations, occurring only in small numbers in 11 catches from August through October.[18]

The highest concentrations of the anchovy were observed during the months of August through October and were confined primarily to Haverstraw Bay.[18] There appears to be a general dispersal of the anchovy population from lower Haverstraw Bay in July throughout the entire Bay during August. The anchovy was caught in every surface and bottom trawl sample taken in September by Raytheon Co. investigators in 1969.[35] There is an abrupt decrease and general disappearance of the anchovy from the area during November and December. This species occurred at only 3 of the 14 bottom trawl stations sampled during December, and the 3 stations were located in the immediate vicinity of the Indian Point and Lovett Power Plants.[17]

The eggs are buoyant when spawned but gradually become demersal. They hatch in about 24 hours at room temperature.[17] The newly hatched fish, 1.8 to 2.0 mm long, are rather slender, are perfectly transparent, and have no pigment spots. The yolk sacs are absorbed within about two days, and the large mouths, which are terminal at this stage, then seem to be functional. Larvae of this species occur at Indian Point.

Young-of-the-year fish, immatures, and adults are abundant from late spring to early autumn in the lower Hudson River. The early young of the season may become sexually mature during their first summer, for specimens

45 to 60 mm long that remained quite transparent, taken late in July and during the first half of August, contained well-developed roe.[18]

The food apparently consists mostly of *Mysis* and copepods, the latter being the sole food of the young. Other items taken are small fish, gastropods, and isopods.[17]

Eels (*Anguilla rostrata*)

The American eel is a catadromous species found in abundance in the Hudson River. The species occurs from the Gulf of Saint Lawrence as far south as Brazil. The eel spends most of its life in freshwater creeks and ponds, rivers, and estuaries but migrates to the Sargasso Sea southwest of Bermuda to spawn. Newly hatched larvae, with the help of ocean currents, migrate from the ocean spawning grounds to the coastal rivers. The females travel far upstream into freshwater environments, but the males remain in the estuarine environment near the mouth of the river. As a mature adult, several years later, the eel retraces its route back to the oceanic spawning grounds, where it breeds and then dies. As eels migrate upstream in the vicinity of Indian Point, they are relatively common both in the surface and bottom samples but less so at mid depth.[18]

A small commercial fishery for eels is carried on in the Hudson River. The catch was 5,300 pounds in 1965 and only 2,500 pounds in 1968. Sport fishing catches are undoubtedly much higher than this, but no estimates are available for the Hudson.[3]

This species has been found to be a major component of the fish fauna in certain New Jersey streams[19] and may play a similar role for the tributaries of the Hudson.

Tomcod (*Microgadus tomcod*)

This species was previously described in relation to the Hudson by Clark and Smith.[3] The tomcod is a marine species that commonly spawns in the Hudson. It is a member of the family Gadidae, which contains some commercially important species. Tomcod spawn in shallow estuarine waters and around stream mouths. The demersal eggs are about 1.5 mm in diameter, heavy, and adhesive. They hatch in 24 to 30 days, depending on the temperature of the water. Spawning occurs from January through April in brackish water, and larvae are common at Indian Point in early spring. The adults move into the estuary from October to December and return to the lower estuary or the Atlantic after spawning. The juvenile fish spend their first summer in the waters where they were spawned and grow to a length of 2-1/2 to 3 inches by the following autumn.

Tomcod feed on a variety of organisms including small crustaceans, especially shrimp and amphipods, worms, small molluscs, squids, and small fish. They are most commonly found on the bottom.

White Perch (Morone americana)

This species is found in fresh, brackish, and coastal salt water between South Carolina and Nova Scotia.[20] Spawning of demersal and adhesive eggs (7.5 mm in diameter) occurs in fresh and brackish water from April to June, depending on geographic location, and at water temperatures between 45° and 60°F.[21] The eggs hatch in about 3 days at 58°F. Young and adults remain in fresh or brackish waters. They frequent shoal areas, except in winter, when they congregate in the deeper parts of bays and rivers, where they remain sluggish until spring.[20] During spring, summer, and autumn, localized wandering occurs.[13,20] This species feeds on small crustaceans and small fish.

The white perch is a major resident species at Indian Point. It is one of the most abundant species in the lower Hudson and is found throughout the year in all life stages at Indian Point.[18]

This species grows to about 15 inches and weighs from 2 to 3 pounds. It is of limited commercial importance but is commonly fished for along the shore at many localities.[18]

American Smelt (Osmerus mordax)

American smelt from salt water average 7 to 9 inches long when full grown, and about 12 to 13 inches are the usual maximum. They ordinarily run between 1 and 4 ounces, with very large individuals weighing up to 6 ounces. The following discussion has been abstracted from a discussion by Bigelow and Schroeder.[22]

Females weighing no more than 2 ounces may produce as many as 40,000 to 50,000 eggs; one which was 9.12 inches long (taken in Crystal Lake, Michigan) contained 43,125 eggs. The eggs, which range in diameter from 0.6 mm to about 1.2 mm in different waters and according to different authorities, sink to the bottom, where they adhere to each other in clusters or cling to any object upon which they settle. In European waters, the eggs hatch in 8 to 27 days, depending on the temperature of the water. In Massachusetts they have been reported as hatching in 13 days.

The larvae are about 5 to 6 mm long when they hatch and are perfectly transparent at first. Once hatched they rise close to the surface and drift downstream. On the average, they grow to 17 or 18 mm during their first month, 27 to 34 mm during the second month, and about 40 mm after 3-1/2 months. By the time the larvae have grown to 8 mm, the yolk sac is mostly absorbed; at 15 mm all the fins are more or less developed; and by 45 mm the formation of scales has begun.

In their second spring, when 1 year old, the fry average about 3.4 inches long. From scale studies it appears that they average as follows: at 2 years about 5.7 inches and about 0.6 ounces; at 3 years, 6.7 inches and about 1.1 ounces; at 4 years, 8.7 inches and about 2 ounces. The largest measured was about 9 inches. Four or more year classes are often represented in the commercial catches.

The marine fish normally spawn in fresh water, and as a rule they do not travel far upstream; they may go only a few hundred yards above the head of the tide. Others spawn in the tidal zone or even in brackish water behind barrier beaches. They generally spawn on pebbly bottom where there is a current, often in water only a few inches deep. Most often the spawners are 2 years old or older. Spawning takes place in late winter or early spring, depending on the temperature of the water. According to data from hatchery operations, the chief production of eggs takes place in temperatures of 50° to 57°F in Massachusetts and of about 45° to 50°F in Grand River, Quebec, representative of the northern part of their range. The spawning period lasts 10 to 14 days and is completed ordinarily by mid-May. The spent fish - except those that die, as many do - move downstream to brackish or salt water immediately after spawning, so that all of them have left fresh water by the middle of May.

The smelt mature in brackish or salt water if they are not landlocked. During the marine phase of their life they are confined to so narrow a coastal belt that none has ever been reported more than 6 miles or so out from the land and seldom below 2 or 3 fathoms; the deepest record for them is 9 or 10 fathoms at the mouth of Port-au-Port Bay on the west coast of Newfoundland. Many of them spend their entire growth period in estuarine areas, including the tidal reaches of rivers.

Their habitat in the summer along any particular section of the coast appears to depend chiefly on the temperature of the water. From Massachusetts southward, most of them (though not all) desert the harbors and similar situations during the warmest season, moving, it seems, only far enough out and deep enough to find slightly cooler water. Along the coasts of Maine and the Maritime Provinces of Canada, however, where water temperatures are lower, they are found in the harbors, bays, and estuaries all summer.

With the onset of autumn, those that have moved out to sea reenter the harbors and estuaries, so that by mid-October or early November practically the entire population is concentrated there. The smaller ones tend to reappear the earliest, but reports are contradictory in this respect. By December, some have even worked up into stream mouths to the head of tide. But the fish that will breed that season, most of which are 2 years old or older, do not actually enter fresh water until late winter or early spring, when the water off the mouth of the stream has warmed to at least 39° to 42°F (4° to 5.5°C).

The movement of the maturing fish into fresh water commences late in February along the southern coast of New England and southward, sometime in March along northern Massachusetts, seldom until April along the eastern part of the Maine coast, and not until the latter half of May along the southern shores of the Gulf of Saint Lawrence.

This species, though confined to shallow water, is not a bottom fish but tends to hold position at some intermediate level. The small ones, and probably the large ones also, gather and travel in schools that are composed for the most part of fish of about the same size, the product of one year's hatch. In the smaller harbors, they tend to move in and out with the tide, especially if the tidal flow is strong.

This species is carnivorous and predaceous. In salt and brackish water, shrimps (decapod and mysid) probably are their chief support on the Massachusetts coast; similarly, the stomach contents of those in the Gulf of Saint Lawrence have consisted chiefly of copepods, amphipods, and mysids, with algal debris probably taken incidentally. In some localities, small fish rank next. They have been found packed full of young Atlantic herring on the coast of Maine, and a wide variety of fishes has been recorded as occurring in their stomachs at Woods Hole. They also take small shellfish, small squid, annelid worms, and small crabs. But they cease to feed during the spawning season, as many other fishes do.

American smelt have been a favorite subject for artificial propagation. Many million fry were hatched in past years at the Cold Spring Harbor Hatchery, New York, as well as the Palmer Hatchery, Massachusetts. The results have been widely heralded, for great catch increases were reported for streams where fry were released. The most notable example is that 32 million eggs were collected in 1885 from a New York stream where there had been no smelts for at least some years previous. A similar example, though less spectacular, was reported for Massachusetts.

The American smelt is a favorite among the market fish, delicious when fresh-caught or even after being iced properly, and great numbers, especially from the Gulf of Saint Lawrence, are marketed. The average landings reported for the 4-year period 1951-1954 were 5,323,000 pounds for the Canadian Atlantic coast and 150,700 pounds for the United States coast, a total of 5,473,700 pounds; this represents 55 million individuals if these ran, say, 10 to the pound, all marketed for human consumption. Years ago they served as cod bait in the Gulf of Saint Lawrence, and large quantities were used as manure along the Gulf of Saint Lawrence shores of New Brunswick.

Alewife (Alosa pseudoharengus)

The alewife is an important forage species found along the coast from Nova Scotia to the Carolinas. During April and May, the fish travel upstream into many tributary creeks and ponds to spawn at temperatures of 50° to 60°F, sometimes in rapidly flowing water but usually in sluggish water, often only a few inches deep. After spawning, the adult fish return to the sea, remaining in the coastal waters in the general vicinity of their natal estuaries.[12]

The average female deposits about 100,000 adhesive eggs in the annual spawning. After the demersal eggs hatch, the young alewives at about 5 mm long are carried along with the current. They grow to about 15 mm in a month's time, when they are common at Indian Point. When they are about 1 to 1-1/2 inches long, they are found in the shallows of the Hudson upper estuary, as well as in the freshwater parts of the river, and apparently feed on small crustaceans and insect larvae.[18] Raytheon data indicate that these fish prefer to remain near the bottom.[30]

Although some of the young may remain in the river for more than a single season, most move out to sea before or at the end of their first season. They remain in salt water until they reach sexual maturity (at about 3 or 4 years old), at which time they return to the rivers to spawn.[12]

Blueback Herring (Alosa aestivalis)

The blueback herring closely resembles the alewife, and the two are often confused. The blueback has a more southerly range, extending from Nova Scotia to northern Florida, being more abundant south of New England. Bluebacks spawn later in the season than alewives, usually when water temperatures reach 70° to 75°F.[3] They do not seem to run far above tidewater in the Hudson, preferring deeper water, with most spawning probably occurring in the open river above Indian Point.[18] Bluebacks return to the sea soon after spawning, to reside in the inshore coastal waters until winter, when they apparently move offshore.[12]

The eggs of the blueback are demersal and adhesive and hatch in about 50 hours at 72°F. The larvae are common at Indian Point. Within a month the young reach a length of 1 to 2 inches. They spend the summer in fresh and brackish water nursery areas.[3] During a sampling program conducted in the summer of 1966, young blueback herring were found to be the second most abundant species along the shores of the Hudson.[23] In the late summer and fall, they move out of the river to the sea.

Young bluebacks in the Hudson feed mainly on small crustaceans and insect larvae;[13] as adults, they feed mainly on copepods and amphipods.[12] Raytheon data indicate that the blueback herring has a stronger preference for surface water than its relative the alewife.[18]

Striped Bass (Morone saxatilis)

The striped bass is an anadromous species of the family Serranidae. This family includes freshwater, estuarine, and marine forms. Although the species was originally an Atlantic form, it has been successfully introduced on the

Pacific coast and is a common food and game fish in that area. On the Atlantic coast, these fish are found from Florida to Nova Scotia but are most abundant in protected waters between North Carolina and Massachusetts. Large fish often reach 35 or more pounds and are generally found along the open coast but within 5 miles of shore.[3] Most stripers are found associated with bays, sounds, and tidal rivers. However, according to Clark,[24] they are also abundant along the Atlantic seaboard from the Delaware Bay to Cape Cod.

Clark[24] described the movements of striped bass in the area from the Chesapeake Bay to New England. Evidence from his studies, as well as previous studies, indicates that the species is not homogeneous but is instead composed of a number of separate groups which are more or less isolated from other groups. In southern waters, the fish remain in protected water throughout their life span, and as a consequence the various populations have little interchange and are most intensely isolated from each other. In contrast, striped bass from the Chesapeake Bay north to New England commonly leave their nursery areas after 3 or more years and migrate in groups along the open coast. Summer movements are generally north, while winter movements are generally south. In the northern part of their range, the striped bass become dormant in the winter.

Striped bass tagged in the Hudson have been caught in fisheries as far away as Massachusetts. However, most of the Hudson striped bass contribute to the commercial and sport fisheries in Connecticut, New York, and New Jersey.[3] Stripers that originate within the Hudson appear to be subdivided into three major groups: those which remain within the Hudson River, those which are in the southwestern portion of Long Island Sound, and those which are typically located along the New York - New Jersey coast.[24] In New York, Connecticut, and New Jersey, where the striped bass fishery is most dependent on the supply from the Hudson, the 1965 commercial catch amounted to 1,500,000 pounds, and the sport catch has been estimated as over 19,000,000 pounds caught by some 200,000 anglers.[3]

The best available evidence indicates that bass from New Jersey to Connecticut spawn in the Hudson. Clark[24] concluded that the "Hudson River is by far the most important spawning stream" in the New York area.

Details of the spawning and distribution of the species in the Hudson were described by Clark and Smith,[3] McCann and Carlson,[25] Jensen,[21] Schaefer,[26] Raney,[27] and Rathjen and Miller.[28] Their conclusions are summarized in the following description. The species spawns from Kingston to Bear Mountain, with the greatest concentration of eggs in the vicinity of West Point, although the exact location varies from year to year. The variability is the result of the fact that the greatest area of spawning is a few miles upstream from the salt water front, which varies in location from year to year. The nonadhesive demersal eggs are semibuoyant and require sufficient vertical water flow in order to remain suspended. Eggs are encountered most often in fresh or only slightly brackish water (salinity below

1 part per thousand). They average 0.134 inches in diameter and hatch in 2 or 3 days at 60° to 64°F.[29] After hatching, the larvae, which are about 0.13 inches long, continue to drift downstream. At this stage in development, the larvae are still unable to move effectively against the currents and will settle to the bottom in quiet water despite swimming efforts to approach the surface. These larvae are reported to be concentrated above the Haverstraw Bay area, with the greatest abundance between Peekskill and Newburgh. Once the larvae reach a length of 0.5 inches, they appear capable of sustained swimming. The larvae make extensive vertical diurnal migrations, being found in surface water at night and nearer the bottom during the day.[21,30] After they reach a length of about 1 in., they are found in greatest abundance in Haverstraw Bay.

As related to the Indian Point site, the striped bass generally spawn upstream from the area. Both eggs and larvae drift downstream past Indian Point. However, the majority of the spawn that drifts through the Indian Point area is composed of larvae rather than eggs. A large proportion of the yearly spawn passes Indian Point as eggs, larvae, or early juvenile stages. The young fish apparently stop along shoal areas, where they remain.

This species, like white perch, shows a definite preference for the bottom waters in shoal areas. Only small numbers were collected in the bottom trawls at the channel stations north of Stony Point, whereas large numbers were caught on shoals in Haverstraw Bay and in Peekskill Bay.[30]

After spawning, the adults generally return to sea. Larvae and young of the year remain in freshwaters and estuaries. Striped bass in the Hudson may remain in the estuary for 2 or 3 years before migrating to the sea. During winter, adults and young are found in the lower regions.

As larvae and young of the year, striped bass feed primarily on microcrustaceans. As they grow, their diet changes from smaller to larger forms. Gammarus apparently makes up a major proportion of their diet, but most other microcrustaceans are also taken, and there is evidence that a variety of food is needed for normal growth.[31] Small fish also become an important food item as the fish grow larger.

Note

A great deal of information on the migrations and growth of various life stages of striped bass from and within the Hudson is available in references 21, 23, 24, 25, 26, 27, 28, 30, 32, 33, 34, 35, 36, and 37. This information is currently being examined to provide a more complete picture of the striped bass population in the Hudson River.

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APPENDICES FOR CHAPTER III

APPENDIX III-I

WATER VELOCITY CALCULATIONS THROUGH THE INTAKE STRUCTURES OF INDIAN POINT UNIT NO. 1 AND UNIT NO. 2

UNIT NO. 1 Design flow = 300,000 gpm* or 668 cfs*

4 openings each 11 ft 2 in. wide x 20 ft 6 in. high

FIXED FINE MESH SCREENS - 4 x 11 ft 2 in. x 20 ft 6 in. = 917 ft^2

Assume 0.080 in. diameter wire in 3/8 in. square mesh screen

$$\frac{(0.375 - 0.080)^2}{(0.375)^2} = 0.62 \text{ fraction of area available for flow.}$$

Velocity through fine mesh screen, Unit No. 1

$$\frac{\text{Flow}}{\text{Area}} = \frac{668}{917 \times 0.62} = 1.17 \text{ fps}$$

UNIT NO. 2 Design Flow = 840,000 gpm or 1872 cfs

6 openings each 13 ft 4 in. wide x 26 ft 0 in. high

INTAKE OPENINGS, 6 x 13 ft 4 in. x 26 ft 0 in. = 2080 ft^2

Velocity through main openings, Unit No. 2

$$\frac{\text{Flow}}{\text{Area}} = \frac{1872}{2080} = 0.9 \text{ fps}$$

TRASH BARS - 1/2 in. thick x 3 in. wide @ 3.5 in. on center apart

$$\frac{3}{3.5} = 0.857 \text{ fraction of area available for flow}$$

Mean low water = 27 ft depth
Cross sectional area of water intake = 6 x 13 ft 4 in. x 27 = 2160 ft^2

Velocity through trash bars, Unit No. 2

$$\frac{1872}{2160 \times 0.857} = 1.01 \text{ fps}$$

*Note - 1 cubic foot per second (cfs) is equal to about 450 gallons per minute (gpm).

FIXED FINE MESH SCREENS

Assume intake aperture dimensions with 2 in. wide frame, i.e., screened area = 13 ft wide x mean low water depth less 2 in. or 26 ft x 10 in. = 2100 ft^2. Screen is 0.080 in. diameter wire, 3/8 in. square mesh 0.62 fraction of area.

Velocity through the fixed screen, Unit No. 2

$$\frac{1872}{2100 \times 0.62} = 1.44 \text{ fps*}$$

TRAVELING SCREENS - 12 ft 0 in. wide

Each panel = 2 ft 0 in. x 12 ft 0 in. = 24 ft^2 area

Assume 2 in. wide frame around each panel or open area = 1 ft 8 in. x 11 ft 8 in. = 19.44 ft^2

$$\frac{19.44}{24.0} = 0.81 \text{ fraction of area available for flow.}$$

Screen is 0.080 in diameter wire, 3/8 in. square mesh, 0.62 fraction of area.

Velocity through traveling screen, Unit No. 2

$$\frac{1872}{6 \times 12 \times 27 \times 0.81 \times 0.62} = 1.92 \text{ fps*}$$

Thus, for Indian Point Unit No. 2, the calculated water velocity increases from 0.9 fps at the intake openings of the intake structure to 1.92 fps through the traveling screens. This latter flow is more than 60% greater than the flow through the traveling screens of Indian Point Unit No. 1.

*At mean low water - depth = 27 ft.

APPENDIX III-2

SOURCE TERM DETERMINATION

TECHNICAL BACKGROUND

INDIAN POINT UNIT NO. 2 - 100% POWER LEVEL

The following parameters were used in the calculation of Indian Point Unit No. 2 estimated radioactive releases.

Percent fuel leak - 0.25%
Power level - 2,758 MW(t)
Primary to secondary leakage - 20 gallons per day (gpd)
Steam generator blowdown - 10 gallons per minute (gpm)
Containment purge - 12 times per year
Decay time - Waste Gas Processing Systems - 45 days

1. Gases

a. Containment Purge Releases

Assumed 12 purges annually. It was assumed that the activity in the containment would be reduced to 10X the occupational MPC by drawing air through a prefilter, HEPA filter and charcoal adsorber before being discharged to the Plant vent.

b. Blowdown Tank Vent Releases

It has been estimated that 0.62 Ci/yr of I-131 will be released via the blowdown vent. This estimate assumes: a 20 gpd primary to secondary leak; a 10 gpm blowdown rate; 1/2 of the steam flashes in the tank; and a 10^{-1} iodine partition factor. The radioactivity in curies released is approximately 1/20 of the curie input. We have also estimated an annual release of 35 Ci/yr in liquid effluent without treatment. The proposed intertie between Units Nos. 1 and 2 and the blowdown purification system should reduce this to less than 3.5 Ci/yr.

c. Waste Gas System

Strip main coolant 4 times per year. Combined fill - hold - release time yields 45 effective days of holdup.

2. Liquids

a. Chemical and Volume Control System (CVCS)

Release 4 primary coolant volumes per year (per Supplement No. 5 of FFDSAR). Use 10^5 Decontamination Factor (D.F.) for Evaporator-Demineralizer except 10^3 for Iodine, and 1 for H^3 and 10 hour holdup.

b. Waste Disposal System

130,000 gallons per year - evaporator - 10^4 except 10^2 Iodine - 10 hour holdup.

c. Steam Generator Blowdown

20 gpd leakage from primary system and 10 gpm released untreated to the discharge canal.

APPENDIX III-3

SUMMARY OF RADIOACTIVE WASTE DISCHARGES TO THE ENVIRONMENT FROM PRESSURIZED WATER REACTORS 1965-1970

This is a summary of discharges of radioactive wastes from pressurized water reactors operating in the United States from 1965 to 1970, except for the Saxton Nuclear Experimental Reactor, which has a net electrical capacity of only 3.25 megawatts.

It should be noted that 10 CFR 20 provides alternatives for determining permissible limits to the activity of radioactive liquid effluents. One of the limits specifically mentioned is 1×10^{-7} microcurie per cubic centimeter, which is sufficiently restrictive that it can be used for mixtures of fission and corrosion products in liquid waste from light water nuclear power reactors without any identification of the radioisotopic composition of the mixture. Other alternatives require knowledge of the identity and concentration of the radionuclides present and establishing that certain isotopes are not present. Typical compositions of radioactivity in water from light water power reactors are such that much higher limits are expected to be available to the applicant if it wishes to support them by adequate radiochemical analyses.

The corresponding proposed 10 CFR 50 guideline (June 9, 1971) is 0.2×10^{-7} microcurie per cubic centimeter, a value one-fifth as large as the 10 CFR 20 limit; 10 CFR 50 makes no provision for analysis for specific radionuclides. Therefore the percent of limit values in the tables for radioactive discharges in Chapter III (for 10 CFR 20 limits) may be converted to the percent of the 10 CFR 50 guideline by multiplying these values by 5, except for the instances where the applicant analyzed the discharge for specific radionuclides. In those cases, the 10 CFR 50 guideline of a maximum discharge of 5 curies per reactor can be used for comparative purposes.

The values for 1965-1968 are from "Radioactive Waste Discharges to the Environment from Nuclear Power Facilities," J. E. Logsdon and R. I. Chissler, U. S. Department of Health, Education and Welfare, PB-190717 (BRH/DER 70-2) March 1970 (Reference 1).

The values for 1969 are from Hearings Before the Joint Committee on Atomic Energy, Congress of the United States, 91st Congress, Second Session, on Environmental Effects of Producing Electric Power, January 27-30, February 24-26, 1970, Appendix 10, pp. 2316-2317 (Reference 2).

The values for 1970 are from B. Kahn, B. Shleien, and C. Weaver, in Vol. 2 of U. S. Papers for the Fourth United Nations International Conference on the Peaceful Uses of Atomic Energy, Geneva, Switzerland, September 6-16, 1971, Session 3.3-28 to 3.3-45, A/Conf-49/P-087 (Reference 3). Also another paper is from B. Kahn, *et al*. "Radiological Surveillance Studies at a Pressurized Water Nuclear Power Reactor," EPA, Cincinnati, Ohio, August 1971 (Reference 4).

TABLE A-III-1

RADIOACTIVE WASTE RELEASES TO THE ENVIRONMENT
FROM PRESSURIZED WATER REACTORS

Annual Liquid Wastes, Gross Beta-Gamma Less Tritium, in Curies

Facility	Rated Power MW(e)	Curies Released in Liquid Wastes 1965	1966	1967	1968	1969[a]	1970
Connecticut Yankee	600			0.216	3.9	12	22
Ginna	420					0.02	9.4
Indian Point Unit No. 1	285	26.3	43.7	28.0	34.6	28	7.8
San Onofre	450			0.32	1.6	8	3.8
Shippingport	90	0.14	0.06	0.07	0.08		
Yankee	185	0.029	0.036	0.055	0.008	0.019	0.034

(a) 28 Ci for Indian Point No. 1 represent 1.5% of the limit expressed in 10 CFR 20 where individual isotopes are analyzed. (Rogers, L. and Gamertsfelder, C. C., "U. S. Regulations for the Control of Releases of Radioactivity to the Environment in Effluents from Nuclear Facilities," IAEA Symposium on Environmental Aspects of Nuclear Power Station, New York, N.Y., August 10-14, 1970.)

TABLE A-III-2

RADIOACTIVE WASTE RELEASES TO THE ENVIRONMENT
FROM PRESSURIZED WATER REACTORS

Tritium in Liquids, in Curies

Facility	1965	1966	1967	1968	1969	1970
Connecticut Yankee			221	1,740	5,200	7,400
Indian Point Unit No. 1		125	297	787	1,100	410
San Onofre				2,350	3,500	4,800
Shippingport	3.04	27.3	34.8	35.2		
Yankee	1,300	1,920	1,690	1,170	1,700	1,500

* Modified to 150 MW(e) in 1965.

TABLE A-III-3

RADIOACTIVE WASTE RELEASES TO THE ENVIRONMENT FROM PRESSURIZED WATER REACTORS

Noble and Activation Gases, in Curies[a]

	Rated Power MW(e)	Maximum Permissible Release[b,c]	1965[b]	1966[b]	1967[b]	1968[b]	1969[c]	1970[d]
Connecticut Yankee	600	18,900			0.021 (29.8)	3.74 (73.4)	190 (75.0)	700 (71.3)
Indian Point Unit No. 1	285	5,360,000	33.1 (46.4)	34.6 (50.3)	23.4 (68.3)	59.7 (64.9)	600 (72.1)	1750 (14.1)
San Onofre	450	567,000			4.02 (21.3)	4.83 (33.6)	260 (69.2)	1610 (81.0)
Shippingport	90[b]	40[b]	0.032 (42.0)	0.030 (67.0)	0.002 (60.8)	0.001 (46.8)	(39.1)	(49.1)
Yankee[e]	185	6,600	1.7 (64.7)	2.4 (85.9)	2.3 (85.7)	0.68 (81.5)	4 (75.3)	17.2 (78.8)

[a] In parentheses, beneath the radioactivity discharge values, are power plant capacity factors (%) taken from Table 8 of "Operating History, U. S. Nuclear Power Reactors," Division of Reactor Development and Technology, 1970, Atomic Energy Commission.

[b] Data from Reference 1.

[c] Data from Reference 2.

[d] Data from Reference 3, except as noted.

[e] See, in particular, Reference 4.

TABLE A-III-4

RADIOACTIVE WASTE RELEASES TO THE ENVIRONMENT
FROM PRESSURIZED WATER REACTORS

Halogens and Particulates in Gaseous Effluents

Facility	Rated Power MW(e)	Curies Released in Gases			
		1967	1968	1969	1970
Connecticut Yankee	600			<0.0001	0.00046
Ginna	420			<0.0001	None Detected
Indian Point Unit No. 1	285	*	*	0.025	0.075
San Onofre	450	0.001	*	<0.0001	None Detected
Shippingport**	90	*	*		
Yankee	185	*	*	<0.001	None Detected

* Negligible
** Modified to 150 MW(e) in 1965.

APPENDICES FOR CHAPTER V

APPENDIX V-1

CHEMISTRY OF CHLORINATION AT INDIAN POINT

Much progress was made in the 1940's in the use of chlorine for the sterilization of water supplies. Griffin[1] gave an annotated guide to over a hundred papers published between 1939 and 1952. Fair[2] gave a lucid exposition of the behavior of chlorine as it was then understood. The subject has been summarized recently by Lewis.[3]

Certain terms have come into use to describe chlorine in water. They are often used carelessly in industrial practice. The distinctions given are those of Lewis.[3]

a) <u>Free chlorine</u> (short for free available chlorine): that part of the chlorine injected into the water that remains as molecular chlorine, hypochlorous acid, and hypochlorite ion.

b) <u>Combined chlorine</u> (short for combined available chlorine): that part of the chlorine injected into the water that remains combined with ammonia or other nitrogenous compounds.

c) <u>Active chlorine</u> (alternative for total available chlorine or chlorine residual): the total free and/or combined chlorine that remains. The terms "active" and "available" refer by implication to activity and availability for sterilization. The amount of "active chlorine" present is recognized as being equivalent to the amount of iodine that will be released from potassium iodide at acid pH.

d) <u>Chlorine demand</u>: by implication, the exact amount of chlorine required to oxidize completely all compounds that reduce free chlorine in the water. These compounds include both organic and inorganic substances. In practice, the term is used when referring to the difference between the dose and the active chlorine left (chlorine residual) after a particular period of contact, for one particular dose rate.

<u>Reactions During Chlorination</u>

As soon as chlorine dissolves in water it hydrolyzes:

$$Cl_2 + H_2O \rightleftarrows HClO + H^+ + Cl^-.$$

This hydrolysis is virtually complete, and only when the pH is below 3.0, or if the chlorine concentration is of the order of 1,000 ppm, hydrolysis is complete within seconds at ordinary temperatures. The full oxidizing capacity of the chlorine is retained in the hydrolysis product, HClO, although one chlorine atom from each molecule has been transformed to a chloride ion. The hypochlorous acid then ionizes:

$$HClO \rightleftarrows H^+ + ClO^-,$$

At pH 7.0 the equilibrium is approximately 75% HClO, and 25% ClO^-, and at pH 8.0 this is reversed to approximately 25% HClO, and 75% ClO^- (at a water temperature of 20°C). When sodium hypochlorite is dissolved in water it dissociates into a sodium ion and a hypochlorite ion:

$$NaClO = Na^+ + ClO^-, \text{ and } H^+ + ClO^- \rightleftarrows HClO.$$

Similarly, at pH 7.0 the equilibrium is approximately 75% HClO, 25% ClO^-, and at pH 8.0 this is reversed to approximately 25% HClO, 75% ClO^- (at a water temperature of 68°F).

There are apparent differences in disinfecting properties of chlorine gas and hypochlorite solutions, which Fair et al.[2] considered were caused by failure of the experimenter to adjust the pH, or other experimental errors. Injection of chlorine gas will lower the initial pH, whereas addition of hypochlorite solution will raise the pH.

When ammonia or organic amines are present in the water they react with hypochlorous acid to give chloramines. The first step is the formation of monochloramine:

$$NH_3 + HClO \doteq NH_2Cl + H_2O.$$

The rate of reaction between ammonia and hypochlorous acid is dependent on pH and is at a maximum at pH 8.3. Fair[2] found that for a mixture of 0.8 ppm* chlorine and 0.32 ppm ammonia nitrogen, at 25°C, 99% of the chlorine reacted in 1 minute at pH 8.3, in 210 minutes at pH 5.0, and in 50 minutes at pH 11.0. They found that the rate of reaction varied with temperature (Q_{10} values ranging from 2.0 to 2.5 according to pH).

The next step is the formation of dichloramine from monochloramine and hypochlorous acid:

$$NH_2Cl + HClO \rightleftharpoons NHCl_2 + H_2O,$$

the dichloramine being in equilibrium with monochloramine:

$$2NH_2Cl + H^+ \rightleftharpoons NH_4^+ + NHCl_2.$$

*ppm = parts per million.

This equilibrium depends upon both pH and the ratio of chlorine to ammonia. Fair[2] found that with a chlorine-to-ammonia-nitrogen ratio of 5:1, the relative percentages of the two chloramines were: at pH 5.0, 16% monochloramine and 84% dichloramine; and at pH 8.0, 85% monochloramine and 15% dichloramine. The third step in the chloramine formation is quoted as:

$$NHCl_2 + HClO \leftrightharpoons NCl_3 + H_2O,$$

but, little is known about the reactions at this stage.[3] As more chlorine is added in excess of that required for the above reactions, the chloramines break down, with an overall reaction:

$$3Cl_2 + 2NH_3 = N_2 + 6Cl^- + 6H^+,$$

giving a chlorine-to-ammonia-nitrogen ratio of 7.6:1.

Theoretically, with a chlorine-to-ammonia-nitrogen ratio of 7.6:1, the reaction should be complete, so that no residual chlorine remains. This is known as the breakpoint. With a higher percentage of chlorine, the excess should remain as free chlorine, and with a lower percentage of chlorine, the chlorine should consist of a mixture of mono- and dichloramine.

In practice, when waters containing organic amines, as well as ammonia, are chlorinated, such a clearcut breakpoint is not obtained. Pulham[4] gave some "illustrative" breakpoint curves for these conditions. These curves show that where organic amines are present it is possible for chloramines and free chlorine to coexist. This is shown diagrammatically in Fig. A-V-1. Presumably, where free chlorine coexists with combined chlorine, all mono- and dichloramine (inorganic) must have been oxidized, and the remaining combined chlorine must be organic chloramine.

Ingols[5] studied reactions between chlorine and sulfur-containing amino acids (at concentrations of 10^{-4} M amino acid). It was found that HClO would oxidize sulfhydryl groups to sulfonic groups and then deaminate the amino acid via the formation of chloramines. With slightly more monochloramine, an organic chloramine formed that was stable for some hours. With monochloramine the sulfhydryl groups were oxidized to give disulfide linkages.

Reactions During Periods of Salt Intrusion.

When saline water is present at Indian Point, another reaction will be involved. Since the low flow conditions which favor the buildup of chlorinated residues are accompanied by saline water at Indian Point, these reactions are important.

In 1955 Johannesson[9] pointed out that seawater may contain up to 68 ppm bromide and that the reaction:

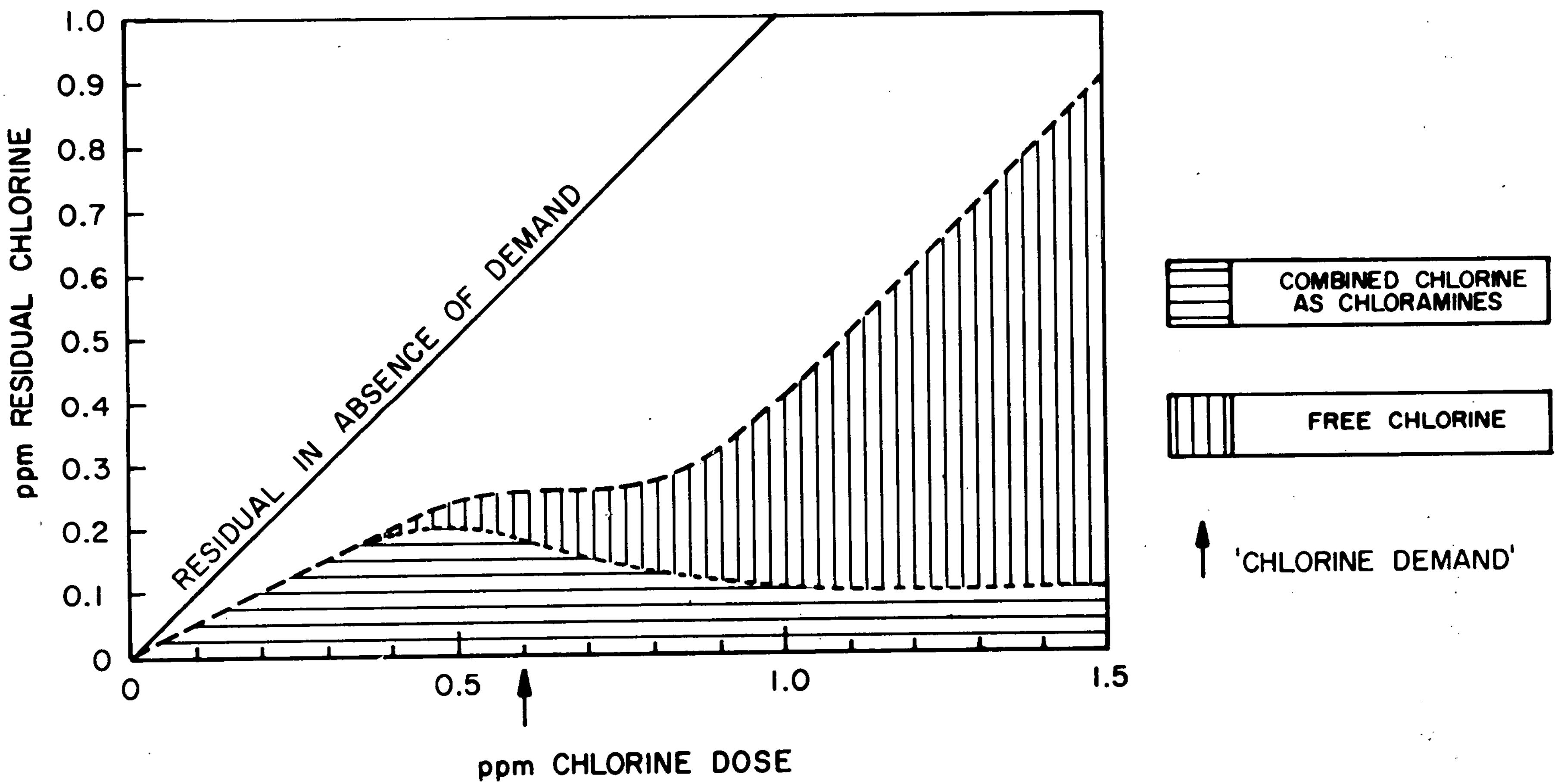

Fig. A-V-1

Typical Pattern of Chlorine Reaction With Natural Water. Actual Scale Values Are Dependent Upon Local Conditions.

$$Cl_2 + 2Br^- \rightarrow 2Cl^- + Br_2$$

goes to completion. The dissociation products, HClO and ClO^-, will, however, release bromine from the bromide ion in the form of hypobromous acid and hypobromite ion:[3]

$$ClO^- + Br^- \rightarrow BrO^-,$$

$$BrO^- + H^+ \rightleftarrows HBrO.$$

Addition of chlorine water to a solution of bromide and ammonium salts, buffered to pH 8.3 with bicarbonate, resulted in a mixture of monobromamine and some monochloramine, but addition of a sodium hypochlorite solution gave mostly monochloramine. This relationship results because the hypochlorite in solution will react with both the bromide and ammonia according to the equations:

$$ClO^- + Br^- \rightarrow BrO^- + Cl^-, \qquad (A)$$

$$ClO^- + NH_3 \rightarrow NH_2Cl + OH^-. \qquad (B)$$

Reaction A is only rapid at pH values below 8.0 (at pH values between 8.0 and 10.0 the reaction takes some minutes to reach completion). Reaction B is rapid at pH 8.3 (99% complete in 1 minute at 25°C), but slower at higher and lower pH values. If chlorine gas is injected into seawater, local acidity can be produced, depressing the pH below the normal range of 8.0 to 8.3. In these circumstances reaction A will be favored. However, when sodium hypochlorite is added, the pH is not depressed, and reaction B is favored.[3,9]

Johannesson[10] also stated that he had found dibromamine was formed:

$$NH_2Br + BrO^- \rightarrow NHBr_2 + OH^-.$$

This existed only in equilibrium with monochloramine, the balance depending on the ammonia-to-bromine ratio (i.e. monochloramine and dichloramine). In the presence of excess bromine the mono- and dibromamine break down, and the same form of breakpoint curve is obtained as for chlorine and ammonia. But Johannesson[10] was not convinced that nitrogen tribromide took part in the breakpoint reactions, although its analogue, nitrogen trichloride, had been proposed as a stage in the breakdown of chloramines.

Monobromamine apparently has greater oxidizing properties than monochloramine, and, as a result, tests that distinguish between free and combined chlorine fail to distinguish between free and combined bromine. Johannesson[10] explained that this was on account of the presence of significant proportions of a monobromammonium ion:

	pH 7.5	pH 8.5
Ratio of monobromammonium ion to base monobromamine	1:10	$1:10^2$
Ratio of monochlorammonium ion to base monochloramine	$1:10^7$	$1:10^8$

These reactions are essentially similar to those described for chlorine, with the exception that monobromamine is a stronger oxidizing agent than monochloramine.

At Indian Point the normal chlorination process will be to inject sodium hypochlorite into the circulating water flow. During periods of salt water intrusion, some of the chlorine can be expected to react with the bromide as described above. The net result, presumably, will be that there will always be some combined chlorine and some combined bromine in any chlorinated saline water passing through the Indian Point Station. The actual composition of the residual must vary with mixing, amount and types of organics present in the water, and rates of reaction (particularly the dissociation of hypochlorous acid, the release of bromine, and the formation of chloramine), which will depend on temperature, pH, and length of contact.(3)

Analyzing for Chlorine Residuals.

Several evaluations have been made of the numerous analytical methods used for determining residual chlorine in water (Appendix V-1, Table V-1). Nicolson,(6) who evaluated 9 colorimetric and 3 titrimetric methods, found that the barbituric acid method was the best laboratory colorimetric procedure if combined chlorine residual was absent. In the presence of combined chlorine, the N,N-diethyl-p-phenylenediamine (DPD) method was more satisfactory. Lishka,(7) who analyzed the results from 72 participating laboratories using several different analytical methods, reported that the ferrous-DPD method had the best accuracy and precision, followed closely by the methyl orange, SNORT (Stabilized Neutral Orthotolidine), and amperometric methods. None of the methods has outstanding reliability even when care is taken. (See Appendix V-1, Table V-1) Reliability is undoubtedly even less in truly routine analyses.

The standard methods for the examination of water and wastewater(8) includes the ferrous-DPD, the orthotolidine-arsenite, the leuco crystal violet, the methyl orange, and the SNORT methods all of which determine both free and combined chlorine residuals. However, the determination of combined residual is dependent upon monochloramine and dichloramine and the extent of their influence depends upon the types of organic compounds present.

The role of bromine as related to these determinations is not clear at present. Most of the tests for residual chlorine would include the residual bromine but would not tell the relative proportion of the two elements. It

APPENDIX V-1

TABLE A-V-I

PRECISION AND ACCURACY DATA FOR RESIDUAL CHLORINE METHODS BASED UPON DETERMINATIONS BY SEVERAL LABORATORIES[8]

Method	Residual Chlorine Concentration Free µg/l	Residual Chlorine Concentration Total µg/l	Number of Laboratories	Relative Standard Deviation %	Relative Error %
Iodometric		840	32	27.0	23.6
		640	30	32.4	18.5
		1,830	32	23.6	16.7
Amperometric	800		23	42.3	25.0
		640	24	24.8	8.5
		1,830	24	12.5	8.8
Orthotolidine	800		15	64.6	42.5
		640	17	37.3	20.2
		1,830	23	35.0	49.6
Orthotolidine-arsenite	800		20	52.4	42.3
		640	21	28.0	14.2
		1,830	23	35.0	49.6
Stabilized neutral orthotolidine	800		15	34.7	12.8
		640	16	8.0	2.0
		1,830	17	26.1	12.4
Ferrous DPD	800		19	39.8	19.8
		640	19	19.2	8.1
		1,830	19	9.4	4.3
Leuco crystal violet	800		17	32.7	7.1
		640	17	34.4	0.9
		1,830	18	32.4	18.6
Methyl orange	800		26	43.0	22.0
		640	26	30.1	14.2
		1,830	26	19.9	7.2

is evident that the chemistry of chlorine in seawater is quite complex and that further work is required to investigate this chemistry and to produce useful analytical techniques.[3]

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APPENDIX V-2

ENTRAINMENT

The impact of the Indian Point station on entrainment is associated with seasonal variations of the extuarine hydraulics near the site. Under average conditions, the fresh water flow of the Hudson River ranges from a maximum of over 30,000 cfs in the spring to a minimum of 6,500 cfs during the late summer. With water requirements of Indian Point Unit Nos. 1 and 2 of 2,580 cfs, this would correspond to a range of less than 10% to about 40% of the available fresh water flow. If extreme drought conditions such as those in August 1964 were to be repeated, when the fresh water flow rate dropped to about 3,050 cfs, the water requirements might be as high as 85% of the fresh water flow. Over the course of a year under average conditions, the water requirement could be about 14% of the fresh water flow.

This proportionally high usage of Hudson River water appears to have a potential for a large exposure of the planktonic community to the thermal, physical, and chemical damage associated with entrainment within the circulating cooling water. The ecological effects of such entrainment are associated with both biological and nonbiological factors. The biological factors (see Section V.D.2) indicate that two aspects of entrainment may be particularly important: the concentration of entrained organisms at various points in the river and the fraction of organisms originating above the site which pass through the Station (the 2 Units) before they leave the area in the downstream direction. The equilibrium concentration of entrained organisms can be estimated using Equation 3 or 4 of Appendix II-1 with certain additional terms:

$$C(t) = \frac{R\ (1-c)}{V\Lambda}\ (1-e^{-\Lambda t}), \qquad (1)$$

where

$C(t)$ = fraction of organisms in the area of Indian Point which have been entrained, and discharged in the cooling water,

C = fraction of organisms in the area of Indian Point remaining in the Hudson River and not entrained,

R = rate of cooling water flow,

V = volume of the river affected,

Λ = $\lambda + r/v$ = rate of removal from the area being considered,

r = rate of water loss from the area (dilution flow), and

λ = rate of recruitment resulting from increased reproduction or survival.

Again, as discussed in Appendix II-1, the relationships between r, V, and λ are interrelated through time because of the circulation pattern of estuarine flows. For uniformly distributed planktonic forms with long (annual) generation times and an extended duration of operation, Equation 1 reduces to:

$$C \text{ equil.} = \frac{R(1-c)}{r} \quad . \tag{2}$$

Unfortunately, the utility of this relationship is limited because it requires the development of an additional equation to estimate the survival and reproductive rates of entrained organisms, which would change the value of R(1-c). This equation (2) cannot be solved at this time for the organisms in the area because of the time element introduced by mixing (see Appendix II-1) and the survival rate of entrained organisms. Thus, analysis of susceptibility of various resident plankton populations to entrainment and the interactions so induced must be done on the population level. The staff is presently evaluating this aspect of the entrainment situation. The staff's preliminary results of its evaluation are discussed below.

Many fish species spawn in the area above Indian Point, and the young drift downstream past the Station. In this case it is important to know the fraction of downstream migrants which will pass through the Station.

In order to predict the probability that an organism drifting downstream with the net flow will be entrained, let

Q_T = tidal flow, cfs,

Q_D = dilution flow, cfs,

Q_C = Station cooling water intake flow, cfs,

P_e = probability of withdrawal per exposure, and

P_T = total probability of withdrawal.

The probability that a particle (organism) moving past the Station intake (assuming uniform distribution) will be withdrawn is

$$P_e = Q_C/Q_T. \qquad (3)$$

If the discharged organisms from the condenser are assumed to be mixed with the fresh ones, then the probability of an organism being withdrawn on each exposure reduces to

$$P_e = \frac{Q_C}{Q_T} (1-\upsilon), \qquad (4)$$

where υ is the fraction resulting from re-exposure of the same water volume from direct recirculation.

The number of exposures of the same organism to the Station intake will be

$$n = Q_T/Q_D. \qquad (5)$$

From statistical reasoning, the probability of an organism not being withdrawn with each exposure is $1 - P_e$, and for n exposures it is $(1 - P_e)^n$. The total probability of being withdrawn at least one time is then

$$P_T = 1 - (1 - P_e)^n . \qquad (6)$$

Substituting Equation 4 and 5 into Equation 6, we get

$$P_T = \left[1 - \left(1 - \frac{Q_C}{Q_T}\right)(1 - n)\right]^{Q_T/Q_D} . \qquad (7)$$

By using the binomial expansion, we have

$$(1 - P_e)^n = 1 - \binom{n}{1} P_e + \binom{n}{2} P_e^{\,2} - \binom{n}{3} P_e^{\,3} + \binom{n}{4} P_e^{\,4} \ldots, \qquad (8)$$

where

$$\binom{n}{N} = \frac{n!}{N!(n - N)!} \quad \text{(binomial coefficient).}$$

Substituting into Equation 6, we get

$$P_T = \binom{n}{1} P_e - \binom{n}{2} P_e^{\,2} + \binom{n}{3} P_e^{\,3} - \binom{n}{4} P_e^{\,4} + \ldots \,. \qquad (9)$$

Where the number of exposures or the probability per exposure is high, many terms of Equation 9 are needed to produce an accurate total probability of withdrawal. However, where the number of exposures is not large, the total probability can be estimated if we take only the first two terms of Equation 9 to get

$$P_T = nP_e - \frac{n(n - 1)}{2} P_e^{\,2}. \qquad (10)$$

When both Units are operating at full capacity, the cooling water flow will be approximately 2580 cfs. The tidal flow past the site 80% of the time is about 178,000 cfs.(16) At this flow, the probability that a planktonic organism moving past the Plant will be withdrawn is

$$P_e = \frac{Q_C}{Q_T} = \frac{2,580}{178,000} = 0.015.$$

This estimate is an average probability of withdrawal since the rate of tidal flow changes from no flow to a peak which may exceed 300,000 cfs. With lower tidal flows the Q_C/Q_T ratio would increase and thereby increase the probability of withdrawal. On the other hand, the 178,000 cfs estimate of the average tidal flow would often be exceeded, thereby decreasing the probability of withdrawal from the maximum value. Based on these considerations, the staff agrees that the applicant's estimate of 0.015 (1.5%) seems reasonable.

Because of the cyclic nature of the tide, planktonic forms in the water are subject to withdrawal each time the tidal volume passes the area. This event occurs 3.86 times per day, or approximately once every 6.25 hr.(1) Planktonic organisms move downstream at a net rate which is determined by the dilution flow (see Appendix II-1). Thus, they will move slowly downstream into the volume of water which is moving back and forth in front of the Indian Point site. Once planktonic species enter this area of the river, they will pass back and forth in front of the intake of the Station. The number of times they are so exposed in turn depends upon the duration of their stay in the area and can be calculated using Equation 5. Thus, for 14,700 cfs dilution flow:

$$n = \frac{Q_T}{Q_D} = \frac{178,000}{14,700} = 12.1 \approx 12.$$

The probability of an organism being withdrawn or entrained, P_T, can be then calculated using Equation 10 to be 0.18.

$$P_T = n\, P_e - \frac{(n)(n-1)}{2}\, P_e^{\,2}$$

$$= (12)(.015) - \frac{(12)(11)}{2}(.015)^2$$

$$= 0.18$$

The additional increase in cooling water temperature difference is an indication of the amount of mixing at the outfall. The basic condenser temperature difference is reported to be 14.9°F; and, therefore, the amount of mixing due to direct recirculation will be

$$\upsilon = \frac{\text{additional increase in condenser } \Delta T}{14.9},$$

$$\upsilon \approx \frac{2}{14.9}, \text{ and}$$

$$\upsilon = 0.14$$

Thus with maximum recirculation, the probability of withdrawal of planktonic organisms on each pass is reduced by 14% to provide a low estimate of 0.15 for 14,700 cfs. In order to understand how variations in the magnitude of the tidal flow may affect the probability of entrainment, we substitute into Equation 10 using Equations 4 and 5 to get

$$P_T = (1-\upsilon)\frac{Q_C}{Q_D}\left[1 - 1/2\left(\frac{Q_T}{Q_D} - 1\right)\frac{Q_C}{Q_T}(1-\upsilon)\right]. \qquad (11)$$

For the case where $Q_T >> Q_D$, we get an approximated simplified equation, namely,

$$P_T \approx \frac{Q_C}{Q_D}(1-\upsilon)\left[1 - 1/2\,(1-\upsilon)\frac{Q_C}{Q_D}\right]. \qquad (12)$$

Equation 12 shows that the total probability of being withdrawn is proportional mainly to the ratio of cooling water flow to the river fresh-water flow. It is almost independent of the tidal characteristics, although these characteristics are important in that they provide the mixing and dilution which must be met in order for this model to be accurate.

Figure A-V-2 gives the probability of organisms being withdrawn as a function of dilution flow for different amounts of recirculation. The 1.5 - 2.0°F increase in condenser ΔT could occur only under conditions of incoming tide and is not expected to be this great. However, if it were to occur, this amount of increased ΔT would correspond to about 15% recirculation.

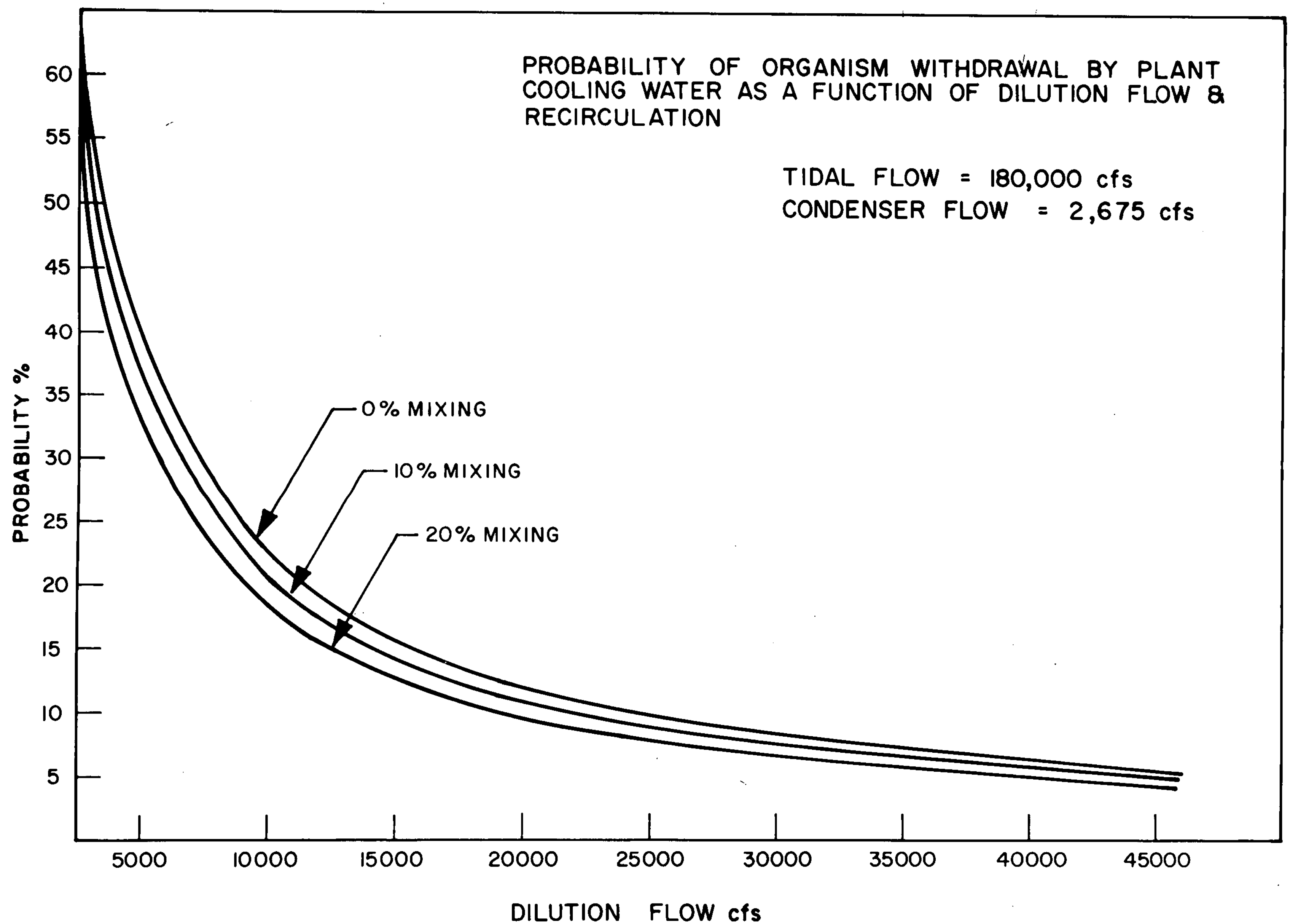

Fig. A-V-2
Entrainment by Indian Point Units No. 1 and 2 vs Dilution Flow.

Figure A-V-3 shows the river fresh-water flow at each month of the year based on monthly average for the years 1918-1964. The same figure shows the corresponding probabilities for an organism to be withdrawn assuming a 5% water recirculation. It can be seen that the withdrawal probability changes from a low value of 6% (for April) to a high value of 31% (for August). The annual average value for the years 1918 to 1964 is about 17%. Organism withdrawal of 17% can then be seen as the representative average value. However, in some dry years, like in 1964, the yearly average might be close to 30%, and monthly averages may exceed 45% during dry months.

These predictions are based on average tidal conditions which include the water velocities that vary both horizontally and vertically in the river. A probability value of 18% refers to the average likelihood of withdrawal of randomly distributed planktonic forms that originate upstream from Indian Point. Various sections in the river would have different probabilities associated with each section. Areas close to the intake structure would have the greatest probabilities, and the area near the west shore would have the smallest probability of being withdrawn with each pass. With tidal flows of 180,000 cfs and a dilution flow of 7,000 cfs, an average organism near the west bank on its first pass would have about 8 days exposure to the intake and would be mixed through 25 cycles of the tide, which would increase its susceptibility over a higher dilution flow where proportionally less mixing would occur before the organism left the area. The importance of the horizontal mixing is related to the possibility of passing the same organism through the condensers more than one time. The greater the value of this factor, the less the overall percentage of organisms entrained. However, the greater the magnitude of the density flow and the intensity of the stratification, the less will be the recirculation factor.

The area-average susceptibility as discussed in this appendix would require that the organisms be randomly distributed. As should be expected, no such random distribution exists for most species. As a consequence, it is necessary to consider the behavior of each species separately in order to obtain a quantitative estimate of its population's susceptibility to entrainment. The manner in which this influences the susceptibility of withdrawal is associated with the vertical migration patterns of the organisms involved and the relative velocities within the different areas. At present, inadequate data are available to quantify the flow volume and velocity in the various zones. The importance of this factor must be evaluated in relation to the entrainment susceptibility of each species considered.

Example: entrainment of larval striped bass. For pertinent biological information upon which the following analysis is based see the Section on striped bass in Appendix II-3.

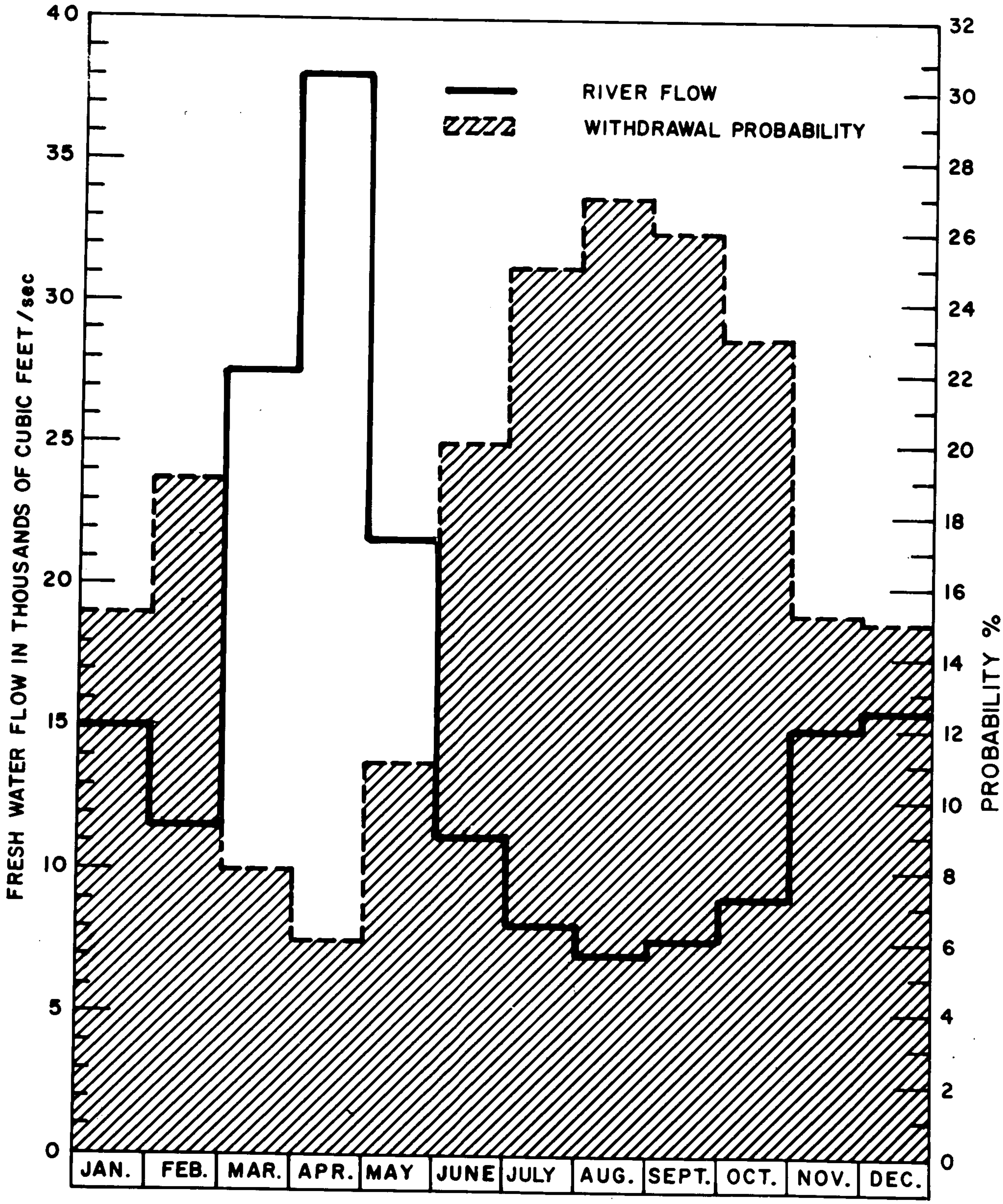

Fig. A-V-3
Probability of Entrainment of Downstream Moving Plankton Which Orginates Above Indian Point for Average Monthly Flow Conditions from 1918-1964.

The adult bass spawn upriver from the Indian Point, and a significant portion of the eggs and larvae drift downstream past Indian Point and take up residence on the shoals in Haverstraw Bay. The percentage of these downstream migrants which may be entrained by Indian Point Units No. 1 and 2 may be predicted as follows:

The peak larval migration is in June-July:

a) average salinity during the time period in 1970 = 2 ppt [17],

b) average flow during the same time period = 7,500 cfs [7,18].

Thus, the dilution flow =

$$V_T = V_F + \frac{(V_F)(\Delta C_F)}{C_S} ,$$

$$V_T = 7{,}500 \text{ cfs} + \frac{(7500 \text{ cfs})(2 \text{ ppt})}{30 \text{ ppt}} , \text{ and}$$

$$V_T = 8{,}000 \text{ cfs}.$$

Note that this dilution flow is less than would be predicted from the figure given in Appendix II-1. This apparent discrepancy is the result of the fact that the dilution flows in Appendix II-1 are based on steady-state salinity profile where the net movement of ocean water is zero. In contrast, during the period of June and July there is a net upstream movement of seawater such that the dilution flow is slightly greater than would be predicted by direct salinity measurements, i.e., 8,730 cfs.

$$P_e = \frac{Q_C}{Q_T} = \frac{2,580}{178,000} = 0.015,$$

$$n = \frac{Q_T}{Q_D} = \frac{178,000}{8,730} = 20.39 \approx 20 \text{ exposures}.$$

Since the number of exposures is relatively high we will use the first four terms of Equation 9:

$$P_T = \frac{n}{1} P_e - \frac{n}{2} P_e^{\;2} + \frac{n}{3} P_e^{\;3} - \frac{n}{4} P_e^{\;4}$$

$$P_T = (20)(0.015) - \frac{(20)(19)}{2} (0.015)^2 + \frac{(20)(19)(18)}{2x3} (0.015)^3 - \frac{(20)(19)(18)(17)}{2x3x4} (0.015)^4 ,$$

$$P_T = 0.262 .$$

With 5% direct recirculation the P_T would be reduced to:

$$P_T = 0.262 - (0.262)(0.05)$$

$$P_T = 0.25$$

Thus, the probability that a larval striped bass migrating downstream would be entrained is about 25%. Comparison of the fresh water inflows used in these calculations with inflows during the period from 1944 to 1964 indicates that these values were similar to the median conditions. Therefore, a susceptibility of 25% or more would probably be common, although the range in susceptibility would vary from year to year.

These values are based on area-average susceptibility. However, it is known that the larval striped bass make vertical diurnal migrations in the water column and are most concentrated from mid-depth to the surface at night but from mid-depth to the bottom during the day. These distributional patterns are important since the cooling water is taken from mid-depth to the surface. Thus, there would be a significant difference in the day vs. nighttime susceptibility of the larvae, i.e., lower during the day and higher at night. Since the length of day and night are not equal at this time of year, these organisms may be slightly less susceptible to entrainment than predicted using this technique, provided that the deeper water is moving seaward.

However, if the density flow is well developed, then these diurnal migrations will cause them to occupy an inland-moving zone during the day and a seaward moving zone at night. Since their occupancy within the water mass moving inland would be of longer duration than within the water mass moving seaward on the surface, the length of time which they are susceptible to entrainment may be much longer than predicted in the above calculations. This is an important consideration in that the probability that they will be withdrawn is related to the number of exposures. A single week of exposure would increase the likelihood of withdrawal to about 34% and 10 days would result in about 45% of the larvae being entrained (assuming random distribution in the water column). These time periods do not seem unrealistic based on the behavior of larval striped bass and the high probability for the occurrence of density flows at Indian Point. As a consequence, the staff believes that the 25% estimate derived by the above calculations is probably somewhat low. However, the increased residence time within the volume of water which passes back and forth in front of Indian Point may be partly offset by a reduction in the average probability of withdrawal per pass, which results from the non-random distribution within the water column. Consequently, the staff believes that the total average probability of withdrawal of larval striped bass migrating downstream past the Station is approximated by the 25% figure, and that this fraction is the best estimate that can be made using available information.

In conclusion, based on these considerations, about 25% of the larval striped bass may be entrained as they migrate downstream past the Indian Point site.

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APPENDIX XI-1

STAFF'S SUMMARY OF ALTERNATIVES AND COST-BENEFIT

ENVIRONMENTAL COSTS:

1. Heat Discharge to Natural Water Body

1.1 Cooling Capacity of Water Body

1. Applicant's design

6.35×10^9 Btu/hr

The number of acre-ft within the 4°F isotherm is given by the applicant as 42 acre-ft.

The staff's calculations based on the applicant's model show that about 1.55×10^3 acre-ft will be within the 4°F isotherm.

Using Appendix K, Figure S-1 of the applicant's Supplement No. 1 for the critical summer condition, the volume enclosed was calculated to be 3.6×10^3 acre-ft for the 3-Unit operation. Since the volume varied as a function of the flow, the fraction of the input from Unit No. 2 was used to determine its impact. The contribution is $0.43 \times 3.6 \times 10^3$ acre-ft or 1.55×10^3 acre-ft for Unit No. 2 (once-through).

2B Open-Cycle Cooling Tower, Natural-Draft
2C Open-Cycle Cooling Tower, Mechanical-Draft

Calculations were carried out by the staff, using values for average river temperatures from Figure 4, Appendix J, and Table B-5 of Appendix J of the applicant's Supplement No. 1 shown below.

	Summer Conditions °F	Remainder of the Year Conditions °F
Average River Temp.	74*	49
Avg. Rise Across Condenser	14.6	14.6
Condenser Outlet Temp.	88.6	63.6
Avg. Wet Bulb Temp.	65	35
Approach	11	15
	76	50
Tower Inlet Temp.	88.6	62.6
Tower Effluent Temp.	76	50.0
Range	12.6	12.6

$\frac{12.6}{14.6}$ = 0.86 or 86%. Because of the uncertainty, it is assumed 80% of the heat will be dissipated to the atmosphere while 20% of the 6.35×10^9 Btu/hr or 1.27×10^9 Btu/hr will be released to the river. Since the tower effluent is elevated less than 4° above the river temperature, less than 1 acre will be within the 4°F isotherm. Cooling ponds were not evaluated because of the lack of specific data.

2E Closed-Cycle Cooling Towers, Natural-Draft
2F Closed-Cycle Cooling Towers, Mechanical-Draft

The methods used were similar to the above calculations.

	Summer Conditions °F	Remainder of the Year Conditions °F
Avg. River Temp.	74*	50
Avg. Rise Across Condenser	15.1	15.1
	89.1	65.1

* The applicant reported on page S-3 A32 of Supplement No. 3 the average river temperature of 70°F for summer conditions.

Avg. Wet Bulb Temp.	65	35
Approach	30	33
	95	68
River Temp.	74	49
	21	19

Therefore, the average ΔT of the blowdown water will be 19.5°F above ambient.

Btu's/hr discharged to the river will be 6.56×10^6 lbs/hr $\times$ 19.5° = 1.28×10^8 Btu/hr. There will be less than 0.1 acre within the 4°F isotherm.

Calculations for the Mechanical-Draft Closed-Cycle and the Spray-Pond Closed-Cycle are those of the applicant. No detailed analysis was conducted to verify these figures. However, the value for the Spray-Pond Closed-Cycle alternative appears low when evaluated against the open-cycle option.

1.2 Aquatic Biota

The amount of damage will be different for each alternative. Since the areas affected for all closed-cycle alternatives are small, no significant impact is expected to result. For the once-through alternative, in view of the low tolerance of many of the species to increases in temperature and the high probability of exposure to elevated temperature, some thermal effects are anticipated.

Migratory Fish

No effect is expected for upstream migration with any of the alternatives, except as discussed under entrainment.

2. Effects of Intake Structure and Condenser Cooling Systems

2.1 Primary Producers (Entrainment)

Open Cycle - Potential for significant damage exists. (See discussion in Section V.D.3.a(2).

Zooplankton (Entrainment)

Open Cycle - Potential for significant damage exists. (See discussion in Section V.D.3.a (3)).

Closed Cycle Operation		% Impact Compared to Open Cycle
49/1930 Natural Draft Cooling Tower	=	2.5
51/1930 Mechanical Draft	=	2.6
63/1930 Spray Pond	=	3.3

Withdrawal = Blowdown and consumption (drift + evaporation)

Blowdown	21 cfs
Withdrawal for Closed Cycle Alternative:	Natural Draft = 21 + 28 = 49 cfs
	Mechanical Draft = 21 + 30 = 51 cfs
	Spray Pond = 21 + 42 = 63 cfs

Once-through Withdrawal = 1940 cfs*

2.2 Potential for significant damage exists as discussed in Sections V.D.1.E and V.D.2.f. This pertains to all open-cycle alternatives. Closed-cycle alternatives would be expected to have less impacts.

Two major impacts on fish exist at the Indian Point Plant. These are the impacts resulting from entrainment and from impingement. Entrainment can be reduced by a reduction in the volume of water used by closed-cycle alternatives as indicated in Item 2. Impingement is not as easily reduced, because the factors responsible are not as well understood. It appears, however, to be related to intake velocity, ambient water temperature, and size of the fish. Six alternatives to reduce impingement were reviewed in Chapter XI.

Entrainment - Potential for serious damage exists as discussed in Sections V.D.1.d, V.D.1.e, V.D.3.a, and Appendix V-2. for open-cycle alternatives.

*The maximum flow rate through the 6 pumps is 840,000 gpm and 30,000 gpm through the service water system.

Closed-cycle alternatives would be expected to have a reduced impact.

Natural-Draft Cooling Towers 2.5% as great
Mechanical-Draft Cooling Towers 2.6% as great
Spray Ponds 3.3% as great

These reductions result from the lower withdrawal of water as a result of closed-cycle operation.

3. Chemical Discharge to Natural Water Body

3.2 Aquatic Biota

Most organisms entrained during periods of chlorination will be killed. See discussion in Section V.D.2.e(3) of this Statement.

3.3 Water Quality - Chemical

Chlorine 100% of allowable limits. Other chemicals for the applicant's proposal are considered to be less detrimental. (See Section V.D.2.c)

Cooling tower chemicals and concentrations are not available at this time.

4. Consumption of Water

4.1 People: 0 gal/yr

4.2 Property:

Alternative 1. Plant as is.

6.35×10^9 Btu/hr will be discharged. Assuming that about one-half of the heat is transferred to the atmosphere by conduction, the loss from evaporation will be:

$$\frac{6.35 \times 10^9 \text{ Btu/hr}}{100 \text{ Btu/lb} \times 62.4 \text{ lb/ft}^3 \times 3600 \text{ sec/hr}} =$$

$$\frac{6.35 \times 10^9 \text{ Btu/hr}}{2.25 \times 10^8} = \frac{28.2 \text{ cfs/hr}}{2} = 14.1 \text{ cfs}$$

Alternative 2B. Natural-Draft, Open-Cycle Cooling Towers.

Assumptions: Evaporative heat transfer 0.8 of total heat discharged
Drift: 0.0025% flow of 1940 cfs

Drift = 0.05 cfs

Evaporation = 22.56

22.61 Approx. 23 cfs (14.6 mgd)

2C Mechanical-Draft, Open-Cycle Cooling Tower.

Evaporative heat transfer	=	0.8
Drift - 1% of flow	=	1.9 cfs
Evaporation	=	22.56
		24.46 cfs (15.9 mgd)

2D Spray Pond, Open-Cycle.

	Evaporative Transfer	=	0.6
Assumption:	Evaporation	=	17 cfs
	Drift - 1% of flow		19.3 cfs
			36.3 cfs (23.6 mgd)

2E Natural-Draft, Closed-Cycle Cooling Tower.

	Evaporative Transfer approx. 1		
Assumption:	Evaporation	=	28.2 cfs
	Drift - 0.0025% of flow	=	0.05
			28.25 cfs (18.3 mgd)

2F Mechanical-Draft Closed-Cycle Cooling Tower.

	Evaporative Transfer approx. 1	
Assumption:	Evaporation	28.2 cfs
	Drift - 0.1% of flow	2.0
		30.2 cfs (19.2 mgd)

2G Spray Ponds Closed-Cycle.

	Evaporative Transfer = 0.78		
Assumption:	Evaporation	=	22 cfs
	Drift - 1% of flow	=	19.3 cfs
			41.3 cfs (26.6 mgd)

Drift values are from the applicant's discussion in Supplement No. 3 of the Environmental Report (p. S3 A25).

Evaporative transfer functions are assumed from: waste heat discharged, blowdown fraction, and calculations from other studies.

5. Chemical Discharges to Ambient Air. The staff accepts the applicant's annual average concentrations estimated for the emissions from the two "package boilers" at Unit No. 2 and the percentage of standard values for each as listed on pg. S3-50 of the applicant's Supplement No. 3 Benefit-Cost Analysis.

5.1 Air Quality - Chemical. Effects of dust and emissions from construction equipment were considered negligible.

5.2 Air Quality - Odor. The staff concurs with the applicant's assessment that there will be no perceptible odors at offsite locations.

6. Salts Discharged from Cooling Towers. The staff accepts the applicant's salt disposition rates as tabulated in Table 6.1-1 of the Supplement No. 3. The calculations assumed an average salinity of the cooling water of 6 parts per thousand which would occur during periods of low flow in the river. This would tend to overestimate the annual salt discharge rates. On the other hand, the drift of 0.1% assumed for mechanical draft towers is that guaranteed by vendors and the actual drift should be less with accompanying lower salt discharge rates. Therefore, these two factors tend to reinforce each other and represent a worst condition with respect to salinity. The staff feels the actual salt release would be less than that indicated for mechanical draft cooling towers.

7. Chemical Contamination of Groundwater. No effect is expected from the applicant's proposal or the alternatives.

8. Radionuclides Discharged to Water Body

8.1 People-External Contact: 0.47 man-rem/year (swimming), for all alternatives.

8.2 People-Ingestion: 3.2 man-rem (fish), for all alternatives.

8.3, 8.4 Plants, Invertebrates, and Fish

Organism	Once-Through Cooling and Open Cycle	Closed Cycle
Plants	0.479 Rads/year	1.79 Rads/year
Invertebrates	0.134 Rads/year	0.50 Rads/year
Fish	0.064 Rads/year	0.24 Rads/year

The radiation doses shown for the once-through cooling and open-cycle alternatives are for organisms living in the discharge canal (See Table V-3). No detailed evaluation was made for the closed-cycle alternatives.

9. Radionuclides Discharged to Ambient Air

9.1 People - External Contact

9.2 People - Ingestion

} 15 man-rem/year (1970)-immersion (for all alternatives)

9.3 Plants and Animals. Sufficient information is not available to allow the determination of a meaningful number.

Although the concentration at the point of discharge will be 3.75 times as great for closed-cycle alternatives. The dose to the population within 50 miles is expected to be the same for all alternatives.

10. Radionuclide Contamination of Groundwater - no effect

11. Fogging and Icing. The staff accepts the applicant's assumptions and calculations as being representative of average year-round conditions.

12. Raising/Lowering of Groundwater Levels. None is expected from any of the alternatives. (See Chapter II.E.1.)

13. Ambient Noise. The staff accepts the applicant's estimates.

14. Aesthetics

14.1 Appearance

Plant

We concur with the applicant's assessment.

Transmission Facilities

As the transmission lines from the station to the Buchanan Substation utilize the existing right-of-way, we conclude that the impact is minor for all cases.

15. Permanent Residual of Construction Activity

15.1 Accessibility of Historical Sites

We agree with the applicant's position that the Indian Point Station does not interfere with the access routes to any historical sites.

15.2 Accessibility of Archaeological Sites

Reference: Applicant's Benefit-Cost Analysis page S3-119, "Construction activity at the Indian Point site has revealed no evidence of items having archaeological value."

15.3 Setting of Historical Sites

We accept the applicant's assessment that the natural draft cooling tower alternatives would be visible from some historical sites in the area and would cause a minor impact.

16. Temporary Impacts of Plant Construction

16.1 Land Disturbance

Values for the alternatives were estimated by scaling from the plot plans shown on Figs. 2B-2G, pages S3-A3 through S3-A8, of the applicant's Benefit-Cost Analysis.

16.2 Air Quality

Effects of dust and emissions from construction equipment were considered negligible.

16.3 Water Quality

Dredging did cause some disturbance of bottom organisms and turbidity during the construction of the intake and discharge structures. There is a possibility for siltation and turbidity to occur during construction of the open-cycle spray pond alternative caused by storm drainage if the pond and pipeline trenches are open and interconnected.

16.4 Water Diversion

Diversion of the Hudson River was not required.

16.5 Waterways Effects

Construction activities did not interfere with water transportation.

16.6 Spoilage

It is assumed that there was a negligible amount of spoilage in excavated areas due to erosion. It is also assumed that this will be the case for each of the alternatives listed.

16.7 Housing

Since the site property has been used as a power Station for approximately 10 years, no housing had to be relocated as a result of the construction of Unit No. 2.

16.8 Schools

As the majority of the construction workers commute, there has been no great influx of families to the general area. Therefore, the impact on the schools has been negligible.

16.9 Traffic

The effect of increased traffic at shift changes and delivery of construction materials by truck is judged to have a moderate impact on local traffic.

16.10 Community Services

The impact is considered negligible for the same reasons cited in 16.2 above.

17. Transportation - Solid Wastes

17.1 Fuel Transport

The applicant's Supplement No. 2 to the Environmental Report states future fuel cycles will require about 64 new fuel assemblies at approximately one-year intervals. For this number of assemblies, from 4 to 6 new fuel shipments will be required.

17.2 Fuel Storage

Assumed to be equal to the number of new fuel assemblies required per year.

17.3 Waste Products - Fuel

The number of units per year will range from 90 to 150 drums. Reference: Applicant's Supplement No. 2 to the Environmental Report, page S2-4.

18. Waste Products - Nonfuel Solid Wastes

Based on plants presently in operation, it is expected that approximately 100 to 200 55-gallon drums of solid waste will be transported offsite each year.

21-3 B