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ENVIRONMENTAL REPORT

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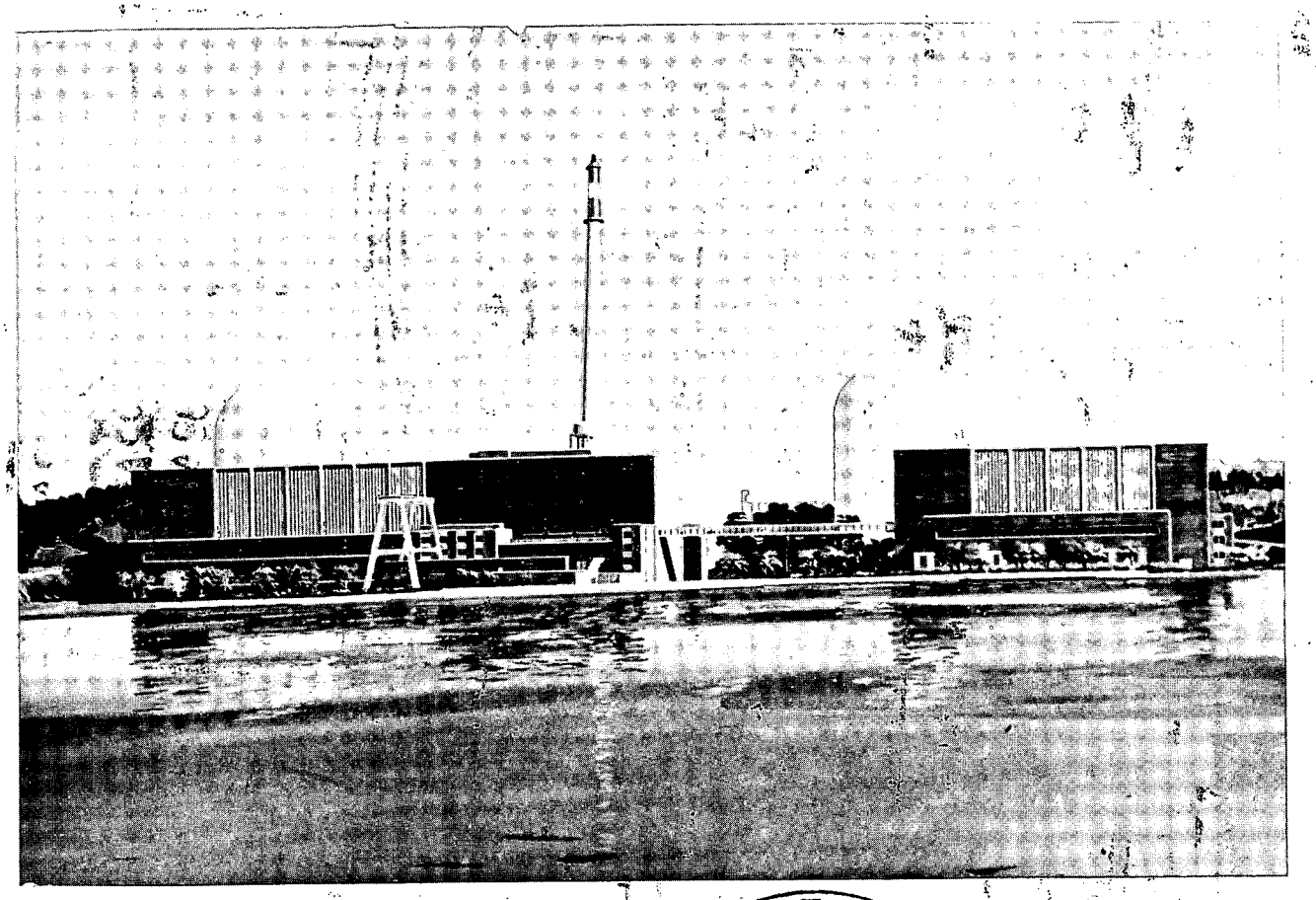

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INDIAN POINT UNIT NO. 3

Con Edison

TABLE OF CONTENTS

1.0 INTRODUCTION

BASELINE CONSIDERATIONS

2.0 LOCATION OF THE FACILITY

3.0 PHYSICAL ASPECTS OF THE FACILITY

4.0 THE ENVIRONMENT IN THE AREA

4.1 Geography and Geology
4.2 Hydrology
4.3 Physical and Chemical Characteristics of the Hudson River
4.4 Meteorology
4.5 Plant and Animal Life
4.6 Population and Land Use
4.7 History
4.8 Other Considerations

5.0 NEED FOR POWER

5.1 Recent Past
5.2 Summer of 1972
5.3 Outlook for 1973
5.4 Outlook for 1974 and Beyond
5.5 Need to Replace Obsolete Facilities
5.6 New York Power Pool
5.7 Consequences of Delay

6.0 ENVIRONMENTAL APPROVALS AND CONSULTATIONS

6.1 Licenses and Permits
6.2 Consultation with Planning Authorities

ENVIRONMENTAL IMPACT OF INDIAN POINT UNIT NO. 3

7.0 LAND USE COMPATIBILITY

8.0 WATER USE COMPATIBILITY

8.1 Uses of the Water Resource
8.2 Impact on the Water Resource

9.0 HEAT DISSIPATION

9.1 Condenser Cooling Water System
9.2 Cooling Water Outfall
9.3 Spatial and Temporal Characteristics of Thermal Discharges
9.4 Thermal Standards and Water Quality Certification

TABLE OF CONTENTS (Continued)

10.0 CHEMICAL DISCHARGES

10.1 Treatment Facilities
10.2 Releases During Construction and Testing
10.3 Releases During Normal Operation
10.4 Comparison with Water Quality Standards
10.5 Gaseous Emissions

11.0 SANITARY WASTES

12.0 ECOLOGICAL CONSIDERATIONS

12.1 Biological Impact of Plant Operations
12.2 Adequacy of Ecological Studies

13.0 ENVIRONMENTAL MONITORING PROGRAMS

13.1A Indian Point Ecological Studies
13.1B Other Ecological Studies
13.2 Radiological Monitoring

14.0 RADIOACTIVE DISCHARGES

14.1 Description of Radwaste System
14.2 Radioactive Release Estimates
14.3 Releases for Unusual Operating Conditions
14.4 Pathways of Exposure to Man
14.5 Other Considerations

15.0 CONSTRUCTION

15.1 Status of Construction
15.2 Impact of Construction Activities

16.0 AESTHETICS

17.0 ALTERNATIVES

17.1 Alternative Sources of Power
17.2 Alternative Fish Protection Measures
17.3 Alternative Cooling Methods

18.0 PRODUCTIVITY AND USE OF RESOURCES

19.0 ACCIDENTS

20.0 TRANSMISSION LINES

21.0 TRANSPORTATION OF RADIOACTIVE MATERIALS

21.1 Transportation of New Fuel
21.2 Transportation of Spent Fuel
21.3 Transportation of Radwaste to Burial Grounds

22.0 BENEFIT/COST ANALYSIS

LIST OF FIGURES

Figure - 1	Topographical map of Indian Point site and surrounding area.
Figure - 2	Plot plan of the Indian Point site.
Figure - 3	Profile looking north thru turbine, containment and fuel storage buildings.
Figure - 4	Vapor container at intermediate level.
Figure - 5	Aerial representation of Indian Point site.
Figure - 6	Map and description showing location of sources of potable and industrial water supplies and watershed areas.
Figure - 7	Diurnal variation of mean vector wind for virtually zero pressure gradient conditions, Sept. - Oct., 1955, 70 ft. above river.
Figure - 8	Diurnal variation of mean vector wind for 24 hr. periods of weak pressure gradient conditions (Geostrophic winds less than 16 mph) Sept. - Oct., 1955, 70 ft. above river.
Figure - 9	Pre-construction view of the Indian Point site.
Figure - 10	Map and description showing land usage.
Figure - 11	Population distribution for 5 mile radius.
Figure - 12	Population distribution for 60 mile radius.
Figure - 13	Master site and landscape plan — Illustrative plan.
Figure - 14	Master site and landscape plan — Indian Point site (existing conditions).
Figure - 15	Master site and landscape plan — Indian Point site (staging plan).
Figure - 16	Intake structure — Indian Point Unit No. 3.
Figure - 17	Cross section through intake structure — Indian Point Unit No. 3.
Figure - 18	New intake proposal — Indian Point station.
Figure - 19	Hydraulic models for thermal discharge studies.
Figure - 20	Indian Point II Model — general arrangement.
Figure - 21	Indian Point II Sub-Model — surface isotherms.
Figure - 22	Indian Point III Model — general arrangement.
Figure - 23	Comparison between prototype and model pathlines.
Figure - 24	Comparison of field and model velocities.
Figure - 25	Near field data.
Figure - 26	Near field data.
Figure - 27	Site locations of electronic installations.

LIST OF FIGURES (Continued)

Figure - 28	Water stage height installation.
Figure - 29	Temperature sensor buoy system locations.
Figure - 30	Thermal chain buoy configurations.
Figure - 31	Radiation sampling site locations.
Figure 13-6	Indian Point Ecological Studies
Figure 13-7	Indian Point Ecological Study Regions
Figure 13-8	Hudson River striped bass transport model parameters
Figure 13-9	Schematic life cycle for striped bass to the Hudson River
Figure 13-10	Striped bass development from fertilized egg to one year of age
Figure - 32	Simplified diagram — gaseous waste disposal system.
Figure - 33	Liquid waste disposal schematic.
Figure - 33A	Blowdown intertie — general scheme.
Figure - 34	Exterior view of the Vapor Containment Building showing rebar work and the personnel lock.
Figure - 35	Vapor Containment Building shield wall being erected.
Figure - 36	Steam generator being lifted into position to be set.
Figure - 37	Steam generators No. 33 and No. 34 set in place.
Figure - 38	Reactor vessel at foot of the temporary road where preparations are being made to attach lifting rig.
Figure - 39	Reactor vessel with the lifting rig attached.
Figure - 40	View of brickwork and siding on the Turbine Generator Building.
Figure - 41	View looking south of main generator floor.
Figure - 42	Conduit piping in the transformer yards leading into the Control Building area.
Figure - 43	Stator at main turbine generator floor level ready to be set in place.
Figure - 44	Stator in place on the main turbine generator floor.
Figure - 45	Aerial photograph — Displays the overall site construction as of January 1971.
Figure - 46	Artist's rendition of the completed Indian Point complex.

LIST OF FIGURES (Continued)

Figure 17-1	Dry Cooling Tower.
Figure 17-2	Mechanical Draft Wet Tower (Counterflow).
Figure 17-3	Mechanical Draft Wet Tower (Crossflow).
Figure 17-4	Natural Draft Wet Tower (Counterflow).
Figure 17-5	Natural Draft Wet Tower (Crossflow).
Figure 17-6	Spray Pond Cooling with Power Spray Modules.
Figure 17-7	Unit 3 – Indian Pt. Station Natural Draft Wet Cooling Tower Closed-Cycle.
Figure 17-8	Unit 3 – Indian Pt. Station Mechanical Draft Evaporative Cooling Towers Closed-Cycle.
Figure 17-9	Unit 3 – Indian Pt. Station Spray Pond (PSM) Closed-Cycle.
Figure 17-10	Intake Structure and Discharge Canal Modifications.
Figure 17-11	Vacuum Correction to Load.
Figure - 47	New steel transmission pole.
Figure - 48	Route of Transmission lines in the Indian Point Buchanan area.
Figure - 49	Schematic of ring busses at Buchanan Substation.

LIST OF TABLES

		Page
Table 4-1	Chemical Analysis of the Hudson River near Indian Point	4-7
Table 4-2	Relation of Turbulence Types to Weather Conditions	4-12
Table 4-3	Historic Places in the Vicinity of Indian Point Generating Station	4-20
Table 5-1	Members of New York Power Pool	5-8
Table 8-1	Drinking Water and Industrial Intakes on the Hudson River near Indian Point	8-2
Table 9-1	Parameters of Thermal Plume Study	9-10
Table 10-1	Class "SB"Waters	10-7
Table 10-2	Proposed Concentration of Chemicals at Confluence	10-8
Table 11-1	Sewage Disposal Plant	11-3
Table 13-1	Indian Point Station Environmental Survey	13-9
Table 14-1	Estimated Annual Average Liquid Effluents	14-
Table 14-2	Estimated Annual Average Gaseous Effluents	14-
Table 14-3	Annual Average Doses at the Site Boundary in the Worst Meteorological Sector from Estimated Gaseous Releases	14-
Table 17-1	Increased Generation and Stack Emissions at Con Edison Generating Stations as a Result of Indian Point Unit No. 3 Not In Service from June 1974 to May 1975	17-4
Table 17-2	Physical Description of Alternative Cooling Systems	17-34
Table 17-3	Cost Estimates for Cooling System Alternatives	17-36
Table 17-4	Capital Estimate Summary	17-37
Table 17-5	Yearly Average Generation Capability and Change in Net Plant Heat Rate for Alternative Cooling Systems	17-41
Table 17-6	Generation Capability of Cooling System Alternatives for 77°F Wet Bulb Temperature	17-43
Table 17-7	Blowdown, Drift and Evaporation Effects	17-45
Table 19-1	Radiological Consequences of Postulated Accidents	19-6
Table 21-1	Spent Fuel Element Shipments	21-5
Table 21-2	Impact Accident Comparison	21-5

TABLE OF APPENDICES

APPENDIX - A: TRANSPORT OF CONTAMINANTS IN THE HUDSON RIVER ABOVE INDIAN POINT STATION
Quirk, Lawler and Matusky Engineers
May 1966

APPENDIX - B: HYDROLOGY OF INDIAN POINT SITE AND SURROUNDING AREA
Metcalf and Eddy Engineers
October 1965

APPENDIX - C: A MICROMETEOROLOGICAL SURVEY OF THE BUCHANAN, NEW YORK AREA
New York University - College of Engineering
November 1965

APPENDIX - D: EVALUATION OF POTENTIAL RADIATION HAZARD RESULTING FROM ASSUMED RELEASE OF RADIOACTIVE WASTES TO ATMOSPHERE FROM PROPOSED BUCHANAN NUCLEAR POWER PLANT
New York University - College of Engineering
April 1957

APPENDIX - E: SUMMARY OF CLIMATOLOGICAL DATA AT BUCHANAN, NEW YORK
New York University - College of Engineering
March 1958

APPENDIX - F: 1980 PROJECTIONS OF POPULATION AND LAND USE FOR AN AREA CIRCUMSCRIBED BY A 55-MILE RADIUS FROM BUCHANAN, NEW YORK
Regional Economic Development Institute, Incorporated
November 1965

POPULATION ESTIMATES FOR 1970 AND THE POPULATION PROJECTIONS FOR SPECIFIED ZONES WITHIN A 60 MILE RADIUS OF INDIAN POINT NUCLEAR POWER PLANT,
Environmental Analyst, Inc.
March 1972

APPENDIX - G: LETTER FROM WESTCHESTER COUNTY DEPARTMENT OF PLANNING
November 1970

APPENDIX - H: PERMITS RELATING TO INDIAN POINT UNIT NO. 3

APPENDIX - I: EFFECT OF INDIAN POINT COOLING WATER DISCHARGE ON HUDSON RIVER TEMPERATURE DISTRIBUTION
Quirk, Lawler and Matusky Engineers
January 1968

APPENDIX - J: EFFECT OF INDIAN POINT COOLING WATER DISCHARGE ON HUDSON RIVER TEMPERATURE DISTRIBUTION
Quirk, Lawler and Matusky Engineers
February 1969

TABLE OF APPENDICES (Continued)

APPENDIX - K: INDIAN POINT MODEL STUDIES
Alden Research Laboratories
March 1969

APPENDIX - L: EFFECT OF SUBMERGED DISCHARGE OF INDIAN POINT COOLING WATER ON HUDSON RIVER TEMPERATURE DISTRIBUTION
Quirk, Lawler and Matusky Engineers
October 1969

APPENDIX - M: INFLUENCE OF HUDSON RIVER NET NON-TIDAL FLOW ON TEMPERATURE DISTRIBUTION
Quirk, Lawler and Matusky Engineers
October 1969

APPENDIX - N: INDIAN POINT COOLING WATER STUDIES: MODEL NO. 2
Alden Research Laboratories
May 1969

APPENDIX - O: HYDRAULIC SURVEY OF HUDSON RIVER: THE HAVERSTRAW BAY AREA
Alden Research Laboratories
February 1970

APPENDIX - P: INDIAN POINT ECOLOGICAL SURVEY: REPORT I
Raytheon Company
June - December 1969

APPENDIX - Q: INDIAN POINT ECOLOGICAL SURVEY: REPORT II
Raytheon Company
January - June 1970

APPENDIX - R: HUDSON RIVER AT INDIAN POINT
New York University Medical Center — Institute of Environmental Medicine

APPENDIX - S: FISH PROTECTION AT INDIAN POINT UNIT NO. 1
Consolidated Edison Co. of New York
November 1970

APPENDIX - T: COST EXPENDITURES ON ENVIRONMENTAL STUDIES

APPENDIX - U: ENVIRONMENTAL MONITORING SURVEY

APPENDIX - V: CONSOLIDATED EDISON INDIAN POINT REACTOR POST OPERATIONAL SURVEY: AUGUST 1965
Division of Environmental Health Services
New York State Department of Health

APPENDIX - W: CONSOLIDATED EDISON INDIAN POINT REACTOR ENVIRONMENTAL AND POST OPERATIONAL SURVEY: July 1966
Division of Environmental Health Services
New York State Department of Health

TABLE OF APPENDICES (Continued)

APPENDIX - X: TECHNICAL SPECIFICATION - INDIAN POINT UNIT NO. 2
Section 3.9: Effluent Release

APPENDIX - Y: MANMADE RADIONUCLIDES IN THE HUDSON RIVER ESTUARY
New York University Medical Center - Institute
of Environmental Medicine
November 1970

APPENDIX - Z: THE BIOLOGICAL EFFECTS OF CHEMICAL DISCHARGES AT
INDIAN POINT
Consolidated Edison Company of New York
January 15, 1973

APPENDIX - AA: THE BIOLOGICAL EFFECTS OF ENTRAINMENT AT INDIAN POINT
Consolidated Edison Company of New York
February 15, 1973

APPENDIX - BB: THE BIOLOGICAL EFFECTS OF FISH IMPINGEMENT ON THE INTAKE
SCREENS AT INDIAN POINT
Consolidated Edison Company of New York
January 15, 1973

APPENDIX - CC: THE BIOLOGICAL EFFECTS OF THERMAL DISCHARGES AT INDIAN
POINT
Consolidated Edison Company of New York
January 15, 1973

APPENDIX - DD: (1) EFFECT OF THREE UNIT OPERATION AT INDIAN POINT ON
HUDSON RIVER TEMPERATURE DISTRIBUTION
Quirk, Lawler and Matusky Engineers
October 30, 1972

(2) INDIAN POINT III EXTENDED MODEL
THREE UNIT TESTS
Alden Research Laboratories
November 2, 1972

APPENDIX - EE: - (1) TESTIMONY OF JOHN P. LAWLER ON THE EFFECT
OF INDIAN POINT UNITS 1 AND 2 COOLING
WATER DISCHARGE ON HUDSON RIVER
TEMPERATURE DISTRIBUTION
April 5, 1972

(2) SUPPLEMENTAL STUDY OF EFFECT OF SUBMERGED
DISCHARGE OF INDIAN POINT COOLING WATER
ON HUDSON RIVER TEMPERATURE DISTRIBUTION
Quirk, Lawler and Matusky Engineers
May 1972

TABLE OF APPENDICES (Continued)

APPENDIX - FF: RESPONSE TO ATOMIC ENERGY COMMISSION QUESTIONS

APPENDIX - GG: THE CONTRIBUTION OF THE HUDSON RIVER TO THE MID-ATLANTIC FISHERY AND THE IMPACT OF INDIAN POINT UNIT 3 ON THIS FISHERY

APPENDIX - HH: RESPONSE TO ATOMIC ENERGY COMMISSION REQUEST FOR ADDITIONAL ENVIRONMENTAL INFORMATION

APPENDIX - II: ECONOMIC IMPACT OF INDIAN POINT UNIT 3 ON THE MID-ATLANTIC STRIPED BASS FISHERY

1.0 INTRODUCTION

This Environmental Report has been prepared in connection with the proceeding before the United States Atomic Energy Commission (AEC) in which Consolidated Edison Company of New York, Inc. (Con Edison) has obtained a construction permit and is seeking an operating license for the 965 MW(e) nuclear generating plant, Indian Point Unit No. 3. This is the third of three nuclear power generating plants to be built on the Indian Point site. On April 25, 1967, Con Edison filed its application for licenses with the AEC. On August 13, 1969, the AEC, after several months of public hearings and after favorable recommendations from the Atomic Safety and Licensing Board as well as the Advisory Committee on Reactor Safeguards issued Construction Permit CPPR-62 for this facility. The present schedule anticipates that the unit will be ready for commercial operation by late 1973 or early 1974.

There are several threshold considerations of which the reader of this report should be aware. The site in question was devoted to nuclear power generation as early as 1956, when the construction permit for Indian Point Unit No. 1 was issued by the AEC. When the National Environmental Policy Act of 1969 (NEPA) was enacted into law the Indian Point site contained one nuclear unit in commercial operation (Unit No. 1) and two in process of construction (Units No. 2 and 3). Today, the total investment in the Indian Point site is approximately $315,000,000, and the investment in Unit No. 3 alone as of May 31, 1971 amounted to approximately $115,000,000.

Any evaluation of the environmental impact of Indian Point Unit No. 3 must therefore consider that the unit is located at a site which already contained two other such units when its construction was commenced and that NEPA became effective at a time when the construction of Unit No. 3 was at an advanced stage. In a very real sense there is and has been a substantial and irretrievable commitment of economic resources to the site and to Unit No. 3.

Despite the degree to which development of the Indian Point site, and the construction of Unit No. 3, had progressed before NEPA was passed Con Edison feels that its environmental efforts with respect to Indian Point have been consistent with the objectives of NEPA and have resulted, as this report will demonstrate, in a minimal adverse environmental impact.

Moreover, at what is now the pre-operational stage for Unit No. 3, some of those efforts have produced a broad spectrum of baseline data with respect to the important environmental aspects of the site and its environs. The development of this information in sufficient quantity to serve as a foundation for any meaningful evaluation of the impact of a nuclear generating unit, or of any electric generating facility, on a complex, interacting ecological system is a necessarily painstaking, lengthy and expensive process.* One facet of the effort to obtain meaningful baseline information on the Indian Point environment has been underway since 1958, when the New York University Medical Center commenced its survey of the Hudson River's ecology under the aegis of the United States Public Health Service and the New York State Department of Health. NYU's investigations have been continued under contract with Con Edison both as to radiological and other environmental matters. The results of these surveys, and of others, are reported on at length in the body of this report.

Indian Point Unit No. 3 interacts with its environment in several ways. Its physical presence, alongside Units No. 1 and 2, is perhaps the most obvious. The additional facet of land use associated with Indian Point is the development of the Indian Point site for public and recreational purposes. Low level radioactivity will be released to the air and to the Hudson River during operation of the plant, as will be minimal amounts of chemicals used for cleaning and water purification purposes. A substantial volume of cooling water will be drawn from and returned to the Hudson.

As this report will demonstrate, releases of heat, chemicals and radioactivity will at no time exceed regulatory limits, and in the case of chemicals and radioactivity those releases will be far below allowable levels.

Throughout this report, as in this introductory section, reference will be made to Units No. 1 and 2 where appropriate for the purpose of completeness.

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*It has been necessary, for example, to develop special procedures and equipment as a prerequisite to the acquisition of necessary data.

BASELINE CONSIDERATIONS

2.0 LOCATION OF THE FACILITY

The Indian Point generating station is located on the east bank of the Hudson River about 24 miles north of the New York City boundary line, at Indian Point, Village of Buchanan in upper Westchester County, New York State. The station is about 2.5 miles southwest of the city of Peekskill; 8.3 miles south of West Point; 1.5 miles northeast of the Lovett generating station site; 4.6 miles north of the Bowline Point generating station site; and 2.3 miles north of Montrose Point. The site is approximately 239 acres in size and in addition to Unit No. 3, contains Unit No. 1, adjacent to and north of Unit No. 3, and Unit No. 2, adjacent to and north of Unit No. 1. Figures 1 and 2 of this report contain a map showing the general location of the Indian Point site and its environs, and a plot plan of all facilities at the site.

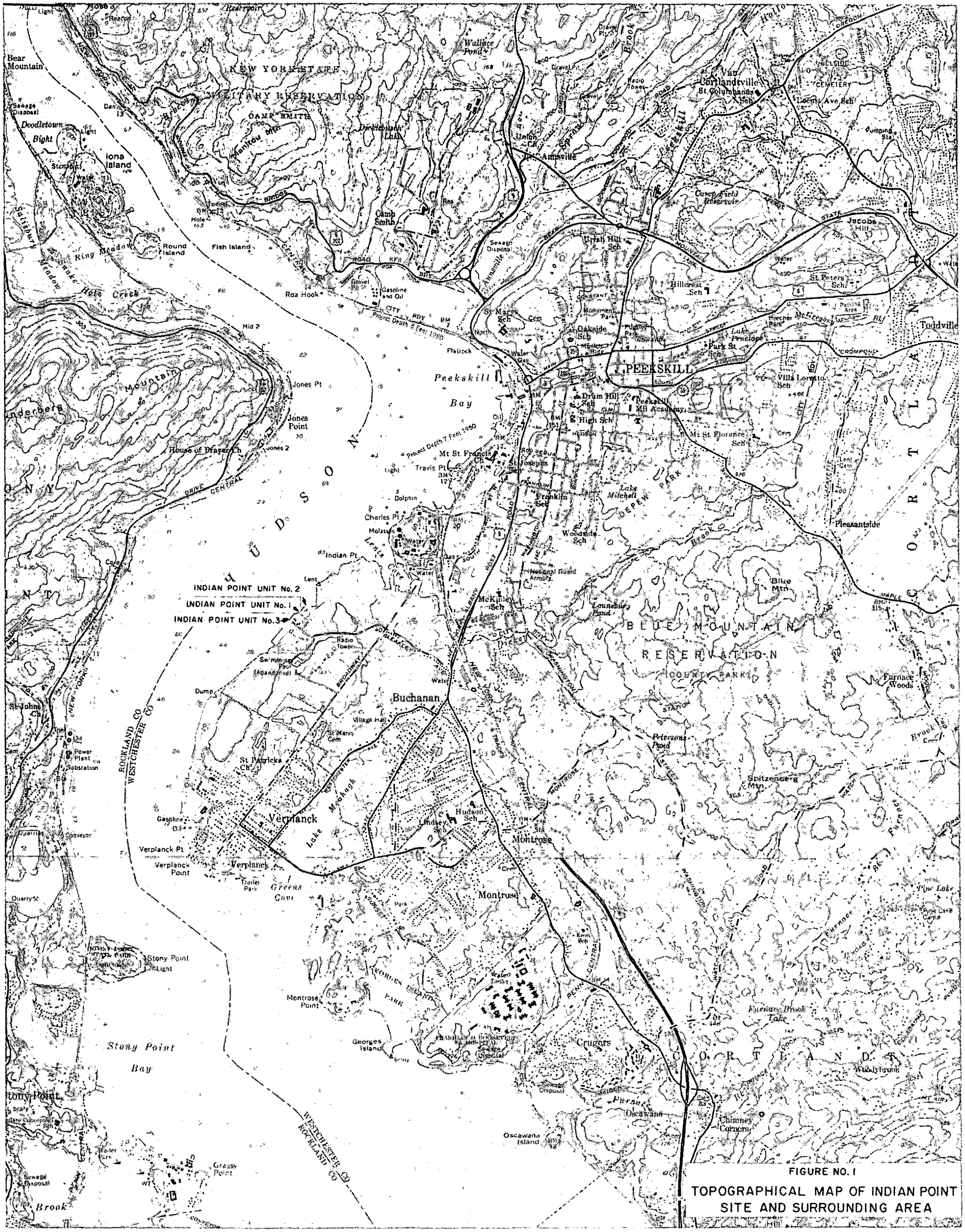

Figure - 1 Topographical map of Indian Point site and surrounding area.

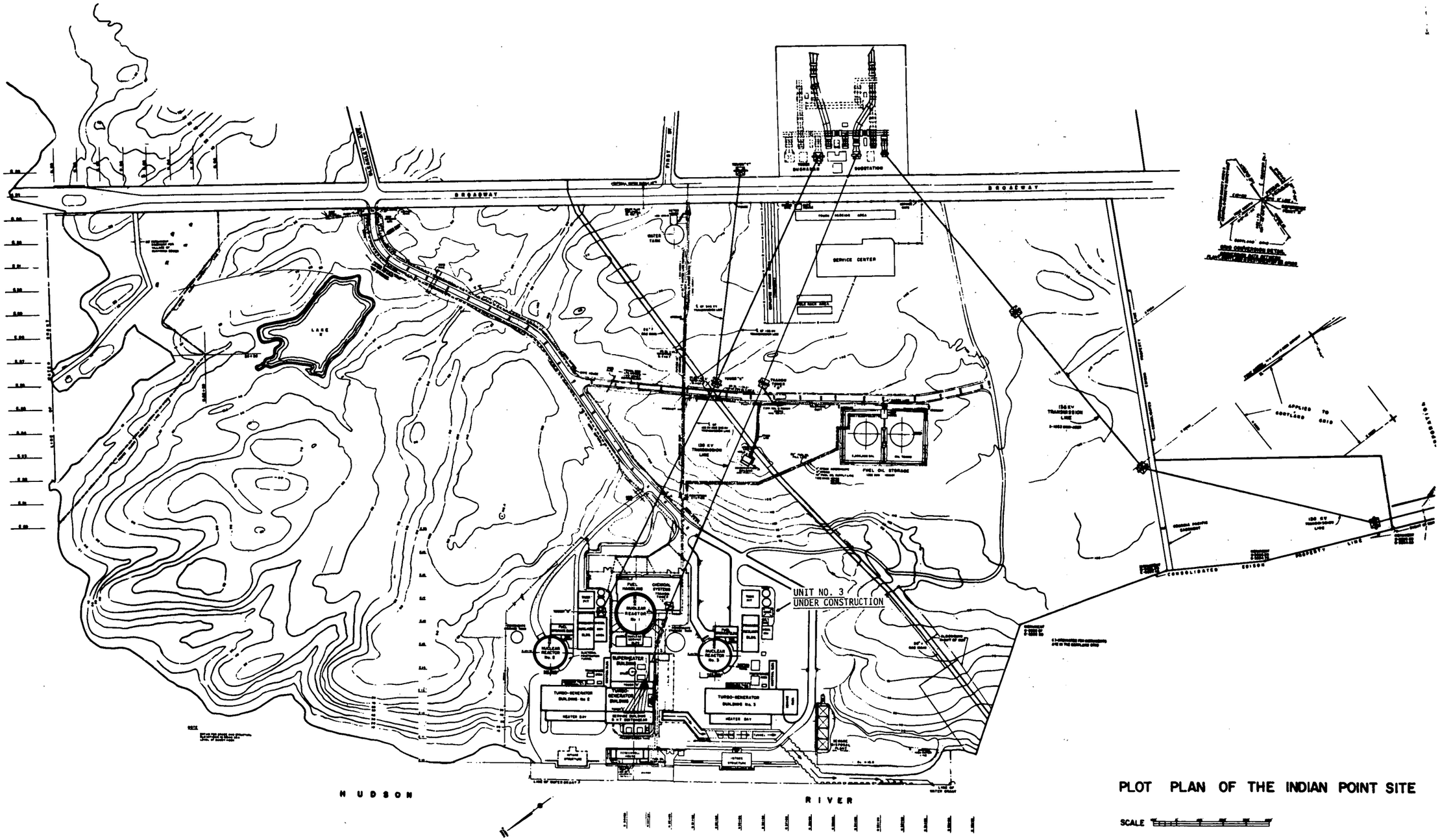

Figure - 2 Plot plan of the Indian Point site.

3.0 PHYSICAL ASPECTS OF THE FACILITY

The major structures comprising Unit No. 3 are the reactor containment building, the auxiliary, diesel generator, control, and turbine building. Relative locations of these facilities and of the facilities for Units No. 1 and 2 are shown in Figure-2.

Indian Point Unit No. 3 is a closed cycle four-loop pressurized water reactor designed by the Westinghouse Electric Company. It will be owned and operated by Con Edison. Westinghouse is the prinicpal contractor and has turnkey responsibility for the design, construction, testing, and initial startup of the facility.

The reactor is fueled with slightly enriched uranium dioxide in the form of ceramic pellets contained in zircaloy fuel tubes. The core is initially loaded in three regions, each with different enrichments. New fuel is introduced into the outer region at successive refuelings after the remaining regions have been either moved inward or discharged to spent fuel storage. Water serves as both the moderator and the coolant. Heat is removed from the reactor core by four separate coolant loops, each provided with a coolant pump and steam generator. The heated water flows through the vertical U-tube steam generators where heat is transferred to the secondary (steam) system. The water then flows back to the pumps to repeat the cycle. The system pressure is controlled by the use of an electrically heated pressurizer connected to one of the 4 loops in which steam and water are maintained in thermal equilibrium.

The secondary steam produced in the steam generators is used to drive a tandem-compound turbine generator unit comprised of one high pressure and 3 low pressure cylinders. Six combination moisture separator-reheater units are employed to dry and superheat the steam between the high and low pressure turbine cylinders. The turbine generator has a guaranteed capability of 1,021,793 kw. The heat removed from the condensing steam is transferred to the circulating water system and this water is discharged to the Hudson River.

The reactor is controlled by a coordinated combination of chemical shim (boron) and mechanical control rods, the later consisting of clusters of stainless steel clad absorber rods and guide tubes located within the fuel assembly.

The primary coolant system includes the reactor, steam generators, primary coolant pumps, primary coolant piping, and the pressurizer. This system is housed inside the

containment building which is a steel-lined, leak-tight, reinforced concrete structure. The containment provides a barrier to the release to the environment of radioactive fission products that might be released inside the containment in the event of an accident. Auxiliary systems, including the chemical and volume control systems, the waste handling system, and additional auxiliary cooling systems are housed separately, principally in the adjacent Primary Auxiliary Building. The Primary Auxiliary Building also houses components of the engineered safety features. A separate fuel handling building is provided for storage of spent fuel. A separate turbine building houses the turbine generator.

Figure-3 of this report provides a cross section of the Unit No. 3 plant and Figure-4 illustrates the steam generating equipment within the containment vessel. An artist's representation of an aerial view of the site when completed is presented in Figure-5. This figure shows the general locations of the various facilities at the site.

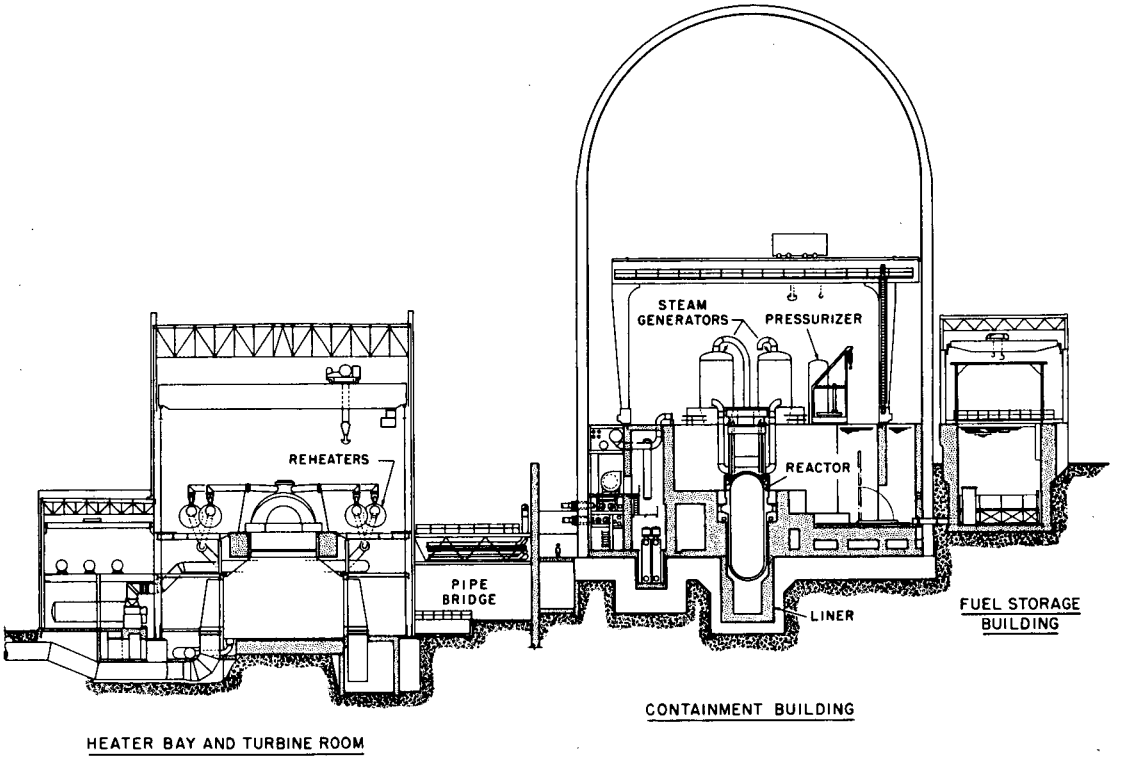

Figure - 3 Profile looking north thru turbine, containment and fuel storage buildings.

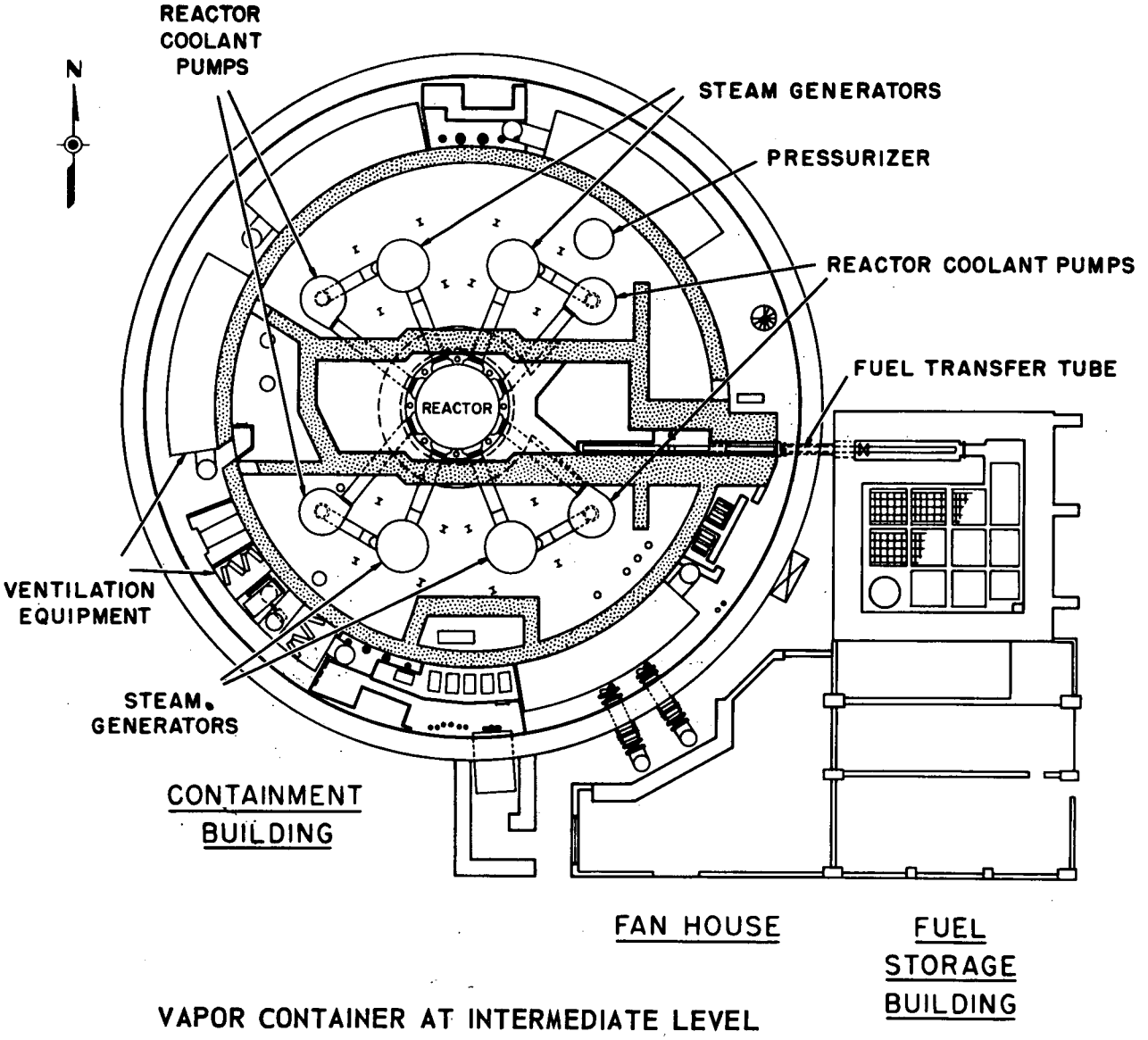

Figure - 4 Vapor container at intermediate level.

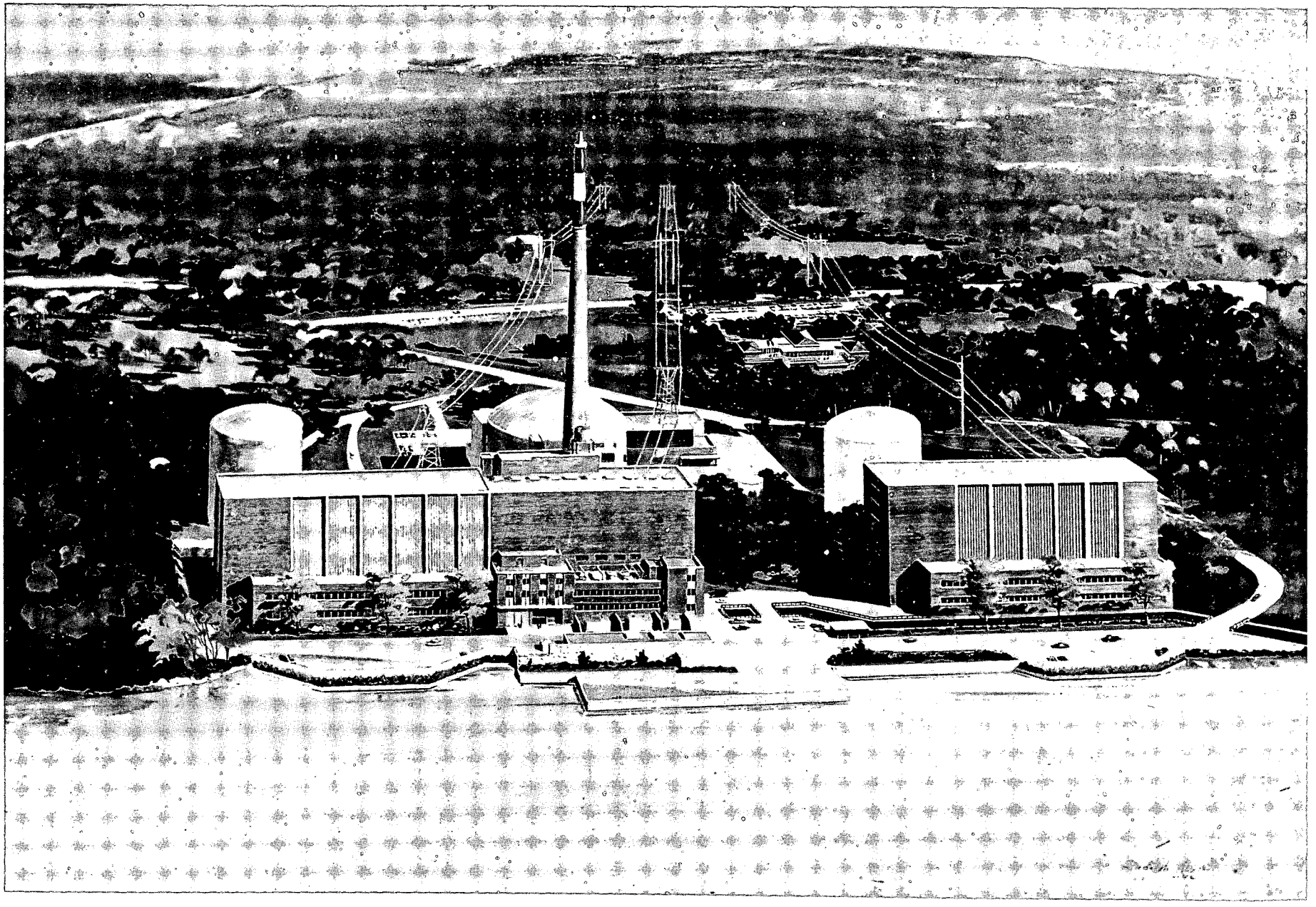

Figure - 5 Aerial representation of Indian Point site.

4.0 THE ENVIRONMENT IN THE AREA

4.1 Geography and Geology

The Indian Point site is surrounded on almost all sides by high ground ranging from 600 to 1,000 feet above sea level. The generating station is on the east bank of the Hudson River which runs northeast to southwest at this point but turns sharply northwest approximately two miles upstream of the plant. The river south of the site bends sharply to the southeast and then widens as it flows past Croton and Haverstraw. Figure-1 illustrates these topographic features of the actual site and surrounding area.

The west bank of the Hudson, opposite Indian Point, is flanked by the steep, heavily wooded slopes of the Dunderberg and West Mountains to the northwest (elevations 1,086 feet and 1,257 feet respectively) and by Buckberg Mountain to the west-southwest (elevation 793 feet). These peaks extend to the west (by other names) and gradually rise to slightly higher elevations. To the east of the site, peaks are generally lower than those to the north and west. They include Spitzenberg and Blue Mountains which average about 600 feet in height, and there is a weak, poorly defined series of ridges which extends in a north-northeast direction.

The site itself is hilly, rising from the Hudson River to elevations of about 150 feet, with the most frequent elevation being approximately 100 feet. The northern portion of the site includes an 80 acre wooded area and a fresh water lake.

The three nuclear units are located on the south-central portion of the site. The dominant features of these units are their containment domes and the stack for Unit No. 1, which primarily serves its oil-fired superheater. A considerable portion of this area has been cleared for construction and for storage, parking, roads, and temporary structures related to current construction. This portion of the site is presently affected in a manner quite typical of large construction projects in progress.

Access roads and electrical transmission lines run from Units No. 1 and 2 to the eastern site boundary. A 26 inch and a 30 inch gas transmission line owned by the Algonquin Gas Transmission Company traverse the property on a 65 foot wide right-of-way running east to west across the site and passing 1,450 feet south of Unit No. 2. A permanent easement for the village of Buchanan sewer system crosses the eastern corner of the Indian Point property,

approximately 2,300 feet east of Unit No. 2. A temporary visitor's center is located on a hill overlooking the generating station.

Adjoining the Indian Point site to the south is another tract owned by Con Edison, known as the Trap Rock site, which was purchased as a site for future nuclear generating units. The waterfront portion of that site is separated from the Indian Point waterfront by an industrial complex owned by the Georgia-Pacific Corporation. This complex contains a grassy area bounded on the west by a curving ridge and on the north and east by a series of large earth mounds. This area is used for overhead electrical power and telephone lines, and underground gas, water and sewer lines. An abandoned quarry, now a lake of about 30 acres, dominates the area.

The geology of the Indian Point site and surrounding area was studied in 1955 prior to the construction of Unit No. 1. From a geologic standpoint, the Indian Point site consists of a fine-grained phyllite, a schist, and limestone with bedrock lying very close to the surface. Units No. 1, 2 and 3 are located on limestone, which is hard although jointed. The consulting geologist has stated that the bedrock is sufficiently sound to support any loads which may be anticipated up to 50 tons per square foot. This far exceeds any foundation load that will be superimposed on the site. In addition to being noncavernous, the intensely jointed condition of the limestone shows that residual stresses within the rock formations have been dissipated, almost elminating the possibility of any further local changes within these formations. The jointed limestone formation is very permeable and all ground water flows from the hills toward the river, thereby making it impossible for drainage from the site to go anywhere except to the river.

In 1965, to review the geology of the site and confirm that the geologic features pertaining to Unit No. 3 were the same as those for Unit No. 1, additional borings were made. Thomas W. Fluhr, P. E. and Engineering Geologist, after conducting this survey, stated not only that bearing strength of the foundation rock for Unit No. 3 exceeded any load which was superimposed on it, but also that properly grouted could support "...any engineering structure that man might build."

The borings also indicated that the use of the Indian Point site in no way interferes with any substantial subsurface resources. Although these borings do not exclude the possibility of such resources (e.g., fossil fuels or other ore deposits), they do preclude any economical utilization of these resources.

4.2 Hydrology

The hydrological features of the Indian Point site are relevant to the analysis of heated water, radioactive liquid and gaseous discharges from the plant. These features are the Hudson River, local ground water and wells and surface water reservoirs.

During normal plant operation liquid wastes are discharged to the Hudson River through the circulating water discharge canal. The ground water is not susceptible to contamination from accidental ground seepage or leakage from the plant because of the impermeability of the bedrock and the higher elevation of the plant relative to the river. Gaseous releases from the plant following a hypothetical accident have been studied for possible deposition of contaminants into surrounding surface water reservoirs.

Both Con Edison consultants and government agencies have studied the hydrology of the Hudson River near the Indian Point site. Water depths within 1,000 feet of the shore near the site are variable with an average of 65 feet, and at some points exceeding 85 feet. River width opposite the plant ranges from 4,500 to 5,000 feet.

Flow in the Hudson River is controlled more by tides than by runoff from the tributary watershed. Tidal flow past the plant is more than 80,000,000 gallons per minute, 80% of the time, and it has been estimated that this flow is at least 9,000,000 gallons per minute 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 11,700,000 gpm 20% of the time; of 4,710,000 gpm 60% of the time; and of 1,800,000 gpm 98% of the time.

Flooding at the site is nonexistent. Flood stages primarily result from tidal influence and the highest recorded water elevation in the vicinity of the site was 7.4 feet above mean sea level. This is well below the basement elevation of Unit No. 3.

Within a five-mile radius of the plant only one municipal water supply utilizes ground water. Other wells in this area are used for industrial and commercial purposes. The rock formations in the area and elevations of wells relative to the plant are such that accidental ground leakage or seepage percolating into the ground at Indian Point will not reach these sources of ground water but will flow to the river.

Only two reservoirs within a five-mile radius are used for municipal water supplies. The first, Camp Field Reservoir, is the raw-water receiving basin for the system which

supplies the City of Peekskill; which uses the Catskill Aqueduct and the Montrose Water District as auxiliary sources of supply. The impounding reservoir for the Stony Point water system serves the towns of Stony Point and Haverstraw, and the villages of Haverstraw and West Haverstraw. The Stony Point system is connected to the Spring Valley Water Company to provide an alternate source of supply. A third reservoir within five miles of the plant, Queensboro Lake, supplies water to a state park area only. The location of these reservoirs, and of others within a fifteen-mile radius, are shown in Figure-6.

Con Edison consultants have studied the hydrology of the Hudson in the vicinity of Indian Point. Reports on this subject have been prepared by Metcalf and Eddy Engineers and by Quirk, Lawler and Matusky Engineers (QLM) and are appended to this report (Appendices A and B). A more detailed discussion of the hydrology of the Hudson River at Indian Point is included later in this report under the general caption of "Heat Dissipation."

4.3 Physical and Chemical Characteristics of the Hudson River

The Hudson River at Indian Point is subject both to tidal and salinity changes on a diurnal and a seasonal basis. Superimposed on these influences are those due to meteorological conditions — variations in precipitation, insolation, wind and air temperature. Hence the aquatic ecosystem is subject to daily, tidal and seasonal changes in such parameters as water depth, flow, salinity and temperature. A number of other water characteristics also vary in response to these primary changes, viz, density, dissolved oxygen and suspended particulates.

Because of the relatively well mixed character of the estuary at Indian Point, the tidal impact on salinity and temperature is quite small. In addition, the small tidal height change restricts the extent of tidal temperature variations because relatively little of the river margins are exposed at ebb tide. As a result, areas of shore are not exposed for long periods to act as heat accumulators or dispersors, a characteristic of other estuarine environments, which can lead to rapid temperature changes in the overlying water as the tide begins to flood.

In contrast to the small environmental changes consequent on tidal activity, there are marked changes on a seasonal basis, and also on an annual basis as drought periods (e.g.

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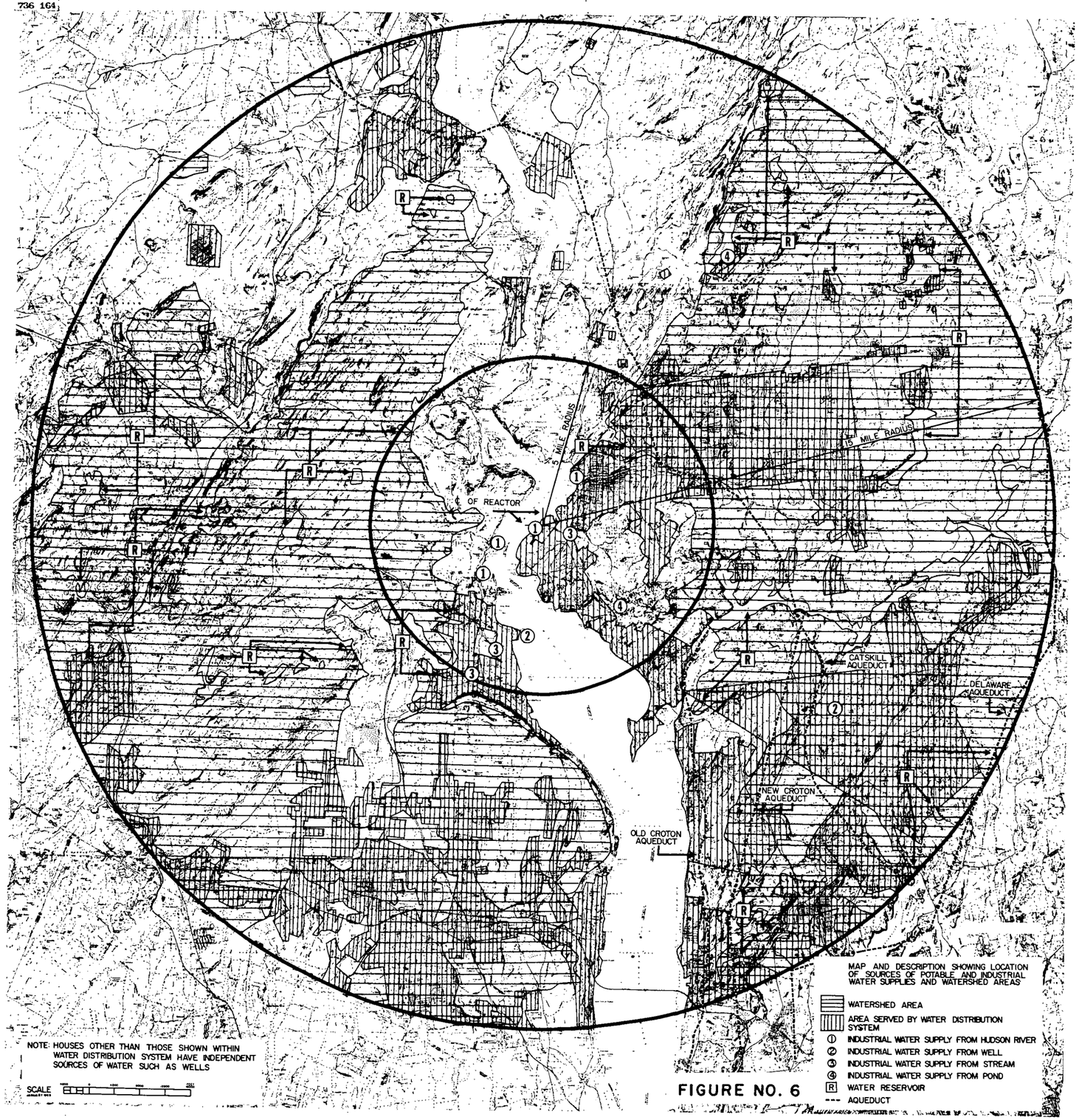

FIGURE NO. 6

Figure - 6 Map and description showing location of sources of potable and industrial water supplies and watershed areas.

middle 1960's) are succeeded by more normal rainfall years. Most importantly, these seasonal changes affect river temperature.

Seasonal changes in water temperature reflect ambient air temperatures and range from freezing conditions from late December to late February, to water temperatures of nearly 30°C (85°F) in shallow in-shore areas during August, which is characteristically the warmest month for the river water. Channel water temperatures will reflect the movement of the major water masses with the tide, while inshore water will be strongly affected by insolation or cooling in the shallow bays, by exposure of the littoral during the ebb, as well as by discharges of streams or of effluents.

The rate of change of water parameters may also be important in defining the physical characteristics of the ecosystem. Again, the most marked changes are exhibited by temperature which may change seasonally at a rate of 10°F / month (taking midday mean temperatures). During the 24 hour daily period there will also be quite rapid changes, amounting to as much as 5°F during spring or autumn when night and day ambient temperatures are most different. By contrast, changes in flow, tidal height or salinity are much more gradual.

Some physical and chemical characteristics of the Hudson River water at Indian Point have been summarized in Table 4-1. The variability in the chemical constituents is due in part to the variable nature of the salt-front and the changing proportions of fresh and salt water.

Nitrate and phosphate concentrations reflect, for the most part, the natural and man-made inputs of organic material to the river. The values found are characteristic of most organically rich waters. The concentrations of nitrate and phosphate are insignificantly affected by the salinity pattern.

Dissolved oxygen in the water at Indian Point is generally around 70% of saturation at all observed temperatures. It shows little change with depth, and there is no indication of oxygen depletion in the bottom muds. Occasional low values for dissolved oxygen seem related to discrete masses of water with a high Biochemical Oxygen Demand (BOD). For this reason the lowest dissolved oxygen values found in the river are generally observed near the largest population centers (for example, < 1 ppm in August, south of Albany). However, for the most part oxygen levels are 6 to 7 ppm throughout the year.

TABLE 4-1

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

	Concentration mg/l		
	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	2800**	7200**	4575**

	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

4.4 Meteorology

(a) Annual Meteorological Statistics

The most important meteorological characteristic of the Indian Point site is the prevalent north-south wind direction. Air flow is channeled through the axis of the Hudson Valley by the ridges which surround it. This predominant wind direction holds at different altitudes and also for lapse, neutral and inversion conditions. There are no populated areas immediately to the north and south of the site and wind trajectories towards the center of the largest city in the area, Peekskill, are infrequent.

New York University under a contract with Con Edison made extensive tests of the meteorological conditions at the Indian Point site. The testing program, begun in 1955 and completed in 1957, is described in three technical reports prepared by the New York University staff under the immediate direction of the late Prof. Benjamin Davidson. Prof. Davidson had on several occasions in the past 12 years acted as consultant to Con Edison on meteorological matters and thus had a continued association with the Indian Point site. The original New York University reports or applicable excerpts thereform which had been reviewed by Prof. Davidson and Con Edison are appended to this report (Appendices C, D, and E).

The most frequent wind flow at low heights under inversion conditions is down the axis of the valley. This direction, roughly 010 - 030°, is also the direction of maximum wind frequency at the 100 ft. level. The valley wind is diurnal in nature, i.e., up-valley during unstable hours and down-valley during stable hours. In general, these local winds are most frequent under clear sky and relatively light prevailing wind conditions such as occur mostly in the fall of the year. The diurnal variation of the vector mean wind as measured 70 ft. above the river surface during September-October 1955 is shown in Figure-7. for conditions in which the geostrophic wind was virtually zero (12 days) and in Figure-8 for conditions in which the geostrophic wind was less than 16 mph (35 days). It may be seen that for these virtually stagnant prevailing wind conditions, there is a regular diurnal shift in wind direction and that the mean vector wind associated with the down-valley flow is on the order of 6 mph.

(b) Severe Conditions

The site is located in a region where natural phenomena such as tornados are uncommon. The nearest weather stations to Peekskill having wind recording instruments capable

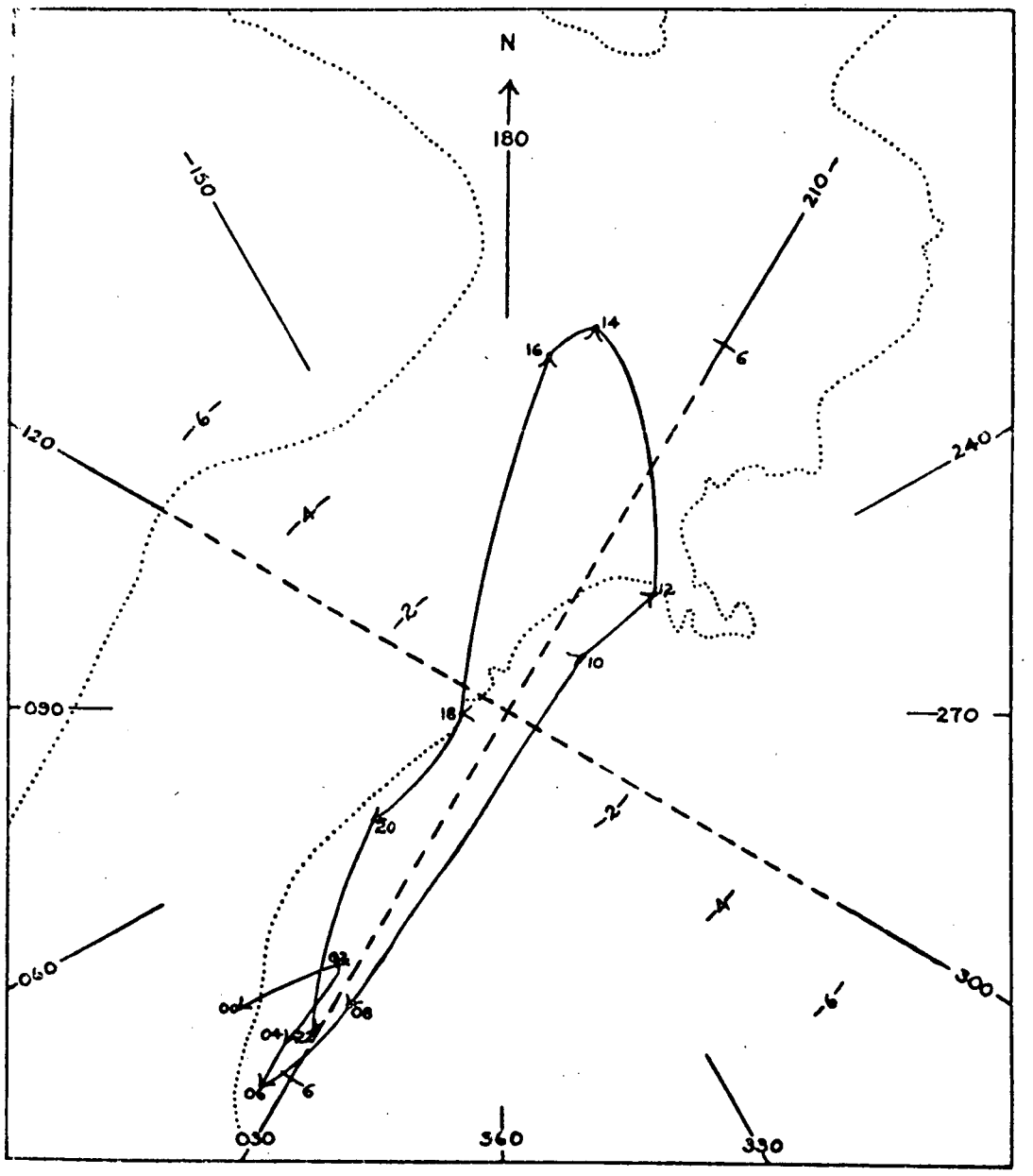

Figure - 7 Diurnal variation of mean vector wind for virtually zero pressure gradient conditions, Sept., - Oct., 1955, 70 ft. above river.

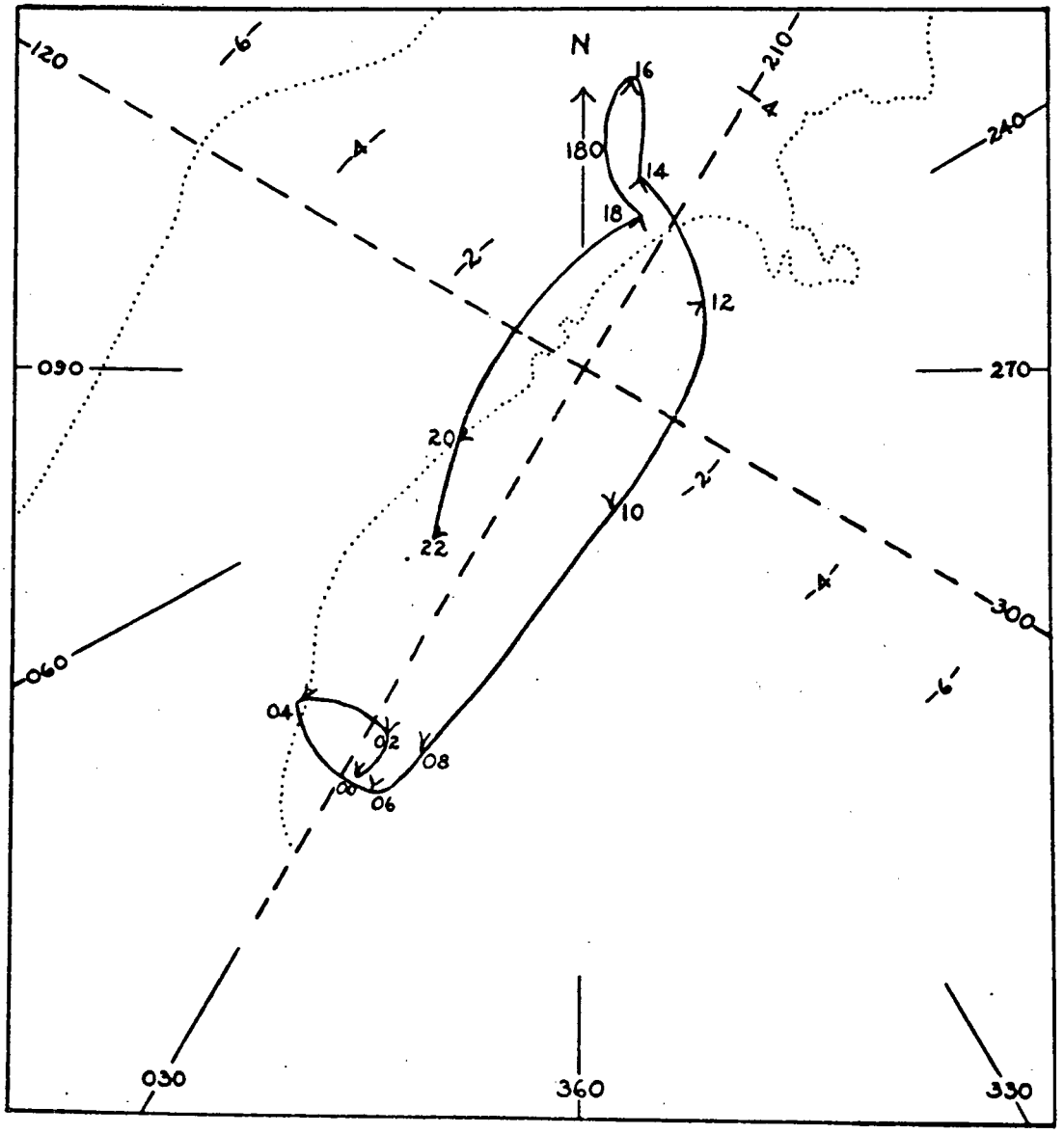

Figure - 8 Diurnal variation of mean vector wind for 24 hr. periods of weak pressure gradient conditions (Geostrophic winds less than 16 mph), Sept. - Oct., 1955, 70 ft. above river.

of recording wind gusts of 100 mph or greater, and with records for twenty years or more, are at Newburgh, N. Y. (Steward Air Force Base), Bedford, Mass. (L. G. Hanscom Field), Atlantic City, N. J. (Naval Air Station and Weather Bureau), Rome, N. Y. (Griffiss Air Force Base) and Patuxent River, Md. (Naval Air Station).

The National Weather Records Center, Asheville, N. C., searched the records of the above stations for observations of wind speeds greater than or equal to 100 mph. Only two cases of wind velocities exceeding 100 mph (110 mph and 111 mph maximum gusts) were found. Both these cases occurred during the passage of hurricanes. Nevertheless, tornado protection is incorporated into the Unit No. 3 design by virtue of tornado proof structures capable of withstanding 360 mph winds and equipment and system redundancy. Meteorological assumptions considered for purposes of the Indian Point Unit No. 3 safety analysis are discussed later herein.

(c) Recent Meteorological Data

A meteorological monitoring program designed to update the 1956-57 data in the Hudson River Valley has recently been initiated. The report of this program is currently being prepared by Dr. James Halitsky (formerly of NYU) and has not yet been submitted to Con Edison. The two questions to be answered by this report are: whether or not the annual meteorological conditions as recorded in 1956-57 can be expected to recur within reasonable limits; and whether or not periods of prolonged poor diffusion — as defined by the joint criteria of low wind speed, constant wind direction or small angular fluctuations — occur with any regularity.

Preliminary data with respect to the second question indicates that no periods of very prolonged poor diffusion potential were found. Poor diffusion occurred under moderate inversion conditions, whereas stronger inversions produced meandering winds. Also the wind direction ranges measured under inversion conditions while occasionally approaching the F stability category* during random hours, most consistently corresponded to the C-D category when averaged over periods of poor dispersion potential.

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*See Table 4-2 for category definitions

TABLE 4-2

RELATION OF TURBULENCE TYPES
TO WEATHER CONDITIONS

A---Extremely unstable conditions
B---Moderately unstable conditions
C---Slightly unstable conditions
D---Neutral conditions*
E---Slightly stable conditions
F---Moderately stable conditions

Surface wind speed, m/sec	Daytime insolation			Nighttime conditions	
				Thin overcast	
	Strong	Moderate	Slight	or $\geq 4/8$ Cloudiness†	$\leq 3/8$ Cloudiness
< 2	A	A-B	B		
2	A-B	B	C	E	F
4	B	B-C	C	D	E
6	C	C-D	D	D	D
> 6	C	D	D	D	D

* Applicable to heavy overcast, day or night.
† The degree of cloudiness is defined as that fraction of the sky above the local apparent horizon which is covered by clouds.

(from Meteorology and Atomic Energy, David H. Slade, editor, USAEC, July 1968)

4.5 Plant and Animal Life

Plant life at the Indian Point site may best be described as an oak-maple-hemlock forest and these primary species occur throughout the site. In addition, a great variety of other species, not part of the normal ecological succession, has been introduced to previously cleared areas. These include wild cherry, dogwood, hickory, sumac, cottonwood and linden.

The wildlife at and around the site area includes a typical group of North American species associated with a hardwood forest such as porcupines, woodchucks, squirrels, opossums, insects, reptiles and a variety of bird life such as robins, thrushes and occasional waterfowl.

By comparison with pollution levels existing near population centers such as Albany, Poughkeepsie and New York City, the quality of water reaching Indian Point, including the dissolved oxygen content, is relatively good. Hence, the river at the site is capable of supporting a considerable variety and abundance of aquatic life. Migratory fish in the area include striped bass, shad, alewife, blueback herring, smelt, and sturgeon. The principal resident fish are eels, catfish, white perch, minnows, tomcod, and sunfish. Both commercial and sport fishing are carried on in the area, although the amount of commercial fishing has generally been declining during the past twenty years. Shad and striped bass are the two most important species for commercial fishing, while the striped bass is the most important for sport fishing. There is no commercial shellfish industry in the area, and there are no commercially harvested crustaceans. The river also contains various underwater plant life, small aquatic insects and small crustaceans in sufficient amount to support fish life.

Con Edison has financed extensive surveys of the fish population in the Hudson River at Indian Point. These surveys have provided a great deal of baseline data and are discussed in detail later in this report.

4.6 Population and Land Use

The Indian Point property, which is zoned for industrial use, was formerly the site of the Hudson River Day Line amusement park. Its use had decreased substantially and the park was consequently abandoned prior to its acquisition by Con Edison. A pre-construction view of the site is shown in Figure-9.

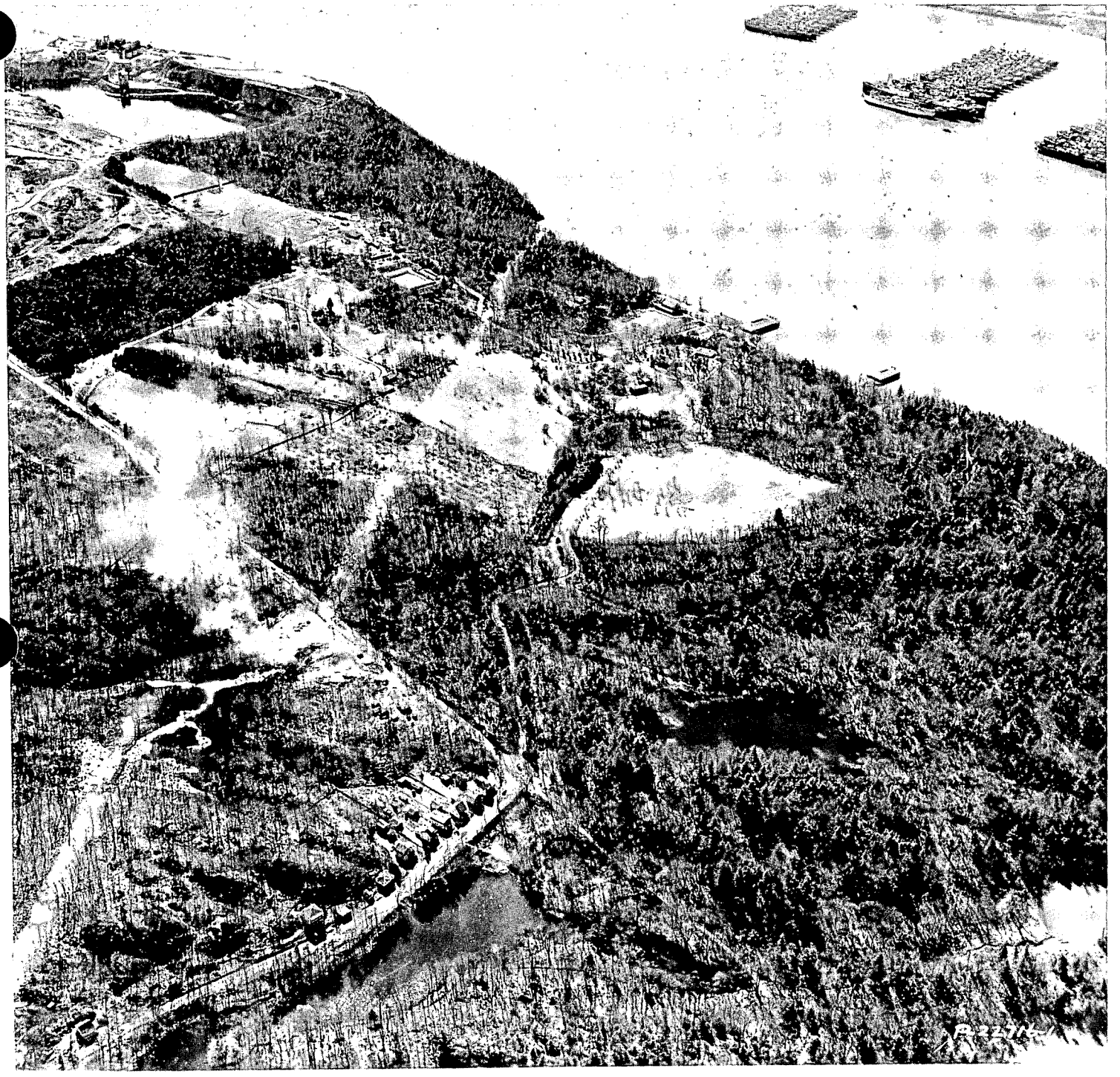

Figure - 9 Pre-construction view of the Indian Point site.

A study compiled for Con Edison by the Regional Economic Development Institute (REDI), Inc., in 1965 under the direction of Dr. Edward M. Hoover (Appendix F) reviewed the existing and projected population and land use within a 55-mile radius of Indian Point. Although there is some industrial activity* with a little agricultural and grazing activity, the majority of land within a 15-mile radius is zoned principally for residential and state park usage. Projections do not indicate, and there is no other reason to conclude, that the land usage within this radius will shift appreciably by the year 2010. Land usage for this area is shown in Figure 10. The results of the study support Con Edison's conclusion that Unit No. 3 represents a desirable land use consistent with both the short and long-term development of the surrounding area. This conclusion has been affirmed in comments expressed by the Westchester County Department of Planning (see Appendix G) and by the Atomic Energy Council of the State of New York. (see discussion under the caption "Environmental Approvals and Consultation," later herein).

With respect to the population distribution of the area surrounding the site, the initial estimates reported by REDI have been revised to reflect the 1970 population census. The new population estimates based on 1970 census data are contained in the following report, "Population Estimates for 1970 and the Population Projections to 2010 for Specified Zones Within a Sixty-Mile Radius of Indian Point Nuclear Power Plant Site", prepared in June 1972. This report is also included in Appendix F.

Approximately 50 people reside within a 1,100 meter radius of Unit No. 3 (low population zone), all of them to the east southeast, and about 745 people live within one mile of the new unit. An estimated 53,000 people now reside within a five-mile radius of the facility and the largest population concentration is the City of Peekskill, the center of which is about 2.5 miles northeast of the site. As a result, the most densely populated 15 degree sector within 5 miles of the site is northeast toward Peekskill.

Within a 15-mile radius of the site, 1970 census population records indicate approximately 450,000 individuals reside. Current predictions for this same area in the year 2010 anticipate approximately 1,425,000 residents. Population distributions within a 5 and 60 mile radius of the site are shown in Figures 11 and 12, respectively.

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*Industries in the vicinity include Georgia Pacific Complex, New York Trap Rock Corporation, Fleishmann's Distillery, and Sanitas Company.

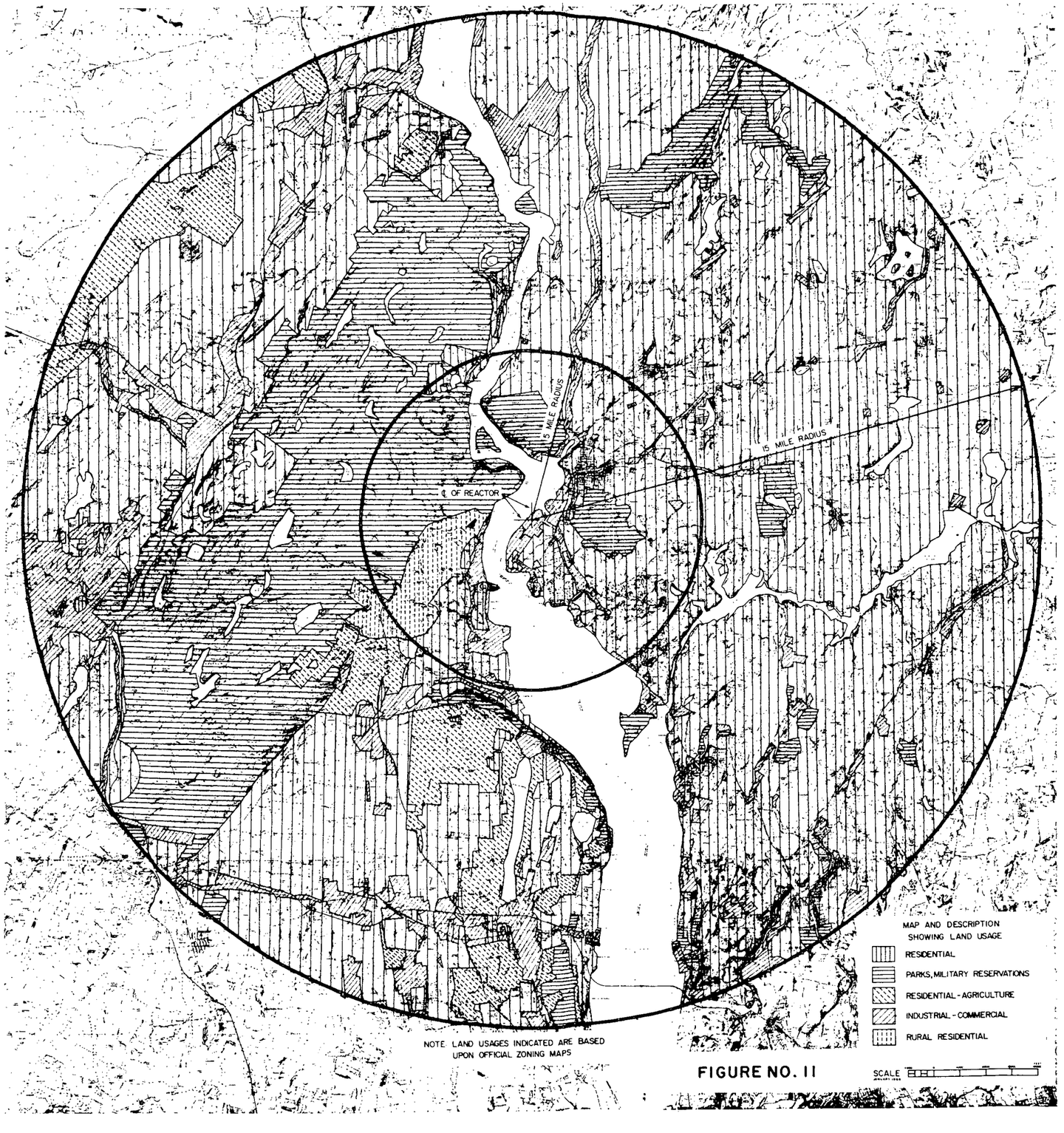
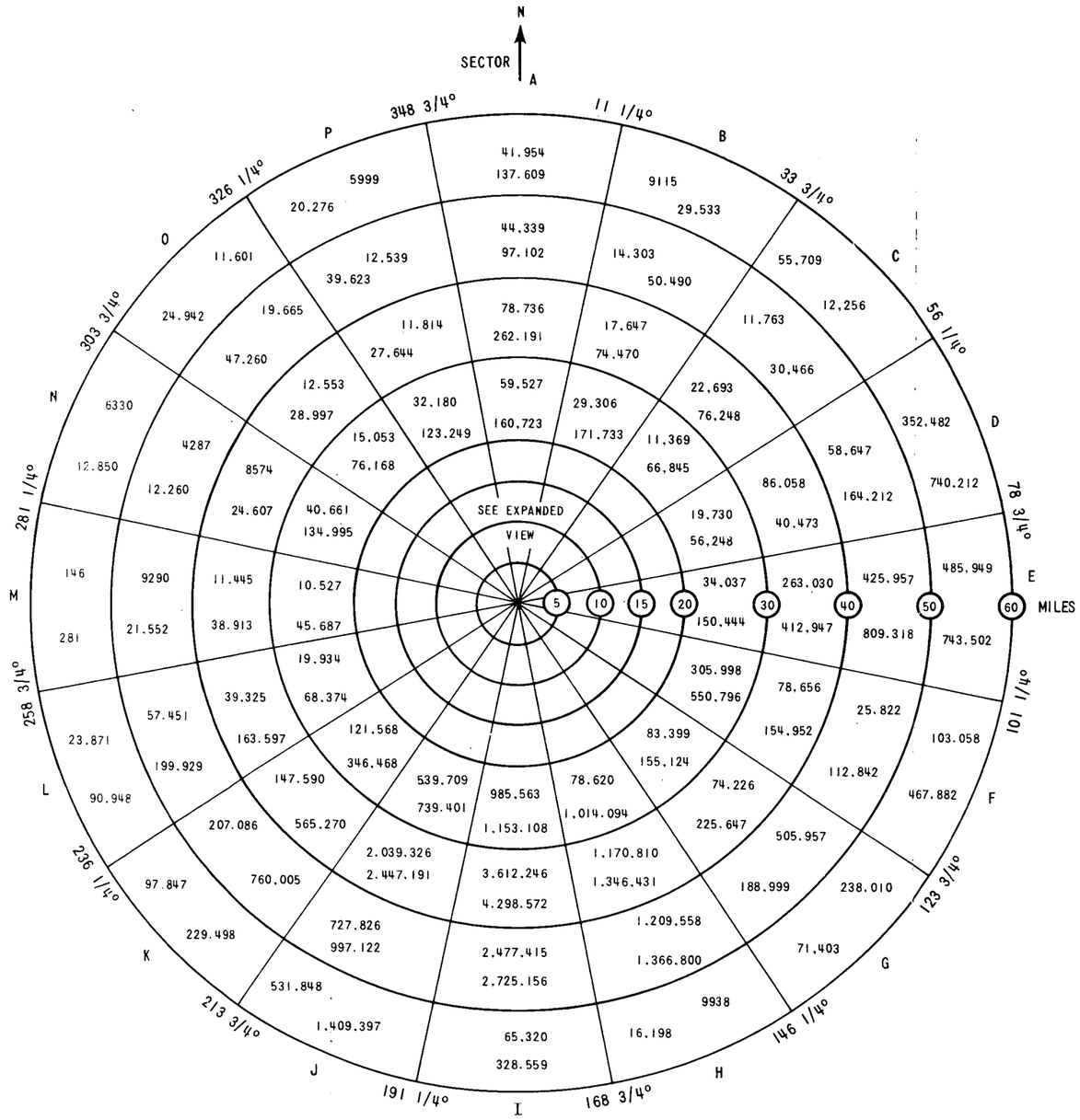


Figure 4-10 — Map and description showing land usage.



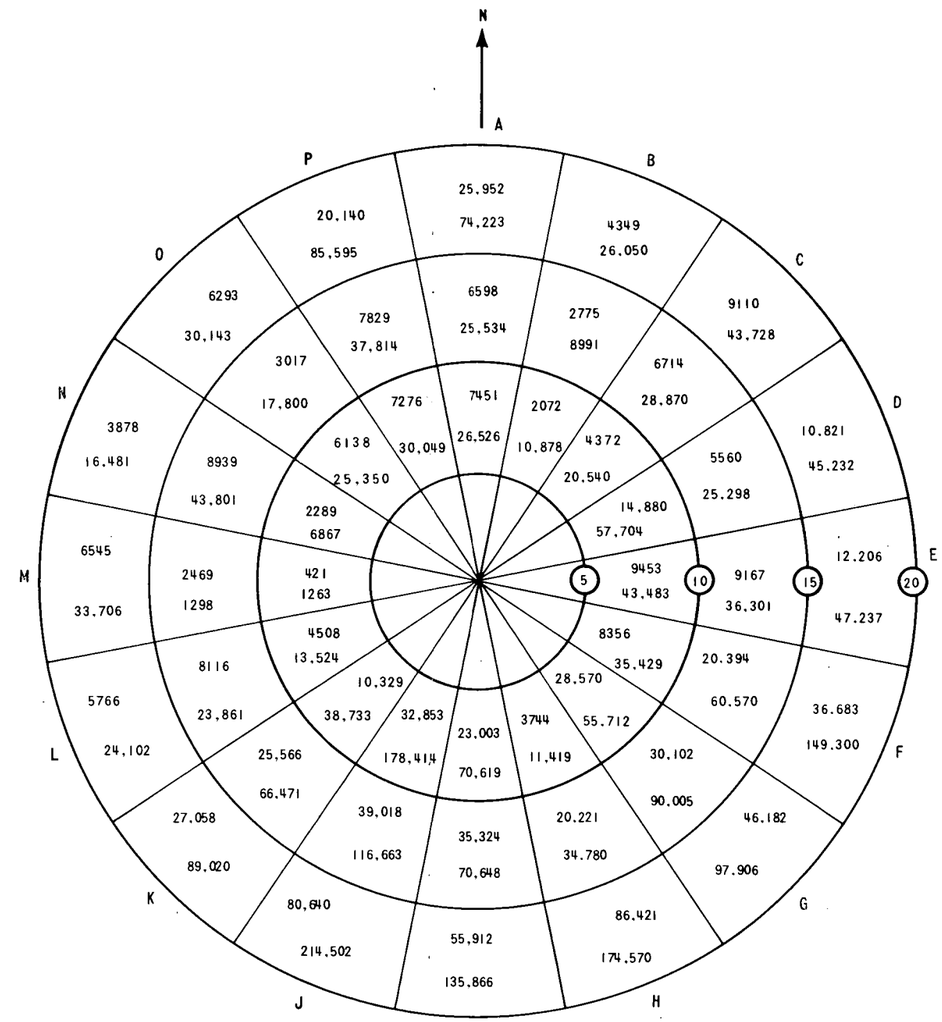
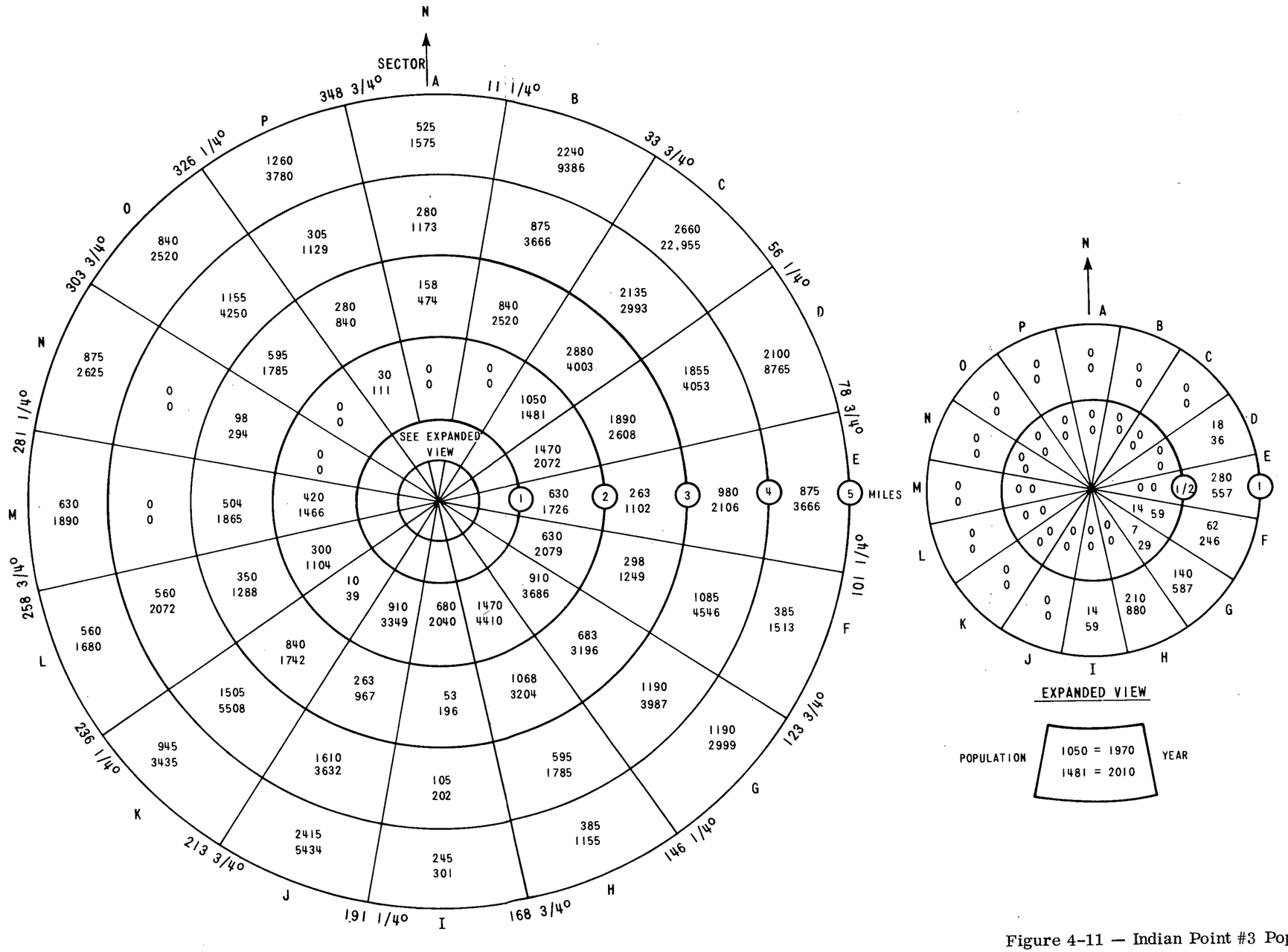


Figure 4-12 — Indian Point #3 Population Distribution — 60 Mile Radius Based on June 1972 Report



EXPANDED VIEW

POPULATION 1050 = 1970 YEAR
1481 = 2010

Figure 4-11 — Indian Point #3 Population Distribution — 5 Mile Radius Based on June 1972 Report

4.7 History

The lower portion of the Hudson River is one of the earliest areas in the present United States to be settled by the colonists and the valley played an important role in the American Revolution. Many places throughout the general area, therefore, are of historical significance.

Historical sites listed in the NATIONAL REGISTER OF HISTORIC SITES for surrounding counties appear in Table 4-3.

The closest such place to the Indian Point site is the Stony Point Battlefield Reservation on the west side of the Hudson River, approximately one mile from the plant. By letter dated October 10, 1968, addressed to the Director of Regulation of the Atomic Energy Commission, the Executive Secretary of the Advisory Council on Historic Preservation concluded that the probable effect upon the Stony Point Battlefield Reservation "...cannot be judged to be sufficiently adverse to warrant Council comment."

The Hudson River Valley Commission in preparing a preliminary inventory of the historic resources of the Hudson River Valley, an inventory whose preface notes that is was decided to make the list "as all-inclusive as possible," listed 17 sites within a one mile radius of the plant and a total of 31 sites within a two mile radius. It should be noted, however, that this particular listing was oriented more to buildings of historic importance rather than to general areas whose historic nature has been preserved. The listed historic site closest to Indian Point is Lent's Cove, where the British landed for a raid on Peekskill in 1777.

4.8 Other Considerations

(a) Unquantified Values

With respect to the Indian Point site, there is no unique natural environment within the sphere of influence of the facility. There are no unusual phenomena such as geysers, caverns, virgin forest areas, or natural wildlife sanctuaries which could be affected by the presence of Unit No. 3 or any related facilities. With respect to the scenic value of the area, prior to any construction on the site, the Hudson River at Indian Point could hardly have been considered as scenic for two reasons, the first of which was the abandoned condition of the site referred to earlier herein. Moreover, the Hudson River at Indian Point was utilized by the U. S. Maritime Administration as the location of its "mothball fleet." Prior to the construction of Unit No. 1, the "fleet" numbered approximately 189 vessels. By July 31, 1971, the

TABLE 4-3

HISTORIC PLACES IN THE VICINITY OF INDIAN POINT GENERATING STATION†

County	Site	Location
Rockland	*Stony Point Battlefield	north of Stony Point on U.S. 9W and U.S. 202
	*Dewint House	Livingston Ave and Oak Tree Rd. Tappan
Westchester	*Van Cortlandt Manor	U.S. 9, north of intersection with U.S. 9A, Croton-on-Hudson
	St. Paul's Church Nat'l Historic Site	Eastchester, Mount Vernon
	Dutch Reformed (Sleepy Hollow) Church	north edge of Tarrytown on U.S. 9, North Tarrytown
	*Gould (Jay) Estate, Lyndhurst	635 South Broadway, Tarrytown
	*Irving (Washington) House Sunnyside	Sunnyside Lane, Tarrytown
	*Philipsburg Manor	381 Bellwood Ave, Upper Mills
	*Philipse Manor	Warburton Ave and Dock St., Yonkers
Bronx	*New York Botanical Gardens	Southern and Bedford Park Boulevards
	*Van Cortlandt (Frederick) House	Van Cortlandt Park at 242nd Street
Bergen (N. J.)	*Palisades Interstate Park	West Bank of Hudson River (also Orange & Rockland, N. Y.)
Orange	*U.S. Military Academy (West Point)	New York 218
	*Deleware and Hudson Canal	
	*Historic Track	Main Street, Goshen
	*Harriman (E. H.) Estate, Arden	New York 17, Harriman
	Dutch Reformed Church	NE corner of Grand and Third Sts, Newburgh
	*Washington's Headquarters	Liberty and Washington Streets, Newburgh

* Designated National Historic Landmarks by the U.S. Secretary of the Interior.

†List prepared from the National Register of Historic Places, Federal Register, Volume 36, Number 35, Saturday, February 20, 1971, Part II.

entire "fleet" is expected to have been moved from the area. This, in conjunction with the development of a park on the site when Unit No. 3 has been completed will measureably enhance the scenic value of the area. Aspects of scenic enhancement are discussed in greater detail later in this report.

(b) Waterways

The primary waterway in the area of the Indian Point site is, of course, the Hudson River. The entire area is dotted with minor creeks, brooks, lakes and ponds, however, the Indian Point facilities will in no way affect them. The only waterway of any significance whatsoever is the Peekskill Hollow Brook which runs north of the City of Peekskill. No detrimental effects or interference are expected with respect to this waterway from the physical presence or operation of the Indian Point facilities.

(c) Government Reservations and Installations

With the exception of Camp Smith, located one mile north of the site, there are no significant government reservations or installations within the immediate vicinity of the Indian Point facilities. The United States Military Academy at West Point is located approximately 8.3 miles north of the site on the west bank of the Hudson River. No interference with this installation is expected from the physical presence and operation of the Indian Point facilities.

5.0 THE NEED FOR POWER

The need of the people in Con Edison's service territory for the electric power to be produced by Indian Point Unit No. 3 cannot be overemphasized. The people served by Con Edison have been plagued by power shortages in the last few years, created in large part by delays in the completion of the two nuclear units at Indian Point. Indian Point Unit No. 2 was originally scheduled for commercial operation by June 1, 1969 and is now scheduled for service in 1972. Indian Point Unit No. 3 was originally scheduled for commercial operation by June 1, 1971 and is now scheduled for service in 1974.

Indian Point Unit No. 3 is a vital part of an extensive construction program which Con Edison has undertaken in order to meet the rapidly increasing demand for power in the New York City area. The power supply problems of the past few years will be overcome only with the completion of this construction program.

In order to estimate the significance of this problem, it is important to understand the nature of Con Edison's electric service area, which covers the five boroughs of New York City and most of Westchester County. The population of this service area is approximately 8,650,000. An adequate and reliable supply of electric power is essential to the life of this key metropolitan area.

In recognition of the power supply problems of the next few years, Con Edison has initiated programs to reduce the demand for electric power. Con Edison has discontinued promotion of electric sales and is conducting a program of consumer education to prevent wasteful use of electricity. Any involuntary load reduction programs such as power rationing are not within Con Edison's legal authority and would have to be instituted by appropriate governmental authorities.

5.1 Recent Past

Since 1969 Con Edison has been faced with a continuing difficulty in supplying electric energy to the communities which it serves. Immediately prior to 1969 the Company's planned reserve capacity, including purchases from others, was 1,532 megawatts or 21% of its anticipated peak load.

In 1969, however, delays in the addition of new capacity by other utilities limited the amount of the firm purchased power actually available in that year at the time of the peak load to 260 megawatts, approximately one-third of the 710 megawatts for which Con Edison had contracted. In addition, there were several equipment outages and deratings* experienced during the summer period, which is the period of peak demand on the Company's system. As a consequence, the Company had to request large customers to reduce load voluntarily, to appeal to the general public to conserve electricity and to institute voltage reductions on eight different days on which the loss of capacity ranged from 800 to over 2,000 megawatts. On two occasions the voltage reduction reached the maximum allowable level of 8%**, after which the only load control device available to maintain the integrity of the system is to totally discontinue electric service to some customers.

Again in 1970 the Company experienced shortages even though it had planned to increase its capacity resources from 8,882 megawatts to 9,839 megawatts. This would have represented a reserve of 27% of anticipated peak load, and was to be principally achieved by the addition of almost 1,200 megawatts of gas turbine capacity. Construction and start-up delays, as well as a strike which affected one of Con Edison's suppliers, caused slippage in the schedule for adding the gas turbines. They came into operation at various times thereafter, and Con Edison had only 874 megawatts in operation at the end of the summer. This together with equipment deratings and forced outages, made it necessary for Con Edison to make appeals again for the conservation of electricity by the public and to institute voltage reductions on fifteen days. On one occasion Con Edison had to resort to discontinuance of service to approximately 1% of its customers. Discontinuance of service to any customers is a drastic measure, and every effort must be made to avoid its recurrence.

In 1971, Con Edison added 624 megawatts of additional gas turbine capacity and, after re-rating some older units, had a installed reserve equal to only 9% of the estimated peak

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*"Deratings" result from equipment problems which, while they do not require that a generating unit be completely removed from service, restrict its operation to less than its full capacity.

**Voltage reductions in excess of 8% would cause damage to customers' equipment.

load. Con Edison also contracted for 920 megawatts of firm capacity purchases, thus raising the planned reserve to 21%.

This reserve, considering the re-ratings, was of the same order of magnitude as those with which Con Edison faced the summers of 1969 and 1970, and again Con Edison had to resort to the frequenct use of voltage reduction. In 1971, Con Edison reduced voltage on its system on fifteen occasions during the year. Major problems were avoided because forced outages of large units were fewer than in previous years and there were no prolonged hot spells.

5.2 Summer of 1972

For 1972, a total of 1621 megawatts of new generating capacity was planned. This consisted of 873 megawatts from Indian Point Unit 2; 400 megawatts from Bowline Point 1, originally planned for service in July, 1972, and now scheduled for commercial operation in September; and 348 megawatts from two barge-mounted gas turbines which began operation on May 23rd and June 9th, respectively. Bowline Point 1 is a 600 megawatt unit in which Con Edison has two-thirds ownership and Orange and Rockland Utilities one-third ownership.

Arrangements were also made to provide additional capacity resources for the summer period through purchase of capacity on a firm basis from neighboring utility systems. A total of 978 megawatts will be available through the end of September and 287 megawatts thereafter until the end of October, 1972. This includes 200 megawatts from Bowline Point 1, through October when that unit is placed in commercial operation.

Planned capacity resources for the summer of 1972, without Indian Point Unit 2, were 10,553 megawatts. This represented a planned reserve of 2153 megawatts or 25.6% of anticipated peak load. This has not been adequate to assure the reliability of power supply to Con Edison's customers.

The unavailability of equipment, in combination with the capacity deficiency created by the gradual slippage of the Bowline Point 1 service date, made it necessary for Con Edison to institute voltage reductions on six occasions through September 1, 1972.

5.3 Outlook for 1973

Two 600 MW fossil-fueled generating units are being constructed by Central Hudson Gas and Electric (Roseton Nos. 1 and 2) near Newburgh, New York. The first unit is scheduled for service in the Fall of 1972 and the second for the Spring of 1973. Con Edison is a joint owner, with a total share of 480 MW.

Con Edison anticipates a peak system requirement for 1973 of 8,850 MW. If all the new capacity described above should be available, with firm purchases of 190 MW and an additional purchase of 270 MW now being negotiated for the Summer of 1973, Con Edison's planned capacity will be 12,018 MW. This will result in a planned reserve of 2,268 MW or 25.6%.

5.4 Outlook for 1974 and Beyond

Indian Point Unit No. 3 is presently scheduled to be in commercial operation to meet the peak load for 1974. Con Edison's latest evaluation of load growth and prospective power supply indicates that Indian Point Unit No. 3 will represent a significant portion of the capacity which must be maintained in 1974 and future years to assure adequate reliability of service to its customers.

The estimated peak load for 1974 is 9,300 MW, and anticipated installed capacity, assuming that Indian Point Unit No. 3 is on-line, will be 12,049 MW. This includes 800 MW from Con Edison's Astoria No. 6 fossil-fueled generating unit in New York City, scheduled for service by the Summer of 1974, 40 Mw of firm purchased capacity, for which the Company has a contract and another 510 MW of firm purchases for which negotiations are now in progress. It will provide a reserve of 2,749 MW or 29.6%, which should represent adequate reserves to prevent a recurrence of the difficulties which have been encountered since 1969 and allow retirment of older, less reliable generating units which contribute heavily to New York City air pollution.

Without Indian Point Unit No. 3 in service in 1974, anticipated installed capacity will be reduced to 11,084 MW, equivalent to a reserve of only 1784 MW or 19.2%. This would not be significantly greater than the reserves which have been maintained to date and which have proven inadequate to the needs of the system.

It must be kept in mind that another major unit is scheduled for 1974. The Astoria No. 6 Generating Unit is on a tight construction schedule and pending litigation threatens this schedule.

If Indian Point Unit No. 3 and Astoria No. 6 were both delayed, the anticipated capacity for the Summer of 1974 would be only 10,284 MW, which provides an inadequate reserve of 984 MW or 10.6%. The public interest requires an end to recurring power crises. That end will come when Indian Point Unit No. 3 and the other units referred to are in operation.

5.5 Need to Replace Obsolete Facilities

In addition to meeting the requirements of load growth, the availability of planned new capacity including Indian Point Unit No. 3, is essential to allow the retirement of units which are now 40 to 50 years old and which would have already been removed from service were it not for delays already experienced. These units are inefficient and environmentally undesirable. Because of their inefficiency, they emit substantially more pollutants per MWH than more modern fossil fueled plants. Indian Point Unit No. 3 will not, of course, emit such pollutants.

Moreover, despite substantial expenditures for maintenance, they provide a much less reliable source of capacity than that provided by the newer units, and their reliability has continued to deteriorate. Any delay in the operation of Indian Point Unit No. 3 by relying on the deferral of the retirement of these units scheduled for retirement would be ill-advised because these old units will be unable to provide dependable output when required. A total of 1,284 MW, including three complete generating stations and miscellaneous capacity at five other stations, are planned for retirement from now through the Summer of 1974.

5.6 New York Power Pool

Con Edison is a member of the New York Power Pool (NYPP) which membership includes the eight major operating utilities in New York State (see Table 5-1). Indian Point Unit No. 3 will substantially contribute to the reliability of operation of the New York Power Pool.

The forecasted electric supply situation for the New York Power Pool prepared in 1972 indicates that New York Power Pool reserves in 1974, with Indian Point Unit No. 3 and Astoria Unit No. 6 in service, will be 7,242 MW or 32.5% of estimated co-incident peak load. If Indian Point Unit No. 3 were not in service this reserve would be reduced to 6,277 MW or 28.2%. This would represent a substantial reduction in New York Power Pool installed reserves and a corresponding reduction in the reliability of the Pool.

Under the rules of the New York Power Pool, each Company is required to secure sufficient capacity to meet its needs including purchases of firm power. Pool resources are available for emergencies, but cannot be used as a substitute for necessary capacity additions.

5.7 Consequences of Delay

In the event an operating license for Indian Point Unit No. 3 is not obtained, Con Edison will use its best efforts to obtain substitute sources of power for 1974 and, over the long term, provide replacement capacity. There are substantial difficulties with all of the potential alternatives and it may be impossible, in the short run, to obtain alternative power in the amounts necessary to offset unavailability of planned new capacity. As indicated in the preceding sections (see also the Alternatives Section), this would lead to a difficult power supply situation.

The emergency procedures which would be implemented in the event of a power shortage have been prescribed by the New York Public Service Commission in Case 25937 (August 3, 1971). In accordance with the Public Service Commission's order, the Company would make every effort to contract for the purchase of supplemental and emergency capacity from neighboring utilities. The availability of such capacity will depend largely upon two factors: the installation of new capacity in neighboring systems and the transmission capability between systems. Since neighboring systems have experienced delays in meeting service dates and outage problems similar to those of Con Edison, this source of power cannot be relied upon. Also, Con Edison's attempts to strengthen the transmission system have experienced delays caused by local opposition along transmission line routes.

If emergency power were not available, the Company would be required, depending on the severity of the power shortage, to institute load conservation measures such as voltage reductions and disconnection of customers. The number of instances in which the public would be inconvenienced by these measures would depend on the magnitude of the forced outages of generating equipment installed on the Con Edison system and the availability of capacity in other utility systems for sale to Con Edison on an emergency basis.

The Public Service Commission in its opinion in Case 25937, after discussing all possible emergency measures, concluded as follows:

> "There can be no doubt, of course, that this great region will face awesome difficulties if Consolidated Edison does not, reasonably soon, acquire additional generating and power import capacity. It is to that solution, however, that all energies should be turned and not to measures that so plainly invite economic disaster."

TABLE 5-1

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, Incorporated

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, Incorporated

*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

Date: March 1972

6.0 ENVIRONMENTAL APPROVALS AND CONSULTATIONS

6.1 Licenses and Permits

Con Edison has obtained permits from several agencies with respect to environmental matters. A list of these permits as well as building permits from the Village of Buchanan are found in this report as Appendix-H. Approvals were obtained from the New York State Department of Health, the New York State Water Resources Commission, the U. S. Army Corps of Engineers, and the Hudson River Valley Commission.

The New York State Health Department approved the sewerage disposal system which serves the Indian Point site, including Unit No. 3, on June 10, 1959. On December 10, 1970 the Department of Environmental Conservation issued a permit authorizing the construction of an effluent canal and diffuser which will serve all three units at the Indian Point Station.

The Corps of Engineers has issued permits for the screenwell structure, for extension of the discharge canal and for the dredging in Lents Cove which was necessary in order to facilitate the transport of major components to the site. The New York State Water Resources Commission has also issued permits for these three activities.

The Hudson River Valley Commission, which has authority to review the environmental impact of projects in the Hudson River Valley, has reviewed the Indian Point Unit No. 3 project and has issued a letter commenting thereon on February 8, 1968. That Commission has also issued letters of approval with respect to the dredging at Lents Cove, the screenwell structure and the discharge canal extension.

As to future environmental approvals required for the operation of Unit No. 3, it will be necessary for Con Edison to obtain an operating permit from the New York State Department of Environmental Conservation (formerly Health Department) in order to discharge effluent through the canal and diffuser for which it holds a construction permit. A similar requirement exists with respect to Unit No. 2. Under new regulations and policies a permit for discharge will have to be obtained from the U. S. Army Corps of Engineers.

6.2 Consultation With Planning Authorities

The Company has consulted throughout the development of the Indian Point site with the Westchester County Department of Planning. As a result, the use of the land at Indian

Point for nuclear power generation is consistent with the overall land use and development plan for Westchester County, and with local planning. Attached to this report as Appendix-G is a letter from the Westchester County Department of Planning which summarizes its views as to the fashion in which Indian Point contributes to the development plan for Westchester County. That letter states in part:

> "The site is zoned for industrial use and the use of this site for nuclear power generation is consistent with the overall land use and development plan of the Department for Westchester County."

The Department of Planning also comments on the propriety from a planning viewpoint of selecting Indian Point as a site for Unit No. 2 given the existence of Unit No. 1 and the fact that the area was both committed to industrial use and accustomed to the presence of a nuclear reactor. That reasoning applies with equal force to the site selection for Unit No. 3.

The Department of Planning also referred to the proposed development of the site for recreational and public purposes and commented that "this policy is strongly endorsed for its consistency with both county and local planning."

The Atomic Energy Council of the State of New York, in its comments to the AEC on Con Edison's Environmental Report for Indian Point Unit No. 2, expressed an opinion consistent with that of the Department of Planning when it said, "It appears that the nuclear power development at this particular site may have resulted in an improved land usage."

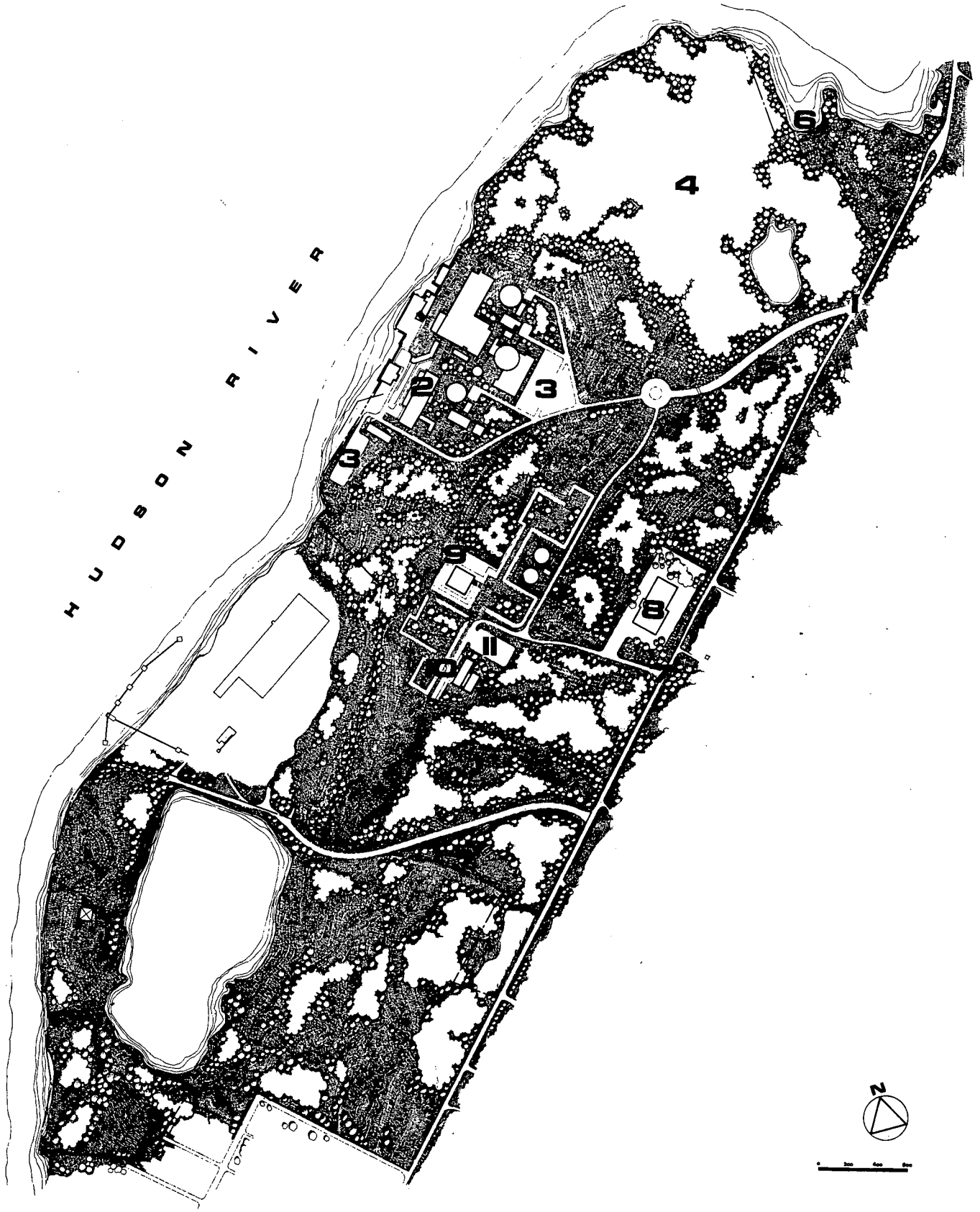
7.0 LAND USE COMPATABILITY

Of the 239 acres comprising the Indian Point site, about two-thirds is currently being used for construction related activities. Following the completion of Unit No. 3 the plant area will occupy only 35 acres, approximately 16% of the site. This represents a very low "use density" compared to other kinds of industrial development which might have occurred at Indian Point. Figures 13, 14 and 15 portray the development of this site for recreational purposes. Figure-13 is an illustrative plan, and Figure-14 is an aerial photograph of the site as it exists during construction. The overlay indicates existing conditions. Figure-15 is the same aerial photograph with an overlay showing the stages for development of the master plan, with projected completion dates. The actual dates will depend on the progress of construction with respect to Unit No. 3. In any event, landscaping and planting are scheduled to begin in 1971 in vacated construction areas and will continue as use of other areas for construction are discontinued. Most of the landscape areas will be completed and usable upon the completion of Unit No. 3 now scheduled for 1973.

The master plan envisages that a new Visitors' Center will be constructed to the south and east of the plant, within an area presently cleared for construction parking. The new center will be considerably larger than the existing facility and include more sophisticated exhibits. Its construction is expected to begin in 1973 and to be completed in late 1974.

The area surrounding the Visitors' Center will contain paths, open and enclosed spaces for horticulture and outdoor exhibits. The exhibits will be designed by Atkins & Merrill and will focus upon the peaceful uses of nuclear energy. The location of a training simulator at the site, where visitors could view personnel learning nuclear plant operations, is currently under consideration. Outdoor overlooks and other amenities, along with expanded parking facilities, will also be provided. The master plan allows for the eventual development in a consistent manner of the adjoining Trap Rock site, south of Indian Point.

In addition to this recreational development, a parcel of approximately 14 acres at the northwest corner of the site has already been transferred by Con Edison to the Village of Buchanan. This property which is adjacent to Lent's Cove, is to be developed as a public marina.



1 EXISTING ENTRANCE
2 UNIT NUMBER 3
3 EMPLOYEE PARKING
4 NATURAL AREA
5 PARKING
6 PROPOSED MARINA
7 PROPOSED ENTRANCE
8 WAREHOUSE-STORAGE AND PARKING
9 VISITORS' CENTER
10 TRAINING SIMULATOR
11 PARKING

MASTER SITE AND LANDSCAPE PLAN

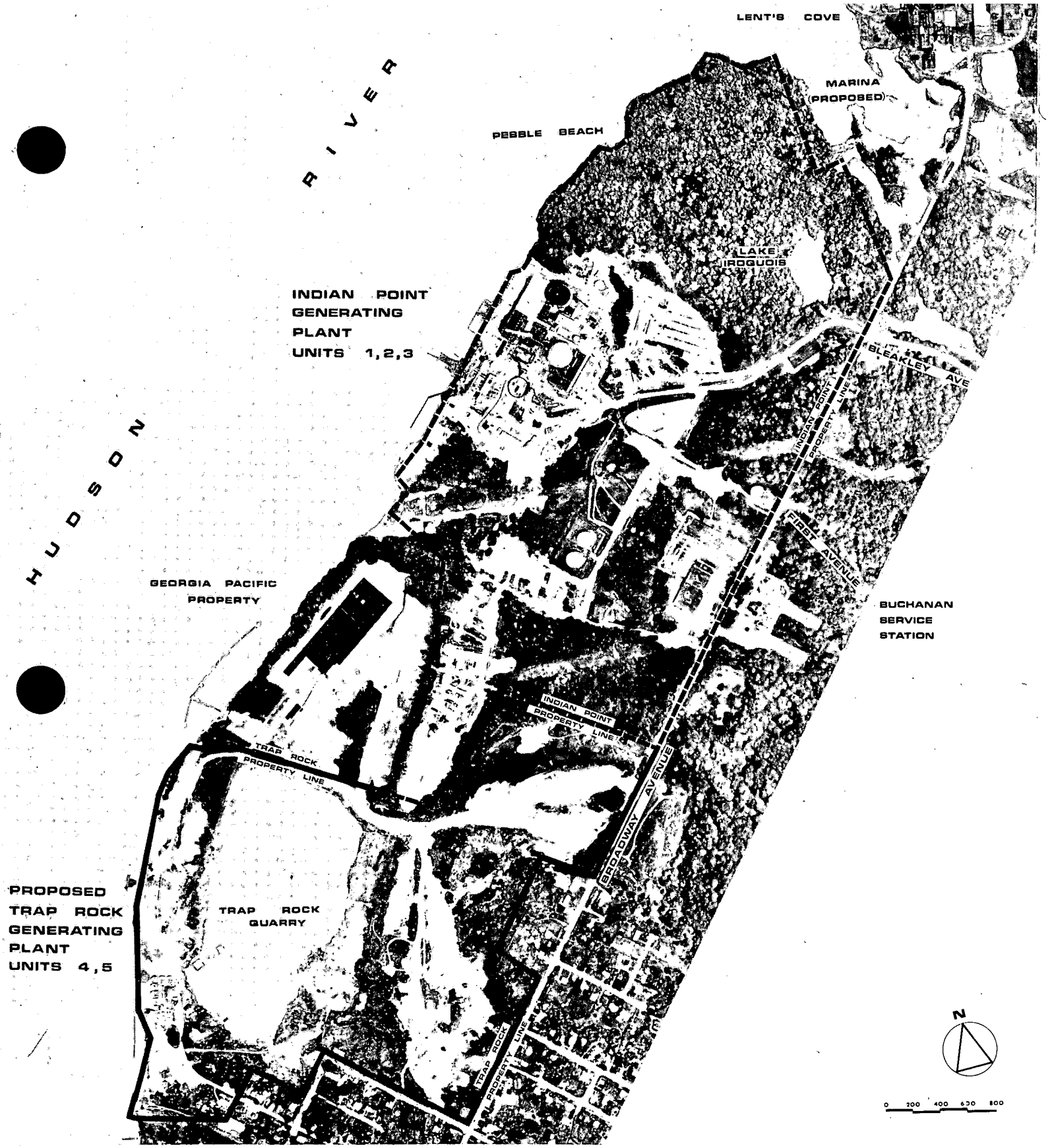
CONSOLIDATED EDISON

INDIAN POINT, NEW YORK

ILLUSTRATIVE PLAN

M. PAUL FRIEDBERG AND ASSOCIATES

FIG. 13



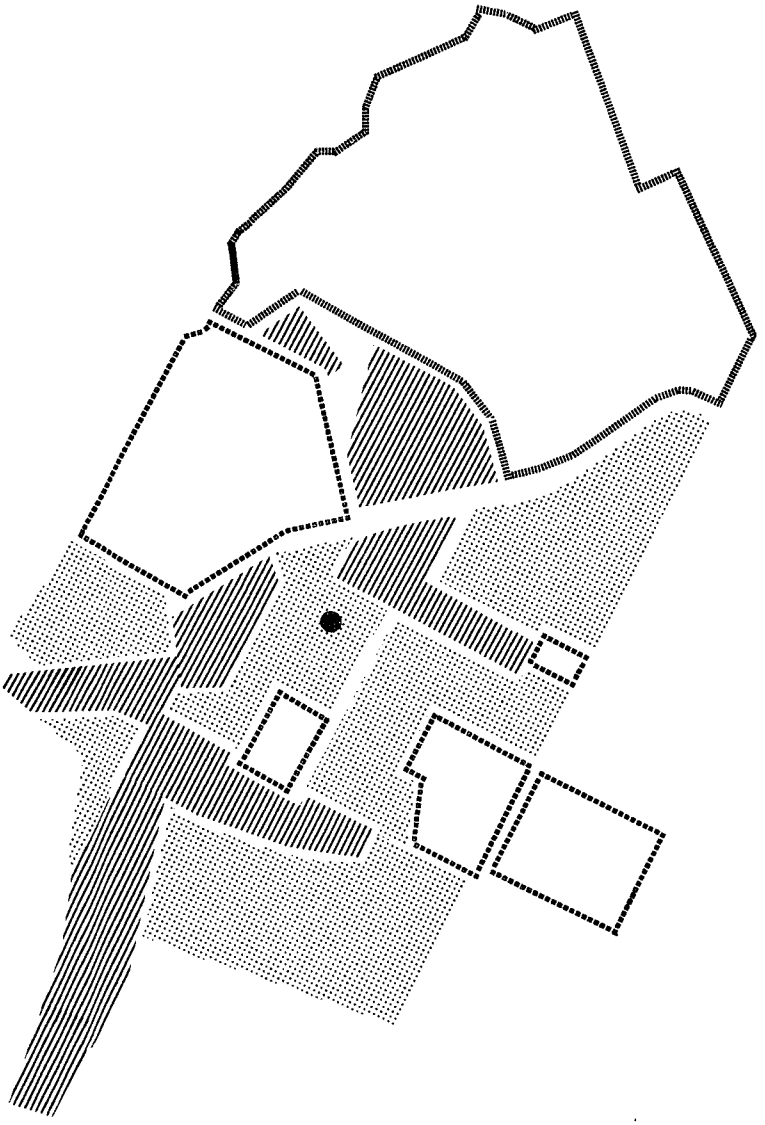
MASTER SITE
AND LANDSCAPE PLAN

CONSOLIDATED EDISON

INDIAN POINT, NEW YORK

INDIAN POINT SITE

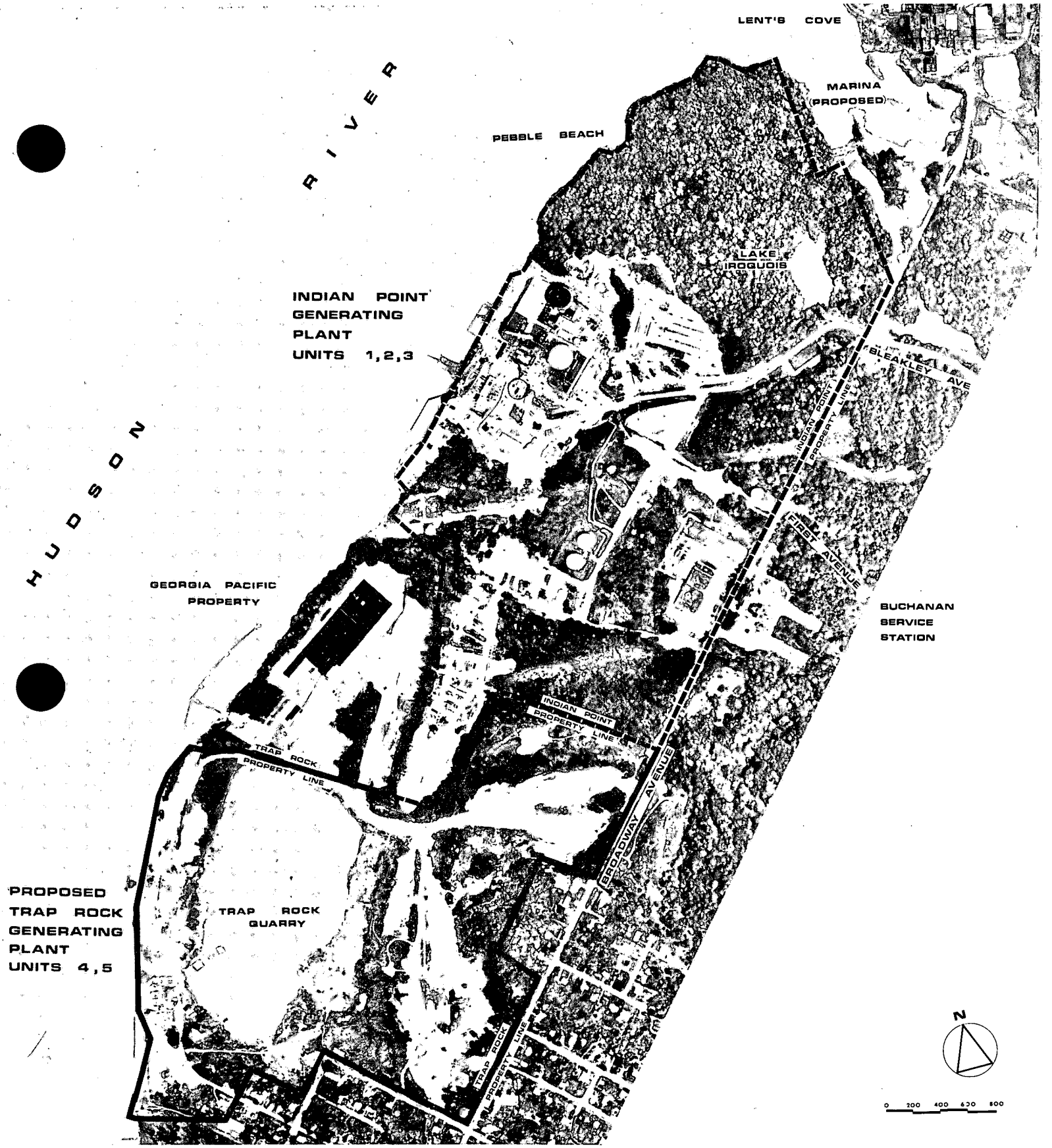
M. PAUL FRIEDBERG
AND ASSOCIATES



GENERATING PLANT AND EXISTING FACILITIES
VISITOR'S CENTER
NATURAL AREA
PARKING, STAGING AND SPOILS AREAS
INTERSTITIAL

EXISTING CONDITIONS

FIG. 14



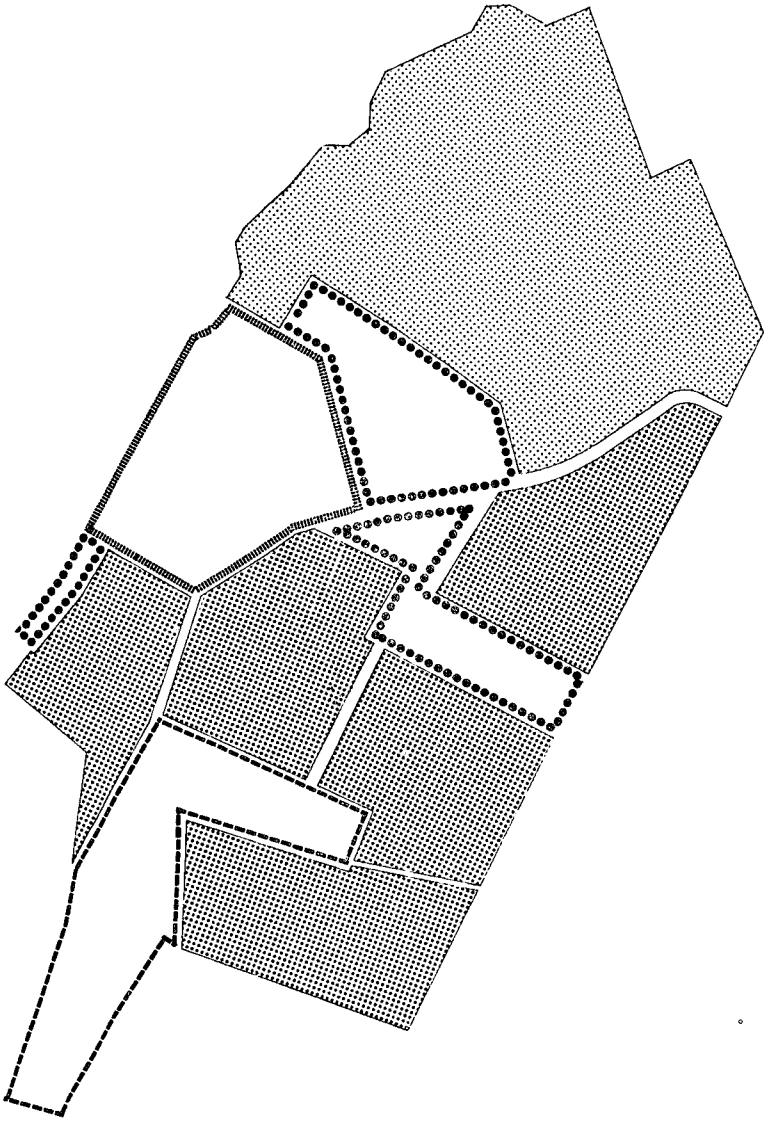
MASTER SITE
AND LANDSCAPE PLAN

CONSOLIDATED EDISON

INDIAN POINT, NEW YORK

INDIAN POINT SITE

M. PAUL FRIEDBERG
AND ASSOCIATES



JANUARY 1971 - 72
JUNE 1971 - 72
JANUARY 1972 - 73
JUNE 1972 - 73
JUNE 1973 - 73

STAGING PLAN

FIG. 15

In addition, there exist 80 acres of wooded area in the northern part of the site which will be considered as a nature preserve. Picnic facilities, trails and other accommodations will be improved and expanded while otherwise maintaining the wooded area in its natural state. Con Edison is also considering providing facilities for nature study in this area.

The major recreational uses of the area surrounding this site are fishing, boating and the use of the various parks in the general vicinity. Neither these nor any other recreational uses of the area will be foreclosed or impaired by the three-unit Indian Point complex.

8.0 WATER USE COMPATABILITY

8.1 Uses of the Water Resource

Although the Hudson River is not used for any irrigation diversions in the Indian Point area, other water withdrawals are made from the river in order to serve municipal and industrial needs. The City of New York's Chelsea Pumping Station is located on the east bank of the river approximately 22 miles upstream from the Indian Point site, measured along the centerline of the river. In addition, the Castle Point Veteran's Hospital has a relatively small intake approximately 20 miles upriver from the site. Neither intake is considered to be within the sphere of influence of the Indian Point site and the operation of the Indian Point Station will in no way affect these sources of water supply. This particular aspect is discussed later in the report.

Industrial withdrawals from the river in the Indian Point site area are limited primarily to Standard Brands, Inc. and the Lovett Generating Station. A summary of the existing capacities of these industries, as well as drinking water intakes and capacities are given in Table 8-1. In no way does the operation of the three nuclear units at Indian Point affect these additional uses of the Hudson River as a water resource.

Within a 5-mile radius of the site only one municipal water supply utilizes ground water. Other wells are for industrial and commercial uses. As discussed earlier in this report, rock formations in the area and elevations of wells relative to the plant are such that accidental ground leakage or seepage percolating into the ground at the site will not reach these sources of ground water but will flow to the river.

8.2 Impact on the Water Resource

The flow past the Indian Point site is variable, as discussed in an earlier section. During peak tidal flow past the plant the total flow is about 80,000,000 gallons per minute approximately 80% of the time. This flow assures adequate dilution and complete mixing of the discharges from the site. With respect to water-utilization, Indian Point circulates 2,052,000 gallons per minute when service water is included. The plant will use, therefore, approximately 2.5% of the Hudson River water as it passes the Indian Point site, a usage which will not interfere with multiple utilization of the river. No portion of the river water is intentionally evaporated as it passes through the facility.

TABLE 8-1

DRINKING WATER AND INDUSTRIAL INTAKES* ON THE HUDSON RIVER

User	Location**	Capacity (MGD)
Poughkeepsie	+32 miles	7.00
Chelsea	+21.5 miles	100
Castle Point Veteran's Hospital	+20.3 miles	0.06
Standard Brands, Inc.	+1 miles	23.04
Lovett Power Station	-2 miles	484.7

* Industrial intakes limited to Indian Point Site only.

** + = miles above Indian Point, measured along centerline of river.
- = miles below Indian Point, measured along centerline of river.

9.0 HEAT DISSIPATION

9.1 Condenser Cooling Water System:

Approximately 2,000,000 gpm of Hudson River water is used for condenser cooling in the three Indian Point electric generating plants. The intake structure for each plant is located directly in front of its respective plant. The cooling water passes through the intake structure where it is screened of debris and is then delivered by the circulating water pumps to the condensers. After condensing the steam, the cooling water is returned to the river via a common discharge canal at a sufficient distance from the intake structures to minimize recirculation effects.

The circulating water system for Indian Point Unit No. 3 includes the piping and equipment necessary to insure a reliable flow of river water through the condensers. Components of this system are (a) the Trash Bar Screen and Traveling Screen System, (b) the Chlorination System, (c) the Circulating Water Pumps, (d) the Main Condensers, (e) the Discharge Canal Level Control Weir and (f) the Deicing Pumps.

Approximately 870,000 gallons of cooling water per minute, including 840,000 gpm of condenser cooling water and 30,000 gpm of service water, will be drawn through the Unit No. 3 reinforced concrete intake structure. The intake structure contains seven separate channels (one channel for each of the six circulating water pumps and a partitioned channel for the six service water pumps). Concrete walls separate the channels as they lead inland from inlets flush with the river's edge. Each channel has a skimmer wall, de-icing piping, a trash bar rack, a vertical traveling screen (the partitioned service water channel also has a fine mesh screen) a stop log gate (2 sets are provided for the service water channel) and chlorination piping.

River water flows under the floating debris skimmer wall (a concrete partition extending down to the mean low level of -1'0" elevation) through heavy steel trash bar racks into the seven separate channels. The service water intake may also receive water from adjacent circulator intakes via by-pass gates. The trash bars extend from the intake structure deck down to the intake opening bottom. The trash bar racks (also called coarse screens) and the skimmer wall are designed to restrain logs and other large debris as well as floating ice in the wintertime, thus providing protection for the finer mesh traveling screens. The area between the trash bar rack and the vertical traveling screen is served by de-icing piping which provides warm water in the winter months to prevent ice formation on the screens.

Approximately 15 feet downstream of the trash bar rack is a relatively fine mesh vertical traveling screen which prevents entry of small material. The traveling screen consists of a number of screen sections, fastened top to bottom, to form an endless belt of screens. The addition of top and bottom rotating wheels results in a screen which continuously moves vertically upward through the cooling water and is then sprayed with high pressure water supplied by the service water pumps to wash off any material picked up during the ascension before it enters the water on its downward pass. The trash falls into a common trough.

The lower part (below elevation 0' - 0") of the section of channel wall between the trash bar rack and the traveling screen was removed from the design to allow lateral movement of fish and small crustaceans thus reducing the possibility of their being impinged on the traveling screen. In addition, this modification will allow longitudinal washing of the face of the traveling screen by the river current. To evaluate the fish protection feature of this modification, the flow path from one circulating water pump to the condensers has been temporarily rerouted to the discharge canal. However, at the time of this writing, no conclusive results are available.

Beyond the traveling screens there are guides into which stop log gates, constructed of horizontal wooden logs, may be lowered to allow dewatering of any individual pump screenwell for maintenance purposes. Chlorination piping and individual distributors intermittently (5 gpm for approximately one hour, three times a week) inject sufficient liquid sodium hypochlorite into the river water leaving the traveling screens prior to its entrance to the pump screenwells to prevent the formation of algae and slime forming bacteria in the circulating water system.

Six (6) circulating water pumps deliver cooling water through individual 84 inch pipes to the three main condensers. There are no pump discharge valves in this system and the pumps must be primed before they are started. This is accomplished by a condenser water box priming system consisting of two steam jet air ejectors which take suction from a dropout tank connected by piping to individual condenser outlet waterboxes. In addition, a discharge canal level control weir maintains the discharge canal level sufficiently high at all flow rates thus maximizing the siphon recovery and therefore minimizing circulating water pump horsepower. The weir will position itself automatically to maintain a predetermined

water level set point regardless of variations in circulating water flow. The set point can be altered if necessary.

Unit No. 3 has three main condensers each served by two circulating water pumps. Each pump discharges to one of the two inlet water boxes on the condenser serviced. The condensers are of the straight flow design suited to the large quantity of water circulated and the seasonal and temperature variations (32°F to 78°F) found at Indian Point. Each condenser is located directly underneath the low pressure turbine section which it serves.

The normal mode of operation is to keep the two circulating water pumps serving each condenser in operation while the unit is on the line. However, it is possible to stop one circulating water pump and dewater that half of the condenser for inspection purposes with the turbine generator continuing in operation. Downstream of the level control weir, there are two de-icing pumps which are isolated from the discharge canal by means of individual slide gates. The de-icing pumps may be put in service individually or in combination to recirculate warm water in the discharge canal back to the intake structure whenever there is a possibility of ice forming at the trash bar screens. The de-icing pumps require priming in a manner similar to the circulating water pumps. There are two steam jet priming ejectors and a priming level tank located at the intake structure to prime the de-icing pump discharge pipes.

Downstream of the de-icing pump slide gates, a special discharge canal returns the circulating water to the river. This discharge canal in the form of a new outfall structure was designed, based on model studies conducted by the Alden Research Laboratories in Massachusetts, to reduce potential effects of thermal discharge. This outfall will discharge heated water ten to fourteen feet below the river surface at such an exit velocity as to allow sufficient mixing of the heated water with the river water so that the surface temperature of the water will meet criteria established by New York State. It is expected that for full flow conditions the cooling water temperature will be raised approximately 16°F during its passage through the plant. Figures 16 and 17 show the general arrangement of the Unit No. 3 intake structure.

The cooling water intake of Unit No. 1 has experienced problems with fish being impinged on the screens from time to time since it went into full operation in 1963.

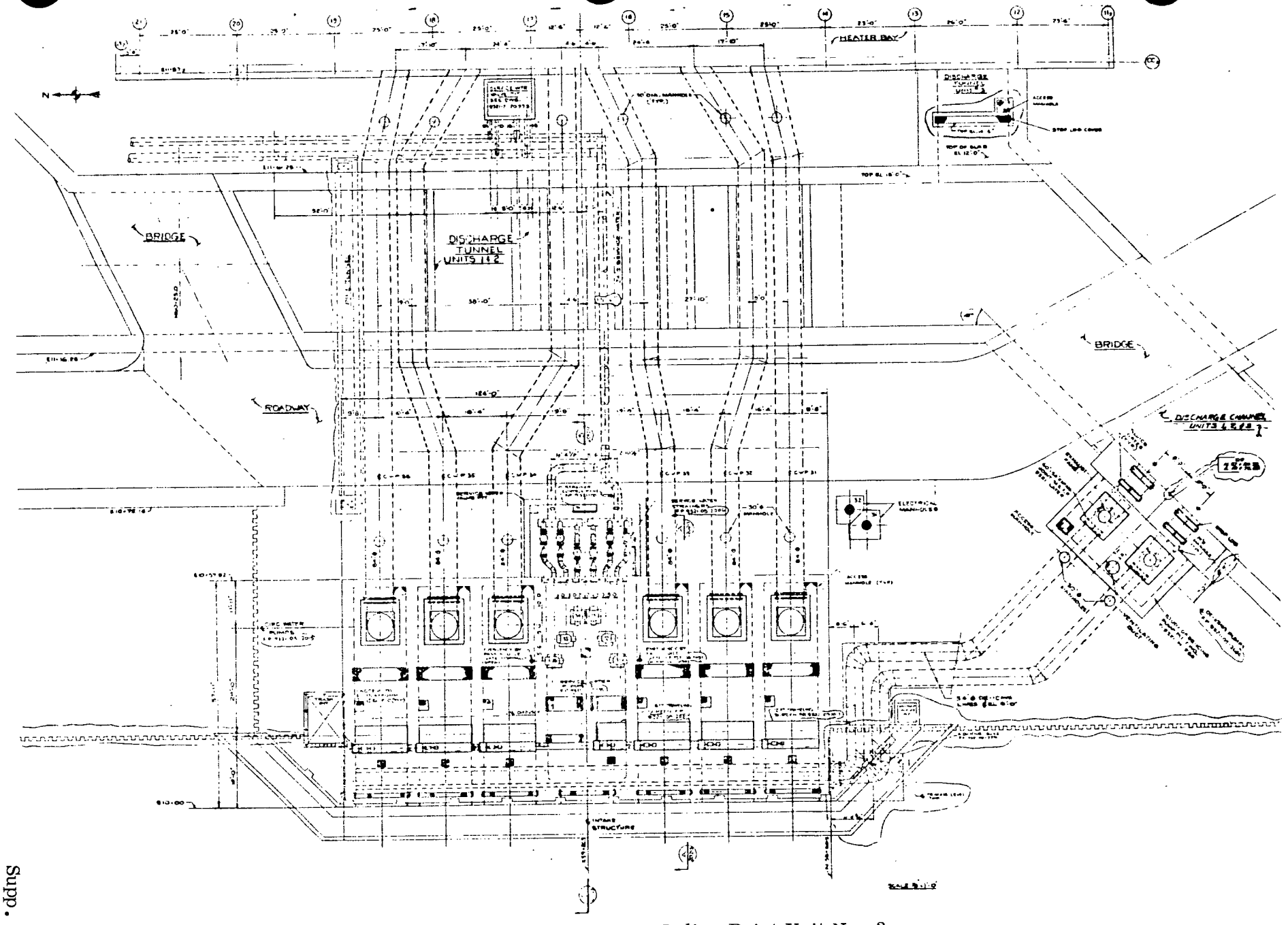


Figure - 16 Intake structure - Indian Point Unit No. 3

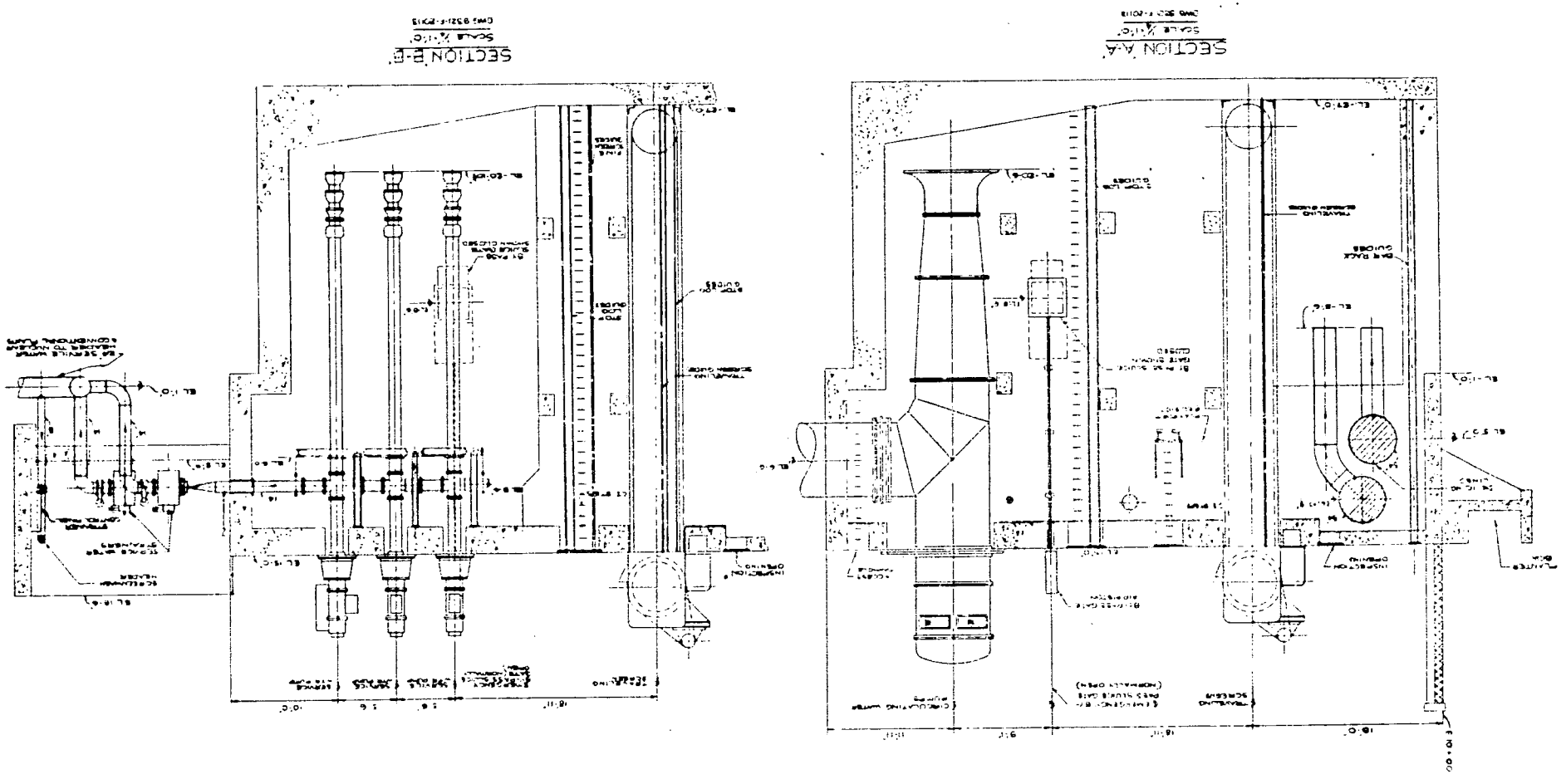


Figure - 17 Cross section through intake structure - Indian Point Unit No. 3

Much effort has been expended both to determine why the problem exists and to solve it by design modifications. Investigations indicate that chemical and radioactive discharges from the plant are not contributing factors in harming fish, nor are thermal discharges. The intake structure of Unit No. 1 has been modified a number of times to improve the protective devices and enable fish to avoid the intake more easily. Because it was felt that warm water from the Unit No. 1 discharge might have been attracting the fish, the outfall was moved downstream on two occasions so that the closest discharge point is now more than 1000 feet from the centerline of the Unit No. 1 intake, 1250 feet from the centerline of the Unit No. 2 intake, and 572 feet from the centerline of the Unit No. 3 intake.

Several modifications to the Unit No. 3 Circulating Water System design are presently being considered in order to protect fish. Besides providing openings in the bottom part of the channel walls as already explained, Con Edison is presently in the process of incorporating a recirculation cross-header to the existing circulating pumps of Unit No. 3. The water recirculation scheme is designed to reduce the water flow through the condenser and thus reduce the magnitude of the intake velocity at the trash bar racks. Preliminary engineering design and associated research and development are in progress.

Reducing the flow of condenser cooling water will increase the temperature rise of the condenser cooling water. For example, a 40% recirculation of condenser cooling water would cause a 26.1°F temperature rise of the 534,000 gpm cooling water (504,000 gpm condenser cooling water and 30,000 gpm service water). However, since the above measures would be used only in the colder months of the year, (river temperatures less than 50°F) plant discharges will continue to comply with the thermal criteria of New York State.

As a long term solution in the area of fish protection for Unit No. 3, as well as for the other units at Indian Point, Con Edison engineers are considering new intake water concepts. This would include a new screen structure built farther out from the shore (75' - 100') and thus further into the main longitudinal flow of the river. The structure would screen water for all three units at Indian Point and would be designed to permit intake velocities below 0.5 feet per second during the colder parts of the year. The attached sketch (Figure 18) shows a plan of the proposal. Its main advantages are believed to be that it will (1) minimize recirculation effects to the intake from the discharge outfall which

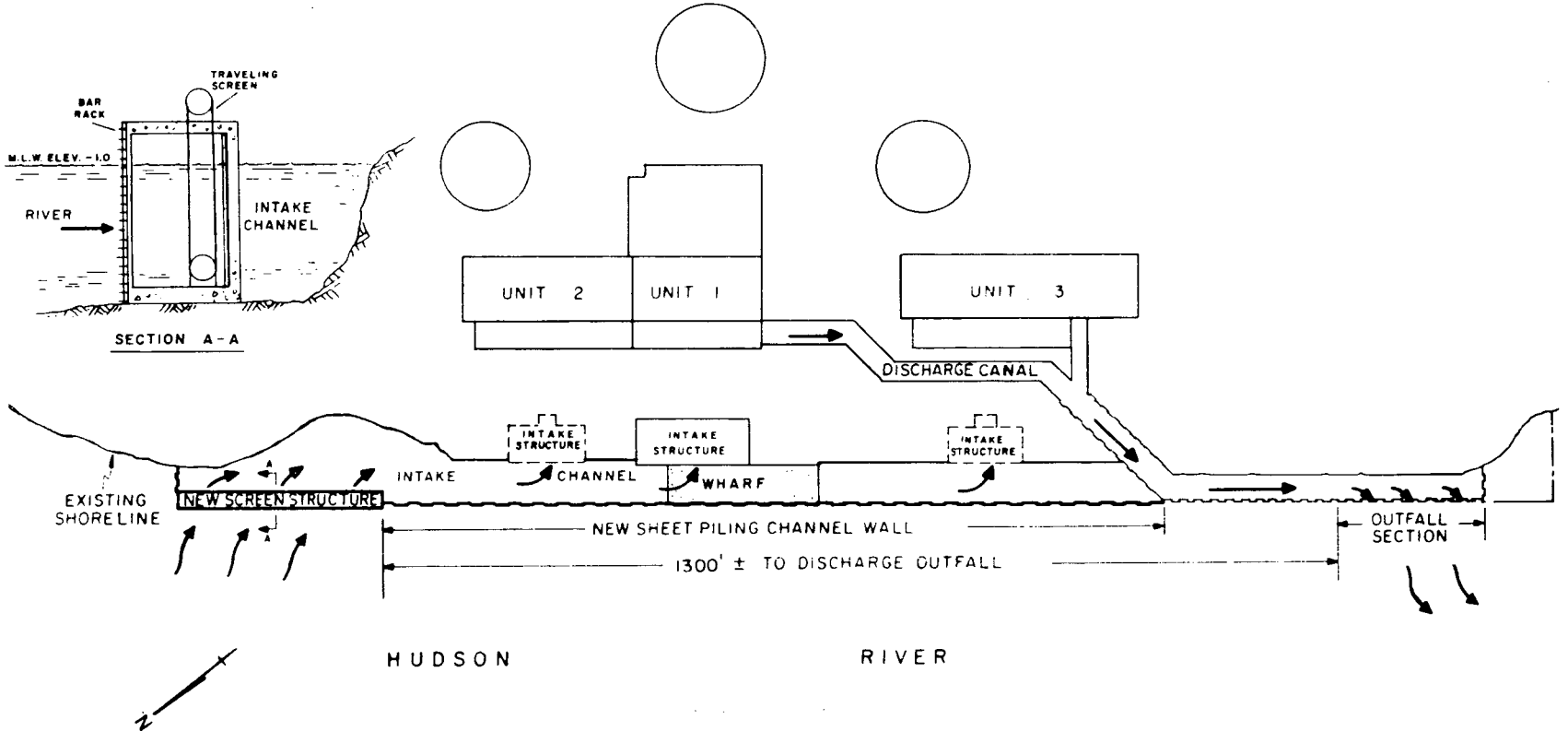


Figure - 18 New intake proposal - Indian Point station

is a possible attraction mechanism, (2) deny access under the unloading wharf to fish, thereby eliminating the probability that the wharf is acting as an attraction, (3) place the traveling screens out where the river's stronger currents can longitudinally wash the face of the screens, (4) achieve low intake velocities and (5) provide other operational benefits not directly related to fish protection such as greater unit efficiency with reduced recirculation, and removal of the existing eddying conditions which lead to greater accumulation of river debris in front of the individual units.

Engineering design and associated research and development have already begun on this project. The total cost of this project is estimated at $18,000,000.00.

Con Edison recognizes that regardless of the anticipated effectiveness of a fish protection system, the possibility exists that further improvement might be deemed desirable. As a result, in addition to considering the design modifications mentioned above, the company is engaged in a broad program of ecological and engineering studies in the area of fish protection. Results of this program, discussed later in this report, will be utilized with further work on this project.

9.2 Cooling Water Outfall

The combined cooling water flow from all three nuclear units (about 2,058,000 gpm including service water) will be discharged into the Hudson River utilizing the outfall structure designed with the aid of the modeling study discussed later herein.

The actual outfall structure is approximately 270 ft. long. Heated water will be discharged through twelve (12) ports, 4 ft. high by 15 ft. wide, spaced 21 ft. apart (center to center). The entire structure of ports is itself submerged to a depth of 12 ft. (center to surface) at mean low water. The ports described above will be equipped with adjustable gates such that the discharge velocity through each port can be maintained at 10 fps for any combination of units in operation and river flow conditions.

9.3 Spatial and Temporal Characteristics of Thermal Discharges

Any thermal discharge to a tidal estuary will be distributed throughout the estuary. Factors affecting this distribution include tidal amplitude and current, river geometry, salinity distribution, and fresh water discharge as well as the prevailing meterological conditions. Quirk, Lawler and Matusky Engineers (QL&M), and Alden Research Laboratories (Alden) have made extensive studies of the influence of these factors and have assisted Con Edison in the study of the transport of discharges in the river. Detailed descriptions of and results obtained from the QL&M Mathematical models and the Alden physical, hydro-thermal models are presented as follows:

9.3.1 Summary of Findings

The thermal plume characteristics of simultaneous operation of the three Indian Point Units, five Lovett and two Bowline Units are analyzed. The design parameters of the study are presented in Table 9-1.

I. The significant findings from a preliminary mathematical model study are as follows:

1. The significance of density induced circulation on Thermal Plume is established. Supported with field observations, the minimum river flow available for dilution at Indian Point is estimated to be a fresh water flow of 20,800 cfs for which the salt, carried by upstream moving seawater, just reaches Indian Point. Freshwater flow higher or lower than this value provides more dilution of heat rejected into the river due to contribution of more river runoff or density-induced circulation, respectively.

2. The most critical hydrological and meterological conditions which could result in a maximum thermal severity are identified. Thermal effects corresponding to four hypothetical combinations of hydrological and meterological conditions are studied. The four sets of conditions are:

a. Severe drought flow occurring during periods of low heat transfer rates.

b. Critical low freshwater flow, summer conditions.

c. Non-summer conditions characterized by absence of ocean-derived salt at Indian Point and low heat transfer rates.

d. Incipient salt flow conditions of 20,800 cfs occurring during certain winter months characterized by a low heat transfer coefficient of 90 Btu/sq.ft./day/°F. The last set of

TABLE 9-1

PARAMETERS OF THERMAL PLUME STUDY

	Indian Point (3)					
I. Power Plants Operating Conditions	1	2	3	3 Units	Lovett (5)	Bowline (2)
1. Rated Capacity, MWe	265	873	965	2103	503.5	1200
2. Heat Load, BBtu/hr	1.915	6.350	6.950	15.215	2.38	5.17
3. Condenser Water Flow, 1000 gpm	280	840	840	1960	323	768
4. Service Water Flow, 1,000 gpm	38	30	30	98	--	--
5. Total Circulating Water Flow, 1,000 gpm	318	870	870	2058	232	768
6. Cooling Water Temperature Rise, °F (through condenser)	12.0	14.6	16.0	14.8	14.8	13.8

II. Hydrological & Meterological Conditions

1. Fresh Water Run off, 4,000—20,800 cfs
2. Heat Transfer Coefficient 90—140 Btu/sq.ft./day°F
3. Indian Point Discharge Velocity, 10 fps
4. Bowline Discharge Velocity, 15 fps

conditions (item (d) above) has been identified as the most critical conditions which could result in a maximum thermal severity with respect to the New York State Thermal Discharge Criteria. An exception is the maximum surface temperature in the vicinity of the discharge, which will reach the highest value during the critical summer conditions when the river ambient temperature can occasionally reach 79°F.*

3. The maximum thermal severity at Indian Point is found to be marginal to, but not contravene, the New York State Thermal Discharge Criteria. The tabulation below shows percentage of cross-sectional area and surface width expected to experience temperature rises equal to or greater than 4°F above naturally occurring river ambient temperature for the critical tidal phase, during the most critical conditions described in item d. The values of the maximum surface temperature rise, and the hypothetical maximum surface temperature, corresponding to the expected highest river ambient temperature of 79°F, are also shown in the tabulation.

Two different models were employed to calculate the values in the aforementioned table. The Constant Parameter model gave identical results to the Four-Segment Model at the Indian Point plane of discharge. However, at Lovett the former gave a value of 43% for the per cent of surface width bounded by the 4°F isotherm, while the latter gave 90% for the same condition.

4. The presence of thermal stratification near Indian Point indicates that the Indian Point thermal plume behavior could be further improved by modifying the existing outfall structure. The ratio of the predicted surface average temperature rise to the predicted cross-sectional area average temperature rise at the plane of discharge of Indian Point ranges from 1.5 to 2. For a well mixed river body, this temperature or "Thermal Stratification Factor" (TSF) approaches unity. The estimated range reported above reveals that steep temperature

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*This value was obtained from temperature measurements on the intake cooling water of the Lovett Plant. Available temperature measurements over a ten year period from 1956 through 1965 show that the 79°F monthly average cooling water intake temperature is reached only once in eight years. Although these temperature measurements may be about two degrees higher than ambient because of recirculation of effluent cooling water, they represent the most extensive survey of ambient river temperature for the Indian Point-Lovett area. (QL&M, "Supplemental Study of Effect of Submerged Discharge of Indian Point Cooling Water on Hudson River Temperature Distribution", May 1972 [Appendix - EE]).

INDIAN POINT PLANT THERMAL EFFECTS PREDICTED BY MATHEMATICAL MODEL‡

Parameter	At plane of discharge	At the worst cross-sectional area**	NYSDEC Criteria
% of area bounded by 4°F	40		50
Portion of surface width bounded by 4°F	2/3	$\frac{2}{5} - \frac{9}{10}$	2/3
Maximum surface temperature rise, F	9-10	—	—
Maximum surface temperature*, F	88-89	—	90

‡Quirk, Lawler & Matusky Engineers; Effect of Three Unit Operation at Indian Point on Hudson River Temperature Distrubution, October 1972. (Appendix - DD)
*the calculation is based on a river temperature of 79°F.
**the worst cross-sectional area is identical with the plane of discharge of the Lovett units.

gradients may exist at Indian Point and that the thermal effect of discharge water on the river could be reduced by using a more effective discharge system, such as a submerge thermal diffuser.

II. The significant findings from the physical hydro-thermal model study are as follows:

1. Experimental results of tests simulating the critical hydrological condition are found to be not totally compatible with the New York State Thermal Discharge Criteria. As summarized in the following table, the results of hydraulic modelling for critical tidal phases indicate some difficulty in operating within the limits of State criteria. These are preliminary results on the extended Model III Model (see section 9.3.3).

2. The hydraulic model results indicate that a great degree of thermal stratification can exist near Indian Point. The "Thermal Stratification Factor" defined previously is estimated to range from 1.75 to 2.

INDIAN POINT PLANT THERMAL EFFECTS
PREDICTED BY PHYSICAL MODEL‡

Parameter	At plane of discharge	At the worst cross-sectional area**	NYSDEC Criteria
% of area bounded by 4°F	27	40	50
Portion of surface width bounded by 4°F	3/3	3/3	2/3
Maximum surface temperature rise, F	9-11	—	—
Maximum surface temperature, F*	88-89	—	90

‡Communication from Alden Research Laboratories to Consolidated Edison; "Indian Point No. 3 Extended Model - Three Unit Tests," November 1, 1972 (Appendix - DD).
*the calculation is based on a river temperature of 79°F
**the worst cross-sectional area is the plane of discharge of Lovett units.

III. Concluding Remarks

1. The temperature distrubutions predicted by the QL&M mathematical model and the Alden physical model appear to be not in complete agreement. These findings suggest the complexity of developing a model perfectly representing the prototype. Scarcity of field data available makes the modeling difficult.

Con Edison is in the process of formulating an elaborate thermal plume study program for Indian Point Unit No. 2. The program consists of temperature measurements at both near field and far field, hydrological and meterological data measurements, and comparisons of field data with model predictions. This program would enable us to predict more accurately the thermal plume characteristics during simultaneous operation of all Indian Point units.

The above-presented mathematical model predictions were estimated using previously developed models and are based upon a number of assumptions. These assumptions are derived from available observations and hydraulic model studies. However, lack of significant heat quantities in existing Hudson River discharges and in comprehensive hydrodynamic measurements made the selection of certain system parameters extremely difficult.

Most of these assumptions are related to overall dilution with ambient water in the vicinity of Indian Point and performance of the existing submerged discharge outfall. In particular, the mathematical model study assumed:

- existence of at least 20,800 cfs dilution flow in the vicinity of Indian Point
- the present outfall design is capable of attaining an initial dilution ratio of 2 to 1, effecting a thermal stratification factor on the order of 1.5 to 2.0 and a far field intratidal behavior similar to existing Hudson River discharges.

The planned field surveys will be directed at providing information to confirm these assumptions.

2. The great degree of thermal stratification predicted by the model studies is being analyzed. The feasibility of developing a more effective effluent discharge scheme, such as a submerged thermal diffuser, will be explored. This stems from the fact that with a Hudson River dilution flow on the order of 20,000 cfs, three unit rated capacity operation at Indian Point would yield an overall temperature rise of abour 3°F. In other words, on the basis of the thermal assimilation capacity of the Hudson River, compliance with the controlling thermal discharge criteria can be achieved via a properly designed outfall. The degree of vertical temperature stratification will be affected by using a submerged outfall diffuser. Con Edison is presently participating in the evaluation of the submerged diffuser installed for the Bowline plant.

3. The preliminary results from the physical hydro-thermal model indicate potential difficulties in meeting New York State Criteria with the operation of the current once through cooling arrangement for all three I.P. nuclear units, coincident with the operations of Bowline Units 1 and 2, and Lovett Units No. 1 through 5. Further analyses are being made and it is expected that these results, in conjunction with field surveys, will be employed to evaluate the efficiency of and possibilities for modifying the present I.P. outlet design. It is the intention of Con Edison to operate the Indian Point facility so that the addition of the Indian Point thermal discharge to the existing Lovett and Bowline discharges will not create a violation of State thermal criteria.

4. A preliminary study on alternate cooling systems, including the use of either natural-draft cooling tower, mechanical-draft cooling tower, or spray pond, has been completed. If it is concluded that a cooling system other than the existing once-through system should be used, the study will aid in selection of the alternative system and its design optimization.

9.3.2 Mathematical Models

I. Heat Dissipation Model

Hudson River salinity dispersion studies have been conducted by Quirk, Lawler, & Matusky Engineers for Con Edison since 1965. These studies have included the construction of a mathematical model to predict temperature distributions at various tidal and salinity conditions, for the Indian Point thermal effluent. Northeastern Biologists, Inc., obtained field data used in the development of a mathematical model, performing temperature distribution measurements of the Hudson River in July 1966 and April, 1967. Measurements were taken at different tidal cycles while Indian Point Unit No. 1 was in operation.

This resulted in a QL&M report "Effect on Indian Point Cooling Water Discharge on Hudson River Temperature Distribution", dated January, 1968 (see Appendix - I). In this report the expected capacity operation of all three units at Indian Point was assumed to result in a temperature rise of 16.4°F in a total of 2,040,000 gpm cooling water flow. These values were rounded to 17°F and 2,100,000 gpm for the conservative calculations, which yielded a total heat load of 430-x 10^9 Btu/day.

Mathematical analyses were developed to estimate the expected cross-sectional area average temperature rise along the longitudinal axis of the river and the departure from this average at any point within the cross-section.

The temperature distribution across the river cross-section was represented by two different mathematical expressions. These are "the exponential decay model" and "the reciprocal decay model." The "exponential decay model" represents temperature as an exponentially decreasing function of river cross-sectional area. The "reciprocal decay model" represents temperature as being approximately inversely proportional to cross-sectional river area. These analyses yielded computed temperatures which were higher than field temperature measurements made while Indian Point Unit No. 1 was operating.

At the time these models were derived, the New York State thermal criteria proposed the dividing of the river's cross-section at any point along its length into a mixing zone and a passage zone. The mixing zone allowed dilution of the heated effluent with cooler water. No specific constraints were affixed to this zone except that it should not exceed 50% of the total cross-sectional area. The remaining portion of the cross-section is called the "passage zone," which provides a passageway for migratory fish and other aquatic life. The criteria for this zone included a maximum temperature of 80°F. The results computed by the two models are summarized as follows:

Non Summer Condition	Exponential Decay	Reciprocal Decay
Maximum Area, $\Delta T = 4°F$	30%	25%
Maximum ΔT, at 50% Cross-Sectional Area	1.5%	2.3°F
Summer Conditions		
Maximum Area, $\Delta T = 1.5°F$	44%	64%
Maximum ΔT, at 50% Cross-Sectional Area	1.1°F	1.9°F

The effect of the expected river temperature rise on river dissolved oxygen concentration was evaluated, and was not expected to cause any significant changes in the dissolved oxygen content of the water as it passes through the plant.*

In August 1969, criteria governing thermal discharges were adopted effective immediately. The new regulations, discussed later in this report, differed from the criteria which had been proposed, and necessitated additional analyses by QL&M. In particular, the criteria on water surface temperature required replacement of the planned surface discharge by a submerged outfall. A revised QL&M report, dated February, 1969, reflected the changed circumstances and is also appended hereto (see Appendix - J). The revised report incorporated the work of Texas Instruments, Inc., which conducted airborne infrared temperature

*QL&M, "Effect of Indian Point Plant on Hudson River Dissolved Oxygen," Feb. 72.

surveys of the Hudson River in the Indian Point vicinity in October, 1967 and April, 1968. The surveys were undertaken to collect data for compilation of isothermal maps of the river surface.

The revised QL&M report adjusted the mathematical model by reducing the heat load to 79% of the value used in prior calculations. Previously, the heat load used was 6% higher than that associated with the maximum possible three unit electrical output of 2351 MW. Planned operation and the initial AEC licensed power loads, however, are 90% of this value or 2114 MW. These corrections lead to a design heat load of 345 x 10^9 Btu/day.

The circulating water flow was 2,052,000 gpm. The three unit effluent channel temperature rise for initial power levels becomes 14°F, rather than the 17°F previously used.

Comparison of the values predicted by the unadjusted mathematical model for Unit No. 1 behavior with the field measurements are presented below:

	Area - Average Temperature Rise, °F			
	July 1966		April 1967	
Location	Measured	Predicted	Measured	Predicted
Across Plane of Discharge	0.20	0.25	0.09	0.17
Across Plane 800 Ft. Below Discharge	0.14	0.24	0.08	0.17

The mathematical model was then adjusted to yield the observed values when operating at the Unit No. 1 heat load. The adjusted model showed that the area average temperature rise across the plane of discharge is between 50% and 75% of the values previously predicted. Also, temperature decay above and below the plane of discharge becomes much more rapid, resulting in a substantial reduction of the extent of temperature rises greater than 1°F (this improved dilution and dispersion was attributed to salinity-induced circulation in the estuary). Results obtained from operation of the Indian Point Hydraulic Model II at the Alden Research Laboratories* were employed to check and confirm the rapid heat dispersion as predicted by the adjusted mathematical model.

*This refers to undistorted Outfall Model discussed later herein

Summer conditions are supposed by the State to constitute the critical biological conditions. These consisted of a sustained six month drought flow of about 4,000 cfs which occurred in the latter half of 1964, and a heat transfer coefficient of 135 Btu/sq ft/day/°F. The predicted results using the adjusted mathematical model are presented below as well as those for conditions of maximum severity, combining a record drought flow 4000 cfs and a low (late fall-winter) heat transfer coefficient of 90 Btu/sq.ft/day°F:

	%Area Bounded by 4°F Isotherm		Portion of Surface Width Bounded by 4°F Isotherm	
	Criterion	Prediction	Criterion	Prediction
Maximum Severity	50	26	2/3	1/2
Critical Summer	50	21	2/3	1/3

The percentage of the surface width bounded by other isotherms at various distances above and below Indian Point were also computed using the adjusted model. The results show that temperature rises greater than 1°F are limited to the vicinity of Indian Point.

II. Submerged Discharge Model

The studies indicated that the criterion of a maximum surface temperature of 90°F at any point could not be met with a surface discharge. Hydraulic model studies conducted by Alden Research Laboratories showed that the 14°F effluent channel temperature rise can be reduced markedly, before reaching the river's surface, by discharging the cooling water through a submerged discharge. Model studies showed that submerged rectangular ports located along the West wall of the discharge canal would yield maximum surface temperature lower than the 90°F criterion.

In October 1969, QL&M prepared for Con Edison a report on "Effect of Submerged Discharge of Indian Point Cooling Water on Hudson River Temperature Distribution" (see Appendix L). This study consisted of the development of a mathematical model in three stages. The first stage was the mathematical development based on a consideration of the fluid mechanics of submerged jets. Secondly, a comparison was made between the

theoretical model observations of actual submerged jet behavior both in the Alden model* and in the Hudson River. The final section of the report is a prediction of effluent behavior at Indian Point.

The mathematical model consists of a set of twelve simultaneous equations. It incorporates the effect of plant intake temperature, density and salinity; plant outfall temperature, density, salinity and flow; outfall geometry including port size, shape, edging, orientation, and submergence; and linear velocity (both runoff and tidal), tidal phase, and ambient temperature, density, and salinity.

The major assumptions made in the development of this model are that initial jet momentum, induced buoyancy, and entrained river flow and momentum are the controlling mechanisms and the drag force and river boundaries, such as the river's bank, surface and bottom, can be neglected.

The computed results agree in general with measurements made in the undistorted hydraulic Outfall Model, and with measurements taken in the river in the vicinity of the submerged outfall of Orange & Rockland Utilities Lovett Unit No. 4.

Computed results for a condition of river ambient temperature of 79°F and a condenser rise of 17°F, showed that the surface temperature can be expected to rise 9°F. The surface area bounded by the 4°F isotherms, and the lateral distance from the shore, bounded by this isotherm, compare very well with values given for these parameters in QL&M's report of February, 1969, and previously presented in this report.

These results and recent investigation conducted in connection with Indian Point Unit 2 hearing preparation [x,+] showed that the submerged discharge would meet New York State Thermal Discharge Criteria. The proposed outfall structure for the combined discharges from Indian Point Units Nos. 1, 2 and 3 will consist of twelve 4' x 15' ports, spaced on 21 ft. centers, submerged 12 feet below the water's surface, and discharging at 10 ft/sec normal to the river's longitudinal axis.

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*This refers to undistorted Outfall Model discussed later herein.

x QL&M "Supplemented Study of Effect of Submerged Discharge of Indian Point Cooling Water on Hudson River Temperature Distribution", May 1972 (Appendix - EE)

+ "Testimony of John P. Lawler on the Effect of Indian Point Units 1 & 2 Cooling Water Discharge on Hudson River Temperature Distribution", April 5, 1972 (Appendix - EE)

Additional refinements and investigations on the submerged discharge model were done by QL&M in May 1972[x] to answer questions raised by U.S. Atomic Energy Commission personnel. These questions were presented in the AEC Draft Detailed Statement Unit No. 2.

The refinements included (a) calculation of entrainment coefficients corresponding to the slopes of jet boundaries used in QL&M mathematical model, (b) sensitivity analysis of the model results to the choice of the model parameters, (c) comparison of the model results for rectangular and circular jets and (d) refinements of the temperature distribution over a jet cross-section.

III. Net Non-Tidal Effect Study

QLM made an additional study which was reported in a document entitled "Influence of Hudson River Net Non-Tidal Flow on Temperature Distribution" and dated October, 1969, (see Appendix - M) in order to provide additional support for the mathematical model, and to confirm the existence of the salinity-induced circulation in the estuary. The report shows that this salinity-induced circulation results in different speeds and times of tidal reversals nearer the river's bottom than in its surface layer.

Analysis of salinity and current measurements showed that over a tidal cycle there is a net upstream movement of sea water in the lower layers and a net downstream movement of fresher water in the upper layers of the Lower Hudson River. The surface of no net motion which separates the two layers usually occurs above mid-depth. These net movements are induced by density differences which exist on account of the vertical and longitudinal distribution of salinity. Such movements exist mainly in the saline portion of the estuary. This effect is called the net-tidal flow or density-induced circulation.

In order to obtain information to refine the mathematical model reported by QLM and to provide data to check the tidal hydraulics of Model III at Alden, further work was undertaken. On October 1 and 7, 1969, field surveys were carried out by Alden Research laboratories to collect additional information on water velocities during ebb and flood conditions in the upstream portion of Haverstraw Bay. At the same time, the Raytheon Company took temperature and salinity measurements. The Alden study was aided by the use of aerial photography carried out by Lookwood Kessler and Bartlett, Inc.

x QL&M "Supplemented Study of Effect of Submerged Discharge of Indian Point Cooling Water on Hudson River Temperature Distribution", May 1972 (Appendix - EE).

When flood tide conditions were surveyed on October 1, 1969, two interesting phenomena were observed. The turn of the tide from ebb to flood occurred about one half to three quarters of an hour earlier along the west bank of the river than at mid-river. It was also found that at mid-river, the bottom water turned approximately one hour earlier than the surface water.

Salinity measurements taken later in the day showed that there was no significant density gradient. The salinity varied between 4 and 6 parts per thousand. The specific weight with these conditions was between 62.5 and 62.6 lbs, slightly higher than fresh water. During this survey, the water temperature was essentially constant over the depth, at about 70 F. The difference in turning time, therefore, seems to be attributable to momentum differences between the fast-moving mid-channel surface water and the slower moving bottom and bank waters. The maximum flood velocity at the down river section was approximately 1.5 fps and a slightly higher velocity of 1.8 fps was measured at the Grassy Point section where the river narrows.

When ebb conditions were surveyed on October on October 7, 1969, results showed that the bottom current turned from flood to ebb approximately one hour later than the surface current. This behavior was the opposite of that found with the river turning from ebb to flood and indicated that forces other than momentum governed the water motion during this phenomena. Salinity measurements revealed a pronounced density stratification. The specific weight varied between 62.5 and 62.9. The average water temperature was 68°F with insignificant variation.

Recent QLM studies* utilized available Hudson River tidal current and salinity observations to confirm existence of density induced circulation in the Hudson River and to derive a quantitative relation of net non-tidal flow to salinity levels and freshwater runoff.

These studies confirmed that the absolute minimum river flow available for dilution at Indian Point is the freshwater flow value of 20,800 cfs for which the salt just reaches Indian Point.

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*QLM "Environmental Effects of Bowline Generating Station on Hudson River" March 1971. "Testimony of John P. Lawler on the Effect of Indian Point Units 1 and 2 Cooling Water Discharge on Hudson River Temperature Distribution" April 5, 1972. (Appendix - EE)

Analyses of available field measurements showed that when the Lower Hudson fresh water runoff is about 7,300 cfs, there is a seaward flow of about 22,000 cfs at Indian Point in the upper layer, and an upstream flow of some 14,700 cfs in the lower layer.

The net non-tidal flow concept explained the measured area-average temperature rise at Indian Point. The predicted area-average temperature rise at the Indian Point plane of discharge taking into account the net non-tidal flow concept was only 9% less than the the area-average temperature rise measured in July, 1966.

QLM predicted, through their use of the mathematical heat dissipation model written for Con Edison, that the expected heat load would cause an area-average temperature rise of 1.7 F when the fresh water runoff is 7,300 cfs. A maximum value of 3.2 F may occur when the net non-tidal flow effect is weak, and the area-average temperature rise is expected to range between 1.7 F and 3.2 F.

The establishment of the existence of the net non-tidal flow in the Hudson River and the conclusions outlined above gave additional justification and support to the theoretical findings of February, 1969.

9.3.3 Alden Research Laboratories Studies

Alden Research Laboratories has been modeling the hydraulics of effluents from Indian Point since 1964. These models simulate the geometry and hydrodynamics of both the tidal estuary and the thermal discharge. The river topography is modeled in concrete and tidal flow is controlled by synchronized weirs and gate valves at each end of the model. Modeled power plants include orifice flow meters and pumps and all models are enclosed in large sheds with monitored environments. The temperature measurements are made with thermocouple temperature sensors, located at critical locations such as the inlet and outlet sections of the model, and the intakes and discharges of the modeled plants. The sensors also placed in various sections of the model to measure the temperature distribution and flow patterns of the warm water.

Six models have been used to simulate various aspects of the Indian Point thermal discharge. In order of construction these are designed Model I, Model II, Outfall Model, Model III, Enlarged Outfall Model and the extended Model III. The river areas included in

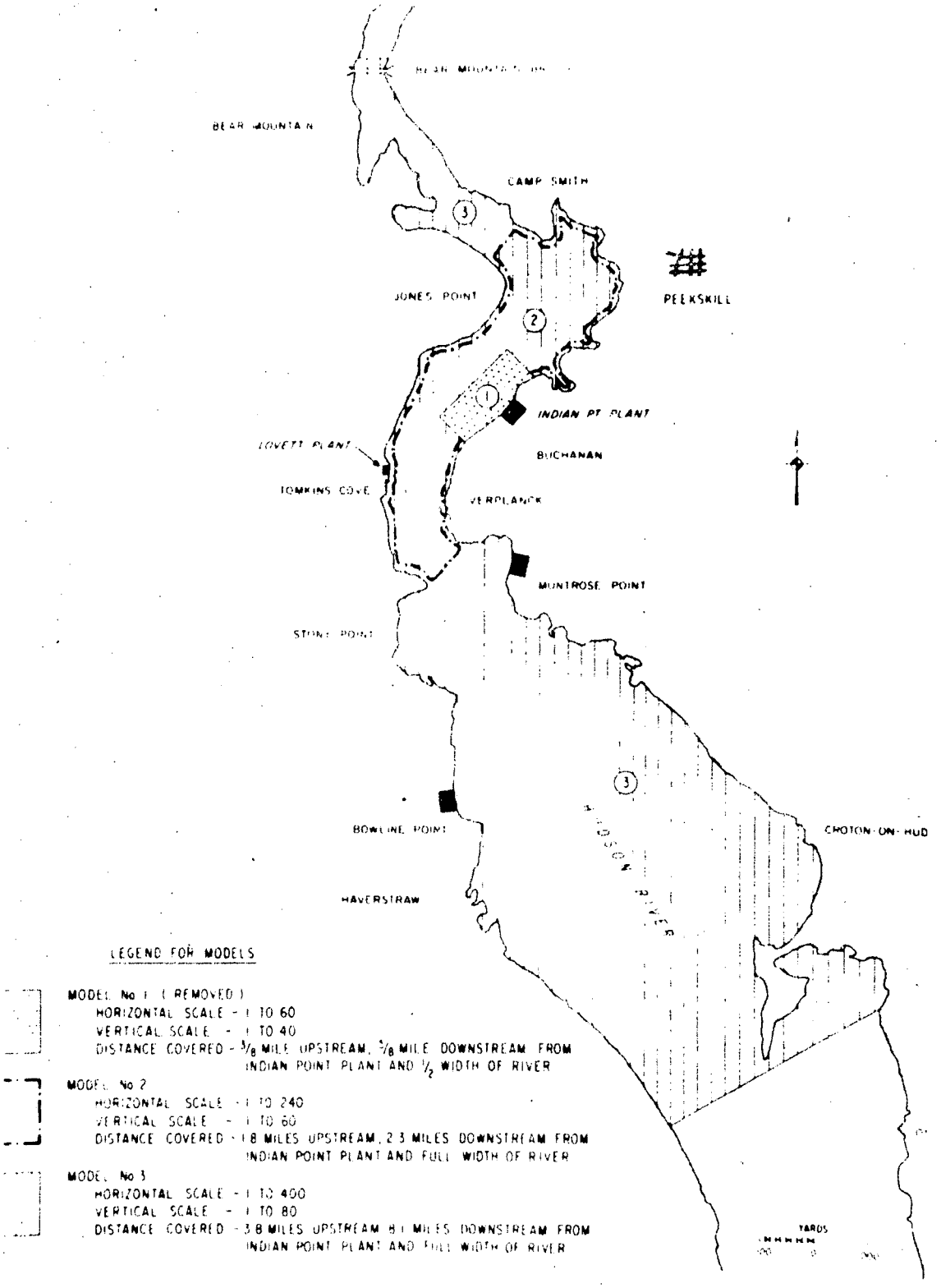
each of Models, I, II and III are shown in Figure 19. The extended Model III is the latest hydraulic model for the far-field thermal plume study. It is a modification of Model III extending the northern boundary of Model III about 2.7 miles further upstream from the Bear Mountain Bridge.

The first model (Model I) was constructed to study the recirculation problems of Indian Point Unit No. 1. This led to a discharge canal design which minimized the recirculation of heated discharge water.

In the winter of 1967-68, a model (Model II) of the Hudson River simulating 9000 feet upstream and downstream of Indian Point was constructed (see Appendix - N). Addition of a third generating unit could not be studied in Model I due to the limited river area reproduced. The layout of Model II which was scaled 1:250 in horizontal dimensions are 1:60 in the vertical, is shown in Figure 20. It was vertically distorted to avoid shallow depths and laminar flow while simulating a significant horizontal extent of the river.

Prior to the initiation of the final testing of this model, the New York State Thermal Criteria was formulated. Because of these criteria, it was necessary to design and construct a submerged discharge to dilute the heated effluents from Indian Point in the river water. In order to optimize this design and provide data to verify the near field thermal plume in Model II, an undistorted scale Outfall Model was constructed at Alden to a scale of 1 to 50. The Outfall Model simulated 900 feet along the east shore and 400 feet of the river's 4,000 foot width.

The plant parameters for which Alden tested outfalls were: (1) the plant flow and temperature rise for three units (Units No. 1, 2 and No. 3 operating at initial licensed power levels, water flow of 2.05 million gpm. 14 F temperature rise), (2) the total dynamic head available from the circulating water pumps, (3) the property line and bulkhead line of Con Edison. During tests on the Outfall Model, the thermal criteria were modified and finalized by the State. The predicted temperature distribution created by plant discharge through the outfall is presented in Figure 21. The tide simulated in the test was 0.4 fps steady ebbing flow. The expected dilution at the point where the plume reaches the surface was shown by this model to be approximately 1:2.



HYDRAULIC MODELS FOR THERMAL DISCHARGE STUDIES
AT ALDEN LABORATORIES, WORCESTER POLYTECHNIC INSTITUTE

Figure - 19 Hydraulic models for thermal discharge studies.

A submerged discharge developed through the studies conducted in the Outfall Model was incorporated into Model II. These studies were conducted with assistance from QLM. Final tests with Model II were conducted with this submerged outfall. These tests simulated two unit and three unit plant operation and indicated that the transient thermal plume would comply with the thermal criteria. The QLM mathematical models reported in February and October 1969 (Appendicws J and L) also supported this conclusion.

Plans for additional power plants in the area indicated that a larger part of the river should be simulated to include effects of the additional plants and to assess the long term accumulation of heat in the river. In order to accomplish this purpose, Model III (shown in Figure 22) was constructed in the spring of 1969. Model scales are 1:400 in the horizontal and 1:80 in the vertical direction. The model simulates the topograph of the river for a distance of over 13 miles. Thermal discharges of all existing and proposed power plants in the area are included and both tidal flow and net river flow are reproduced.

Tides are modeled according to prototype observations which are reported in "Tides and Currents in the Hudson River." Field measurements of velocities at numerous points across the river and at several depths were also made in August of 1968 and in October of 1969. These data are summarized in Alden's February 1970 report, appended hereto (Appendix - O). Drogues were tracked to obtain velocities in both model and prototype, and agreement is shown by typical results in Figures 23 and 24.

In order to simulate effects of a heated discharge on a river's temperature profile, mixing with ambient water and heat transfer to the atmosphere must be evaluated in the model. The initial mixing was simulated based on data from the 1:50 uniformly scaled Outfall Model. However, the distortion of Model III prevents exact modeling of this near-field mixing. The near-field temperatures in Model III were "forced" into the model by adjusting the modeled outfall so that the temperature field was in agreement with that observed in the uniformly scaled outfall model.

Initial mixing of the effluent changes with prototype conditions of tidal velocity, and relative buoyancy. The buoyancy of the effluent depends on the relative density of the effluent compared to the density of ambient river water. This relative density, in turn depends

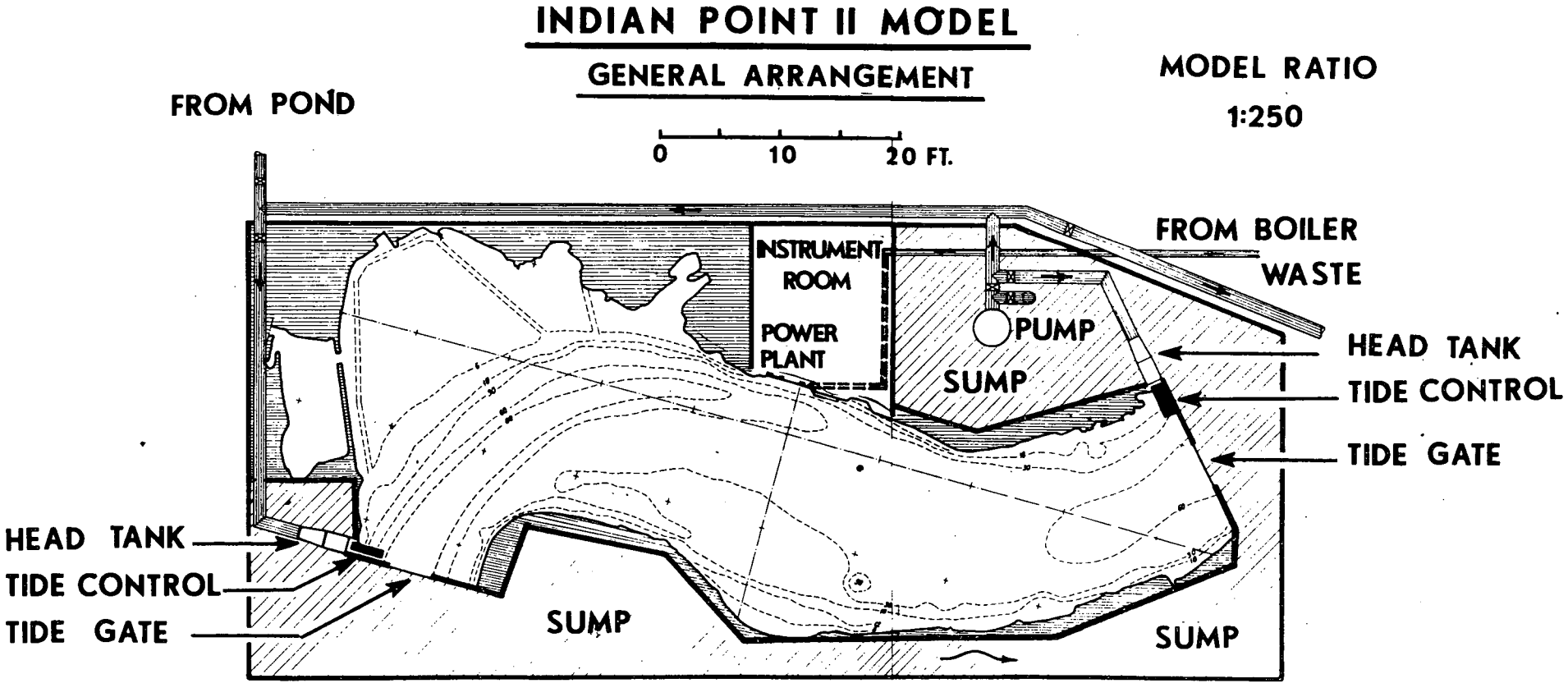


Figure - 20 Indian Point II Model - general arrangement.

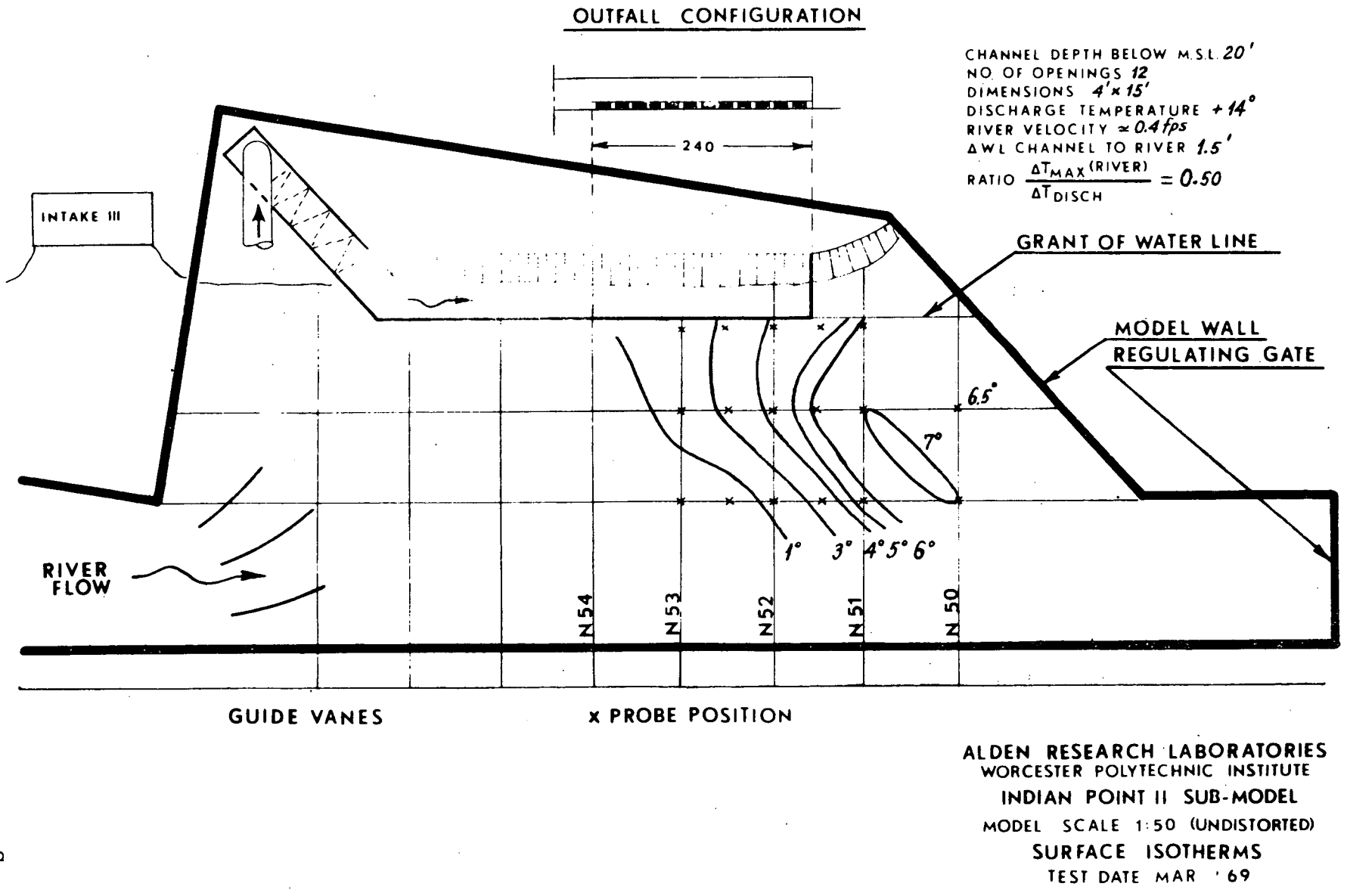


Figure - 21 Indian Point II Sub-Model - surface isotherms.

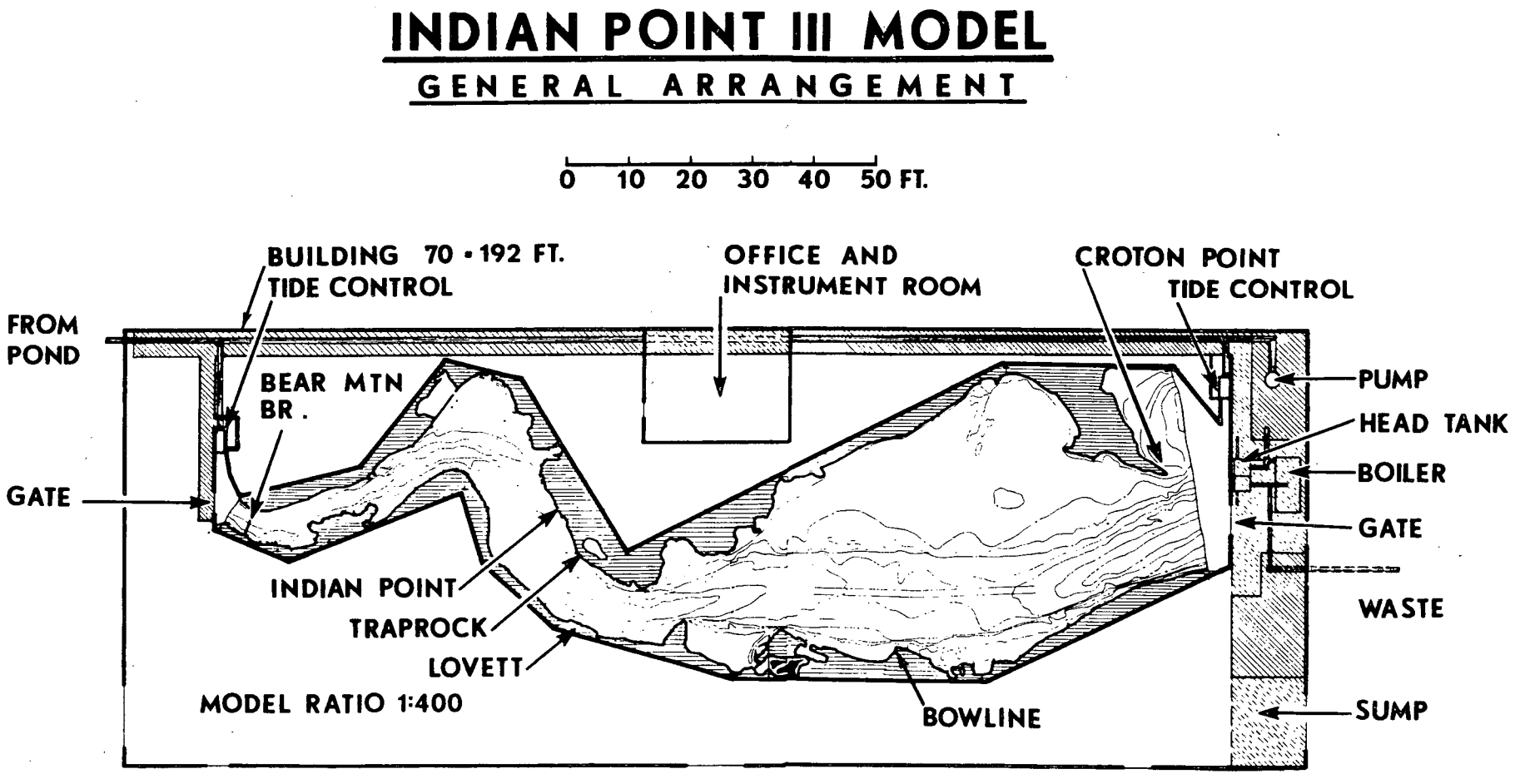


Figure - 22 Indian Point III Model - general arrangement.

primarily on ambient river temperature, since the condenser temperature rise is taken to be fixed.

Typical average freshwater river flow and ambient river flows and ambient river temperatures with the associated relative density changes for several months are shown in the table based on data from Appendix - I. The maximum relative density change and thus maximum buoyancy occurs in summer.

	Feb.	Apr.	June	July	Aug.	Oct.	Dec.
Freshwater River Flow (10^3 cfs)	11	38	11	8	6	9	15
Ambient Temperature (°F)	34	46	69	77	78	63	43
Relative Density Change x 10^4	1	8	20	23	23	17	7

As previously indicated in section 9.3.1, the minimum river flow available for dilution at Indian Point is estimated to be a freshwater flow of 20,800 cfs for which salt, carried by upstream moving seawater, just reaches Indian Point. Freshwater flows higher or lower than this value provide more dilution due to contribution of more river runoff or density-induced circulation respectively. As the above table indicates, 20,800 cfs river runoff occurs in the spring months. However, the most critical model condition is taken as co-incident occurrence of the 20,800 cfs runoff and a maximum relative density change typical of summer conditions. The table shows that this situation is not typical for the river, but such conditions may occur occasionally.

The simulation of heat transfer in a model is difficult since the indoor meteorology over the model is not easily changed, although controllable to constant conditions.* The appropriate scale ratio for the heat transfer coefficient has been developed and indicates that if the heat transfer coefficient over the model is approximately half that expected in the prototype, then the temperatures observed in the model will correctly simulate prototype temperatures. Observations of heat transfer in the model are being gathered. They indicate that the model closely simulates typical August heat transfer conditions near Indian Point.

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*Appendix N.

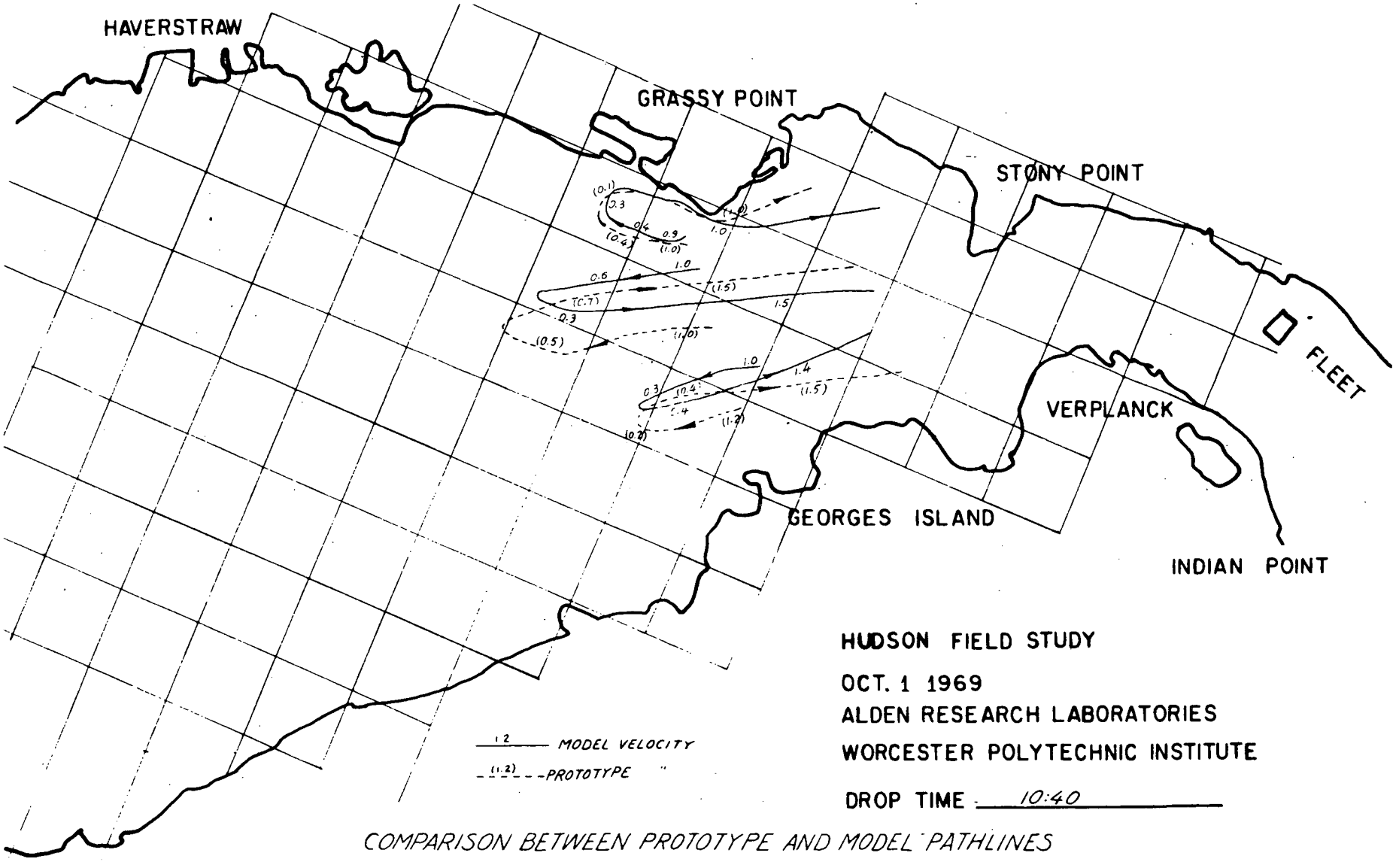

Figure - 23 Comparison between prototype and model pathlines.

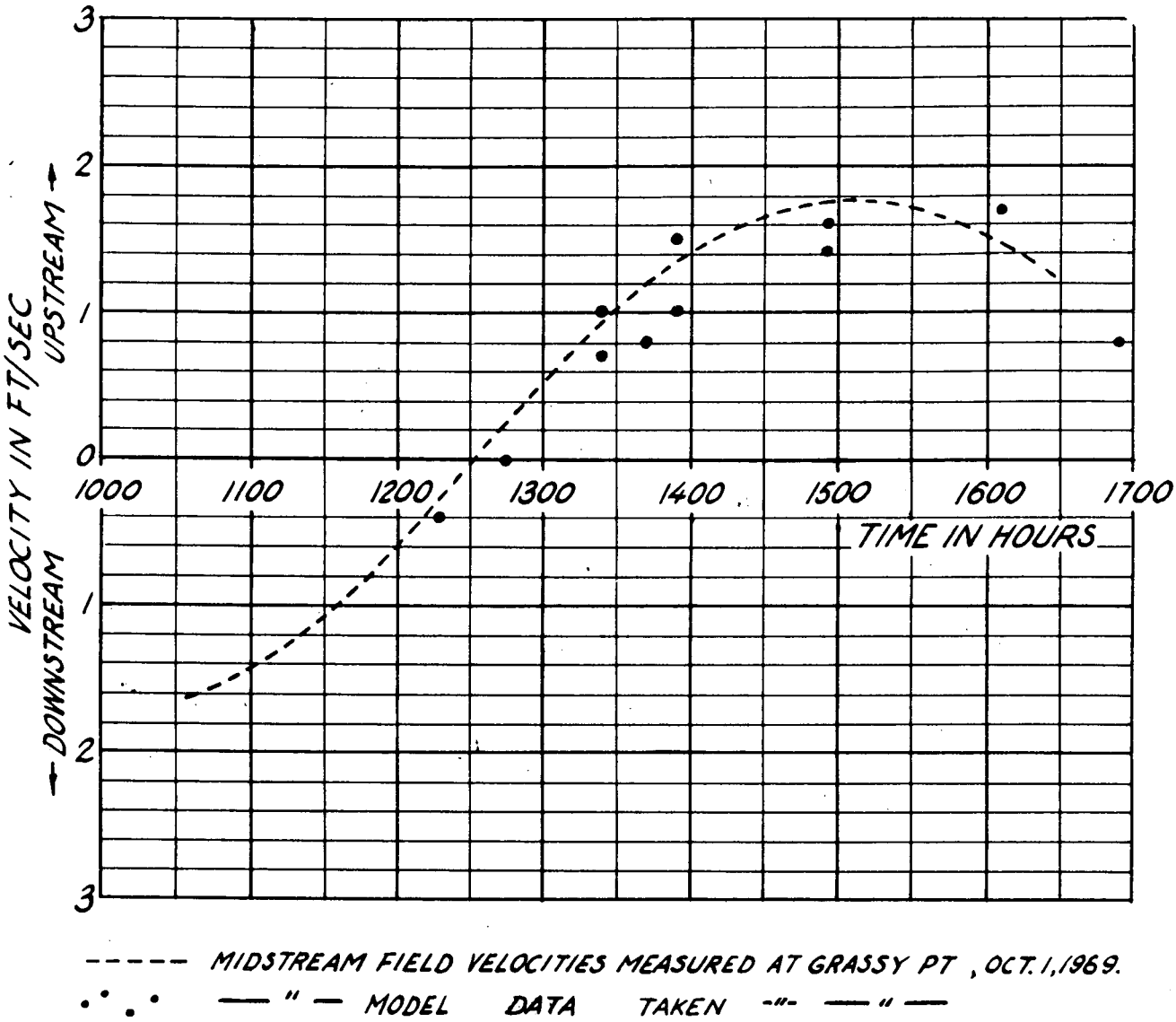

Figure - 24 Comparison of field and model velocities.

Operation of Model III indicated that near field conditions were more critical to results than was the case with Model II and a more accurate calibration of the outfall structures was desirable. The undistorted outfall model was therefore enlarged to minimize boundary effects. Figures 25 and 26 show typical data from the undistorted model which provided near field temperature rises and was used to calibrate the outfall in the enlarged Model III. Preliminary results of Model III also suggested that, in order to study the thermal effect of simultaneous operation of all three I.P. units, together with five Lovett and two Bowline stations, the hydraulic model should cover additional mileage upstream from the Bear Mt. Bridge, which was the northern boundary of Model III.

The Model III was thus modified in early 1972 by extending its northern boundary about 2.7 miles upstream from the Bear Mt. Bridge.

9.4 Thermal Standards and Water Quality Certification

The detailed criteria adopted by the New York State which cover thermal discharges into the Hudson River at Indian Point, classified as "an estuary", are as follows [6 NYCRR 704.1 (b) (4)]:

> "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 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 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 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 detailed criteria effect the water quality standards of New York State. As discussed elsewhere in this report, Con Edison has developed a design for effluent discharge facilities now under construction in order to assure compliance with these criteria.

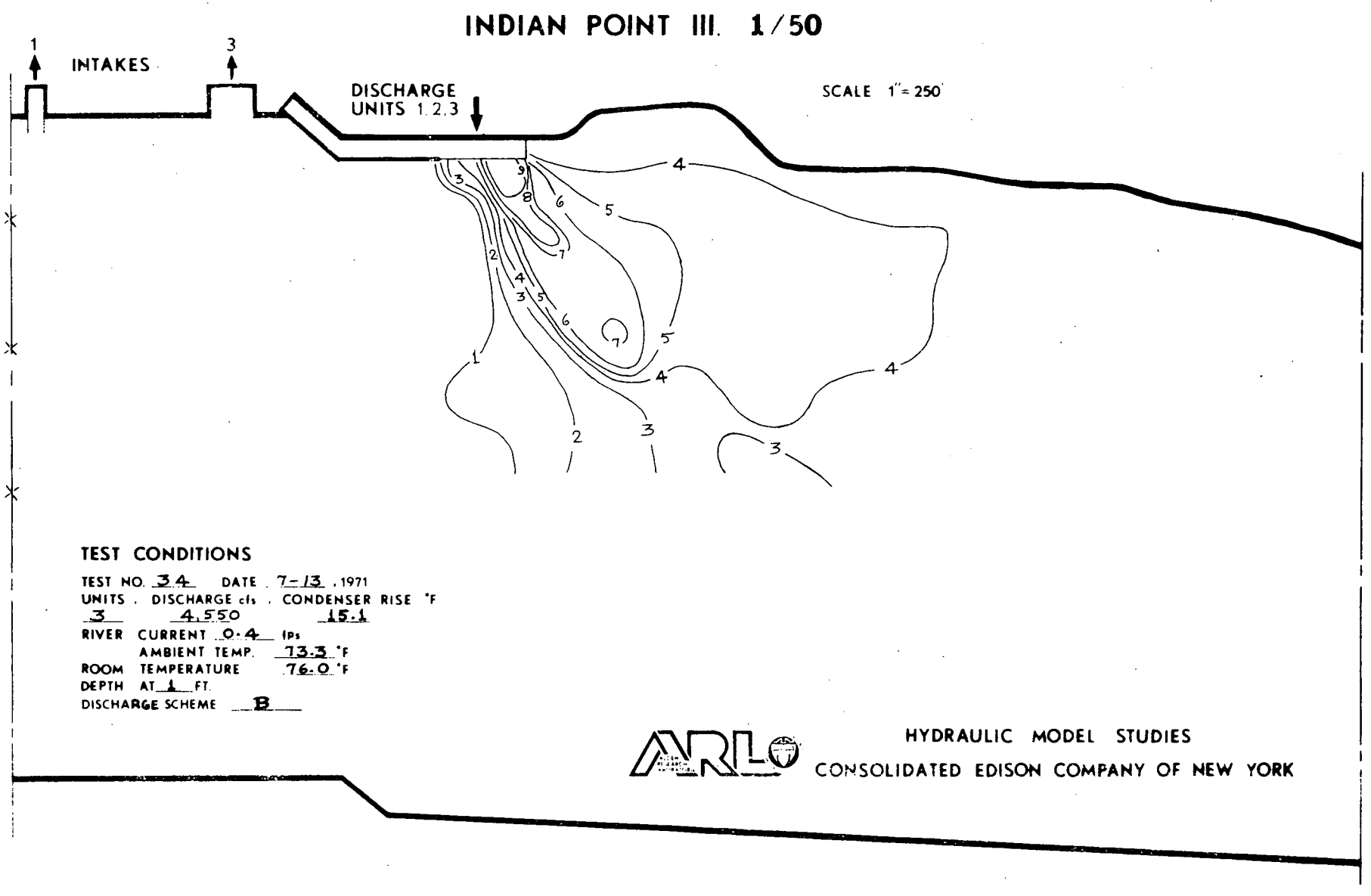

Figure - 25 Near Field Data

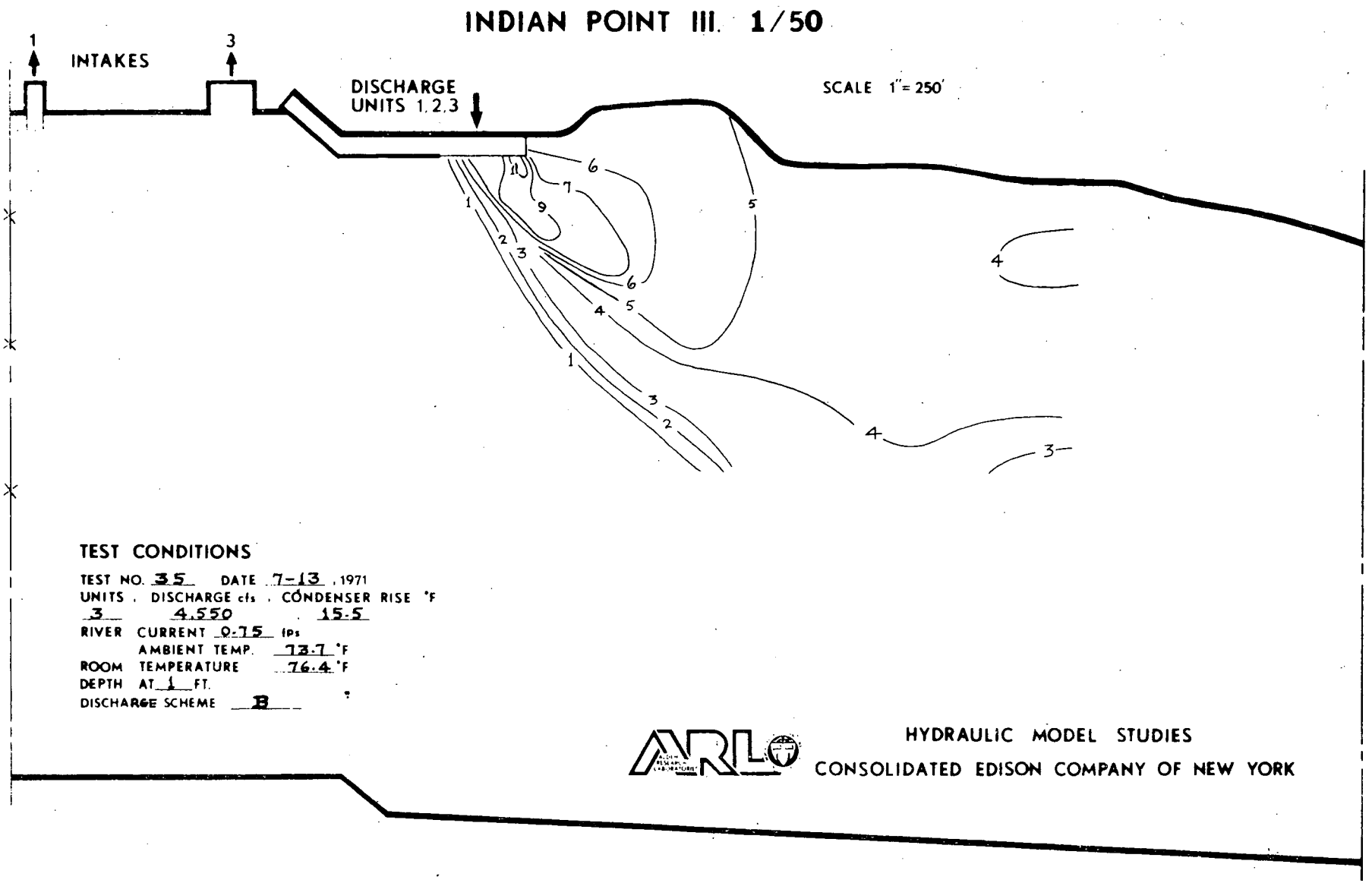

Figure - 26 Near field data.

The New York State Department of Environmental Conservation will receive an application from Con Edison for a Certificate of Reasonable Assurance to satisfy the requirements of Section 21-b of the Water Quality Improvement Act of 1970. Such a certificate has already been obtained with respect to the discharge from Units No. 1 and 2.

10.0 CHEMICAL DISCHARGES

10.1 Treatment Facilities

The primary method of treatment of chemical effluents released from the Indian Point Generating Station is dilution with circulating water so that chemical concentrations are reduced to levels well below those acceptable for discharge. Evaporators may also be utilized in the event of any primary to secondary leakage in the reactor coolant system. In effect, these evaporators are a treatment mechanism for radioactive chemical discharge and are not used as routine treatment facilities. A complete discussion of radioactive waste treatment facilities will be found later in this report.

10.2 Releases During Construction and Testing

During various construction and testing phases of Indian Point Unit No. 3, various non-routine releases of chemicals into the Hudson River will be required. At no time during this operation will the concentration at confluence with the Hudson River exceed the proposed limits discussed in Section 10.4.

(a) Phosphate

Trisodium and disodium phosphate are used in the secondary system to control steam generator pH. Phosphate concentration (expressed as PO_4) will not exceed 10 ppm on a sustained basis. Intermittent and/or continuous releases are planned during plant testing, as dictated by the steam generator chemistry. The maximum intermittent release concentration expected is 250 ppm. The expected maximum flow rate is 100 gpm and the expected sustained release (expressed as PO_4) is 12 pounds per day. The phosphate will be released with hydrazine and possibly morpholine or cyclohexylamine in the blowdown as described below.

(b) Hydrazine

Hydrazine is used in the secondary system to control oxygen in the steam generators. The concentration will not exceed 20 ppm on a sustained basis or 100 ppm on an intermittent basis. Releases will be dictated by the need for oxygen control. The expected maximum flow rate is 100 gpm and the expected sustained release is 24 pounds per day. As indicated, hydrazine will be combined with phosphate and cyclohexylamine or morpholine in the blowdown.

Hydrazine is also used in the primary system to control oxygen. Should the conduct of the testing program cause the hydrazine to be retained in the primary system for too long a period of time, it might be required to discharge approximately 200,000 gallons of solution containing hydrazine. The hydrazine concentrations would not exceed 100 ppm. This release would amount to approximately 170 pounds of hydrazine. The maximum discharge flow rate would be 300 gpm.

(c) Lithium Hydroxide

Lithium hydroxide is used in the primary system for pH control. If the need to discharge the previously mentioned batch of 200,000 gallons arose, lithium hydroxide would also be released at a concentration of 10 ppm (as lithium), which would amount to 17 pounds of lithium. As before, the maximum discharge rate is 300 gpm.

(d) Potassium Chromate

Potassium chromate is used in the closed cooling systems as a corrosion inhibitor. These solutions will be discharged only on a contingency basis, and would involve about 25,000 gallons of solution containing a maximum of 94 pounds of chromium at a concentration of 450 ppm. These batches would be discharged along with the 200,000 gallons mentioned earlier such that the concentration in the combined stream would be approximately 50 ppm chromium. It is proposed to discharge at a rate such that the diluted concentration at the confluence with the Hudson River would not exceed 0.05 ppm of hexavalent chromium.

(e) Boric Acid

Boric acid is used in the primary system as a chemical shim. Small quantities of boric acid are accumulated in the waste hold up system and discharged in the 200,000 gallon batch discussed earlier for hydrazine and lithium. The boron in such a batch should not exceed 500 ppm or approximately 850 pounds of boron.

In the course of completing the construction of the plant, the need to discharge the boric acid tanks might arise. These tanks hold about 12,000 gallons of a solution containing about 2.3 weight per cent boron, or approximately 2,300 pounds of boron. The boron release would be diluted in the refueling water storage tank to about 700 ppm and then discharged at flow rates not exceeding 300 gpm into the circulating water flow.

(f) Sulfuric Acid

Sulfuric acid is used to control pH in the flash evaporator. The flash evaporator distills river water for use as make-up for various systems and the concentrates are blown down to the discharge channel. The blowdown pH is between 7.0 and 8.5. The amount of H_2SO_4 stored near the flash evaporator is 600 gallons of concentrated (95%) H_2SO_4. Measurable amounts of H_2SO_4 in the circulating water are not expected.

(g) Sodium Hydroxide

Sodium hydroxide is used in the primary system at the spray tank for system control and at the demineralizer for resin regeneration. It is also used in the waste disposal system for pH control at the waste evaporator. Although the caustic in the spray tank is not expected to be discharged to the river, such a need might arise. The waste distillate would be discharged at 2.5 gpm at a concentration of 10 ppm for a total of 0.5 pounds per day of NaOH.

(h) Sodium Hypochlorite

Sodium hypochlorite is used to treat river water prior to use.

10.3 Releases During Normal Operation*

Because the nature of chemical discharges from Unit No. 1 differs from Units No. 2 and 3, and because of a use of a common discharge canal, any report on the environmental impact of Unit No. 3 with respect to chemical discharges must (a) identify separately the chemicals discharged from Unit No. 1 and (b) also report such discharges from Units No. 1 and 2. In order to more clearly delineate the environmental impact of Unit No. 3 with respect to chemical releases and for purposes of completeness, the combined estimated releases from Units No. 2 and 3 will be stated in brackets following the release estimates of Unit No. 3, as appropriate.

*Discussion of releases, usually referred to as occurring during evaporator breakdown, or on an intermittent basis, are included under this caption. Such releases should not be construed as occurring on any routine basis during normal operation. Moreover, at no time will discharge limits be exceeded.

(a) Phosphate

Trisodium and disodium phosphate are used in the secondary system to control steam generator pH as well as in combination with sodium hydroxide in the treatment of the house service boilers. Phosphate concentration (expressed as PO_4) for Unit No. 3 will not exceed 250 ppm at any time nor 10 ppm on a sustained basis. The expected maximum flow rate is 200 gpm and the expected sustained release (expressed as PO_4) is 24 [63] pounds per day.

(b) Hydrazine

Hydrazine is used in the secondary system to control oxygen in the steam generators. The concentration of hydrazine will not exceed 2.0 ppm during normal operation. The cold shutdown concentration will not exceed 100 ppm. A discharge at 100 ppm is not expected during normal operation, but may occur once per year at the end of the refueling outage. The expected maximum flow rate is 200 gpm and the expected sustained release is 5 [10] pounds per day during normal operation. Hydrazine is discharged approximately once per year from Unit No. 1 during the refueling outage. The maximum concentration at this time will not exceed 50 ppm at a discharge flow rate of 40 gpm. The maximum possible release rate would be 24 pounds per day.

(c) Cyclohexylamine or Morpholine

Cyclohexylamine or morpholine is used to adjust feedwater and steam pH. Concentration of cyclohexylamine or morpholine in the blowdown will not exceed 5 ppm on a sustained basis. The expected maximum flow rate is 200 gpm and the expected sustained release of either amine is 12 [24] pounds per day. Cyclohexylamine is also used for similar reasons in Unit No. 1. The nuclear boilers are blown down continuously at a maximum rate of 40 gpm containing a maximum concentration of 5 ppm cyclohexylamine. The maximum sustained release rate would be 2.5 pounds per day.

(d) Lithium Hydroxide

Lithium hydroxide is used in the primary system for pH control. Waste water from this system is processed by the respective waste disposal systems prior to discharge. There can be lithium hydroxide present in the effluent from this system if the evaporator breaks down.

Estimates of lithium hydroxide releases should be made under the assumption of an evaporator breakdown, or evaporator breakdowns occurring simultaneously in each of the three units. Under these highly unlikely conditions the maximum concentration expected would be 2.2 ppm (Li) with a maximum waste disposal flow rate of 25 gpm yielding a possible sustained release of 2.5 [7.5]* pounds per day.

(e) Boric Acid

Boric acid is used in the primary system as a chemical shim at a maximum concentration of 1000 ppm (as boron). Waste water from the primary system will be processed by the waste disposal system. In the event of an evaporator breakdown or simultaneous breakdown on all three units, which again is highly improbable, the maximum discharge concentration of boron would be 1000 ppm. The maximum waste disposal flow rate would be 25 gpm resulting in a maximum sustained release of 300 [900]* pounds per day.

(f) Potassium Chromate

Potassium chromate is used in the closed cooling water systems as a corrosion inhibitor in Units No. 2 and 3.

Although no discharge of chromated cooling water is planned, some system leakage is assumed to occur leading to a maximum concentration of 100 ppm with a maximum discharge flow rate of 25 gpm. Under such conditions a maximum sustained release of 30 [60] pounds per day would result.

(g) Sodium Hypochlorite

Chlorination of the main condenser is performed with a 15% sodium hypochlorite solution at a rate of 5 gpm for approximately 1 hour, three times per week. The river water chlorine demand is approximately 1 ppm. One half of the condenser is chlorinated to a residual of 1.0 ppm. This insures that the discharge residual is less than 0.5 ppm and in all probability less than 0.1 ppm. Condensers for all units are not chlorinated simultaneously, therefore, these concentrations will not be exceeded.

*Figure is for three units.

(h) Sodium Hydroxide

Sodium hydroxide is used during normal operation for regeneration of the primary system demineralizers. Excess sodium hydroxide is drained to the waste disposal system where it is processed by the waste evaporator.

Again assuming evaporator breakdowns, either individual or simultaneous, sodium hydroxide could be discharged at a maximum concentration of 500 ppm and a maximum discharge flow rate of 25 gpm. The projected frequency of demineralizer regeneration is once every 4 to 7 days for 2 hours. Under these adverse conditions the maximum release rate is 12 [24]* pounds per day.

(i) Detergent

"Colgate Low Foam" detergent is used in the plant laundry at a rate of 3 pounds per day with a discharge flow rate of 25 gpm for approximately 2 hours per day.

10.4 Comparison with Water Quality Standards

In addition to the thermal standards previously discussed herein, New York State has water quality standards applicable to the Hudson River at Indian Point. This water body is classified as "Class SB" and a copy of the applicable criteria appears in Table 10-1.

Although the regulation is phrased in terms of general criteria rather than specific numbers, Con Edison is proposing to meet certain discharge limits with respect to concentrations of various chemicals at the confluence with the Hudson River which it believes will satisfy the criteria (see Table 10-2). The basis for these limits was obtained in part from bioassay work performed by the Raytheon Company and New York University for Con Edison. At the time of this writing, these reports are as yet unavailable as they are in final stages of completion. The proposed limits, are believed to be conservative in nature due to the fact

*It should be noted that Unit No. 1 will have a maximum total release of sodium hydroxide of 120 pounds per day (4% at 6 gpm) once every 2 to 4 days/ and a sustained release of 36 pounds per day (75 ppm at 6 gpm).

TABLE 10-1

CLASS SB WATERS

Best usage of waters. Bathing and any other usages except shellfishing for market purposes.

Quality Standards for Class SB Waters

Items	Specifications
1. Floating solids; settleable solids; oil; sludge deposits	None attributable to sewage, industrial wastes or other wastes.
2. Garbage, cinders, ashes, oils, sludge or other refuse	None in any waters of the marine district as defined in State Conservation Law.
3. Sewage or waste effluents	None which are not effectively disinfected.
4. Dissolved oxygen	Not less than 5.0 parts per million.
5. Toxic wastes, deleterious substances, colored or other wastes or heated liquids	None alone or in combination with other substances or wastes in sufficient amounts or at such temperatures as to be injurious to edible fish or shellfish or the culture or propagation thereof, or which in any manner shall adversely affect the flavor, color, odor or sanitary condition 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.

TABLE 10-2

PROPOSED CONCENTRATION OF CHEMICALS AT CONFLUENCE

Chemical	Concentration (ppm)
Phosphate	1.54
Hydrazine	0.1
Cyclohexylamine	0.1
Morpholine	0.1
Lithium Hydroxide	0.01
Boric Acid	50
Potassium Chromate	0.05 (hexavalent chromium)
Residual Chlorine	0.5
Sodium Hydroxide	10
Sulfuric Acid	10
Soda Ash	5
Detergent	1.0

that upon the recommendation of the New York Department of Environmental Conservation, concentrations at the confluence were based on a discharge flow of 100,000 gpm (with all units in operation, discharge flow is in excess of 2,000,000 gpm).

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. In addition, Con Edison will continue to conduct a continuous environmental monitoring program in the area of its Indian Point site.

10.5 Gaseous Releases

Indian Point Unit No. 3, like other nuclear power plants, will release no combustion products to the atmosphere as a result of reactor operation. Along with Unit No. 2, however, it will have two "package boilers" fueled by #6 fuel oil (0.37% sulphur), 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. The amount of combustion products released per year resulting from the addition of these boilers will be insignificant. Estimated emissions are as follows:

Estimated Millions of Pounds of Pollutants Per Year Based On 6500 Hour Operation Per Year with #6 Fuel Oil

Item	All Package Boilers in Operation	Unit No. 3 Only
Particulates	0.033	0.015
Sulfur Oxides	0.825	0.375
Nitrogen Oxides	0.751	0.342
Carbon Monoxide	Negligible	Negligible

A permit has been obtained from the New York State Department of Health (now Department of Environmental Conservation) to construct these boilers at Indian Point. (See Appendix - H.)

The planned reduction in the Unit No. 1 stack height will not lead to a significant increase in ambient concentrations of emissions. This is evidenced by the following estimated ground level concentration based on the reduced stack height.

Estimated Maximum Ground Level Concentration from Package Boilers (Distance: 1 Km; Wind Speed: 2 m/sec; Stability: Class "A")

Item	All Units in Operation	Unit No. 3 Only
Sulfur Oxides (ppm)	1.4×10^{-2}	7.6×10^{-3}
Nitrogen Oxides (ppm)	1.7×10^{-2}	9.6×10^{-3}
Particulates (Micrograms/m^3)	1.6	0.88

In terms of atmospheric emissions, the advantages of a nuclear unit, such as Unit No. 3, over a fossil-fired unit of equivalent size are considerable. It should also be noted that the use of a nuclear generating unit, such as Unit No. 3, may result in a reduction of air pollution considerably greater than the percentage of the system generator capacity which the unit represents. This is true for two reasons. First, the use of such units will permit the retirement of old and inefficient fossil-fired units located in heavily populated areas. Secondly, it is generally desirable to use the nuclear units for base load and fossil-fired units (with their higher unit fuel costs) for peaking where possible, thus concentrating idle time and operation at less than capacity in the fossil-fired units. A more detailed discussion of these aspects are discussed later herein.

11.0 SANITARY WASTES

There are three sewage treatment facilities at the Indian Point site, a main sewage treatment plant and two auxiliary systems which service the Gate House and Observation Building, respectively.

The main sewage treatment plant treats all of the sanitary wastes from the nuclear and conventional portions of the site with the exception of the Gate House and Observation Building. Raw sewage enters the plant via comminutors located in the Utility Tunnel, where all coarse sewage material is cut into small settleable solids. After passing into a 6'-0" ejector basin, the sewage is pumped into dual septic tanks by 300 gpm pumps located on the top of this basin. Either one or both of these septic tanks may be selected by the use of manually operated sliding gates which are located in a distribution box immediately ahead of the tanks.

In the septic tanks, larger solids are removed and anaerobically decomposed; the process commonly referred to as sludge digestion. Sludge collected on the bottom of the septic tanks is removed when it reaches a depth of 1/4 of the tank. Liquid separated from the sewage flows into a collecting pit at the south end of the septic tanks and is pumped into a dosing tank by means of 100 gpm pumps located therein.

Located in the dosing tanks are four siphons which alternately discharge the liquid sewage effluent to 45 foot square sand filter beds.

Both the 300 gpm and 100 gpm pumps are equipped with mechanical alternators which alternate the operation of the pumps. In addition, the alternator will cause both 300 gpm and 100 gpm pumps to operate simultaneously if the level in their respective pits rises too fast.

After being discharged to the filter beds, the sewage effluent is filtered by passage through the sand in the beds. Below the beds are located underdrains whose normal function is to collect the filtered effluent and discharge it to the river. At the present time, however, the underdrains terminate at a capped header as the rate of percolation in the filter beds is so great that no underdrains are required. In the future, should the load on the plant exceed the percolation capacity of the filter beds to any great extent, the underdrains will be connected to an automated chlorination station and the chlorinated effluent discharged to the river.

Separate sewage systems are provided for the sanitary wastes from the Gate House and Observation Building. The Gate House system is composed of a 512 gallon septic tank, a junction box and two 6'-0" diameter leaching pits. The sewage system which takes care of the sanitary waste from the Observation Building consists of a 545 gallon septic tank, a junction box and five 60 ft. long by 2 ft. wide absorption trenches.

The design parameters utilized in the planning and construction of the overall sanitary waste system are summarized in Table 11-1. This data clearly indicates the adequacy of the sanitary waste system on the Indian Point site.

TABLE 11-1

SEWAGE DISPOSAL PLANT - INDIAN POINT GENERATING STATION

Type of Plant:	Intermittent Sand Filtration
Population:	Normal = 100; During Boiler Outage = 200; Ultimate = 300
Average Daily Flow:	30 gallons per person per day
Max. Cosign Hourly Flow:	6.25 gallons per minute x 200% = 12.5 gpm
Total Sewage Flow:	30 gpd x 300 = 9000 gpd = 6.25 gal. per minute
Elements of Plant:	Comminutor, Plain Sedimentation Tanks, Dosing Tanks with Automatic Siphons, Sand Filter Beds
<u>Sedimentation Tanks</u>:	
Number of Units:	Two
Required Capacity:	1/2 day's flow = 4500 gallons per N. Y. State regulations ∴ each tank has a capacity of 2250 gallons.
<u>Filter Beds</u>:	
Dosing Rate:	50,000 gallons/day/acre (average flow)
Size of Bed:	$\frac{9,000 \text{ gpd}}{50,000 \text{ g/acre}} = 0.18 \text{ acres} \times \frac{43,560 \text{ sq. ft.}}{\text{acre}}$ = 7,840 sq. ft.
	Four square beds (45' x 45') = 8,100 sq. ft.
<u>Dosing Tank</u>:	
Dimensions:	11.0' x 11.0'
Capacity:	Dose = 3" on one bed ∴ Capacity = 3800 gallons
Siphon Flow (Max.):	15.62 gpm
Discharge (avg):	572.6 gpm
Cycle (Max Flow):	4.06 hours

12.0 ECOLOGICAL CONSIDERATIONS

12.1 The Biological Impact of Plant Operation

A. Introduction

The Atomic Energy Commission Regulatory Staff's Environmental Impact Statement for Indian Point Unit 2 recommends that Con Edison be required to provide closed cycle cooling for the plant by January 1, 1978. This recommendation is based on limited data and the output of an experimental mathematical model, the input of which is untested hypothesis. Con Edison has provided extensive testimony by biologists to show that the effects of operating Indian Point 1 and 2 with once-through cooling until September 1981, when a closed cycle cooling system could be in operation, would not cause irreversible damage. Much of this testimony is applicable to Indian Point Units 1, 2, and 3 operating together.

The AEC Staff recommendation to provide a closed cycle cooling system imposes additional study requirements to determine the environmental design requirements of a closed cycle cooling system and its impact. Con Edison has underway or planned studies which are to provide comparative estimates of the long range environmental impact of Indian Point Units 1, 2, and 3 for: A) the existing once-through cooling system and B) alternative cooling systems. It is axiomatic that such studies will require time and Con Edison urges that it be allowed to complete these studies before making any decisions to require closed cycle cooling for any units at Indian Point.

Con Edison's position on cooling towers, as previously stated is that

> "Should Con Edison conclude on the basis of information gathered during the five-year study period that the need has been demonstrated for modification of the once-through system for Indian Point, Con Edison would on its own initiative propose such a modification to the appropriate governmental agencies. In any event, the data would be made available to the agencies having jurisdiction and they would have the information needed to determine what changes in the system were required."

The study program will be integrated into a final report on fish populations and impact of once-through cooling. This report is to be issued in June 1976. This integrated report will then be made available to the consulting engineering firm of

Quirk, Lawler and Matusky Engineers, for further evaluation and preparation of a report on cumulative effects of Indian Point Units 1, 2, and 3, Bowline Units 1 and 2 Roseton Units 1 and 2 on the striped bass population of the Hudson River. This latter report is scheduled for completion on January 1, 1977 and would complete the biological program evaluating the impact on the Hudson River fishes of once-through cooling at Indian Point and other indicated generating stations.

The Indian Point ecological study results will be available on January 1, 1977 and presented to the control agencies for evaluation. A period of four months is allowed for the agency review after which time it would be determined whether to proceed with the installation of an alternate cooling system for Indian Point or the company would be allowed to continue with once-through cooling. The date for this decision would be May 1, 1977 and would be made under this alternative prior to the release for bids by Con Edison for construction work. If the decision is, for example, that cooling towers must be built for Indian Point Unit No. 3, this critical path of activity would continue and would lead to the final cutover to cooling tower operation by September 1, 1981.

Several scientific studies clearly demonstrate that changes indicative of population damage can be detected by the methods employed in the Indian Point ecological study (Section 13). Should serious ecological damage be threatened from the operation of Indian Point Units 1, 2, and 3 it would be clearly demonstrated by 1977 when the ecological study is completed. On the basis of any reasonably postulated loss rate due to operation of Units 1 and 2 commencing in 1973, and Unit 3 in 1974 the fish stocks of the Hudson River would not be subjected to irreversible damage by 1981, the date when alternatives to once-through cooling for all units would be operational if construction were commenced in 1977 following completion of the ecological studies.* The example of cooling towers, as an alternative, is advanced as the structural modification taking the longest time to install.

*McFadden, J. T. 1972. Impact of entrainment and impingement at Indian Point Units 1 and 2 upon fish populations: U.S. Atomic Energy Commission, 30 October 1972. Docket No. 50-247.

If in the course of the studies, losses of the magnitude forecast by Dr. Goodyear in the Unit 2 hearings are experienced, they would be readily identified and mitigating measures could be implemented.

B. Fishery and Water Resources

Fishery Resources

The Hudson River estuary in the vicinity of Indian Point supports large populations of resident and migratory organisms. Of the 56 species of fish reported from the lower Hudson watershed in 1936, 48 were collected near Indian Point in 1971 and 52 species were collected in 1972. The principal commercial species are American shad and striped bass; but sturgeon, herrings, carp, catfish, eel, white perch and yellow perch are also harvested. The total commercial catch in the lower Hudson River in 1971 was 999,185 pounds valued at $20,897*. Striped bass is the principal sport species; and American shad, herrings, largemouth bass, white catfish, chain pickerel, yellow and white perch, pumpkinseed, eel and sturgeon are also caught.

Rare and Endangered Species

The Indian Point area provides suitable habitat for one rare fish species and one endangered fish species (U.S. Dept. of Interior). The Atlantic sturgeon, *Acipenser oxyrhynchus*, is officially classified as a rare species; and the shortnose sturgeon, *A. brevirostrum*, is an endangered species. In New York the status of the American shad, *Alosa sapidissima*, is indeterminate, meaning insufficient data is available for a reliable assessment of status. The commercial harvest for shad has varied from 2,000,000 pounds (1945) to 36,000 pounds (1965). State fishing regulations have been changed to protect this species. Specimens of the Atlantic sturgeon and American shad have been collected in small numbers on the intake screens at Indian Point (Appendix BB). There is no indication that the operation of Indian Point has a detrimental effect on the shad or shortnose sturgeon. Extensive biological collections in the Indian Point area during the past five years have not produced any indication of an endemic species in the lower Hudson River (Appendix AA and CC).

*Churchill Smith. 1972. Bureau of Commercial Fisheries Bayport, L.I., N.Y.

Dominant Species

The Hudson estuary in the vicinity of Indian Point supports large populations of both resident and migratory fish species.* The dominant resident species, white perch, tomcod, hogchoker, and young striped bass are abundant in almost all stages of their life histories in this section of the river. The anadromous species, the majority of which spawn upstream from Indian Point, migrate upstream past the plant site as adults and downstream past the plant as young. Juveniles are especially abundant near Indian Point, and the section of the estuary below Indian Point in Haverstraw Bay is generally considered a nursery area for fish. These populations are dynamic and subject to great natural fluctuations in numbers. For example, there are indications that the striped bass population has been increasing over the past 40 years despite increased fishing pressure, increased pollution, and increased power production on the river using once-through cooling systems. There exists also potential for fluctuations in populations due to man-induced changes in the environment such as improved sewage treatment, increased power production, and changes in the laws governing commercial and sport fishing. This section will discuss the potential for change induced by the addition of Indian Point Unit 3 with its once-through cooling system.

Water Resources

The flow past Indian Point is variable, as discussed more thoroughly in Appendices A and B. Average tidal flow past the plant is about 80 million gallons per minute for approximately 80% of the year. This flow assures adequate dilution and complete mixing of the discharges from the site. At full cooling water flow, Indian Point (3 Units) circulates 2,058,000 gallons per minute including service water. Thus the plant will use approximately 2.5% of the tidal flow as it passes Indian Point, a usage which is unlikely to interfere with multiple utilization of the resource. Water is not intentionally evaporated as it passes through the facility.

*For additional information on aquatic biota, life cycles, and distribution see Appendices AA, BB, and CC.

Under some conditions of power generation and tide the thermal plumes from Indian Point, Lovett and Bowline generating plants may merge. Under conditions of maximum severity, the thermal plume from the three Indian Point units of $4^{o}F$ or more above ambient Hudson River temperatures will cover approximately 600 surface acres, while about 1600 surface acres will be bounded by the $2^{o}F$ isotherm (see Section 9.3). The latter area (within $2^{o}F$ isotherm) represents 2.2% of the surface area of the Hudson estuary between Troy and the Battery (approximately 153 river miles). The effluents of these three plants can be expected to have little influence on the river below Croton Point due to dilution and tidal mixing.

C. Thermal Effects

Many biologists who have studied warm water discharges have concluded that any direct adverse effects of waste heat appear to be limited to the immediate area of the discharge and are usually confined to the season of maximum ambient temperatures. Studies at Indian Point show no signs that operation of Units 1, 2 and 3 will cause irreversible damage to the Hudson River ecosystem during the course of the Indian Point Ecological Study (1973-1977) and the subsequent time necessary to install an alternate cooling system, if necessary (1977-1981) (Appendix CC). If current investigations and monitoring programs indicate significant change during this period, an alternative cooling system could be provided. The Hudson River's striped bass population is believed to have a substantial compensatory reserve which would appreciably reduce losses in the population (see testimony of McFadden*). Raney** predicted that there would be no irreparable damage to striped bass populations of the Hudson River or Long Island Sound and no effect on the major Atlantic Coast populations by operation of Units 1 and 2. No significant changes in abundance or composition of bacteria, phytoplankton or zooplankton will result from the planned operation of Indian Point (see testimony of Lauer***.) Thermal tolerance tests, also by Lauer, show

*McFadden, J. T. 1972. Impact of entrainment and impingement at Indian Point Units 1 and 2 upon fish populations: U.S. Atomic Energy Commission, 30 October 1972. Docket No. 50-247.

**Raney, E. C. 1972. The striped bass, Morone saxatilis, of the Atlantic Coast of the United States with particular reference to the population found in the Hudson River: U.S. Atomic Energy Commission, 30 October 1972. Docket No. 50-247.

***Lauer, G. J. 1972. The effects of elevated temperature and entrainment on Hudson River biota. Testimony before U.S. Atomic Energy Commission, October 30, 1972. Docket No. 50-247.

that there should be little if any effect on the egg and larval stages of striped bass at temperatures encountered in the thermal plume.*

Hydrodynamic Models

Mathematical models to predict the effect of Indian Point cooling water discharge (Units 1 and 2) on the thermal distribution of the Hudson River have indicated that the sub-surface discharge would meet the NYSDEC thermal standards. More recently, a hydraulic model has been developed by Alden Research Laboratories to determine the combined effects of Indian Point (Units 1, 2 and 3), Bowline (Units 1 and 2) and Lovett (Units 1-5) power plants on the Hudson River thermal distribution.** Although preliminary results suggest that river water temperatures may be elevated in excess of the New York State thermal standards (Section 9.3), the model assumed conditions of maximum severity with river flow reduced to 4,000 cfs, low summer heat transfer coefficients, all three Units operating at full capacity, and could not incorporate the effect of salinity. These severe river conditions would occur only 2% of the time. Preliminary estimates of thermal conditions at full scale operation will be verified. Con Edison will take appropriate action to operate the Indian Point power plants to remain within the thermal limits that have been established by New York State.

Producers

The warm water at Indian Point is expected to be primarily a surface phenomenon which will have little or no effect on the phytoplankton populations at Indian Point. Although diatoms were replaced by blue-green algae near the discharge of the Connecticut Yankee plant, the change does not seem to portend obnoxious conditions. Plankton studies to date in the Chesapeake Bay and at Indian Point have found no significant population changes related to thermal discharges (see Appendix CC). Lauer*** states

*Additional information of the effect of plant operation on the Hudson River temperature distribution is presented in Section 9.

**Appendix DD.

***Lauer, G. J., 1972. The effects of operations of Indian Point Units 1 and 2 on Hudson River biota. Testimony before U.S. Atomic Energy Commission, October 30, 1972. Docket No. 50-247.

that no significant changes in abundance or species composition are expected in Hudson River phytoplankton populations due to operation of the Indian Point Plant.

Consumers

Thermally related changes may occur in the benthic and fish communities in a restricted area near the discharge at Indian Point. Sensitive members of the benthos which might undergo abnormal seasonal shifts in abundance or eventually be reduced include *Neomysis americana*, present at Indian Point only during periods of high salinity, and *Crangon septemspinosa*. *Gammarus fasciatus* is an important invertebrate food item for many estuarine fish species at Indian Point which may benefit from slightly elevated temperatures.

Fish species which appear to avoid warm water or are easily stressed by elevated temperatures, (Atlantic tomcode, winter flounder, and sturgeons), are benthic species and would seldom not be subjected to elevated temperatures at Indian Point. Several species are thermally more tolerant and may increase in abundance by having a competitive advantage over less tolerant species. The more tolerant fish include many of the local sunfishes, white catfish, brown bullheads, carp, goldfish, several of the forage species and possibly white perch and striped bass.

Eggs and Larvae

Some developmental stages of fish eggs and larvae appear to be the least tolerant of thermal discharges. Indirect effects of exposure to elevated temperatures may result in decreased survival of fish eggs and larvae. Spatial distribution and thermal tolerance of the eggs and early larval stages of striped bass indicate that during the most temperature sensitive stages of development (the early post-hatch yolk-sac larvae and gastrula stage) both occur in greatest abundance near the bottom far from exposure to plume temperatures. Older larvae migrate vertically in the water column diurnally and are only abundant at the surface during short periods of the night. These larval stages demonstrated a sixty minute exposure maximum temperature tolerance of 88°F which is above the predicted surface plume temperature with the exception of a very small area immediately adjacent to the discharge parts

even during the warmest summer periods*. In addition, the AEC staff indicated that the stressed fish might sound (go towards bottom) which would place them below the elevated temperatures of the plume. Such action may also be taken by fish larvae, although no data has been collected on this subject. The peak abundance of eggs and larvae of eel, smelt, and clupeids collected at Indian Point occur during spring prior to maximum plume temperatures. Anchovy, white perch, and silversides larvae do sometimes occur in the vicinity of Indian Point during periods of maximum plume temperature. The anchovy spawns south of Indian Point and should not be greatly affected by the thermal discharge.

Cumulative Effects of Other Plants

The combined thermal discharges from Indian Point Units 1 - 3 and other Hudson River power plants are not expected to increase the water temperatures of the river to a degree that will cause significant stress or irreversible impact on the aquatic ecosystem, but will extend the area exposed to elevated temperatures. Discharges from the operations of the Danskammer and Roseton plants located north of Newburgh will probably have little or no influence on the water temperatures or the estuarine communities in the Indian Point area. The rapid regeneration times of planktonic flora and fauna during most of the year indicate that any changes in the planktonic populations which may have occurred near the upstream power plants would have returned to normal river conditions before reaching the Indian Point area 22 miles downstream. The thermal discharges from all proposed units of the Indian Point, Bowline and Lovett power plants may increase surface temperatures 2-4°F over approximately 1600 acres of the Hudson River between Indian and Croton Points under critical summer conditions. The thermal receiving capacity of the Hudson River ecosystem will be little stressed by the additional heat load, the proportion of the aquatic community in contact with the elevated temperatures will increase, but the biological effects will probably be insignificant.

*Lauer, G. J., 1972. The effects of operations of Indian Point Units 1 and 2 on Hudson River biota. Testimony before U.S. Atomic Energy Commission, October 30, 1972. Docket No. 50-247.

Advantages of a large surface area of warm waters may include increases in primary productivity of phytoplankton with benefits at other trophic levels resulting in a more productive estuarine system. Although critical life stages of many fish and benthic organisms are planktonic, they would be directly affected by elevated temperatures only in small local areas near the thermal discharges.

The risk of environmental damage increases relative to the portion of the aquatic community in contact with elevated temperatures. Although slight species shifts at the phytoplankton level over limited periods of each year will probably result in equivalent species replacement with no effect on the planktonic stages of fish and benthic organisms, the remote possiblity exists that thermal stress of a single species of phytoplankton may cause consequences at other trophic levels (zooplankton through fish larvae). The risk must be considered slight in considering environmental and economic trade-off.

Research at Indian Point

Interrelated laboratory-field research is necessary to determine ecological consequences of short and long term exposure of important species to elevated temperatures. Although long term changes in community structure may be confused by the combined effects of multiple causative factors and a great deal of natural variability, constant monitoring of populations will increase the reliability of ecological predictions. To date, studies indicate that the thermal discharge from Indian Point Units 1, 2 and 3 will have little direct effect on Hudson River communities. Biological programs have been initiated by Con Edison to describe and monitor the complex community interactions and define the receiving capacity of the aquatic system at Indian Point (Section 13).

D. Chemical Effects

Concentrations of Chemical Discharges

A variety of chemicals will be introduced to the Hudson estuary during construction, testing and normal operation of the Indian Point facility. The concentrations, dilutions, and interactions of these chemicals with the aquatic biota are discussed in Appendix Z (also see Sections 10 and 11). Chemical discharges during normal operation

will include sulfuric acid, sodium hydroxide, phosphate, hydrazine, cyclohexylamine, soda ash, and sodium hypochlorite. Chemicals which may be discharged during infrequent emergency situations are lithium hydroxide, boric acid, and potassium chromate. It is also necessary to provide for the disposal of detergents and sanitary wastes. The various chemicals to be discharged at Indian Point during normal operation are summarized in Table 1.

There are three sewage treatment facilities at the Indian Point plant (Appendix Z and Section 11). At the present time, the treated effluent is percolated through filter beds to eventually enter the groundwater. Therefore, no discharge from the sewage facilities directly enters the Hudson River.

The concentrations of various effluent chemicals and detergent are summarized in Table I, Appendix Z. The concentrations are not expected to exceed the limits of the proposed levels of discharge which were established on the basis of bioassays to cause no adverse effect on the ecosystem. Discharges will always be accompanied by a minimum discharge flow of 100,000 gpm, but during normal plant operation the flow will greatly exceed this minimum. With three units on the line, full flow will be 2,058,000 gpm. Current operating procedure includes reduced flow (60%) from about approximately November through March of each year, and dilution flows will approximate 1,234,800 gpm during this period. The effect of additional dilution from river flows is summarized in Table V, Appendix Z.

Water Quality Criteria

The Hudson River at Indian Point is considered by New York to be a "Class SB" waterway. The state water quality regulations are phrased in terms of general criteria rather than specific numbers (Table II, Appendix Z). Consolidated Edison has proposed certain discharge limits with respect to concentrations of various chemicals which it believes will satisfy the criteria at the confluence with the Hudson River (Table IV, Appendix Z). State approval has been granted (on a single incident basis) for the concentrations of hexavalent chromium, hydrazine, and lithim hydroxide in the discharge canal with a minimum flow of 100,000 gpm. All of the discharges except hydrazine fall far below the proposed limits. The concentration given for hydrazine would only

Table 1. Maximum chemical discharges to the Hudson River during normal operation of Indian Point station (Data from Appendix Z).

Chemical	Maximum Discharge Rate (lbs/day) Unit 1	Unit 2	Unit 3	Total/day	Annual Discharge (lbs/yr)
Lithium hydroxide[a]	2.5	2.5	2.5	7.5	N.A.
Boric acid[a] (as B)	600	600	600	1800	N.A.
Potassium chromate[d] (as Cr^{+6})		15	15	30	N.A.
Sulfuric acid	450	0	0	450	162,250
Sodium hydroxide	156	12[a]	12[a]	156	57,000
Sodium phosphate	15	24	24	63	22,995
Hydrazine	24[b]	5	5	10	3,650
Cyclohexylamine	2.5	12	12	26.5	9,675
Soda ash[c]	1000			1000	4,000
Detergent	3			3	1,095
Sodium hypochlorite	See Appendix Z				

[a]Discharged only during evaporator failure, an infrequency emergency situation

[b]Discharged once a year during refueling outage

[c]Employed two-four times per year for washingt flue gas passages

[d]Discharged only in event of system leakage

occur during cold shutdown for refueling or emergency situations. The normal release of hydrazine (2 ppm) would yield a concentration of 0.004 ppm which is far below the discharge limits approved by the State.

Chlorination

Chlorine is the only chemical to be utilized at Indian Point in concentrations which may be toxic to the aquatic biota of the area (U.S. Atomic Energy Commission, 1972). Although chlorine may be discharged periodically at 0.5 ppm (and probably less than 0.1 ppm), it will be immediately diluted by large volumes of water with a chlorine demand (Appendix Z). The volume of water subjected to increased chlorine levels due to the operation of Indian Point is insignificant when compared with the volume of the Hudson estuary. Consequently, it is unlikely that plant-induced chlorine levels will have an adverse impact on the biotic resources of the estuary. The fate of chlorine and its reaction products, as employed at Indian Point, are discussed in Appendix Z.

Bioassay Studies

Bioassay studies have been performed with many of the chemicals which will be discharged at Indian Point (Appendix Z). The results established the 96 hour median tolerance limits (TLm) of several Indian Point fish and invertebrate species to selected chemicals. The 48 and 96 hour TLm were multiplied by 0.1 to determine "safe" concentrations of these chemicals. Since most of the discharge chemicals have noncumulative effects, the use of 0.1 of the TLm value should be meaningful. This value is very conservative not only because of the 0.1 factor but also because the biota in the river can be expected to be exposed to these discharges for periods of time shorter than the 48 and 96 hours of the bioassay studies. The reasons for this are: 1) some discharges are of short duration with long time intervals in between, e.g. chlorine, and 2) even for continuously discharged chemicals a fish would have to remain right at the outlet for 48 or 96 hours to reproduce the conditions of the bioassay studies. To be even more conservative the "safe" concentrations were estimated from the TLm values for the Atlantic silversides which was the most sensitive of the test species. Under normal operating conditions the discharge concentrations at Indian Point will be below these "safe" concentrations. Additional studies have indicated that

increased temperatures in the discharge have little, if any, effect on the toxicity of metals to fish (Appendix Z). Since the chemicals discharged at Indian Point are non-cumulative, a small but constant concentration could be endured by the biota. Since the concentrations are below the TLm values of most species, the actual concentrations and exposure times may be of little consequence to the ecosystem.

The chemicals discharged from Indian Point will be transported in the water column until they are precipitated to the bottom sediments, or react with other chemicals to form soluble products, or undergo sorption reactions with solids. Regardless of their final fate in the environment, they pose little threat to the Hudson estuary due to the concentrations, dilution potential, and noncumulative properties of the specific chemicals (Appendix Z).

Cumulative Effects of Other Plants

There are four other steam electric generating plants, in construction or operation, within 22 miles of Indian Point (Appendix AA). Although these plants are fossil fueled, the chemicals which they release are generally similar to those of Indian Point. The actual residency and/or fate of these substances in the water column are essentially unknown, but the contaminants probably undergo rapid chemical reactions (especially inorganic sorption reactions) so that a great portion of them are actually removed from the water. If this removal action does not take place, then perhaps an accumulation of these pollutants occurs, but in all likelihood this would represent an exception to the usually occurring phenomena of aquatic systems. Water quality studies in progress at Indian Point will provide additional information regarding the effects of chemical discharges on the biota (Section 13).

E. Entrainment

The use of natural waters for once-through cooling systems imposes varying degrees of physical buffeting, rapid changes in pressure and temperature, and periodic exposures to chemical discharges upon organisms that are contained within the water source and taken into the plant. Evaluation of the effects of these processes upon the aquatic ecosystem must consider the cumulative effects of these factors in arriving at the final assessment. The present state of our knowledge of these effects is admittedly

limited, but has reached a degree of refinement with regard to particular species which allows certain generalizations and preliminary estimates of their impact upon the ecosystem at Indian Point.

Striped Bass

Extensive studies of striped bass indicate that some additional mortalities to larvae could be expected to occur as a result of the operation of Indian Point Unit 3, but these mortalities would represent a small percentage of the population and result in no permanent and irreversible damage to Hudson River population levels. This contention is supported by data on thermal tolerance, distribution of eggs and larvae, and the effects of pressure, mechanical abrasion and chlorine upon those life stages of striped bass which are subject to entrainment (Appendix AA).

A mathematical model of Hudson River fish populations has been developed by Quirk, Lawler & Matusky, Engineers for striped bass.* This is a transport model which relates river hydrodynamics to the life cycle of striped bass in the Hudson River. The model includes biological compensation as a population parameter. Major parameters of the model are life cycle parameters, transport parameters, and plant and impact parameters. The reduction of the striped bass population by operation of Indian Point Units 1 and 2 was predicted to be 5.0% after 10 years. The reduction caused by the operation of Units 1, 2, Bowline, and Roseton was predicted to be 13%. The same model predicts a 6% reduction caused by the operation of Units 2 and 3 and a 16% reduction caused by the operation of Units 2, 3, Bowline and Roseton. These resilts indicate that operation of Units 2 and 3 should not be expected to cause a substantial or irreversible adverse impact on the river's striped bass population, particularly during the first 10 years of operation. Populations are expected to stabilize at these reduced levels after approximately 10 years.

The eggs and larvae of striped bass, while more sensitive to thermal shock than juveniles, are subject to only a low degree of entrainment as a result of the demersal nature of the eggs and early larvae and migratory responses of later larvae and juveniles. Modeling of the hydrography of the Indian Point area has shown that little or no water is taken into the plant from depths below 30 feet. The river bottom drops from

*See Appendix AA

this depth at the intake structures to approximately 60 feet at a distance of one hundred yards (the area influence of intake velocities), thus limiting entrainment to those forms in the upper water column. This reduces the entrainment of eggs and larvae whose behavior or physiology restricts them to areas on or near the bottom all or part of the time. There is ample evidence to indicate that man-induced mortalities considerably in excess of the projected losses from 1, 2, and 3 can be sustained without adversely affecting the productivity of the system.

White Perch

While data specific to white perch are not so readily available as those for striped bass, there are several indications that their population response to the effects of entrainment in Indian Point Unit 3 will not appreciably differ from those of the striped bass. Meldrim and Gift have reported that juvenile white perch are able to withstand 15 minute duration of exposure to 95°F with no ill effects. Since this temperature and duration of exposure exceeds the highest average temperatures at Indian Point Unit 3, it is reasonable to conclude that some degree of thermal shock mortalities of white perch larvae might occur but that these would be limited and occur infrequently. Marcy* reported mortalities as high as 100% for white perch larvae after passage through a nuclear power plant. Conditions at this plant were quite dissimilar from Indian Point. Studies by Lauer** indicate that 7-39% mortality can be expected from entrainment at Indian Point.

Gammarus

Gammarus fasciatus, an estuarine amphipod, is the major food source of many Hudson River fish, including white perch and one to two year old striped bass. Research has shown that these organisms experience limited mortalities when entrained during chlorination but pass through the facility virtually unaffected at all other times. Due to the low frequency and short duration of chlorination, this mortality could not be

*Marcy, D. C. J., 1971. Survival of young fish in the discharge canal of a nuclear power plant. J. Fish. Res. Bd. Canada. 28: 1057-1060.

**Lauer, G. J., 1973. Effects of entrainment on Morone sp. (striped bass and white perch) eggs and larvae at Indian Point. Testimony before U.S. A.E.C., Docket No. 50-247.

expected to result in any appreciable detriment to populations of Gammarus in the Hudson River.

Neomysis

Neomysis americana has been reported as a common member of the plankton community at Indian Point during those portions of the year when salinity exceeds $0.5^{o}/00$. Such periods could be expected in mid-winter and summer when fresh-water runoff is reduced. Post entrainment data for Neomysis indicate that no decrease in percentage survival occurs when temperature is lower than $90^{o}F$, but that sizeable mortalities could be expected above this temperature and during chlorination. The significance of this thermal shock sensitivity is reduced, however, by the dramatic diurnal vertical migrations of Neomysis which reduces their susceptibility to entrainment during daylight hours. Lauer* reports that entrainment at Indian Point is not expected to significantly reduce populations of Neomysis in the Hudson River. Further studies of the population dynamics of Neomysis are now in progress to more completely evaluate the effects of entrainment mortalities on Hudson River populations.

Other Species

Thermal tolerance data for various species as reported in the literature are a staggering assemblage of mortality levels, exposure intervals and acclimation temperatures which are seldom directly comparable to the conditions experienced at a specific generating station. There are, however, indications that tolerance to thermal shock is a function of acclimation temperature, ΔT, total temperature encountered, and duration of exposure.

Coutant** reports that no mortality results from exposure to temperatures $3.6^{o}F$ ($2^{o}C$) below upper stress temperatures. He further states that 80 - 85% reduction in exposure time produces an effect equivalent to that of a $3.6^{o}F$ decrease in temperature.

*Lauer, G. J. 1972. The effects of elevated temperature and entrainment on Hudson River biota. Testimony before U.S. Atomic Energy Commission, October 30, 1972. Docket No. 50-247.

**Coutant, C. C. 1972. Biological aspects of thermal pollution II. Scientific basis for water temperature standards at power plants. CRC Critical Review in Environmental Control. 1-24.

These values then provide a convenient means of estimating the effects of entrainment at a particular generating facility in terms of tolerance limit data of affected species as they appear in the literature.

If a 3.6^{o}F reduction in temperature from the TLm values for a given exposure time results in 100% survival, it is reasonable to assume that an increase of 3.6^{o}F above a temperature at which 100% survival occurs will result in no more than 50% mortality. Further, it seems reasonable to assume that exposure times which do not exceed 15-20% of those reported for a particular temperature will elevate the effective tolerance of the species cited by 3.6^{o}F. With these values, reported tolerance levels for species found in a particular area and the operational regime of a particular facility, it is possible to predict the levels of survival which might be expected following entrainment in once-through cooling systems. Appendix AA contains such an evaluation for 15 species which are common to the Indian Point area.

In addition to these species, research indicates that the decomposer level of the ecosystem will experience no detriment as a result of any level of exposure in the ranges encountered at Indian Point. Actual stimulation of carbon uptake by the phytoplankton community by temperatures up to 90°F (not exceeded during a cool year) has been reported. Some inhibition is indicated at higher temperatures during warmer years (Appendix AA).

Egg and larval stages of common organisms which may be less tolerant than the adult forms and thus more sensitive to the effects of entrainment are subjected to interpretation only on the basis of responses of the individual species. The presence of freshly settled barnacles at the effluent gates of the Indian Point facility during the summer indicates that the larvae have survived entrainment in viable condition prior to attachment. Similar conclusions may be drawn for several benthic and epi-benthic invertebrate species common to the effluent canal (hydroids, ectoprocts, decapods).

Mechanical Damage

Studies at Indian Point with no ΔT indicate that no significant difference in numbers of organisms or percentages of survival can be determined for samples of bacteria, phytoplankton, microzooplankton and macrozooplankton taken at intakes and effluents.

This indicates that entrainment at Indian Point results in no appreciable physical abrasion and that the pressure differentials encountered during passage produce no recognizable detriment to these organisms. Disorientation has been observed in post-entrainment studies for a portion of some juvenile fish species. The reversibility of this effect or the survival success of these fish have not yet been determined (Appendix AA).

Mortality as high as 80% has been reported by Marcy* for clupeid larvae as a result of mechanical damage during entrainment through the Connecticut Yankee nuclear generating facility (Appendix AA). The majority of these were mangled. Research at Indian Point has produced preliminary indications that 7-39% mortality occurred in Morone sp. following entrainment at Indian Point. It is apparent from these conflicting reports, that no generalizations from station to station or from species to species are possible concerning the possibility of mechanical damage. In any event, entrainment at Indian Point will not cause 100% mortality of striped bass larvae but is expected to more closely approximate the 7-39% values. Current studies by NYU to accurately determine these mortalities are expected to be completed in early 1974.

Chlorination

Several factors indicate that chlorination as employed at Indian Point Unit 3 will have no significant biological effect on populations in the river (Appendix AA). Chlorine, as sodium hypochlorite, will first be introduced into one-half of the condenser (3 sections) for one-half hour. The chlorine will then similarly be introduced into the remaining three sections. This procedure will be employed essentially as described in Appendix AA. This would result in the treatment of 1.78% and 1.19% of the water entrained during the summer and spring-fall regimes, respectively. No chlorination whatsoever is scheduled when river ambient temperatures are below 45°F. This limited frequency of chlorination in itself would seem to negate any extensive detriment to the ecosystem. Additionally, the "day-time only" pattern of chlorination employed at Indian Point could be expected to reduce the potential for chlorine damage to diurnally migrating forms.

Research has further shown that chlorine tolerance like thermal tolerance is a dose response. At Indian Point, the short term (8-12 seconds) exposure experienced during normal operation by entrained organisms prior to reduction of concentration should thus further minimize the effects of chlorination on entrained individuals. Additional studies of the effects of chlorination at Indian Point are currently being conducted by New York University. The possible effects of chloramines produced as a result of chlorine added to the ecosystem have been discussed in Appendix Z.

*Marcy, D. C. J., 1971. Survival of young fish in the discharge canal of a nuclear power plant. J. Fish. Res. Bd. Canada. 28: 1057-1060.

Chlorination as it is applied to Indian Point Unit 3 could not affect more than 1.78% of the organisms entrained as a strict function of the duration of application. This fraction of the community could be expected to experience mortality and inhibition of photosynthesis as a function of its exposure, but the short duration of entrainment and relatively low chlorine concentrations encountered should reduce these effects to a low level. Overall effect on the community would be further reduced by the removal of diurnally migrating forms from any contact with chlorine. Total average river flow at Indian Point has been estimated at 80,000,000 gpm. Full flow operation of all Indian Point units is estimated at slightly over 2,000,000 gpm. This represents only 2.5% of the total flow (fresh and tidal) and thus indicates that the fraction of the plankton community passing and repassing Indian Point which might be entrained would also be small.

When these factors are considered simultaneously, it becomes apparent that no significant effect of chlorination can be projected for the operation of Indian Point Unit 3 either alone or in conjunction with Units 1 and 2.

Cumulative Impact of Other Plants

Temperature elevations at the condensers of existing and proposed plants approximate those proposed for the Indian Point facility (see Table 5, Appendix AA). The critical temperature periods projected for Indian Point are then generally comparable throughout the region. The individual effects of other proposed facilities in the area can be assumed to be generally comparable to these values relative to the volume of water entrained at approximately the same ΔT, modified by differences in populations susceptible to entrainment, as they differ in different locations on the river and with different plant configurations. The probability of entrainment of a water mass passing through the area might then be expected to be increased by approximately 1.3 times that expected for those facilities already in operation. Moderating factors such as regeneration of certain populations in passage through the intervening distances, passing of populations below this river reach prior to critical temperatures and reduced tidal surge in upstream areas, plant configurations and population differences will influence the relative effect of the plants in relation to the per unit volume relationship and generally are expected to reduce the 1.3 ratio.

F. Impingement

Since Indian Point Unit 1 began full operation in 1963, large numbers of fish have been collected from time to time on the screens at the cooling water intake. This problem has been a concern to Consolidated Edison, State and Federal agencies, sports enthusiasts, and conservationists. A detailed report on the fish protection at Unit 1 was filed with the Atomic Energy Commission on November 12, 1970 (Appendix S). The findings and conclusions of the AEC were issued in a report dated October 1971, entitled "Report of Inquiry into Allegations Concerning Operation of Indian Point 1 plant of Consolidated Edison Company". During the past ten years various methods of reducing this impingement mortality have been implemented. Studies related to the cause of impingement, its solution and its effect on the natural abundance of fishes, are still in progress and provide the basis for predicting the biological effects of impingement at Indian Point Units 1, 2 and 3 (Appendix BB).

Numbers and Species Collected

The number and weight of fish collected at Unit 1 under current operating conditions (Appendix BB) can be used, within limitations, to predict the anticipated annual impingement at Units 2 and 3. The limitations relate to the differences among the plants and the variation in the abundance of fish in front of the intakes. If one assumes the impingement is directly related to flow rate, one can multiply the projected annual impingement at Unit 1 by a factor of 3 to predict the impingement at each of Units 2 and 3. Thus the projected annual impingement for Indian Point becomes:

	Number	Weight (lbs.)
Unit 1	372,863	4,089
Unit 2	1,118,584	12,263
Unit 3	1,118,584	12,263
Total	2,610,031	28,615

This estimate accumes that all three units will operate every day of the year, which is not the case. The estimate will be reduced by the annual refueling outage of each unit, and impingement may be further reduced by the operation of air curtains in front of all intake bays, which have not yet been fully tested.

A relatively small number of species constitute the bulk of the fish collected at the Indian Point intake screens. White perch, striped bass, tomcod, herrings (*Alosa sp.*), and bay anchovy have occurred for extended periods of time. From December

1970 to March 1972, these species were 97.1 percent of the total catch: white perch, 70.7 percent; tomcod, 8.3 percent; striped bass, 3.1 percent; herrings, 12.8 percent; bay anchovy, 2.2 percent; all other species, 2.9 percent. Definite seasonal variations have occurred in the species collected on the screens (Appendix BB).

Although the absolute numbers of fishes collected on the intake screens seem large, the actual poundage and the number relative to the total population of fingerlings in the river is small. The species collected on the screens are predominantly young-of-the-year which have a high natural mortality and which have not entered the reproductive stage of their life histories. Consequently, the removal of these fishes reduces the reproductive potential of the populations of the Hudson estuary only to the extent that the number of fish produced in the Hudson reaching maturity is decreased. The commercial fishery has demonstrated that, exclusive of shad, a substantial exploitation of fish expressed either in numbers or pounds can be sustained by a fish population without adversely affecting the fishery as a whole. Cases of fish populations sustaining annual removals of 25-30% of the stock or more have been documented. Indeed, the white perch population of the Hudson River has sustained annual removals of 60,000 pounds with evidently no adverse effects. Likewise, the commercial harvest of adult striped bass has varied from 18,000 to 133,000 pounds per year and has been increasing since 1935.

Comparison with Commercial Fishery

It is possible to compare the number of young-of-the-year white perch collected on the intake screens at Unit 1 with the potential number of young-of-the-year removed by the commercial fishery. The comparison can be made by estimating the number of young-of-the-year which would have been produced by an annual commercial harvest of adult white perch. The formula for this estimate is:

$$N = \frac{C}{W} \ (R) \ (F) \ (S)$$

where:

N = young-of-the-year

C = commercial catch in pounds

W= average weights of adults in pounds

R = percent females in the catch

F = fecundity

S = survival to 1 year

Assuming a commercial catch of 3,000 lbs., fecundity of 30,000 or 100,000 eggs per female and survival of 0.01 or 0.001 to age 1+

$$N = \frac{3000}{0.3} (0.5) \times \begin{pmatrix} 30,000 \\ 100,000 \end{pmatrix} \times \begin{pmatrix} 0.001 \\ 0.01 \end{pmatrix}$$

the potential number of young-of-the-year ranges from 150,000 to 5,000,000. If we increase the commercial catch to 60,000 lb./yr., the potential loss of young-of-the-year during the following year is 3 to 100 million. Yet the white perch population in the Hudson estuary has been able to sustain levels of more than 3,000 lb./yr. mortality for about 40 years with apparently no irreparable or irreversible damage. The annual number of young-of-the-year collected on the intake screens at Unit 1 is estimated to be 263,614 (see Table 6, Appendix BB). Consequently, it is unlikely that mortality from the present low commercial harvest (2,000 lb/yr.) and impingement of white perch will cause an adverse or permanent impact on the population while environmental studies are in progress at Indian Point.

A similar calculation may be performed for striped bass. Take the minimum commercial catch in the Hudson in recent times as 18,000 pounds (1935). Assume an average weight for an adult striped bass of 10 pounds, a fecundity of 300,000 to 1,000,000 eggs/female, and survival of 0.001 to 0.0001 to age 1+.

$$N = \frac{18000}{10} \times (.5) \times \begin{pmatrix} 300,000 \\ 1,000,000 \end{pmatrix} \times \begin{pmatrix} 0.0001 \\ 0.001 \end{pmatrix}$$

The potential number of young of the year ranges from 27,000 to 900,000. If we increase the commercial catch to 133,000 pounds, which was the largest recent harvest (1960), the potential loss of young of the year is 200,000 to 6,650,000. The striped bass population in the river has been able to sustain losses in these ranges for almost 40 years. The annual number of striped bass young-of-the-year collected on the intake screens at Unit 1 is estimated to be 11,559. Thus it is unlikely that

the impingement of striped bass will cause an adverse or permanent impact on the population while environmental studies are in progress at Indian Point.

Ecologically, the biomass of fish removed from the immediate area of the plant through impingement is much more relevant than impact based on removal of individual fish. Estuaries are very productive areas, and sustained fishery production of 50 pounds per acre in the Gulf of Mexico and 155 pounds per acre in the Chesapeake Bay and its estuarine tributaries have been reported. If the extreme assumption is made that all fish impinged at Indian Point come from the 4 square miles of river in the immediate area, an annual removal of 11.2 lbs./acre for all species combined can be calculated for operation of all three units at Indian Point. When compared to the minimum estimates of fish biomass in the estuaries mentioned previously, these postulated removals are insignificant. While the total fish population of the Hudson has not been quantified (it is under study), there is every reason to be confident that the common belief that the Hudson is highly productive will be verified. When it is further considered that the removals almost certainly come from an area larger than the 4 square miles, and hence the poundage removal per acre of estuary is even less than the figures given, the significance of mortality by impingement is reduced still further (see testimony of McFadden).*

Since the largest numbers of fish are collected during the winter months, Consolidated Edison now plans to operate the Indian Point Plant at reduced (60 percent) intake flows from October through March of each year. Tests have indicated that flow reduction can reduce the average daily collections as much as 76 percent at Unit 1. Based on the results of flow reduction tests, swim speed tests, and the advice of the Fish Advisory Board, this operational procedure should continue to reduce fish impingement at Indian Point to a level substantially below that previously experienced. If the present best available projection of fish impingement is reasonably accurate, the numbers of fish impinged with all units will be no greater than the impingement experienced

*McFadden, J. T. 1972. Impact of entrainment and impingement at Indian Point Units 1 and 2 upon fish populations: U. S. Atomic Energy Commission, 30 October 1972. Docket No. 50-247.

at Unit 1 before 1970 and to which no adverse population effects can be ascribed. In any case, mortality would not be expected to cause significant irreparable or irreversible damage before mitigating measures can be instituted.

Theoretical Aspects of Fish Mortality

Impingement is one of many mortality factors affecting fish populations in the lower Hudson. Fish populations are controlled by two general classes of factors: extrinsic factors, such as predators or other species which compete for food, space or other environmental requisites; intrinsic factors, such as population density, which result in intraspecific competition for environmental requisites. Each fish species has a reproductive potential determined by its physiology and life history. Natural environmental factors normally control the actual replacement rate. An increase in mortality due to some extrinsic agent, such as a fishery, natural predator, or the operation of a power plant, will be at least partially mitigated by an increase in reproductive rate, increase in growth rate, or an increase in survival at some responsive life history stage. Each fish population has the capacity, within limits, to compensate for additional mortality. A population may maintain its equilibrium through a combination of low mortality rate and low reproductive rate, through a combination of high mortality rate and high reproductive rate, or through other means. It is also possible to balance a high mortality rate with recruitment from adjacent populations in the Hudson estuary. Any of these situations could reflect an ecologically healthy population, and in the latter cases a sizeable component of the total mortality could be man-induced. Studies of striped bass populations have indicated that there is a compensatory response to changes in density.* Over a certain range of population density as the numbers of spawners are reduced, the size of the year class of progeny they produce will remain the same or even increase. Through this mechanism fish stocks have persisted or even expanded during periods of increasing exploitations by man.

A population may be considered ecologically harmed when it is subject to a mortality rate so great that the maximum possible increase in reproductive rate does not compensate adequately to maintain the population. The population would then

*McFadden, J. T., 1972. Impact of entrainment and impingement at Indian Point Units 1 and 2 upon fish populations: U. S. Atomic Energy Commission, 30 October 1972. Docket No. 50-247.

decline in abundance until it reaches a new stable level. If the incremental mortality rate imposed on the population is further increased and not compensated for by modifying the source of mortality, or by natural compensation and stocking, the population could be forced to extinction. The commercial fishery statistics suggest that the annual harvest of white perch and striped bass may be lower than their maximum sustained yield. The shad population declined from its former levels of abundance and productivity due to over-exploitation and environmental changes. The shad population lacked the resistance to exploitation and environmental change. It should be noted that this exploitation averaged 1,450,000 pounds per year during 1939-1948 which was prior to the decline in population. This compares to an average exploitation of striped bass of 58,000 pounds per year in the Hudson since 1939 by commercial fishing and a predicted 1,000 pounds per year by Indian Point Units 1, 2 and 3. The limits to which striped bass can absorb additional mortality are not yet known but are under study. Should this study indicate a need to mitigate losses due to plant operation, several means of mitigation are available.

Projected Impact

Based on the best available projection of fish impingement the normal operation of all three units will remove less than 2,610,031 fish or 28,615 pounds of fish from the Hudson River in the vicinity of Indian Point. When compared with the minimum estimates of fish biomass in estuaries the postulated removals are insignificant. It is expected this loss of biomass would be mitigated by a significant compensatory response in the fish populations. Should the compensatory response be too weak to replenish losses, the fish populations would begin a gradual decline to a new level. This decline would be reflected in population parameters, which are currently being monitored, before irreversible damage to the population occurred. Should serious ecological damage be indicated from the operation of Indian Point Units 1 and 2, it would be clearly demonstrated by 1977 when the current ecological study is completed. On the basis of any reasonably postulated loss rate due to operation of Units 1 and 2 commencing in spring 1973, the fish stocks of the Hudson River would not be subjected to irreversible damage by 1981 due to the addition of Unit 3. Mitigating measures to include closed cycle cooling for appropriate units could be operational

if construction were commenced in 1977 following completion of the ecological studies. Other non-structural mitigating measures can also be considered such as artificial stocking, limiting heat and/or temperature, limiting volume of cooling water and velocities of intakes.

It is worth noting that observations of impinged fish have shown them to be significantly more infested with parasites and to have lower weight to length ratios than their overall populations (see Appendix BB). Thus the impact of the mortality caused by impingement may be somewhat offset by the fact that in cropping the less fit members of the fish populations, competitive pressures on the remaining healthy members may be eased. In addition, it is Con Edison's intention to return all collected fish to the river. Thus, even if they do not survive, they will become food for decomposers, birds, and other species and no biomass will have been removed from the ecosystem.

G. Other Effects

Dissolved Oxygen

The utilization of Hudson River water for cooling and the subsequent discharge of this heated effluent into the river is not expected to alter the dissolved oxygen concentrations of the estuary. Since warm water contains less oxygen in solution at saturation than cooler water, increasing coolant water temperatures by 15° F (or possibly reaching a ΔT of 26° F during winter-time operation) can theoretically result in some loss of oxygen. However, studies have indicated that the oxygen content of cooling water changes very little in its passage through electrical generating stations.* Most unheated water is not saturated, but passage of the coolant through the condensers supersaturates the effluent with dissolved gases. In addition, the turbulent flow of most effluent outfalls allows unsaturated water to be recharged by atmospheric gases, while supersaturated water has a tendency to lose dissolved gases. The net result is a relatively stable oxygen concentration across the condensers. Where oxygen concentrations change, they are relatively small when compared with those occurring in most natural waters through photosynthesis, respiration and the oxidation of organic effluents.

*See Alabaster and Downing. 1966. A field and laboratory investigation of the effect of heated effluents on fish. Fishery Investigations, Series 1. Vol. 6(4):1-42.

Once the warm effluent has entered the Hudson River from the discharge canal, oxygen demand by organic materials could be increased by increased metabolic rates at the higher temperatures and dissolved oxygen levels could fall below those normally expected. The Hudson River estuary near Indian Point has a relatively low load of decomposing organic matter, and the oxygen concentration in the water discharged from Unit 1 averages slightly less (0.2 ppm) than that in the intake water. A mathematical model of dissolved oxygen has indicated that the cooling water passage through the plant will have an unmeasurable effect on the distribution of dissolved oxygen in the Hudson River.*

Nutrient Circulation

The operation of Indian Point could also have an effect on nutrient circulation near the plant. The thermal plume may cause temporary stratification of the water column which could inhibit complete vertical mixing of the water. The submerged jet discharge, tidal turbulence, and dilution from freshwater runoff will aid in mixing the effluent and reducing stratification. Consequently it is doubtful that nutrient circulation will be adversely affected by stratification. Stratification induced by plant operation may be insigificant when compared with the density stratification which occurs when the widely fluctuating freshwater runoff flows over the more saline estuarine water on its way to the sea.

Scouring

The flow of river water toward the cooling water intakes has the potential of scouring the bottom area for a very short distance in front of the intake structures. Bottom sampling at the Indian Point Unit 1 intake has indicated that the substrate is firm and heavily colonized by benthic invertebrates (Texas Instruments, unpublished data). The operation of Units 2 and 3 will increase the volume of water entering the plant and the potential for scouring over an estimated one acre of bottom, an insignificant fraction of the bottom community. This scouring could change the habitat of the

*Quirk, Lawler & Matusky Engineers. 1970. Hudson River water quality and waste assimilative capacity study. Final report to State of New York, Department of Environmental Conservation. 198 p.

existing benthic organisms, and those species which are unable to compete successfully in the new environment will be replaced by other species. The nature and extent of this change in species composition is presently unknown, but its effect on the biotic community would be local and reversible because of the abundance and mobility (recolonization potential) of many of the resident benthic species (Appendix AA). The potential also exists for scouring at the discharge ports, but its effect will be minimal (if any) because of the trajectory of the heated effluent toward the surface under most operating conditions.

H. Integrated Biological Effects of Plant Operation

The incremental additional effects on the Hudson ecosystem caused by Unit 3 operating as planned are not expected to cause irreversible damage to the river from the time of startup in 1975 to 1981 when a closed cycle cooling system can be in operation. During this period ecological monitoring would be continuous and would readily identify the onset of any trend towards irreversible damage in time to permit initiation of mitigating measures to prevent irreversible damage. There is no indication that rare and endangered fish species will be affected. The use of 2.5% of the tidal flow for condenser cooling will not limit additional beneficial uses of the water resource. Dissolved oxygen may be reduced by 0.2 ppm while passing through the condensers, but any reduction in D.O. in the estuary due to operation of the plant will be immeasurable and could be mitigated by aeration if necessary. The plant will not adversely affect nutrient circulation in the estuary. Bottom scouring in the vicinity of the intakes will affect approximately one acre, an insignificant fraction of the bottom community.

Chemical Discharges

Chemicals will be discharged from Indian Point in low concentrations which will be diluted by large volumes of river and tidal flow. Bioassays have been performed which demonstrate that the chemical effluent will not be toxic to the fauna during normal operations. Since the chemicals are noncumulative, a low but constant concentration will have no detrimental effect on the biota. Chemical discharges can be expected to have no adverse biological impact at Indian Point.

Thermal Discharges

The biological effects of thermal discharges at Indian Point will be confined to the area of the thermal plume. This plume will meet New York State standards for thermal discharges. There will be no significant changes in the abundance or species composition of phytoplankton due to plant operation. The thermal discharge will have a negligible impact on river populations of bacteria. Field and laboratory experiments have indicated that maximum plume temperatures will not be lethal to species of the micro- and macro-invertebrate zooplankton which have been studied at Indian Point. Thermal tolerance tests have demonstrated that temperatures which may be encountered generally in the plume will have no measurable effect on the egg and larval stages of striped bass. Post larval and adult fish have the ability to avoid the thermal plume. Although ecological studies are still in progress at Indian Point, information to date suggests that the thermal effluent will have no significant adverse impact on the Hudson River ecosystem, including migration.

Impingement

Fish will be collected on the intake screens at Indian Point. Using the impingement data of 1971-1972 for Unit 1, the projected annual impingement for all units is 2,610,031 individuals or 28,615 pounds, the composition of which is expected to be approximately 71% white perch and 3% striped bass. The biological impact of this mortality is still being investigated and is expected to be insignificant. Any potential adverse impact will be local and reversible within the schedule of environmental studies at Indian Point. There will be no irreversible adverse impact on the Hudson River or Middle Atlantic striped bass fishery before the current studies are completed in 1977 and alternatives to once-through cooling can be evaluated and constructed.

Entrainment

Entrainment at Indian Point will expose plankton to varying degrees of physical buffeting, pressure changes, temperature increases, and chemical treatment. There will be no significant effect on bacteria or phytoplankton during entrainment. Preliminary results of studies underway at Indian Point indicate that mortalities due to pressure differentials and physical abrasion during entrainment can be expected to cause between

7 and 39% mortalities at 95% confidence levels. Chlorination of the condensers at Indian Point has no significant biological effect. Thermal tolerance data for Indian Point indicates that entrainment will have no effect on biota for 9.5 months of the year. During the remaining 2.5 months, one-half of 28.5% of the entrainable species may be killed in their passage through the condensers. This incremental increase in mortality would be local and reversible within the schedule of the current environmental studies at Indian Point.

Studies at Indian Point demonstrate that operation of Units 1, 2 and 3 will cause no irreversible damages to the Hudson River ecosystem before 1981. If current investigations and monitoring programs indicate significant change during this period, mitigating measures could be initiated. No significant changes in abundance or composition of bacteria, phytoplankton or zooplankton will result from the planned operation of Indian Point. Thermal tolerance tests show that there should be no effect on the egg and larval stages of striped bass at temperatures encountered in the thermal plume. The Hudson River's striped bass population is believed to have a substantial compensatory reserve which would appreciably reduce losses in the population due to plant operation. No irreparable damage to striped bass populations of the Hudson River or Long Island Sound is expected and no effect is expected on the major Atlantic Coast populations arising from the addition of Indian Point Unit 3 to the Hudson River.

12.2 Adequacy of Ecological Studies

(a) Fish Advisory Board

Con Edison has organized a Fish Advisory Board consisting of expert biologists and engineers from the United States and Great Britain. The members of the Board are:

1. Dr. Merril Eisenbud, (Chairman), Director, Institute of Environmental Medicine, New York University.
2. Dr. Gerald J. Lauer, (Scientific Secretary), Assistant Director Institute of Environmental Medicine, New York University.
3. Dr. Gwyneth P. Howells, (Member), Ecological Consultant, Great Britain.
4. Dr. John Lawler, (Member), Quirk, Lawler and Matusky, Sanitary Engineer.
5. Dr. James T. McFadden, (Member), University of Michigan, Aquatic Population Dynamics.
6. Mr. Herbert S. Riesbol, (Member), Bechtel Associates, Hydrologic Engineer.
7. Dr. Edward C. Raney, (Member), Ichthyological Associates.
8. Mr. Herbert E. Doig, (Associate Member), New York State Department of Environmental Conservation. Chairman of Hudson River Policy Committee.
9. Mr. Peter Isaacson, (Associate Member), Public Service Commission, New York State.

The Fish Advisory Board provides Con Edison with recommendations on the conduct of its ecological studies and expert opinion on the impact of Con Edison's operations on the aquatic environment.

(b) Hudson River Policy and Technical Committees

Each of these committees consists of representatives of New York State Department of Environmental Conservation, New Jersey Division of Fish and Game, National Marine Fisheries Service, and the United States Bureau of Sport Fisheries and Wildlife. In addition, the Technical Committee maintains a biologist from the Bureau of Sport

Fisheries and Wildlife on site to observe and report on the conduct of the studies. These committees provide technical guidance and review of the studies of the aquatic environment which the Company is conducting on the Hudson River.

13.0 ENVIRONMENTAL MONITORING PROGRAMS

13.1A Indian Point Ecological Studies

In order to determine the environmental impact of operating the Indian Point Nuclear Power Station with a once-through cooling system, Con Edison has initiated an extensive seven year ecological study of the lower Hudson River. This study will:

(1) determine the biological significance of impingement of screenable fishes at the intakes of Indian Point Units Nos. 1, 2, and 3.

(2) determine effects and biological significance of plant operation on non-screenable organisms (including fish eggs and larvae, and plankton) in the coolant water passing through the once-through cooling systems for Units Nos. 1, 2, and 3.

(3) determine the biological significance on the Hudson River ecosystem of thermal and chemical additions from Indian Point Units Nos. 1, 2, and 3.

(4) determine the biological significance on the Hudson River ecosystem of aquatic organisms passing through or being attracted to the thermal plume and/or into the effluent canal or intake.

(5) develop and test concepts of protective measures for minimizing adverse biological effects and ascertaining biological benefits and costs of such measures.

(6) develop and use mathematical models to aid in the evaluation of the effects of entrainment and impingement on the population of striped bass.

A flow chart showing the duration and key points of the studies being performed is shown on Figure 13.6. This schedule was prepared when Indian Point Unit No. 3 was predicted to come on line in 1973. Since it is now estimated that the plant will begin operation in 1974, an extension of the ecological studies for about one year is under consideration.

The studies will evaluate the effects of operation of once-through cooling of Indian Point Units Nos. 1, 2, and 3 on the Hudson River ecosystem. Data provided

from these studies will aid in determining biotic stresses in the river as well as methods and means for minimizing adverse effects. In addition, this survey will provide the information necessary to determine the effect on the ecosystem of the operation of Units 1, 2 and 3 taken individually and in combination, in order to evaluate synergistic effects.

I. SAMPLING PROGRAMS

A. Impingement (See Fig. 13.6, Item 22)

Summary

Evaluation of the biological significance of the mortality rates imposed upon the fish populations at the intake screens, the populations at the intake screens, and the population dynamics of two key species present in the Indian Point area, striped bass, *Morone saxatilis* and white perch, *M. americanus* will be determined. Included will be observations of density, size, and weight of the two species. The mortality rates caused at the intakes and the condition of these fish will be determined directly and compared to natural population densities. Any interactions (i.e. trophic overlap, predation) between striped bass and white perch in the lower Hudson River will be determined and evaluated within the context of plant induced mortalities. Data involving fish kills at the intake screen will also be evaluated with respect to the impact on the Hudson River fish population.

Program

A fish monitoring program at the intake screens of Indian Point Units 1 and 2 and 3 has begun. Quantitative data on species, i.e., size composition, age structure, back calculated growth rates, relative weight, parasite load, health condition (histophysiology and pathology) and egg fecundity values are collected on a regular basis. These measurements are then compared to duplicate measurements done on fish collected by conventional net techniques.

Initial results indicate that impinged striped bass and white perch have higher gillparasite load (6% vs. 0.5%) and lighter body weights (75% less weight per unit of

length) than net-caught fish. These studies are designed to document these initial results, clarify their meaning, and determine if plant operations could cause the differences. The fecundity values, growth rates, and pathological conditions of the impinged fish, relative to the background river fish, will be used to determine if the apparent stress is of chronic or recent origin. Actual age structure (as determined by scale annuli) allows the calculation of age specific mortality rates. These artificial mortalities and the fecundity values of the impinged fish will be quantitatively evaluated within the dynamics of the background striped bass and white perch populations. The results of the number of striped bass impinged, egg fecundity values, etc. obtained from this study will be used to adjust the predicted effect of the Indian Point plants on the Hudson River striped bass population. Impingement mortalities are also being evaluated in reference to seasonal variation (thermal and salinity interactions), pumping intake velocities and volumes and position of intake screens relative to the river and intake structure.

B. Entrainment (See Fig. 13.6, Item 19)

Summary

The biological significance of aquatic organisms being drawn or attracted into the intake canal is being quantitatively determined by measuring the longitudinal and vertical distribution of planktonic organisms on a diel basis, applying these densities to the actual water mass subject to entrainment on a diel basis, comparing these theoretical entrainment values to observed densities of entrained organisms, and finally establishing the immediate and delayed effects of entrainment (passage) of non-screenable organisms through the condenser system of the plant. The purpose of this study is to provide information on the types and quantities of plankton, fish eggs and larvae passed through the condenser cooling water system in order to determine the effect of passage on their survival; and to determine if losses observed from condenser passage will create adverse effects on the existing populations in the receiving waters.

Program

Quantitative sampling is being done in the river, intake bays and discharge canal during all seasons of the year. Survivorship and behavior of zooplankton and fish larvae are immediately compared to see if any statistically significant differences are observed between the control group (intake bays) and the treated group (discharge canal) which passed through the condenser tubes. In addition, a series of experimental laboratory studies are keyed to combinations of ΔT, chemical discharges, and residence times through the system produced by various plant operational schemes. Effects measured are lethality, behavioral, and reproductive changes for zooplankton; lethality and behavioral changes for fish larvae; lethality for fish eggs; and photosynthetic capability and chlorophyll concentration for phytoplankton. Studies include sequential trials, trials of different size groups of key species, and multi-species trials. When possible, all life history stages of each organism are studied.

C. Effects of Thermal and Chemical Effluents on Estuary (Fig. 13.6, Items 35, 37)

Summary

The biological significance of thermal and chemical discharges from the plants will be determined by establishing the rate, quantity and distribution of these discharges, and relating these to the densities and distributions of zooplankton, phytoplankton, fishes and benthos in the study area on a seasonal basis. The population dynamics, turnover rates, productivity, and species diversity of plankton organisms are being determined and will be used to evaluate the significance of any observed effects on the system.

Program

Thermal studies, the attraction of fish to the discharge canal, infra-red mapping of thermal plume, and acute and chronic effects of temperature on survival and behavior of fish and benthic invertebrates have been investigated since April 1, 1972 and will continue through October 1, 1975. Studies of thermal preferences and the impact

of thermal shocks on fish and invertebrates can be carried out simultaneously in the facilities available, and are planned for completion in 1973. They require a full year due to seasonal changes in reactions of the organisms. The temperature avoidance study, which also required one year to complete, is planned for calendar year 1974. Assay of chronic temperature effects through study of active respiration will require two full years for completion. This work is planned to extend through 1974 and 1975.

Active respiration studies will be designed to allow for evaluation of the effect of predicted thermal discharges on secondary production rates of selected fish and benthos. These rates will be determined through laboratory experiments. Additional laboratory experiments will be performed to determine the acute and chronic effects of temperature on the life stages of key aquatic species, the effect of temperature on the behavior of these organisms, the upper and lower temperature tolerances of these organisms, and the relationship of these data to plant operations.

Computer simulation, hydraulic modeling, aerial infrared measurements at critical tidal stages (correlated with control measurements in the river), and a 25 station thermal grid are being used to derive the intensity and extent of thermal discharges (Units 1 and 2). Thermal infrared imagery will be collected during four overflights to coincide as close as possible to the major phases of the tidal cycle, (i.e. high and low slack, maximum ebb and flood).

These overflights will be replicated with Unit 1 operating alone, Units 1 and 2 together, and Units 1, 2 and 3 as a battery. The thermal imagery will be used to compile isothermal maps with 1°F contour intervals from Stony Point to Annsville Creek. The 25 station thermal grid is placed in the river to permit the construction of axial and cross-section isothermal plots of the thermal plume. The grid system will be located in the vicinity of the Indian Point station. The exact location will depend on biological needs and findings.

Plant production records provide data on the frequency of chlorination, concentrations and durations by season as related to organic build-up in various water passages, and efficiency losses in order to establish the minimum amounts of chlorination

that are absolutely necessary. Physical and chemical parameters are being measured in the intake bays and effluent canal and also at three transects (Figure 13.3-1): one from Verplanck southwest to Stony Point, one from Jones Point to Peekskill, and the third, a Y-shaped transect, at Indian Point. Each transect includes a main channel (deep) and a bay area (shallow) which allows for evaluations in different habitats. The northern transect serves as the control and the southern will show the effects of passing through the plant's influence. The middle transect is designed to sample close to the nuclear facility itself. The physical-chemical measurements (along with previous data) will define those physical and chemical properties of the estuary which have important influences on the biota. (Table 13.3-2).

The end result of this measurement program will be an atlas, which presents a multidimensional picture of the pertinent variables in the Indian Point area of the lower Hudson River. This reference will serve as a data base, in a readily usable format, which will allow investigators to quickly recognize the onset of unusual conditions of water quality.

Dissolved ion ratios are being measured to ascertain the location of the migratory "salt wedge" which is a critical factor in several species distributions. These data, along with temperature and specific conductivity, are used to define "salinity".

Dissolved oxygen is measured to assist in the identification of water inputs that degrade water quality and will be included in the atlas via a grid system, as will pH. Turbidity is also included because of its relationship to photosynthesis. Inorganic and organic carbon are monitored as indicators of organic pollution and because of their relationship to secondary production of filter feeders and dissolved oxygen levels.

Chlorine demand, residual chlorine concentrations, and organo-chlorines are also measured as a direct chemical perturbation. Survival experiments will test the immediate effects of chlorine dosages routinely added by plant operations to fish residing in the vicinity of the effluent canal.

Laboratory experiments will be performed to establish the influence of ambient and elevated water temperatures on the physiology of key fish species. The temperature

at which these species suffer equilibrium loss and death will be defined (i.e. thermal tolerance studies). The effects of short term exposure to "shock" temperatures (above or below ambient) will also be determined. An active respiration study (Reference 13.3-12) will be conducted to define the chronic effects of temperature on key fish species. Measurement of internal energy transfers and utilization at specific temperatures will be used (food consumption, assimilation, and growth).

D. Biological Significance of the Thermal Plume on Aquatic Organisms

Summary

Key benthic invertebrates will be subjected to temperature tolerance and shock experiments and will be used to determine the long term effect of temperatures experienced in the effluent canal and discharge area on life cycle processes and growth rates. In addition these species will be used for in situ cage experiments comparing long term survivorship in the intake and effluent canals. Laboratory findings from temperature preference and avoidance experiments of white perch and striped bass will be compared with field results (fish and temperature distributions). Pertinent temperatures for these experiments have been chosen from actual or predicted temperatures for the Indian Point area of the Hudson River (ambient and changed by plant operations).

Program

The significance of attraction into the effluent canal and plume area is primarily directed at fish species. Fish traps, beach seines and electro-shocking are used to provide data on species composition, abundance, size, age, fecundity, and general condition in these areas. Temperature profiles are determined to verify the extent and location of the thermal plume itself. The results of the laboratory experiments on temperature preference and avoidance will be compared to aggregations of fish found in the effluent canal and plume area. A fish tagging program in the discharge canal and plume area will be used to determine residency periods and local dispersal. Tagging procedures will follow those methods found most efficient in the population dynamics studies.

E. Feasibility of Stocking Program (See Fig. 13.6, Item 39.1)

Summary

The feasibility of stocking juvenile striped bass to mitigate losses caused by plant operations will be determined by thoroughly investigating the technology and economics of existing hatchery programs. The federal striped bass hatchery at Edenton, North Carolina will be used in this analysis as will the Washington State salmonid hatchery system that presently replaces salmonid losses due to public hydroelectric dams with hatchery reared fish.

Program

A cost-benefit analysis will follow that will also include developmental, engineering, siting and operational costs of a striped bass hatchery on the Hudson River. If this analysis shows that such a hatchery would be feasible, a test hatchery would first be built to discover possible unforeseen problems and to prove the technological feasibility, followed by the actual hatchery upon completion of satisfactory testing. Such a system would be scientifically advantageous in providing an excellent source of markable fish for total population estimates of the striped bass in the entire Hudson River estuary, migration patterns, survivorship, etc.

F. Fish Flume Study

Summary

Con Edison is considering initiating a flume study to obtain pertinent biological data needed in designing intakes to effectively reduce fish impingement at existing and proposed power plants. The study would develop and evaluate intake designs with respect to protection systems in order to ascertain the combination of device, approach velocity and volume of cooling water which will reduce fish impingement (and entrainment) to an acceptable level on the Hudson River.

Program

The objectives of the study would be to:

1. determine the information existing on flume studies, fish protection facilities and fish behavior pertinent to the present study

2. design, construct and field test a land based experimental flume

3. determine flume flow patterns for each device, water depth and velocity to be tested

4. test the efficacy of the fish protection devices on Hudson River fish at several stages in the life cycle

5. modify the devices found to be most effective in screening fish with minimum mortality rates; design and test entirely new fish screening and guidance devices, if necessary

6. estimate the impact on the fish populations of the Hudson River plants using each of the three best devices developed in Objective 5

G. Striped Bass Life Cycle Model

The life cycle model of the striped bass population in the Hudson River, which was presented at the Indian Point 2 licensing hearing, interrelates river hydrodynamics and the biological features of the striped bass life cycle. The biological concept of a life cycle was employed to permit the model to carry the plant impact through many generations in order to obtain an estimate of the potential long-term impact of plant operations. The concept of "transport" was employed to account for the movement of the early stages of striped bass to determine the vulnerability of these stages to entrainment. The concept of biological compensation was employed so that the population could adjust to changes in mortality/survival rates at different stages as natural populations do.

The concepts incorporate many variables, some of which are well defined and others which are assumed or based on data from other areas. In the concept of transport the factor of dispersion is being studied for possible refinement. Important biological inputs to the transport equations include abundance and distribution of eggs and larvae, growth rate of larvae, and behavior of juveniles. Recent river-wide sampling is producing data that may require modification to the concept of transport in order for the model to reproduce the observed distribution and movements of the young fish.

Important biological data on the striped bass life cycle are currently being obtained through a population dynamics study of this species. Population estimates of the young stages, mortality rates of various stages, growth rate and fecundity data will be available in the future for the life cycle model.

The life cycle model has provided a preliminary estimate of the short term and long term impact of Indian Point and other power plants on the striped bass population of the Hudson River. In addition, it has provided a conceptual framework for the design of ongoing studies by clarifying those areas where additional biological data are needed. The life cycle model is an aid for predicting plant impact along with the results of the 5 year empirical ecological survey. We plan to modify the model as new data are developed.

H. Phytoplankton, Zooplankton and Benthos Studies (See Fig. 13.6, Item 12)

Summary

Another phase of the ecological survey at Indian Point involves the identification and quantification of the nature and the extent of changes in the distribution and abundance of phytoplankton, zooplankton and benthos.

Program

Phytoplankton density will be determined for total phytoplankton, diatoms, green and blue-green algae. Where practicable, algal identification will be to species

and the density of dominant organisms will be reported. Chlorophyll a will be determined at station locations 1 through 7 once a month; and ^{14}C uptake by samples from station location 5 (approximately one-half of discharge ΔT) and either station location 3 or 4 (whichever is outside of thermal plume) will be measured once a month during the months of May through September for the first year of plant operation. Differences in distribution and abundances, species composition, chlorophyll a and ^{14}C among stations as determined by appropriate statistical procedures will be provided.

Micro and macro-zooplankton will be identified by species to the extent practicable. Density in number of micro-zooplankton per liter and macrozooplankton per thousand m^3 will be determined for the major taxa and dominant species. Differences in distribution and abundance, species composition, station location and between night-day will be determined on a statistical basis and reported.

A comparison of benthos population dynamics of the estuarine isopod Cyathura polita will be made between a test region at Indian Point and a control region on the opposite side of the river beyond the effects of the plant. Monthly sampling will consist of three replicate 0.1 m^2 Petersen grab samples taken at random from twelve stations equally divided between the test and control regions. One biological dredge sample will be taken monthly in each region. All specimens of Cyathura polita will be measured (length) and sexed and these data analyzed by station and region. The community structure, species diversity, biomass and seasonal variability of other dominant species in the two sampling areas will be compared.

The above described Hudson River monitoring program is designed to observe the distribution, abundance, and diversity of plankton and benthos both before and after Indian Point Unit 3 comes on line. This will allow a comparison of the effects of plant effluents on river biota at various distances from the plant discharge. We need to know the plant impact on plankton and benthos due to their importance in the food chain and because of the sometimes different spatial and temporal distribution of various life history stages of aquatic organisms.

II. SPECIAL STUDIES

A. Population Dynamics (See Fig. 13.6, Items 4, 12, 15)

Using data from studies completed between 1965-70 and from other studies now underway and planned for completion in 1976, the following fish population parameters will be monitored for striped bass and white perch:

1. Population Density
2. Survival
3. Age Composition
4. Growth Rate
5. Age at Sexual Maturation
6. Sex Ratio

The above parameters change in predictable ways as a result of serious exploitation. The following consequences of serious exploitation may occur: Population density and population survival may decrease; Reduced recruitment may cause a predictable decline in the relative abundance of certain age groups in subsequent years as reflected in age frequency distribution data; Growth rate may increase; Sexual maturity may be attained at young ages; and Aberrations in sex ratio may appear. A data base exists with which each of these parameters can be contrasted before and after commencement of operation of Indian Point Unit #2.

Population Density

Five different measures of fish population density are available:

Catch/Effort Trawl data - relative abundance

Catch/Effort Seine data - relative abundance

Mark-Recapture population estimates - relative abundance

Egg Deposition estimates - relative abundance

Pelagic larvae estimates - relative abundance

In addition, work is underway to develop echo-sounding techniques which would allow much broader collection of catch/effort data. It will be possible, if this technique is successful, to follow changes in abundance and seasonal movements to different locations in the estuary more closely than is possible through trawling techniques alone.

Catch/Effort (See Fig. 13.6, Item 15)

The number of fish caught in a standardized amount of fishing effort using standardized collecting gears is an index or relative abundance of the fish population. Such indices are one of the longest established and most widely used types of data in the study and management of fish populations. Catch per unit of fishing effort - or catch/effort, the term used here - has been used to monitor changes in abundance from year to year and place to place in such widely differing situations as the great high seas fisheries of the world and local, hook and line, sport fisheries.

Catch/effort data have been collected for striped bass, white perch and other species in the vicinity of Indian Point by the use of trawls and beach seines. In the Indian Point Ecological Study now underway stations have been established from Ossining to Denning Point. These sampling stations, are distributed among three study regions, as shown in Figure 13.3-1. The most important region, due to its proximity to the plant, is Region I which extends from Haverstraw Bay to the Bear Mountain Bridge, with a concentration of stations near the Indian Point power plant. The sampling effort is distributed as follows:

	Region I	Region II	Region III
Boundaries	Haverstraw Bay to Bear Mt. Bridge	Bear Mt. Bridge to Storm King Mountain	Storm King Mountain to Beacon Newburgh Bridge
Number Trawl Station	10	3	3
Number Seine Stations	8	4	3

This sampling effort continues, in intensified form, the fish population monitoring begun in the Raytheon Study in June 1969. Because of the continuity in sampling, site, and methods from the Raytheon Study to the present Indian Point Ecological Study, it will be possible to contrast data from 1969, 1970, and 1972 - years free of Unit No. 2 effects - with data from 1973, 1974 and 1975, when Unit No. 2 is operative.

In addition to the main body of data, two additional sources of information which provide some comparison of past conditions within the fish populations of the Hudson River exist. First, trawling stations have been established in the current Indian Point Ecological Study which correspond to some of the stations sampled in the Cornwall study in 1965 - 1968. Secondly, ancillary information is available from fishery studies on the lower Hudson by biologists from QLM, Vassar College, Dutchess Community College, Boyce-Thompson Institute, and New York Department of Environmental Conservation.

Mark-Recapture Population Estimates (See Fig. 13.6, Item 4)

Unlike the catch/effort data which are indices of relative abundance, the mark-recapture methods provide estimates of absolute numbers in the population. Withdrawing a sample to determine the proportion of the population marked, dates back to the latter years of the 19th Century in fishery work (Reference 13.3-4). It has been applied to fish populations in almost every conceivable situation - small streams, large rivers, ponds, lakes, high seas. The same method is used to estimate the North American continental duck population, and has been applied to insect and mammal populations.

The basic method has been elaborated and adapted to a variety of complex situations, including the occurrence of mortality, emigration, and recruitment within the population being estimated (References 13.3-5, 13.3-6, 13.3-7, 13.3-8, 13.3-9, 13.3-10). The same principles underlie the technique in the many forms used today. For example, assume that 1000 Age Group O striped bass are marked and released alive in the Hudson estuary in the vicinity of Indian Point. In subsequent trawling

operations, 2000 striped bass of the same age are collected, of which 32 are recaptures of the previously marked fish. We then reason:

(1) 1000 marked fish are at large in the population

(2) Our subsequent sample indicates that 32/2000 = 1.6% of the total population are marked fish

(3) Therefore, the total population in the locality under study is 1000/0.016 = 62,500 fish.

The basic assumptions underlying the valid application of his method are given by Ricker (Reference 13.3-5). These have been examined during the fish collecting, marking and field trial work of 1972 at Indian Point in preparation for full scale mark-recapture estimates of the white perch and striped bass populations in 1973 and succeeding years. The only basic assumption which has been problematic is that marked fish be distributed at random in the population. However, by reintroducing marked fish to the population in proportion to the abundance of the population in different habitats (as determined from trawling data and possibly from echo-sounding) and by distributing recapture fishing effort proportionally across all segments of the population, this requirement for the valid use of the mark-recapture method can be fulfilled.

The developmental work of 1972 has already proven that large numbers of young white perch and striped bass can be successfully marked and released in healthy condition in the Hudson estuary to provide a basis for estimates of population size. This method is proceeding at full-scale in 1973.

Separate population estimates will be made for different age groups and size groups of fish, and for zones extending various distances from the Indian Point power plant.

Through use of differential marking in different zones of the estuary, the origin of fish collected on intake screens at Indian Point can be determined. At present it is not known whether a very local area or an extensive area of the estuary is affected. Until reliable estimates of the absolute abundance of fish during the first twelve months of life are available, no accurate statistical basis for assessing the

importance of impingement losses is available. The absolute numbers of fish collected from intake screens of the Indian Point plant have been determined with suitable accuracy. What proportion of the stock from the estuary this loss represents can be directly determined from the population estimate data collected in the ongoing ecological study.

Collection of data from three successive years (1973, 1974, 1975) is important for two reasons:

(a) The first year will represent the influence of Unit #1 plus no influence or minimal influence of Unit #2 (depending on operational status); the second and third years will reflect full influence of Units #1 and #2.

(b) Survival rates can be calculated for those year classes of fish included in two or more successive years' population estimates. Not only abundance of fish, but also their survival rates (an important component of population turn-over rate) are important in assessing an increment of mortality, such as expected from operation of the Indian Point power plant. In addition to their direct use in assessing ecological impact, these survival rate estimates will be most useful in "tuning" the parameters of the population dynamics model developed by QLM.

Because of greater abundance and vulnerability to collecting gear, the most precise population estimates will be obtained for the younger age groups of fish. It is planned to estimate the number of Age Group O and of Age Group I striped bass and white perch present in areas of the Hudson River adjacent to Indian Point. The best estimates will be for Age Group O in the fall. It is anticipated that the study will be able to discriminate a 25 percent change in abundance of these fish at the 95 percent confidence level.

Combined Use of Catch/Effort Data and Mark-Recapture Population Estimates

During 1973, 1974, and 1975, catch/effort data will be collected in the same time periods and localities in which the mark-recapture population estimates are made. A relationship between these two types of population data can be developed where the two are collected in parallel, and this relationship can be applied to the catch/effort

data of earlier years (1969, 1970, 1972) to calculate approximate values for absolute abundance of fish.

B. Mortality and Survival Rates (See Figure 13.6, Items 4, 12, 15, 19)

Collections of white perch and striped bass obtained from the standard trawl and seine stations are separated into four size groups (50, 50-125, 125, 250 mm) and 15 individuals of each size (if available) are randomly picked for age determination by scale analysis. Both species show clear annuli and can be aged quickly and reliably so that relative age structure can be determined.

Both data on relative abundance of successive age groups, as obtained from catch/effort study, and data on absolute abundance, as obtained from mark-recapture, egg deposition, and fish larvae estimates can be used as a basis for calculating mortality rate, and its complement, survival rate.

Taking the data from the entrainment studies together with the survival data based on population estimates the following sequence of calculations will be carried out:

(1) the number of eggs spawned in the estuary;

(2) the size of the larval population;

(3) from the entrainment study, the density of eggs and larvae in the immediate vicinity of the power plant water intake;

(4) from (1), (2), and (3) the fraction of the population of eggs and larvae subjected to the influence of the water intake;

(5) from the entrainment study, the number of fish entrained and the number passing alive through the cooling system - hence the survival rate for entrained fish; these data will be integrated with those from laboratory studies of the impact of the physical-chemical conditions of entrainment upon young fish;

(6) from (1), (2), and (5) the fraction of the population killed during early life history stages by entrainment;

(7) from (1), (2), and estimates of juveniles (J_{II} J_{III}), and Age Group I fish obtained from mark-recapture and catch/effort studies, the total mortality rates for each successive stage of the early life history; development of a survivorship curve will allow some useful interpolations, as for the J_I stage;

(8) from (6), and (7) by the use of standard actuarial calculations for survival under exposure to competing risks of death, the survival rate for each early life history stage in the absence of the operation of the power plant (note that Unit #1 and Unit #2 and Unit #3 effects can be treated separately here and both can be differentiated from background natural mortality);

(9) from (7), and (8) the decrease in survival during the early life history due to operation of Indian Points Units #1, #2 and #3.

The calculations of the fraction of the year class affected by entrainment are not sensitive to the natural fluctuations in year-class strength which complicate interpretation of population density changes. Entrainment affects a certain proportion of the fish population and is primarily a function of the fraction of the estuarine water withdrawn by the power plant cooling system. Appropriate allowance for non-random distribution of the fish and avoidance capability of the juveniles must be made, but again these phenomena are not believed to change because of year-class size.

The magnitude of natural mortality varies from year to year in the early life history stages, but is always quite high. The variations do influence the combined natural and power plant induced mortality, but the relationship can be predicted as in step (8) above for any observed or postulated natural mortality rate.

The spatial distribution of spawning and surviving young fish may vary, especially as a function of volume of freshwater discharge in the Hudson, and correlated physical and biological conditions. Such phenomena are causally related to variations in year-class size.

The spatial distribution of early stages of striped bass and white perch would influence the fraction of each year-class exposed to entrainment. By utilizing the population data discussed above in the model of the Hudson estuary striped bass

population developed by Dr. John Lawler of QLM (as modified to incorporate changes indicated by more recent data) (Reference 13.3-3), the effects of any observed or postulated change in spatial distribution of spawning fish and early life stages of the progeny on the entrainment phenomenon can be predicted.

The simulation model is simply a device for assessing the outcome of joint operation of the many population phenomena described individually through the field studies. This comprehensive assessment of the response of an integrated biological system to impact is complementary to assessments of the individual population phenomena empirically studied in the field.

Criteria for Assessing Impacts on Fish Populations

Based upon the population data detailed in this section, the following criteria for assessing the impact of Indian Point Units #1, #2, and #3 upon populations of striped bass and white perch are established. Each criterion is stated in terms of the symptoms of adverse impact.

(1) Decline in density of Juvenile II, Juvenile III, and Age Group I fish coincident with startup of Unit #2 and not accounted for by changes in egg production by parental stock or by natural environmental fluctuations.

(2) Large fraction of the population of eggs, larvae, or Juvenile I fish entrained and high mortality rate of entrained organisms.

(3) Substantial reduction in survival rate from egg stage to Juvenile II, etc. accounted for by entrainment.

(4) Substantial percentage of stock from significant area of estuary impinged on intake screens.

(5) Lack of compensatory increase in survival rate among Juvenile II and Juvenile III fish following fulfillment of criterion (4).

(6) Lack of compensatory increase in survival rate among Juvenile III to Age Group I fish following fulfillment of criterion (5).

(7) Increase in growth rate of fish. Note that increased growth rate is both a classical indicator of a substantial decrease in stock density (hence an indicator of adverse impact) and a compensatory response to reduction in density (hence an indicator of some capability of the fish stock to sustain itself in the face of increased mortality).

(8) Attainment of sexual maturity at an earlier average age. The note in (7) above identifying the criterion as an indicator of both adverse impact and compensatory capability of the population applies here as well.

(9) Continuing decline in population size or stabilization at an undesirably low level following a period of decline, as predicated by a simulation model of the fish population which integrated the empirical data from the ecological studies.

C. Biological Characteristics of Fish Populations (See Figure 13.6, Items 24, 29, 31)

Racial composition

Food Habits

Age Composition

Growth Rate

Reproductive Rate

A study of ecological relationships of major fish species will be completed in 1973. These two studies will provide additional information on the resident or migrating nature of the populations (vital to estimates of population size) and their respective food habits. The report on this phase of work is to be completed by May 1, 1974.

The study of biological characteristics and health of fish populations reached full scale in April 1973 and will continue until January 1, 1976. This is a continuation of efforts begun in 1972, which will provide information as to the age and growth of fishes in the area, sexual maturation, sex rate, fecundity and any possible effects by the once through cooling employed at Indian Point. Data of very high precision are being obtained in this part of the study. Many of the important uses of these data in

reconstructing the dynamics of the fish populations have been described in the preceding sections.

Changes in age composition, growth rate, age at first sexual maturation, and fecundity are classical indicators of important changes in the mortality experience of fish stocks. The first two of these tend to have a historical character, often being detectable in the fish population for some time after their first occurrence. Additional comparative data on age composition and growth rates predating 1969 is available from New York University studies and from the New York Conservation Survey of 1936. All of these population parameters, when closely monitored, are useful in predicting population decline in advance of critical depletion. The first report of this phase of the work will be completed by May 1, 1975. The data are being collected and analyzed in such a way as to provide continuous monitoring of the fish populations with minimal lag time between field collection and examination against previous population trends.

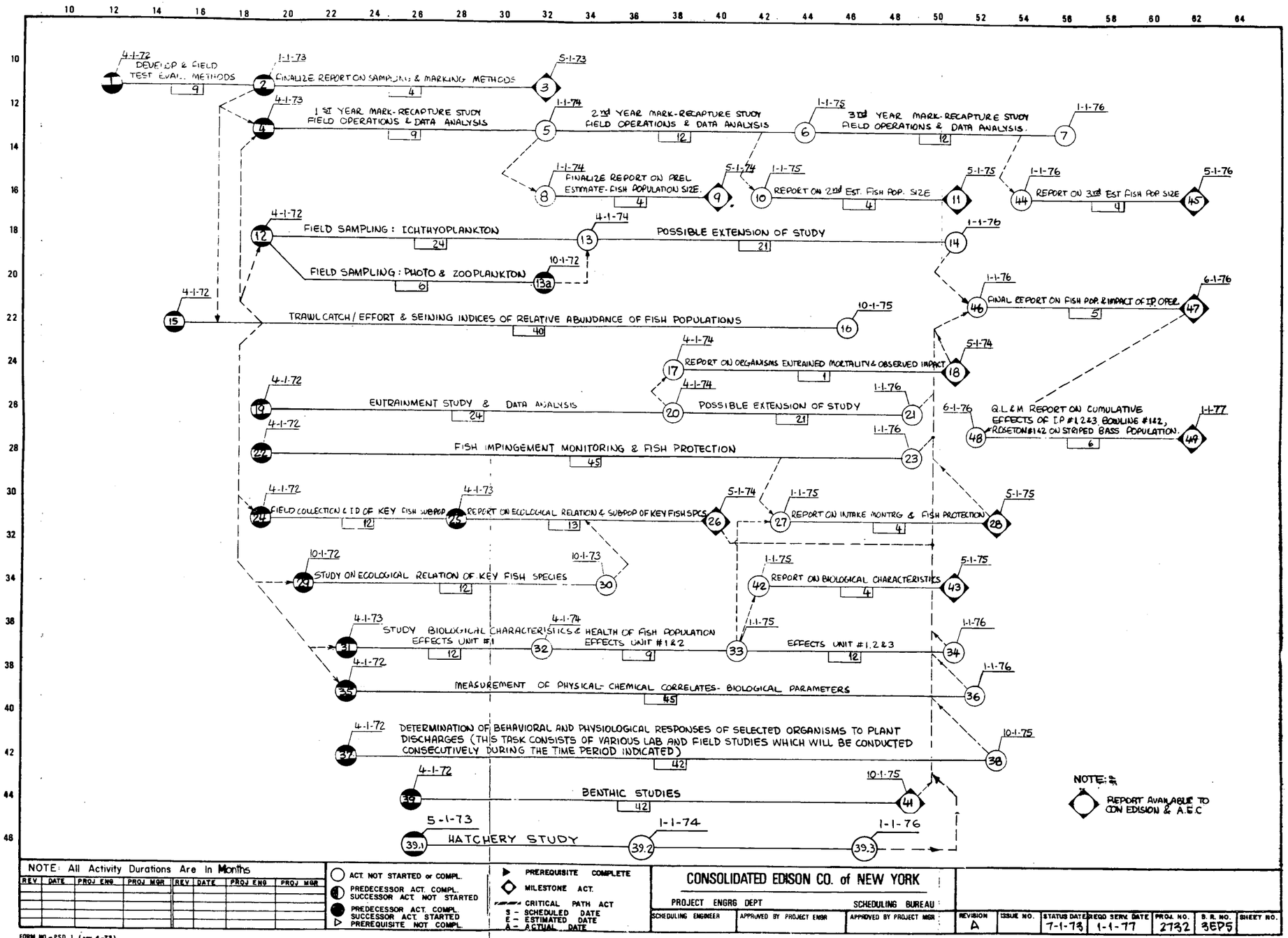

Figure 13.6. General Ecological Survey & Special Studies

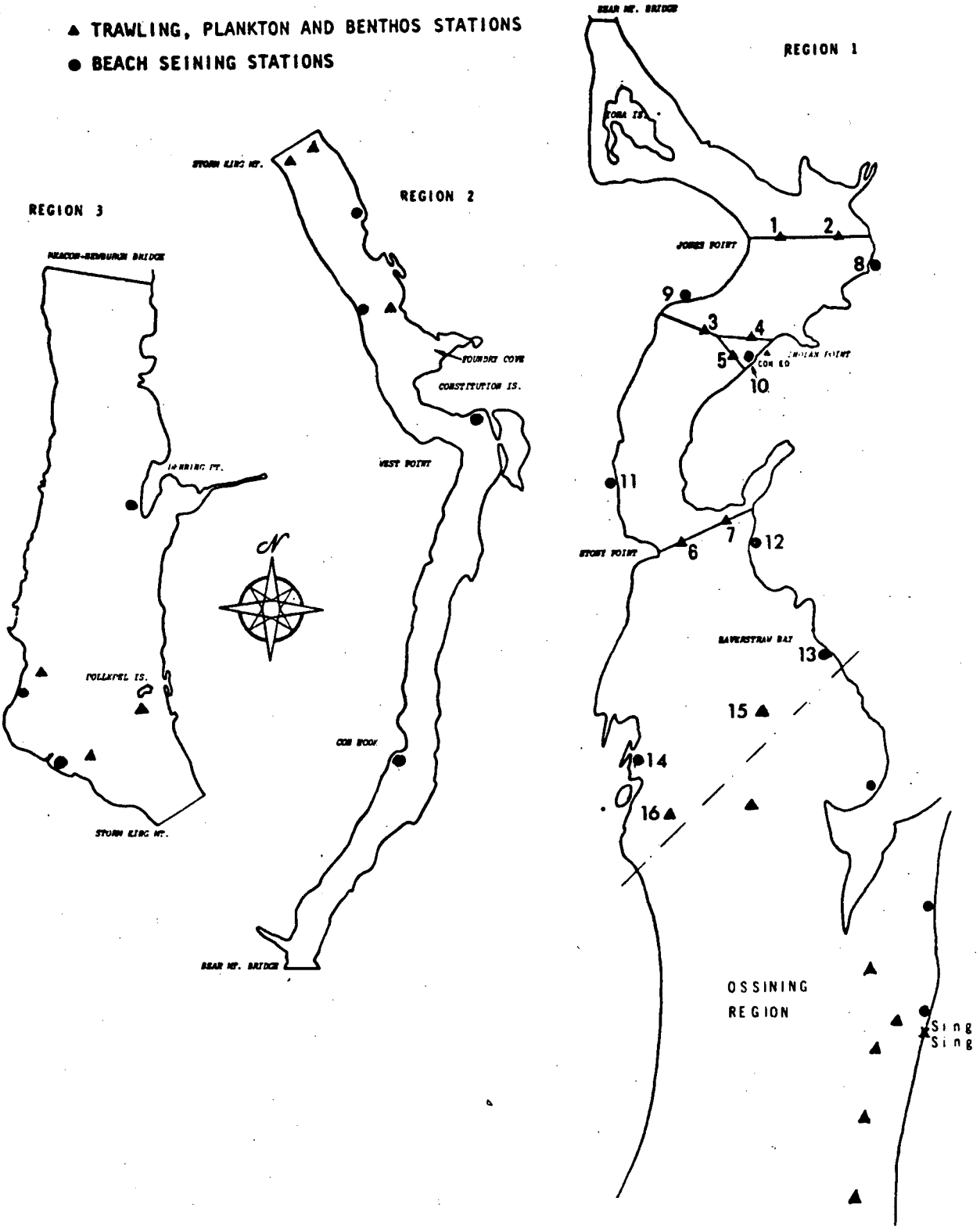

Figure 13.7. Indian Point Ecological Study Regions

Table 13.3-1 Population Data for Assessment of Impact of Indian Point Unit #2 Upon Population Density of Striped Bass and White Perch in Hudson Estuary

	Power Plant Impact		Data on Fish Populations									
					Age Group 0						Age Group	
Year	Unit #1	Unit #2	Eggs	Larvae	Juvenile I	Juvenile II	Juvenile III	Age Group I	II	III	IV
1969	Entrainment Impingement	None	—	—	—	△1' ①1	△1' ①1'	△1' ①1	△1		①1'
1970	Entrainment Impingement	None	—	—	—	△1' ①1	△1' ①1'	△1' ①1'	△1'		①1'
1971	Entrainment Impingement	None	—	—	—	—	—	—		—	
1972	Entrainment Impingement	None	—	—	—	△1 ①1	△1 ①1	△1 ①1	△1		①1
1973	Entrainment Impingement	Impingement	◇1	◇1	—	△1 ①1 □1	△1 ①1	△1 ①1 □1	△1		①1
1974	Entrainment Impingement	Entrainment Impingement	◇2	◇2	—	△2 ②2 □2	△2 ②2	△2 ②2 □2	△2		②2
1975	Entrainment Impingement	Entrainment Impingement	◇2	◇2	—	△2 ②2 □2	△2 ②2	△2 ②2 □2	△2		②2

Legend for Table 13.3-1

△1' Raytheon — Trawl Catch/Effort — Unit 1 effect only

△1 Texas Instruments — Trawl Catch/Effort — Unit 1 effect only*

△2 Texas Instruments — Trawl Catch/Effort — Unit 1 + Unit 2 effect

(1') Raytheon — Seine Catch/Effort — Unit 1 effect only

(1) Texas Instruments — Seine Catch/Effort — Unit 1 effect only*

(2) Texas Instruments — Seine Catch/Effort — Unit 1 + Unit 2 effect

[1] Texas Instruments — Mark Recapture population estimate — Unit 1 effect only

[2] Texas Instruments — Mark Recapture population estimate — Unit 1 + Unit 2 effects

◇1 Texas Instruments — Population estimate eggs and larvae — Unit 1 effect only

◇2 Texas Instruments — Population estimate eggs and larvae — Unit 1 + 2 effects

*Impingement effects of Unit #2 if operational during last half of 1973.

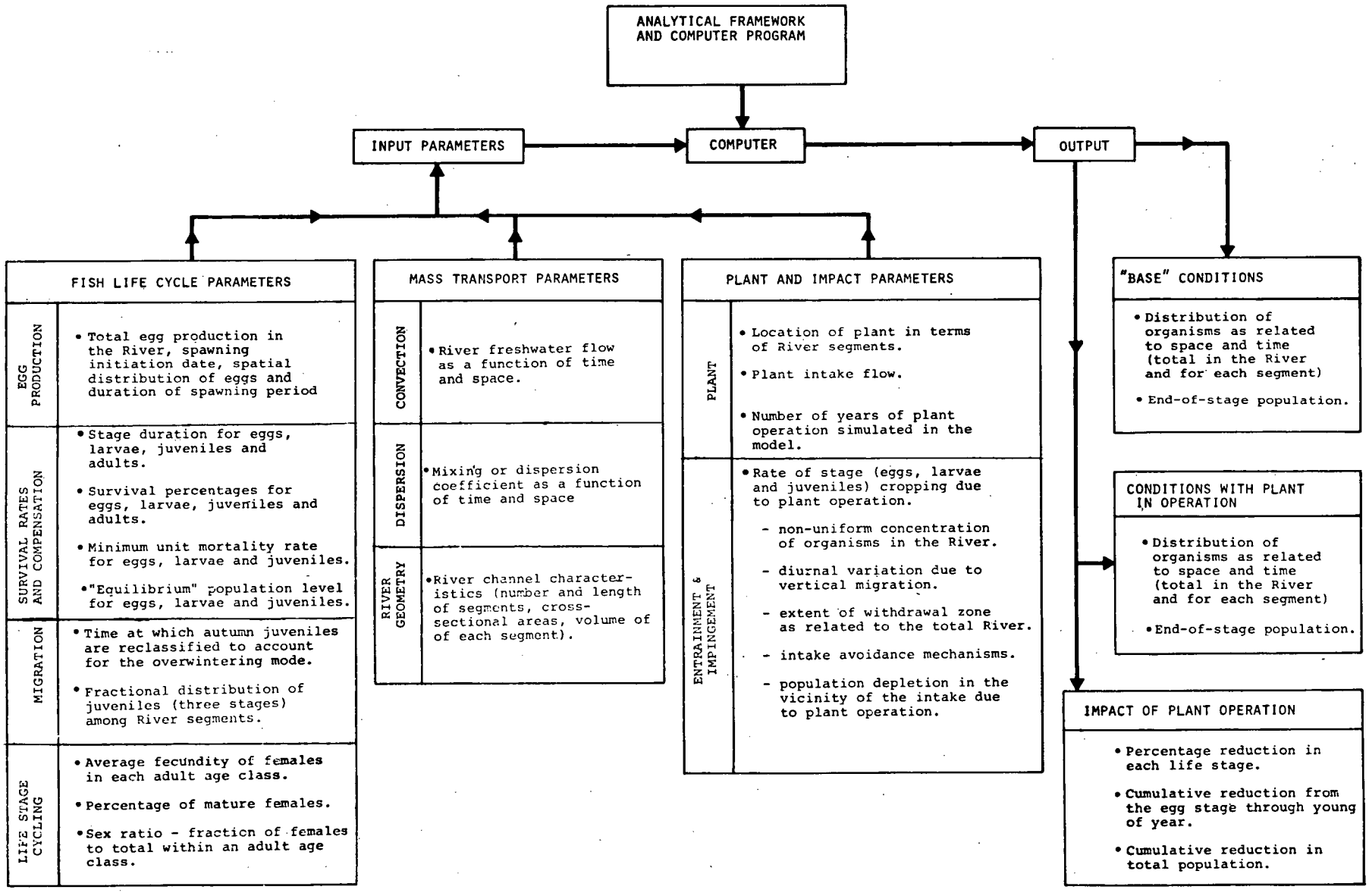

Figure 13-8. Hudson River Striped Bass Transport Model Parameters

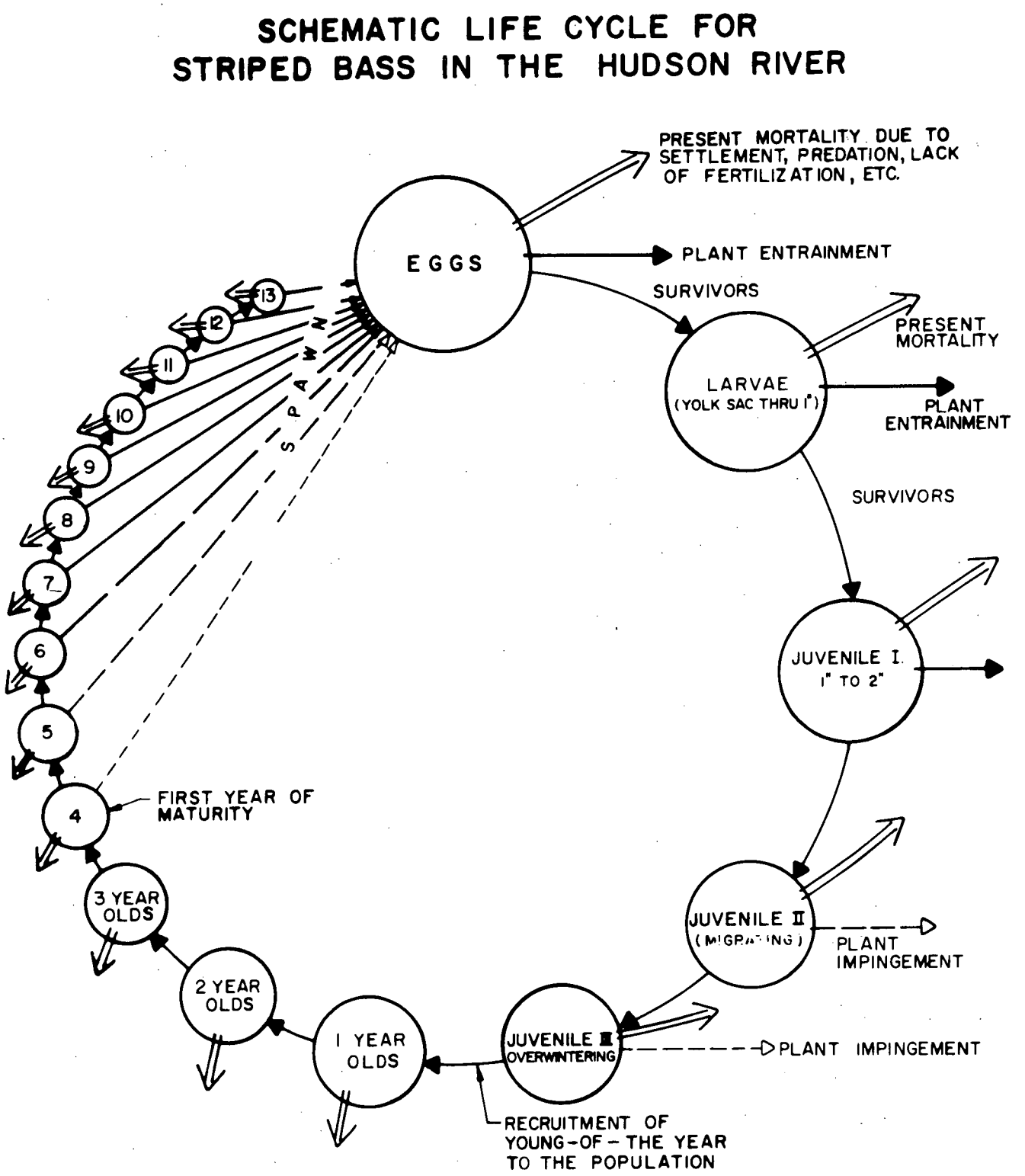

Figure 13-9. Schematic Life Cycle For Striped Bass In The Hudson River

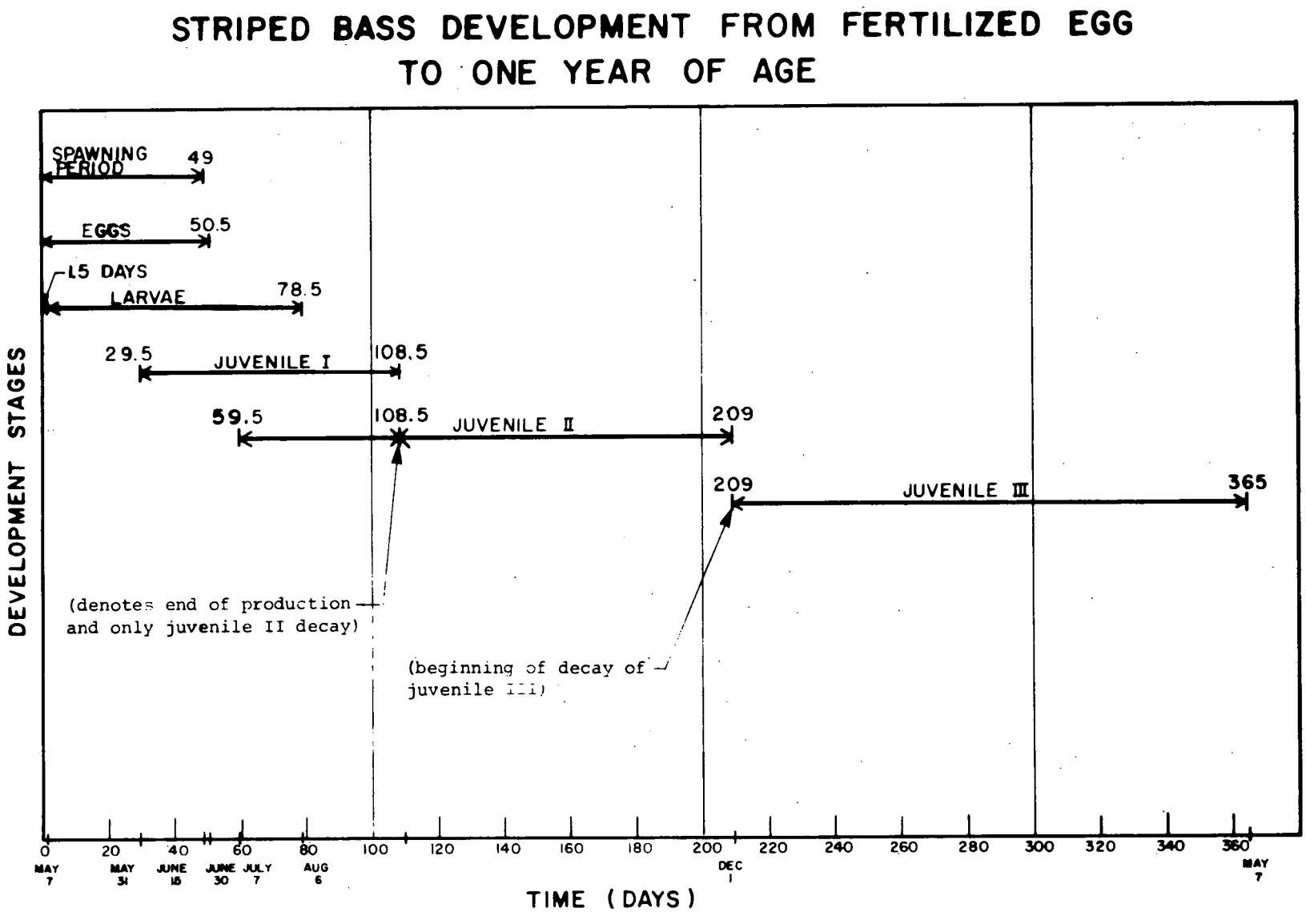

Figure 13-10. Striped Bass Development From Fertilized Egg To One Year Of Age

Table 13.3-2 Ecological Survey Water Quality Measurements

Parameter	Frequency
Temperature	Weekly
pH	Weekly
Conductivity (salinity)	Weekly
Turbidity	Weekly
Alkalinity	Monthly
Bicarbonate	Monthly
Ammonia	Monthly
Orthophosphate	Monthly
Nitrates	Monthly
Carbon (inorganic and organic)	Monthly
Chlorine demand	Weekly
Free Chlorine	Weekly
Residual Chlorine	Weekly
Dissolved Oxygen	Weekly

References

13.3-1 Testimony of Dr. James T. McFadden, Dean, School of Natural Resources, University of Michigan and Harry G. Woodbury, Executive Vice President, Consolidated Edison Company of New York, Inc. "Indian Point studies to determine the Environmental Effects of once through vs Closed Cycle Cooling at Indian Point Unit No. 2," February 5, 1973, Docket No. 50-247.

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13.3-3 Testimony of John P. Lawler, Ph.D., Quirk, Lawler and Matusky Engineers, "The Effect of Entrainment and Impingement at Indian Point on the Population of the Hudson River Striped Bass," October 30, 1972, Docket No. 50-247.

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13.1B Other Ecological Studies

In addition to the Indian Point Ecological Study (Section 13.3) which is scheduled to terminate January 1, 1977, ecological studies are also being conducted for several other proposed and existing plants on the Hudson River. Information obtained in these studies will supplement that obtained in the Indian Point Study.

OSSINING:

As a part of a recently completed Con Edison site feasibility study at Ossining (River Mile Point 32.5) the relative abundance and seasonal fluctuations of various species and life stages of fish in this area have been determined. Collection methods employed in this study were trawling, seining, trap netting and gill netting. A tag-recapture program conducted here supplements the population dynamics study being conducted for Indian Point. Plankton and benthic studies have also been conducted at Ossining.

CORNWALL:

In its Cornwall Study, Con Edison is conducting intensive far-field and near-field ichthyoplankton surveys from river mile points 35 to 125, which encompasses the entire spawning ground of the striped bass. In the far-field study, which will run from April through August 1973, population densities and distributions of eggs and larvae will be determined using epibenthic sleds and Tucker trawls.

A gear selectivity efficiency study was performed in June and July 1973. The purpose of this study is to generate correction factors which will relate the gear used in the old Cornwall Study (by North East Biologists) to the gear presently used by our contractors.

The near field study will determine the effects of tidal movement on fish eggs and larvae near the Cornwall intake, during the early and late larval season. In this study, 13 ichthyoplankton stations will be sampled 2–3 times in rapid succession at each tidal stage (high slack, ebb, low slack and flood) and each set of samples will be taken for each of the 2 tidal cycles of the 26 hour period.

Beach seining for young of the year striped bass, juvenile stages of white perch plus shoal dwelling fish such as carp or cat fish, is being conducted from river mile points 10 to 150. This will determine 1) the length and age at which larvae enter the shoals and thus become behaviorally non-entrainable; 2) the route by which late-larvae and early-juveniles move downriver, and 3) the rate of downriver movement of these larvae and juveniles. At each plankton and fishery station, the following water quality data will also be obtained: turbidity, salinity, pH, temperature, and dissolved oxygen.

Another phase of this study will determine the populations of resident and anadromous fish and follow their movements and distribution, including spring and fall migration patterns as well as winter population distribution. In striped bass and white perch population size determinations, the Indian Point Study effort in the Cornwall region will be supplemented with 10 additional standard fishery stations (trawling and seining) and proportional tagging efforts in the Cornwall region. Distribution of fish in the Cornwall area will be determined by fathometry at 10 day intervals from early April to mid-May.

ARTIFICIAL STOCKING:

As part of its study on the feasibility of mitigating plant impact by stocking artificially hatched and reared fingerlings, Con Edison is supporting a study on the survival of such fish in the river and their contribution to the natural population. In 1973, striped bass larvae from Hudson brood fish were raised to fingerling size at several different rearing facilities. Fifty to one hundred thousand will be tagged with coded internal wire nosetags, according to the facility which raised them, and released into nursery areas of the Hudson Estuary for subsequent recapture efforts.

DEPARTMENT OF ENVIRONMENTAL CONSERVATION:

A striped bass tagging program to determine the contribution of Hudson River Striped Bass to the Mid-Atlantic Fishery is being studied by the New York State Department of Environmental Conservation. The survey will run for three years and will tag approximately 5,000 fish in the Long Island Sound waters.

Studies Conducted by Utilities Other Than Con Edison

Orange and Rockland

Orange and Rockland Utilities Inc. is conducting continuous extensive studies at their Lovett and Bowline Point Generating Stations. Studies of a biological, chemical and physical nature include impingement, entrainment monitoring, sediment characterization, plankton, benthos and water chemistry.

The experimental design for entrainment programs will consist of three basic sampling schemes necessary to sample the River/Pond for the distribution of the source population, the intake for the densities of entrained organisms, and the discharge for lethal and sub-lethal effects of entrainment. With the exception of the month of May, entrainment sampling on a 24 hour basis will be conducted every week for the months of June and July at the Bowline Point Generating Station. In addition, 12 hour night entrainment studies will be scheduled during July and August. Entrainment sampling at Lovett will be conducted on a 24 hour basis twice monthly during May, June, July and August.

Phytoplankton entrainment samples will be collected simultaneously at the river intake and discharge for both plants. Sampling will be conducted monthly; one of the monthly sampling sessions will be conducted during a normal chlorination period.

Larval and selected zooplankton samples collected at the discharge will be studied to determine mortality factors associated with entrainment. Two types of mortality, acute and delayed will be studied. Acute mortality is determined by counting live and dead organisms immediately after collection, and assigning a percent mortality. Calculation of this figure will take into consideration such factors as mortality attributable to sampling gear, and variability of mortality rates between species and larvae of different sizes within the same species. Delayed mortality is studied by placing the live organisms into temperature controlled aquaria to determine if their survival rate is significantly different from the control animals collected at the intake.

In addition, phytoplankton and microzooplankton collections will be analyzed. Chemical parameters such as pH, dissolved oxygen, conductivity, salinity and temperature will be monitored during each survey.

In-plant impingement studies will be conducted twice per month on a 24-hour basis. Fish sampling for background ecological information in the River and Bowline Pond will be conducted twice each month in conjunction with these two 24-hour impingement studies.

Benthic analyses on both pond and river will be based on eight sampling dates, but only four of the samples will be fully analyzed, and the remainder will be stored for future studies, if needed. This scheme will allow samples to be analyzed from year to year on the basis of common temperature rather than common dates or seasons which can vary a great deal in temperature regime from one year to the next. For example, a late spring one year may not show comparable data with an early spring another year if the time of sampling was based on common dates rather than common temperatures.

Emphasis on the Pond benthos is to closely define benthic changes which may occur and indirectly affect the impingement rates of benthic feeders such as some fish. Sediment samples will be collected at all benthic stations in July, September & December. Samples for bacteriological analysis will be collected monthly.

Water quality data will be collected during each day of biological field sampling. For impingement and entrainment studies, the water quality data will be collected at the circulating water intake and discharge where applicable and for fish, benthic, and phytoplankton surveys, water quality data will be collected at the biological sampling locations.

Central Hudson

Central Hudson Gas and Electric Corporation is conducting studies to determine the environmental impact of the Roseton and Danskammer Point generating facilities.

Biological surveys include macro- and micro-zooplankton, ichthyoplankton, phytoplankton and benthic organisms, in addition to impingement monitoring, entrainable organism studies and physical and chemical determinations.

Impingement monitoring programs will continue at least through 1974 and in addition to the basic objectives will incorporate studies involving survival potential of impinged fish, fish tagging, physiological differences caused by impingement, effects of water currents on fish population densities and histological examinations of fish tissues. The study will also serve to establish, with the aid of information generated in the general ecological survey, data required to assess the impact of impingement upon fish populations in the Hudson River, and to assess the effectiveness of fish protection measures incorporated in the Roseton Plant. Methods and techniques to estimate the survival of impinged fish once they are returned to the river will also be evaluated.

Surveys will be conducted to determine the distribution of selected entrainable organisms in the River as functions of time and location, to determine the mortality rate among selected indicator organisms entrained in the cooling water systems of the Roseton and Danskammer plants, and to detect any observable changes in the population densities of the indicator organisms in the River, which may be attributable to the operation of the plants. The entrainment study will focus primarily on fish eggs and larvae. Several planktonic organisms will also be selected for investigation.

Water chemistry and water quality sampling studies will be performed on a monthly basis. The characteristics of chemical discharges and near field concentrations of chemicals in the river shall be determined and compared with applicable State and Federal standards. In addition, a sampling program designed to determine the effects of cooling water chlorination upon free residual chlorine discharges from the Roseton and Danskammer facilities will be performed. Concentrations of free residual chlorine in the river resulting from cooling water chlorination and the influence of passage through the plant upon dissolved oxygen contained in the influent cooling water shall also be determined.

A rooted aquatic plant and general shallow-water survey will be conducted during 1973 as well. This survey will be scheduled to occur when rooted plants are at maximum development, which is usually late summer.

In the past studies were undertaken to characterize the aquatic community of the Hudson River in the vicinity of the Roseton Generating Station. Those studies consisted of collection and analysis of fish, phytoplankton, zooplankton and benthic samples.

POWER AUTHORITY OF THE STATE OF NEW YORK

In early fall, 1973, a tag and recapture program will begin in Kingston, New York, for white perch and striped bass. This study will be coordinated with Consolidated Edison as a part of a unified program and will incorporate methods identical to those used by Con Edison, so that results can be directly applied. PASNY is also acting as a recovery unit for Consolidated Edison's present tagging program.

The Inter-Utility Coordinating Committee (I.U.C.C.) was established to coordinate the efforts of the several utilities conducting studies on the river. Coordination includes standardizing gear and methods and correlating results from different types of gear and methods.

An "Integrated Hudson River Study" for the New York Power Pool, is planned. An objective of this study is to evaluate existing and past studies of the Hudson River to determine their adequacy in defining the limiting aspects of the water body on future power plant siting. In addition, a library and data bank of the present state of knowledge on Hudson River biology and related parameters will be accumulated.

13.2 RADIOLOGICAL MONITORING

This section is under revision and will be submitted shortly.

14.0 RADIOACTIVE DISCHARGES

14.1 Description of Radwaste Systems

(a) General

Indian Point Unit No. 3 contains a number of facilities for the treatment and disposal of liquid, gaseous and solid radioactive wastes. The design of these facilities plus developed operating procedures insure that releases during normal reactor operations and expected operational occurrences are well below 10CFR20 limits.

All components of the liquid, gaseous and solid radioactive waste systems which contain significant radioactivity are located in the containment or the Primary Auxiliary Building. The atmosphere in the Primary Auxiliary Building is continuously exhausted through filters to the plant vent and monitored to insure detection of any radioactive gases which might leak from any tank in the Primary Auxiliary Building. The containment system has recirculating fans and filters which can be used to reduce the radioactivity in the containment air before this air is exhausted to the plant vent. In addition, a charcoal filtration system is provided to significantly reduce any gaseous release of iodine, which might occur from ~~containment~~ purge or Primary Auxiliary Building exhaust in the event of the existence of radioactive iodine in the primary coolant concurrent with primary leakage to containment or the Primary Auxiliary Building atmosphere. Any radioactive liquids which leak or are spilled in either the containment or Primary Auxiliary Building are collected in drains and piped to the liquid waste system.

In addition to the monitors provided on tanks and discharge lines, monitors are provided in various areas throughout the plant to warn of leakage or spills to permit appropriate operator action.

With all equipment operating as designed and assuming 1% leaking fuel and no steam generator leakage, it is estimated that gaseous radioactivity released from Indian Point Unit No. 3 will be approximately 2.7% of the concentrations allowed by Part 20 while liquid released will be less than 0.1% of allowable concentrations. However, actual site boundary doses are expected to be significantly lower than these estimates.

(b) Gaseous Wastes

The gas portion of the Waste Disposal System consists of two waste-gas compressor packages, four large and six small gas-decay tanks and a multipoint gas analyzer (refer to Figure-32). During plant operation, some radioactive gases which may be dissolved in the water in various systems are removed, collected and pumped by compressors to decay tanks where they are held prior to release. Most of the gas processed by the Waste Disposal System during normal plant operation is cover gas from the holdup tanks in the Chemical and Volume Control System. Degassing of the reactor coolant is a major source of gas just before plant shutdown. All radioactive, oxygen-free waste gases vent directly to the vent header and from there go to the suction of the waste gas compressor. One of the two compressors operates continuously, with the second unit acting as back up for peak load operation. From the compressor, gas is sent to one of the four large tanks. The six small tanks are reserved for use during degassing of the reactor coolant and purging of the volume control tank. The control arrangement on the gas-decay tank inlet header allows the operator to place one large gas-decay tank in service and select another as standby. When the tank in service is filled to capacity, flow is automatically switched to the standby tank.

Gas held in the decay tanks can either be returned to the Chemical and Volume Control System holdup tanks, or discharged to the atmosphere if the activity concentration is suitable for release. Generally, the last tank to receive gas will be the first tank emptied back to the holdup tanks to permit the maximum decay time before releasing gas to the environment. Provisions are also made for transferring gas between tanks.

Before a tank can be emptied to the environment, its contents must be sampled and analyzed to verify sufficient decay and to provide a record of the activity to be released. Only then are the tank contents discharged to the plant vent at a controlled rate past radiation monitors in the vent.

Gaseous releases are monitored at the plant vent in three different ways. Two air particulate monitors, one sampling the containment atmosphere and the other the plant vent, measure air particulate gamma activity. Each monitor can be used as a replacement for the other. Two radioactive gas monitors, one sampling the containment atmosphere and the other the plant vent, measure gaseous gamma radioactivity. Each monitor can be used as a replacement for the other. The plant vent gas monitor measures beta and gamma

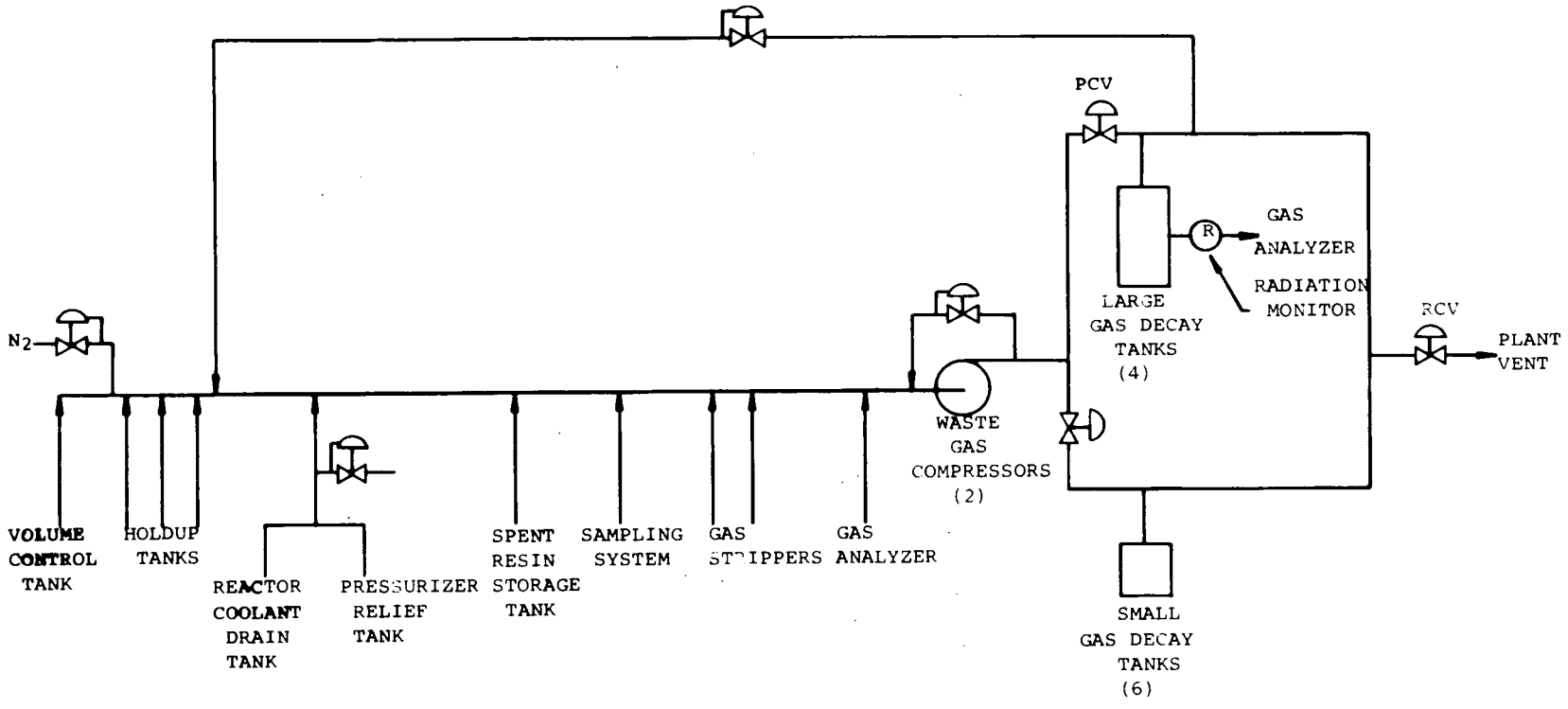


Figure-32 Simplified diagram — gaseous waste disposal system

radiation passing through the plant vent to the atmosphere. This monitor, on high activity, automatically closes the gas release valve.

During release, a trip valve in the discharge line is closed automatically by a high-activity-level indication in the plant vent. Section 3.9 of the proposed Technical Specifications requires that there be a minimum of 20 days holdup of gaseous waste in the gas decay tank prior to release from the Indian Point Unit No. 3 vent (see Appendix-X).

During operation, gas samples are drawn periodically from tanks discharging to the waste-gas-vent header as well as from the particular large gas decay tank being filled at the time, and automatically analyzed to determine their hydrogen and oxygen content. The hydrogen analysis is for surveillance, since the concentration range will vary considerably from tank to tank. There should be no significant oxygen content in any of the tanks, and an alarm will warn the operator if any sample shows two percent by volume of oxygen or greater. This allows the operator time to isolate the tank before the combustible limit is reached. Another tank is placed in service and another standby tank selected while the operator locates and eliminates the source of oxygen. A radiation monitor in the gas analyzer sample line permits monitoring the activity inventory in the gas-decay tanks.

Advantage is taken of both decay time in holdup tanks and a controlled elevated release. However, no credit is taken for elevated release and building wake dilution in calculating the allowable release rates. Thus, the actual concentrations at the worst point on the site boundary would be expected to be only about 1/2 of 10CFR20 limits even if the plant released radioactivity continuously at the allowable proposed Technical Specification limits. The routine gaseous radioactivity releases from the three plants planned for operation at Indian Point will be from three different vents. The combined release of gaseous waste containing radioactivity from these three sources is limited by the proposed Technical Specifications so that the instantaneous release rate will at no time be greater than that release rate which if maintained continuously would result in operation of the site at 10CFR20 limits. The gaseous releases of halogens and particulates with half-lives greater than eight days, are limited by the proposed Technical Specifications to less than 1/700 of that which would result in 10CFR20 concentrations at the site boundary. A diagram of the gaseous waste disposal system is given in Figure-32.

(c) Liquid Wastes

The bulk of the radioactive water discharged from the reactor coolant system is processed and retained inside the plant by the chemical and volume control system. This minimizes liquid input to the waste disposal system which processes relatively small quantities of generally low activity level wastes.

Radioactive water, which may leak from the reactor coolant system and other equipment, along with small amounts of other liquid wastes such as laboratory samples, is collected in tanks where it is sampled and analyzed to determine the quantity of radioactivity present, with an isotopic breakdown if necessary. As a result of operating experience in other plants, two new features have been incorporated into the Indian Point Unit No. 3 Waste Disposal System design. Leakage from the reciprocating charging pumps will be collected and returned to the CVCS and a modified bellow-seal assembly is being provided on the pressurizer spray valves to eliminate the leakage being experienced from these components. These two modifications will reduce the amount of primary coolant leakage, the processing load on evaporators, and, consequently, the amount of radioactivity being released.

The waste holdup tank serves as the central collection point for liquid wastes. Figure-33, a schematic of the Liquid Waste Disposal System, identifies the sources of radioactive liquid wastes and the details of how they are collected and processed.

Since the fluid pumped by the reactor coolant drain pumps is of high quality and can be reused the discharge of these pumps will normally be routed to the holdup tanks of the chemical and volume control system. If the fluid is considered unsuitable for reuse, it will be sent to the waste holdup tank. The discharge of the reactor coolant drain pumps can also be routed to the refueling water storage tank. This path will be used when pumping down the containment refueling canal. In the event the reactor coolant drain pumps are unavailable, the contents of the reactor coolant drain tank or the pressurizer relief tank may be dumped to the containment sump.

The contents of the waste holdup tank are pumped to the waste evaporator package where the high activity solids are concentrated. These concentrates are then pumped to the drumming room for packaging. The waste evaporator package also provides a path for transferring unwanted boric acid evaporator concentrates to the drumming room for disposal.

Distillate produced by the waste evaporator is collected in the waste condensate tanks (2). When a waste condensate tank is full, it will be isolated and the standby tank brought on the line. After suitable sampling and monitoring to assure that releases are within 10CFR20 limits, small quantities of radioactive liquid waste are released under controlled conditions to the condenser circulating water discharge canal where an additional minimum dilution factor of 1000 to 1 occurs prior to the effluent being discharged to the Hudson River. The discharge lines are monitored and the activity recorded. If, for any reason, the effluent exceeds specified limits, an automatic cut-off is provided as well as an alarm and the tank's contents will return to the waste holdup tank.

The Blowdown Treatment Intertie between Indian Point Unit Nos. 1 and 3 will, when complete, provide for the purification of blowdown from the secondary side of the Unit No. 3 steam generators. If leakage from primary to secondary liquid loops has resulted in some low activity being found in the blowdown, the blowdown is bypassed around the blowdown tank, and routed through the circuit shown in Figure-33A for purification.

Ultimately, the blowdown is purified by filtration and passage through a demineralizer to assure that only very low levels of activity remain before discharge to the river. Here again, monitor and alarm instrumentation are employed to assure flow diversion in the event that high activity is found. This intertie will serve to significantly reduce liquid releases in the event of steam generator leakage.

The limits on routine radwaste releases from the three units at the Indian Point site requires that the combined releases, both annual average and instantaneous, from the three units be within the average annual limits specified in 10CFR20. This requirement is stated in Section 3.9 of the proposed Technical Specifications for Indian Point Unit No. 3 (see Appendix-X). Again this requirement for limits on instantaneous releases is more restrictive than 10CFR20 limits.

(d) Solid Wastes

Solid wastes may be accumulated in several ways: resins which are used to purify plant water become radioactive through use; solid wastes are collected in the waste evaporators which are part of the liquid waste system; and solids such as rags and laboratory equipment may become contaminated. A drumming area is provided for the preparation of solid

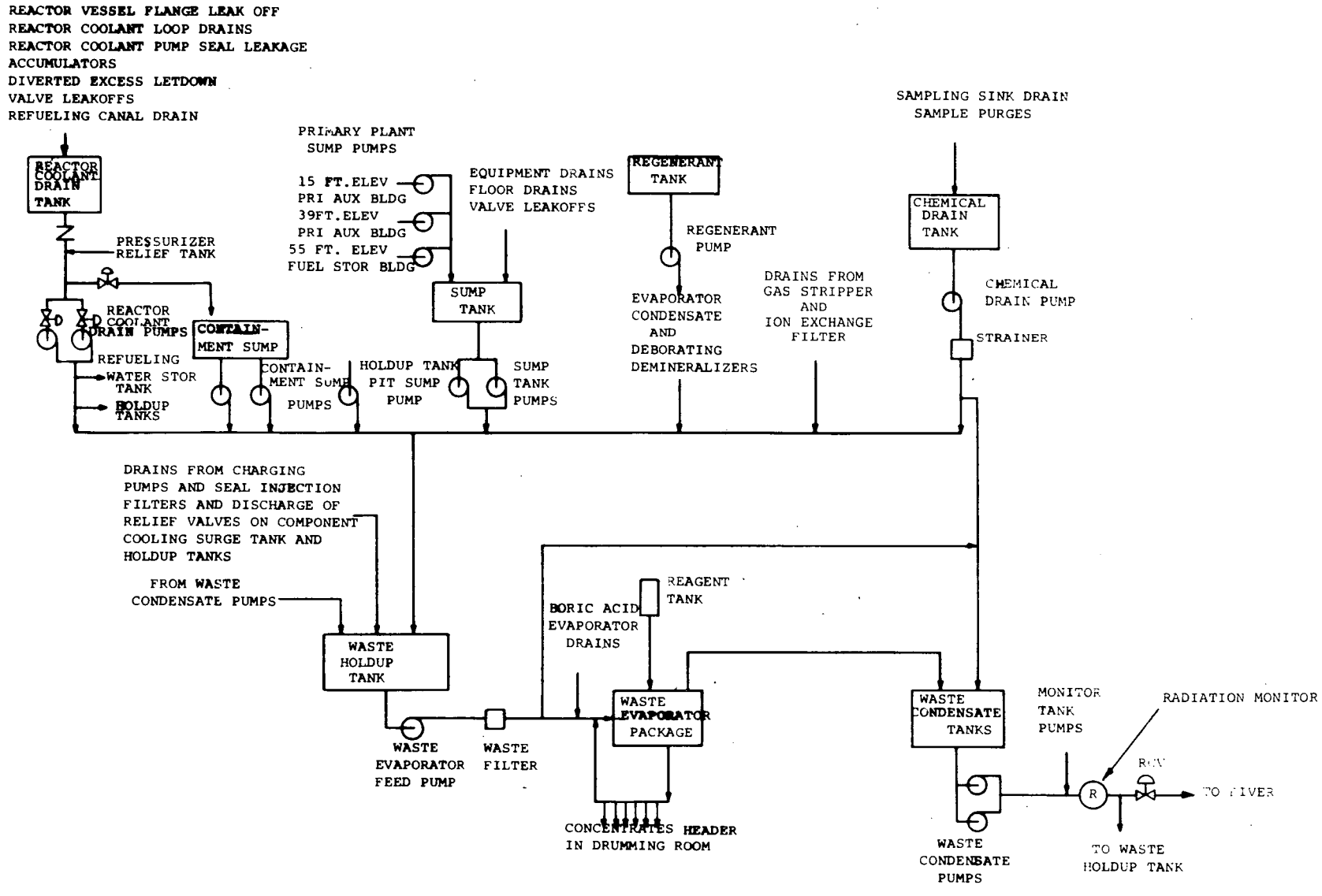
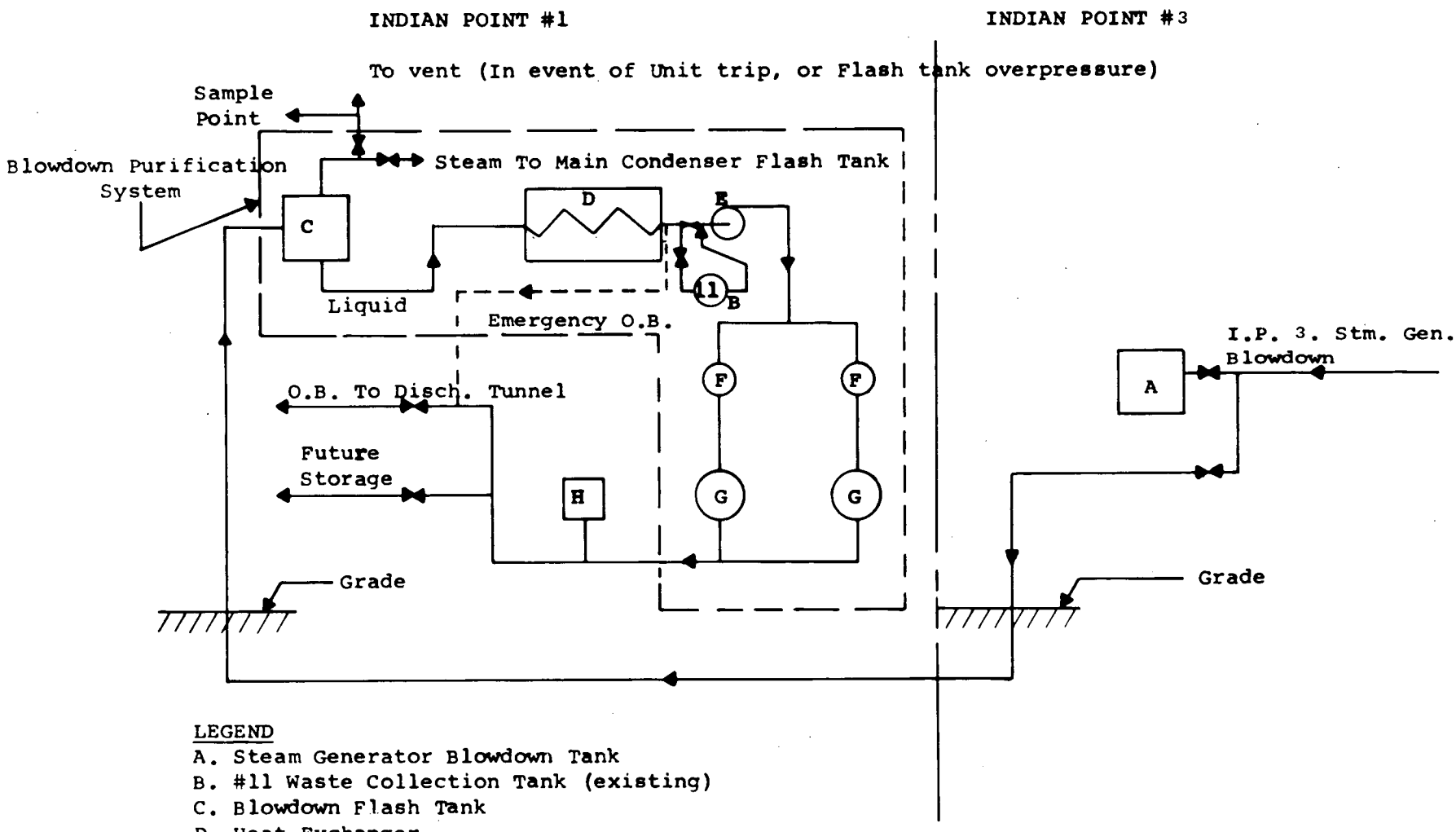


Figure - 33 Liquid waste disposal schematic



LEGEND

A. Steam Generator Blowdown Tank
B. #11 Waste Collection Tank (existing)
C. Blowdown Flash Tank
D. Heat Exchanger
E. Demineralizer Feed Pump
F. Filter
G. Demineralizer
H. Monitoring And Alarm Instrumentation

Figure - 33A Blowdown intertie - general scheme

wastes for disposal off-site. Solid wastes are packaged in AEC approved containers and stored on-site for shipment to an off-site licensed burial ground.

In order to replenish nuclear fuel inventories within the reactor cores, one-third of each core is removed and replaced with new fuel elements on an annual basis. The spent fuel elements are transferred to a special fuel handling pool where relatively short-lived fission products are allowed to decay. At the end of this decay period, these elements are removed from the site in specially constructed shipping casks which have been carefully designed and tested to meet all probable accident contingencies. For a discussion of the transportation of packaged radioactive material to and from the site, see Section 21.0.

14.2 Radioactive Release Estimates

Under normal operating conditions, small amounts of radioactive fission products will be released to the environment from several paths throughout the plant. All paths that may contain significant concentrations of radioactive material are equipped with monitors and the ability to terminate the releases upon high activity signal from the monitor. All releases will be in compliance with the limits set forth in 10CFR20 and the plant's Technical Specifications. The radioactive releases from Indian Point Unit No. 3 as well as the combined releases from all three Indian Point Units are expected to be far below the 10CFR20 limits.

Estimates of the radioactive liquid and gaseous releases from each path to the environment have been calculated. The general assumptions used to calculate these release estimates are:

1. 0.2% equivalent fuel defects
2. core thermal power — 3216 Mwt
3. 20 gpd primary to secondary leak rate
4. steam flow rate — 1.395×10^7 lb/hr
5. 50 gpm continuous steam generator blowdown rate (12.5 gpm per steam generator)
6. 99.75% steam quality
7. 3.2×10^5 lbs. of water in all four steam generators
8. 0.8 load factor

Table 14-1 shows the estimated annual average liquid releases from three paths: the liquid waste processing system, steam generator blowdown and turbine-generator building leakage. Releases from the waste processing system are based on recent operating experience with pressurized water reactors which have treatment systems similar in design to that provided for Indian Point Unit No. 3. Steam generator blowdown releases are generated from all four steam generators blowing down continuously through the blowdown intertie to the Indian Point Unit No. 1 Secondary Boiler Blowdown Purification System (SBBPS). The demineralizers in the SBBPS reduce the concentrations of activity in the liquid blowdown by at least a factor of 10. Radioactive liquid releases due to turbine hall leaks have been calculated assuming a 12 gpm leak of liquids into the turbine building. These liquids are collected in

floor drains and are released to the circulating water discharge canal along with the other radioactive liquid releases. The off-site doses resulting from these releases are presented in subsection 1.5 of the Benefit/Cost analysis (Section 22).

Table 14-2 shows the estimated annual average radioactive gaseous releases from various sources. Releases from the gas decay tanks in the gaseous waste disposal system are based on a 45-day hold-up period during which the short-lived isotopes will have decayed to negligible amounts. The Indian Point Unit No. 3 Technical Specifications call for a minimum of 20 days hold-up in these gas decay tanks, but it is anticipated that 45 days hold-up will be available.

Gaseous releases from the main condenser air ejector are based on the maximum discharge rate of 60 SCFM. An iodine decontamination factor of 100 was assumed in both the steam generator and the main condenser. All the noble gases that leak into the secondary system are assumed to be immediately released via the air ejector.

The activity released to the environment from containment purge is based on an estimated four purges conducted yearly and a reactor coolant leakage into containment of 14.4 gpd. Prior to purging, it is assumed that the containment recirculation filtration system operated for 16 hours at an iodine removal efficiency of 99%. An iodine removal efficiency of 99% was also used for the charcoal filter in the containment purge duct. Gaseous radioactive releases from the Primary Auxiliary Building (PAB) are based on a 20 gpd reactor coolant leak into the PAB. This estimate is based on operating experience to date. It was assumed that all the noble gases that leak into the PAB are immediately released. The iodine release estimates assume a partition factor of 10^3 in the PAB and an iodine removal efficiency of 99% for the charcoal filters in the PAB ventilation system.

Releases from the gland seal condenser air exhauster are based on an exhaust rate of 2.6 gpm and an iodine decontamination factor of 100 in both the steam generator and the gland seal condenser. All noble gases were assumed to be released via the main condenser air ejector and so none are released along this path. Gaseous releases due to steam and liquid leakage in the turbine-generator building are based on leakages of 6 gpm of (equivalent cold

ndensed) steam and 12 gpm of (equivalent cold) liquid. An iodine decontamination factor of 100 in the steam generator was assumed. In addition, an iodine decontamination factor of 3×10^3 was used to calculate the amount of gaseous iodine which evolves from the liquid leakage in the turbine hall.

Gaseous iodine, due to steam generator blowdown which is treated in the Indian Point Unit No. 1 purification system (SBBPS), will be released via the Indian Point Unit No. 1 main condenser air ejector and subsequently, the superheater stack when Indian Point Unit No. 1 is on the line. When Indian Point Unit No. 1 is off-line, such as for the six-week refueling outage, these gases are released from the Indian Point Unit No. 1 Blowdown Flash Tank vent and are treated as a ground release. The assumed iodine decontamination factors are 10 for the blowdown flash tank and 100 for the path through the main condesner air ejector. Table 14-3 shows the annual average thyroid inhalation and gamma whole body doses due to each path of gaseous release. Whole body doses were conservatively calculated by the semi-infinite cloud method. All doses are seen to be far below regulatory limits.

TABLE — 14-1

ESTIMATED ANNUAL AVERAGE LIQUID EFFLUENTS
(CURIES)

	Waste Processing System	Boiler Blowdown	Turbine Hall Leaks	Total
Mn-54	.00026	.0025		.0028
Mn-56	.00009	.017		.0171
Fe-55	.00038			.00038
Fe-59	.00146			.00146
Co-58	.0122	.075		.0872
Co-60	.00045	.0023		.00275
Sr-89	.00174	.0022		.00394
Sr-90	.00008	.000081		.000161
Sr-91	.00001	.00061		.00062
Y-90	.00002	.000086		.000106
Y-91	.00288	.003		.00588
Y-92	.00001	.00011		.00012
Mo-99	.411	2.7	.014	3.125
I-131	.501	1.35	.029	1.88
I-132	.0255	.099	.0023	0.127
I-133	.0975	1.55	.033	1.68
I-134	.00061	.026	.0006	.0272
I-135	.0167	.5	.011	.528
Te-132	.0231	.14		.163
Cs-134	.147	.15	.00089	.298
Cs-136	.0465	.1		.146
Cs-137	.73	.75		1.48
Ba-140	.00119	.0025		.00369
La-140	.00006	.00063		.00069
Ce-141	.00028			.00028
Ce-144	.00013	.00019		.00032
TOTAL	2.02	7.47	0.095	9.58

TABLE — 14-2

ESTIMATED ANNUAL AVERAGE EFFLUENTS (CURIES)

	Waste Processing System	Condenser Air Ejector	Containment Purge (4)	PAB Leaks	Gland Seal*** Condenser Air Exhauster	TURBINE HALL LEAKS (Liquid)	TURBINE HALL LEAKS (Gas)	STEAM GENERATOR BLOWDOWN (IP1 Air Ejector) *	STEAM GENERATOR BLOWDOWN (IP1 Blowdown Flash Tank) **	TOTAL (IP3 Sources)
Kr-85	1062.	30.0	27.1	30.0	-	-	-	-	-	1.15(3)
Kr-85m	-	8.66	.02	8.66	-	-	-	-	-	1.73(1)
Kr-87	-	5.02	.004	5.02	-	-	-	-	-	1.00(1)
Kr-88	-	15.2	.02	15.2	-	-	-	-	-	3.03(1)
Xe-133	908.	1163.	88.1	1163.	-	-	-	-	-	4.23(3)
Xe-133m	-	12.9	.43	12.9	-	-	-	-	-	2.62(1)
Xe-135	-	25.6	.14	25.6	-	-	-	-	-	5.13(1)
Xe-135m	-	0.78	-	0.78	-	-	-	-	-	1.56(0)
Xe-138	-	2.79	-	2.79	-	-	-	-	-	5.58(0)
I-131	-	.00849	1.44(-4)	9.92(-5)	4.92(-5)	7.58(-6)	.0113	.065	.07	2.01(-2)
I-132	-	.00675	2.4(-5)	3.67(-5)	3.91(-6)	6.02(-7)	.000903	3.4(-4)	.0055	1.64(-3)
I-133	-	.0101	1.72(-4)	1.62(-4)	5.85(-5)	9.04(-6)	.0135	.031	.083	2.40(-2)
I-134	-	.000183	8.0(-6)	2.27(-5)	1.06(-6)	1.64(-7)	.000245	3.4(-5)	.0015	4.60(-4)
I-135	-	.00336	8.0(-5)	8.73(-5)	1.95(-5)	2.99(-6)	.00449	.0041	.028	8.04(-3)

* Released via the Indian Point Unit No. 1 Superheater Stack
** Released atop the Indian Point Unit No. 1 Chemical System Building
*** Noble gases are already included in Condenser Air Ejector Effluent

TABLE — 14-3

ANNUAL AVERAGE DOSES AT THE SITE BOUNDARY IN THE WORST METEOROLOGICAL SECTOR FROM ESTIMATED GASESOU RELEASES

	Waste Processing System	Condenser Air Ejector	Containment Purge (4)	PAB Leaks	Gland Seal Condenser Air Exhauster	TURBINE HALL LEAKS (Liquid)	TURBINE HALL LEAKS (Gas)	STEAM GENERATOR BLOWDOWN * (IP1 Air Ejector)	STEAM GENERATOR BLOWDOWN ** (IP1 Blowdown Flash Tank)	TOTAL
Kr-85	.0204	.00058	.00052	.00058	-	-	-	-	-	.022
Kr-85m	-	.0099	.000023	.0099	-	-	-	-	-	.0198
Kr-87	-	.034	.000027	.034	-	-	-	-	-	.068
Kr-88	-	.201	.00026	.201	-	-	-	-	-	.402
Xe-133	0.47	.603	.0456	.603	-	-	-	-	-	1.72
Xe-133m	-	.019	.00064	.019	-	-	-	-	-	.039
Xe-135	-	.043	.00024	.043	-	-	-	-	-	.086
Xe-135m	-	.0026	-	.0026	-	-	-	-	-	.0052
Xe-138	-	.0075	-	.0075	-	-	-	-	-	.015
I-131	-	.0758	.00128	.000886	.00044	6.8(-5)	.101	.013	.82	1.01
I-132	-	.00022	7.7(-6)	1.18(-5)	1.26(-6)	1.9(-7)	.00029	2.5(-6)	.00023	0.0028
I-133	-	.0244	.00041	.00039	.00014	2.2(-5)	.0326	.0017	.26	0.32
I-134	-	.000028	1.2(-6)	3.4(-6)	1.6(-7)	2.5(-8)	3.7(-5)	1.2(-7)	.0003	0.00037
I-135	-	.0025	6.0(-5)	6.53(-5)	1.46(-5)	2.2(-6)	.00336	6.9(-5)	.027	0.0331
TOTAL γ WHOLE BODY DOSE	0.491	0.921	0.047	0.921	-	-	-	-	-	2.38
TOTAL THYROID DOSE	-	0.103	0.0018	0.00136	0.0006	9.2(-5)	0.137	0.148	1.11	1.37

* $X/Q = 5.8 \times 10^{-7}$ for release from IP1 stack

** $X/Q = 3.4 \times 10^{-5}$ for ground release from IP1 Chemical Systems Building

14.3 Releases for Unusual Operating Conditions

Great attention has been devoted in the design and construction of Units Nos. 1, 2 and 3 by Con Edison and its contractors, as well as by the Atomic Energy Commission, to the prevention of accidental releases of radioactive materials to the environment. Much of the cost and design effort of these units is devoted to structures and equipment for the prevention of accidents and the limiting of the consequences of an accident should one occur. Numerous postulated equipment failures, expected operational occurrences and operator errors have been analyzed to assure that health and safety will be protected. A comprehensive quality assurance program is carried out during design and construction to assure that the unit, as constructed, will meet its design objectives. Operator training, detailed operating and emergency procedures, and periodic tests and inspections over the lifetime of the units will assure the safe operation of the facility.

Expected releases for unusual operations, such as for those equipment failures which experience has indicated are likely to occur, may temporarily be higher than those estimated for normal operation. However, the proposed Technical Specifications for Indian Point Unit No. 3 require that in any event these releases shall be within the limits of 10CFR20.

In addition, as is presently the case for Indian Point Unit No. 1, it will be Con Edison's policy to operate Indian Point Nos. 2 and 3, including the waste disposal equipment, in such

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*The general terrain around the plant varies from approximately elevation 15 feet to elevation 70 feet above sea level.

a manner that radioactive releases will be kept as low as practicable below the limits specified in 10CFR20. Available waste disposal equipment will be utilized to the maximum extent practicable, and every effort will be made to restore the availability of equipment which may be shut down for servicing or repair. Section 3.9 of the proposed Technical Specification contains such a requirement, which reads, "Plant equipment shall be used in conjunction with developed operating procedures to maintain surveillance of radioactive gaseous and liquid effluents produced during normal reactor operations and expected operational occurrences in an effort to maintain radioactive releases to unrestricted areas as low as practicable."

Meteorological concerns factored into analyzing non-routine plant behavior include a conservative sequence of wind speeds, wind persistence and stability categories. After any incident on the site, highly stable conditions are assumed for 24 hours with wind speeds on the order of 1 and 2 meters per second and wind direction constant. This is conservative because of the minimal probability of such a meteorological occurrence and because of the diurnal nature of the valley, discussed previously, which one can expect to cause a reversal in wind direction at 12 hour intervals.

14.4 Pathways of Exposure to Man

As mentioned earlier, Units No. 1, 2, and 3 will be treated as a single facility with regard to releases of radioactivity to the environment. Such releases will be small in comparison to 10CFR20 standards and will occur under controlled conditions. The two main pathways for radioactive releases are airborne to the atmosphere and liquid to the Hudson River. After a suitable decay period, airborne wastes from Unit No. 3 will be released through special filtration systems to the plant vent located at the top of the containment structure. Liquid wastes will be released after processing to the cooling water discharge canal which enters directly into the Hudson River. In both cases, radioactivity detectors monitor all releases to insure that various preset limits are at no time exceeded. Should such an event occur, automatic shutoff valves are activated, thereby preventing excessive radioactive material from entering the environment.

(a) Atmospheric Releases

A gaseous waste holdup system designed for a 45 day holdup capability is provided for Unit No. 3. Therefore, when the waste is eventually released from the holdup system and

after filtration it will consist almost entirely of the radioactive noble gases Kr-85 and Xe-133. Both are inert gases which diffuse readily in the atmosphere and are not subject to reconcentration mechanisms. Therefore, gaseous releases during normal operation will be inconsequential as a potential source of exposure to man.

With all three units in operation (assuming 1% leaking fuel and no steam generator leakage for Units No. 2 and 3) the estimated yearly dose to an individual standing continuously at the site boundary under average meteorological conditions is less than 10 mrem. With respect to the natural background in the area surrounding the Indian Point site, which ranges from 110 to 125 mrem per year, the added dose to any population group would be imperceptible.

(b) Liquid Releases

Liquid radioactive releases are controlled to insure that the isotope mixture in the water entering the Hudson River will be substantially below the concentration specified in 10CFR20 as permissible for drinking water. This limitation will be maintained despite the fact that the Hudson River is not utilized as a source of drinking water at any point likely to be affected by plant releases.

The only significant potential exposure to man from plant released radioisotopes may result from the reconcentration of long lived isotopes via the aquatic food chain. The best available data relating to the Hudson River aquatic food chain from which an accurate assessment of the degree of potential exposure can be obtained is provided in extensive studies by the New York University Medical Center's Institute of Environmental Medicine. These studies have included an independent and large scale ecological research program which since 1964 has examined the identity, abundance and distribution of natural, fallout and reactor produced radionuclides in the Hudson River estuarine environment. The study specifically evaluated radioactive releases from Indian Point Unit No. 1. As a result of these studies, the Institute concluded in a paper entitled "Manmade Radionuclides in the Hudson River Estuary", which is appended to this report (see Appendix-Y), that the most important radionuclides with respect to the exposure of man from such releases are Cs-134 and Cs-137. Although a number of radioisotopes are present and reconcentrated in the aquatic food chain, such as Mn-54 which is concentrated in bottom plants, the Cesium isotopes in the edible

portion of fish are the primary source of man-made radiation due to consumption of fish from the Hudson River near Indian Point. The Institute also concluded that during 1969, Cs-137 in fish from fallout would deliver a whole body dose of 0.01 mrem/year whereas releases of radioactivity resulted in radionuclide levels in fish which would deliver approximately 0.03 mrem/year to the whole body, based on an average daily consumption of 30 grams of fish. These estimated dose levels are based on Unit No. 1 releases which averaged 4.0% of MPC levels for the year. An extrapolation of the estimated dose levels for hypothetical releases at 100% MPC indicates that a whole body dose of approximately 0.8 mrem per year would result from consuming Hudson River fish collected near the outfall.

With regard to this dose potential, it should be noted that the total combined radioactivity releases from Units No. 1, 2 and 3 will be reduced by several orders of magnitude as compared to the 1969 releases of Unit No. 1 alone due to the installation of the new blowdown purification system. Therefore, utilization of the new purification system will reduce the potential exposure to man from liquid releases still further.

14.5 Other Considerations

Radionuclides released to the environment due to the operation of all three nuclear units at Indian Point have little or no detectable effect on any species living in that environment. There are two basic reasons why these effects are minimal. First, radionuclides are released in such minute quantities that even when concentration mechanisms are operable, amounts are well below MPC values. Secondly, when concentration mechanisms are operable, allowing for possible reconcentration in food chains, natural biological blocks prevent reconcentration in major species. For example, Manganese-54 is concentrated in bottom flora (see Appendix-Y). Fish feeding on this vegetation are biologically incapable of further reconcentration due to a natural mechanism which prevents the passage of manganese (radioactive or non-radioactive) through the intestinal wall.

Consequently, no detrimental effects will occur due to releases of minute quantities of radionuclides from Indian Point. Whether considered on an individual basis for Unit No. 3 or on a cumulative basis for all three units, radioactive releases amount to only small fractions of existing standards for such releases to the environment.