

## **Appendix E**

APPENDIX E

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OCNGS ALTERNATIVE COOLING WATER SYSTEM STUDY

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## APPENDIX E1

JERSEY CENTRAL POWER & LIGHT COMPANY  
OYSTER CREEK NUCLEAR GENERATING STATION  
ALTERNATIVE COOLING WATER SYSTEM STUDY

APPENDIX E1

STUDY TEXT

Ebasco Services Incorporated  
Two Rector Street  
New York, NY

November 1977

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VOLUME 2

PREFACE

The Alternative Cooling Water System Study prepared by Ebasco Services, Incorporated consisted of three separately bound volumes.

Volume 1 contained an Executive Summary (Chapter I) of the Alternative Cooling Water System Study and is not reproduced as a part of this Appendix.

Volume 2 contains Chapter II (Description of the Existing Cooling Water System), Chapter III (Discussion of Alternative Cooling Water Systems), and Chapter IV (Discussion of Preferred Cooling Water Systems). This volume presents the approach, methodology, analysis and results of the study in detail.

Volume 3 contains all Exhibits cited within Volume 2.

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CHAPTER II

LIST OF EXHIBITS

No of Exhibits

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7

Oyster Creek NGS Site & Vicinity

8

Existing Cooling Water System

#### A. ENGINEERING FEATURES

The Oyster Creek Nuclear Generating Station is located in Ocean County, New Jersey, on a 1400 acre site sitting astride the Lacey Township and Ocean Township boundary. The site is about 35 miles north of Atlantic City along the Garden State Parkway. The site property extends about 3½ miles inland from Barnegat Bay. Exhibit 7 shows the general site vicinity.

The station presently utilizes a once-through condenser cooling water system. An inlet canal with a length of approximately 12 000 ft supplies salt water from Barnegat Bay to the plant cooling water and dilution water intake structures.

There is a common intake structure which accommodates the condenser and auxiliary equipment circulating water pumps, the reactor building service water pumps, and the emergency service water pumps. The intake structure is equipped with traveling screens and screen wash pumps. Each of the four (4) vertical circulating water pumps is rated 115 000 gpm at a total head of 29 ft. Each pump has a vertical motor drive rated at 1000 hp, 327 rpm, 4000 V.

The flow diagram for the existing circulating water system is listed as Exhibit 8. The four pumps service a three shell, single water tube pass, single pressure condenser. Each shell has a divided water box, designed for a test pressure of 25 psig, and a total of 14 562 titanium tubes. The tubes are 7/8 in. outer diameter and 42.5 ft. in length. Tube wall thickness is 0.028 in. (22 Bwg). The tube sheets are 1-1/4 in. thickness aluminum bronze. The total condenser surface is 423 000 sq ft and the total design water flow through the condenser is 450 000 gpm. In addition, the circulating water pumps supply 10 000 gpm to the turbine building closed cooling water heat exchangers. The heated circulating water flow is directed through a common tunnel and a discharge structure to Oyster Creek (discharge canal) and is eventually returned to the bay at a distance of approximately 7000 ft south of the intake canal. At turbine full load the circulating water discharge temperature exceeds the water temperature in the discharge canal by approximately 23°F.

The pressure ratings of the concrete sections of the existing circulating water tunnels are 80 ft for the intake tunnels and 25 ft for the discharge tunnels.

One or two dilution pumps, each rated 260,000 gpm, supply cold water from the intake canal to the discharge canal for mixing with the warm circulating water to reduce the discharge water temperature when necessary. These pumps are located close to the circulating water discharge structure.

It is currently planned that another power plant, the Forked River Nuclear Generating Station (FRNCS), will be built nearby and will discharge blowdown from a natural draft cooling tower into the Oyster Creek discharge canal.

## B. ENVIRONMENTAL IMPACTS

### 1. Introduction

The environmental impacts of the Oyster Creek Nuclear Generating Station as presently designed have been described in detail in public documents as part of regulatory proceedings.<sup>(1, 2)</sup> In Chapters III and IV of this report, environmental impacts of the existing cooling system are also discussed wherever such discussion is believed relevant to an understanding of the merits of alternative systems. The following paragraphs give only a brief sketch of the ways in which the OCNGS cooling system interacts with the environment. For further details, References 1 and 2 or the relevant sections of Chapters III and IV should be consulted.

### 2. Atmospheric Effects

The existing discharge canal contains water at a temperature greater than that which would occur without station operation. This temperature excess, in combination with the large flow volume now in Oyster Creek, affects the frequency and intensity of localized fogging.

### 3. Hydrothermal Effects

The existing system produces elevated temperatures in Oyster Creek and portions of Barnegat Bay. These temperatures appear to be in compliance with applicable regulatory criteria in Barnegat Bay (for periods when the ambient temperature does not exceed 85°F), but may be related to changes in aquatic ecology within a localized area.

### 4. Impacts on Water Resources

Operation of OCNGS has reversed the flow regime of the lower reaches of Forked River and has greatly increased the flow in the near-bay portion of Oyster Creek. Siltation patterns have also changed. Forked River is now effectively an extension of Barnegat Bay. Plant discharges have had no significant effect on water quality, and the added flow in Oyster Creek may have prevented that body from having unacceptable water quality.

### 5. Noise Effects

The station is in compliance with applicable noise regulations.

## 6. Visual Effects

Cooling system elements of the station have low to negligible visual impact.

## 7. Aquatic Ecology Effects

### a. Shipworms

It has been alleged that increases in shipworm populations in the vicinity of OCNGS have been due to improved conditions for shipworm breeding related to plant operation.<sup>(2)</sup> It is also possible that these population fluctuations could be the result of natural environmental causes. JCP&L has undertaken efforts to eliminate favorable habitat for shipworm settlement in the vicinity of the Oyster Creek Station.

### b. Cold Shock

Fish kills have occurred when fish, remaining in the station's thermal plume rather than migrating, were suddenly exposed to low ambient water temperatures during station shutdown.

### c. Entrainment and Impingement

Entrainment and impingement effects at OCNGS are currently being evaluated.

## 8. Terrestrial Ecology Effects

Some organisms were affected by the loss of habitat associated with construction of OCNGS. However, continued operation of the existing cooling system would not have any significant effect on terrestrial ecology.

## 9. Radiological Effects

The existing station is in compliance with applicable regulatory criteria.

Section II-B

REFERENCES

1. Jersey Central Power and Light Company, Environmental Report, Oyster Creek Nuclear Generating Station, 1969.
2. U.S. Atomic Energy Commission, Final Environmental Statement, Oyster Creek Generating Station, Operating License Stage, 1974.

III. DISCUSSION OF ALTERNATIVE  
COOLING WATER SYSTEMS

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A. PROJECT DESIGN PARAMETERS

This section presents a description of the basic design criteria and the principal operating parameters which the alternative cooling water systems must satisfy under varying loads and other operating conditions.

1. Plant Operation

Based on information provided by JCP&L it was assumed that an alternative cooling water system could start operation in the year 1984 and would be used up to the planned decommissioning of the unit in 2004. The predicted average plant capacity factor for the aforementioned period would be 0.65 and the predicted plant availability would be 76 percent. The unit's annual refueling and overhaul period is predicted to last 42 days and the forced outage rate is assumed to be 12.5 percent of total time. Based on the above assumptions, a plant loading period may be developed as follows:

| <u>Plant Loading Data</u> |                                       | <u>Duration Hr/Yr</u> |
|---------------------------|---------------------------------------|-----------------------|
| (i)                       | <u>Plant Operation</u>                |                       |
|                           | Load 100%                             | 3200                  |
|                           | 85%                                   | 2300                  |
|                           | 50%                                   | <u>1158</u>           |
|                           | Total Operation                       | 6658                  |
| (ii)                      | <u>Refueling and Overhaul 42 Days</u> | 1008                  |
| (iii)                     | <u>Forced Outages 45.6 Days</u>       | <u>1094</u>           |
|                           | Total i + ii + iii                    | 8760 hr/yr            |

The weighted average annual load is:

$$\frac{1 \times 3200 + 0.85 \times 2300 + 0.5 \times 1158}{3200 + 2300 + 1158} \times 100 = 86.1\%$$

The maximum dependable plant net output with the existing cooling water system is 620 MW. To achieve the above net output at a turbine design exhaust pressure of 1.0 in. Hga the nuclear steam supply system (NSSS) thermal output requirement would be 1860 MWt. JCP&L has advised Ebasco that the NSSS maximum thermal output would be 1900 MWt.

## 2. Turbine Cycle Heat Balance

The existing turbine generator is a General Electric Company unit with six exhaust flows and design parameters as follows:

Type: TC6F-38 in. LSB, 1800 rpm  
 Throttle Steam: 950 psig, 1191.2 Btu/lb, 0.28% moisture  
 Exhaust Pressure: 1.0 in. Hga  
 Maximum Guaranteed Load: 640 700 kW

The turbine cycle heat balance for maximum guaranteed load at the nominal turbine throttle and exhaust conditions and NSSS thermal output of 1860 MWt is presented in Exhibit 9.

Based on this heat balance and other available General Electric heat balances the following turbine performance data with the existing cooling system were selected to serve as a basis for this study:

### Turbine Performance @ 1.0 in. Hga Exhaust Pressure

|                             | NSSS<br>Thermal<br>Output<br><u>MWt</u> | <u>Turbine-Generator Performance</u> |          |                  |
|-----------------------------|---|--------------------------------------|----------|------------------|
|                             |   | <u>Output (Gross)</u>                |          | <u>Heat Rate</u> |
|                             |   | <u>MWe</u>                           | <u>%</u> | <u>Btu/kWh</u>   |
| Maximum Load                | 1900                                    | 657.4                                | 102.6    | 9 807            |
| Maximum Dependable          | 1860                                    | 640.7                                | 100      | 9 821            |
| Operation with Reduced Load | 1600                                    | 540.2                                | 85       | 9 953            |
|                             | 1010                                    | 320.0                                | 50       | 10 511           |

The turbine heat rate adjustment for various loads and exhaust pressures over the range of 0.5 to 5.0 in. Hga was based on General Electric Heat Rate Correction Curves 452HB158 dated October 28, 1976 (See Exhibit 10).

The maximum allowable exhaust pressure was assumed to be 5.0 in. Hga as suggested in GE Technical Information Letter TIL-772.

The condenser heat duty at 1.0 in. Hga exhaust pressure was calculated to be as follows:

|  |              |              |              |
|--|--------------|--------------|--------------|
| <u>Turbine Generator Output, MW:</u>         | <u>657.4</u> | <u>540.2</u> | <u>320.0</u> |
| <u>Condenser Duty 10<sup>6</sup> Btu/hr:</u> | <u>4210</u>  | <u>3532</u>  | <u>2275</u>  |

The turbine building closed cooling water system requirement was assumed to be 10,000 gpm.

The number of days of unit operation during various seasons and seasonal generation apportionment was based on the assumption that refueling and overhaul would be performed in spring or fall. The assumed data was as follows:

|   | <u>No. of Days<br/>in Operation</u> | <u>Percent of<br/>Total<br/>Annual<br/>Generation</u> |
|---|-------------------------------------|---|
| Summer (June + July + August + September)                     | 112                                 | 43  |
| Spring and Fall (March + April + May +<br>October + November) | 95                                  | 33  |
| Winter (December + January + February)                        | 70.4                                | 24  |

Based on JCP&L information the auxiliary power requirement, excluding the circulating water system, for turbine full load operation is 17.5 MW. At 85 percent load it is assumed to be 15.8 MW and at 50 percent load, 13.0 MW.

### 3. Ambient Air Design Criteria

The selection of ambient air wet bulb and dry bulb temperature was based on meteorological data for Atlantic City, namely:

- a) coincident wet bulb and dry bulb temperatures for 1960-1964  
(See Exhibit 11)
- b) cumulative percent frequency distribution of wet bulb and dry bulb temperatures for 1960-1964 (See Exhibit 12)

Data used for percent occurrence of wind speed ranges and wind directions for each season of year was based on Oyster Creek site data for 1966-1967 (See Exhibit 13).

A summary of the ambient air conditions used in determining circulating water temperatures with the alternative cooling water systems is as follows:

| <u>Conditions</u> | <u>Design</u> | <u>Avg Summer</u> | <u>Avg Spring/Fall</u> | <u>Avg Winter</u> | <u>Maximum</u> |
|-------------------|---------------|-------------------|------------------------|-------------------|----------------|
| Dry Bulb, °F      | 89            | 72                | 52                     | 33                | 94             |
| Wet Bulb, °F      | 74            | 65                | 46                     | 30                | 78             |

4. Intake Water Temperature and Quality in Existing Canal and Atlantic Ocean

Based on information provided by JCP&L it was assumed that the maximum water temperature in the existing intake canal may reach 86° F, whereas maximum ocean intake temperature would not exceed 68° F.

Average water temperatures for each season of the year were assumed as follows:

|             | <u>Existing Canal</u> | <u>Ocean Intake</u> |
|-------------|-----------------------|---------------------|
| Summer      | 76° F                 | 61° F               |
| Spring/Fall | 58° F                 | 48° F               |
| Winter      | 38° F                 | 41° F               |

Existing canal (Barnegat Bay) and Atlantic Ocean water quality data are listed in Exhibit 14.

Based upon existing water quality data (Exhibit 14), the average salinity in the canal was assumed to be 24 000 ppm and in the ocean intake 35 000 ppm.

For saltwater closed cycle systems (cooling towers, ponds and spray modules) the existing intake canal is the makeup water source.

Chlorination of cooling water would be required to avoid biofouling. The average chlorine consumption with various alternative systems was assumed to be:

|  |   |  |
|--|---|--|
| Wet (Evaporative) Cooling Tower Systems      | - | 3,000 lb/day                                   |
| Cooling Ponds and Discharge Pipelines to Bay | - | 2,000 lb/day                                   |
| Spray Canal and Discharge Canal to Bay       | - | 1,700 lb/day                                   |
| Ocean Intake and Discharge Pipelines         | - | 7,500 lb/day                                   |
| Existing Cooling Water System                | - | 2,000 lb/day (summer)<br>1,000 lb/day (winter) |

5. Site Conditions

JCP&L owns an extensive tract of land at the site, extending from Barnegat Bay on the east almost to the Garden State Parkway on the west. This tract extends between the South Branch of Forked River to Oyster Creek, the only exception being the developed section adjacent to where the Forked River flows into Barnegat Bay.

The JCP&L property near the Bay is mainly marshland at a low elevation above sea level. In the Bay the mean range of tide is 0.6 ft; however, tides as high as +4.5 ft have been measured during storms in which wind has a dramatic effect on the water elevation in the Bay (Datum is mean sea level).

In general, the property is unwooded, however, should additional land be required for some alternates, clearing of timber could become a significant cost factor.

A complicating factor in some alternates is the fact that State Highway Route 9 and a branch railway line cross the JCP&L property just east of the Oyster Creek Station. In addition, New Jersey Bell Telephone Co. operates buried cables, New Jersey Natural Gas Company operates buried gas lines located near Route 9, and Ocean County Sewerage Authority is planning to install an interceptor at this location.

The Oyster Creek site lies in an area known geologically as the coastal plain. There are numerous formations underlying this coastal plain area; however, one significant fact for the purpose of our review is that the approximate depth to rock is quoted as 1800 ft. The results of previous test holes at the site indicate the surface layer to be generally yellow, fine to medium textured sand of medium density extending to a depth of approximately 17 ft. The second stratum consists of alternate layers or lenses of clay, silt, and dark grey fine sand. This stratum is underlain by alternating layers of sand, clay-silt and further sand to a depth in excess of 100 ft. The two clay-silt strata appear to act as aquicludes and separate the soil below the surface into three water bearing sand aquifers. There is extensive use of wells in the area for water supply with most wells in the area exceeding 60 ft in depth. Prior to construction of the Oyster Creek Nuclear Generating Station, ground water was found to be close to the surface, generally less than 10 ft depth.

In the vicinity of the Oyster Creek Nuclear Generating Station, the ground surface is at approximate elevation +23 ft.

#### 6. Input Data for Alternative Cooling Water System Evaluation

The performance and economics of a power plant and its cooling water system with a fixed condenser are affected by the following parameters:

- a) Cooling water flow rate

For a fixed condenser this parameter can also be described by the

water velocity in condenser tubes. It affects the temperature rise across the condenser, turbine back pressure and unit gross and net output. In this study the water velocity in condenser tubes was considered over the range of 6.0 to 7.5 fps. The water velocity for the existing system is 6.3 fps based on a condenser flow of 450 000 gpm.

b) Cooling water temperature entering condenser

For an evaporative closed cycle cooling water system this parameter is defined by the approach temperature, which is equal to the difference between the water temperature leaving the cooling facility (entering condenser) and the ambient wet bulb temperature. For a dry cooling tower system the approach temperature is sometimes defined as the difference between water temperature entering the tower (leaving condenser) and ambient dry bulb temperature. For various alternative cooling systems an appropriate series of approaches was established as follows:

|                                     | <u>Approach °F (to <math>T_{wb} = 74^{\circ} F</math>)</u> |
|-------------------------------------|--|
| Mechanical draft wet cooling towers | 10 to 16   |
| Natural draft cooling towers        | 12 to 20   |
| Fan assisted cooling towers         | 14 to 18   |
| Wet/dry cooling towers              | 11 to 22   |
| Dry cooling towers                  | 29 to 31   |
| Spray Cooling Modules               | 12 to 15   |

B. ALTERNATIVE COOLING WATER SYSTEM ENGINEERING DESCRIPTION  
AND EXPERIENCE

1. Open and Closed Cycle Cooling Water Schemes

In open cycle cooling water schemes, which are also called once-through schemes, the intake water flow from a natural water source is used to absorb the heat rejected in the condenser and afterwards is returned to that source at higher temperature. Hence, the total heat rejected in the condenser is transferred to the natural water source.

In closed cycle cooling water schemes, such as cooling towers, almost complete elimination of the warm water discharge to the natural water source can be accomplished. However, the retrofit of a closed cycle cooling system is associated with significant investment costs and increased operation expenses. It also causes various environmental impacts.

Several alternative open and closed cycle schemes sized for substitution for the existing OCNGS once-through cooling water system are described in this section.

2. Open Cycle Cooling Water Systems

a. Existing System with a Modified Intake Screen

At the request of JCP&L, Ebasco considered an alternate system consisting of the modified intake screen shown in Exhibit 15. The modified traveling water screens would be equipped with buckets designed to collect fish and direct them to a sluiceway for return to the waterway. As each bucket clears the water surface, water, debris and fish would travel up the screen assembly and encounter a low-pressure spray (20 psi) that directs the fish to the sluiceway. Then the bucket would be washed by a conventional high-pressure spray (80 psi) to remove debris.

The estimated cost for a refit with Ristroph bucket screens replacing the existing screens in all intake bays would be \$275,000.

The advantages of the Ristroph bucket screen system are discussed in Section III-L-4. Ristroph bucket screens are currently operational at two generating stations, Public Service Electric Gas Company's Salem NGS on the Delaware River and Virginia Electric Power Company's Surrey Station on the James River.

b. Discharge Canal to the Bay

Exhibit 16 shows in schematic form the flow diagram for a discharge canal

to the bay. The existing cooling water discharge tunnel and the dilution pump discharge structure would be extended by pipeline to a new mixing and discharge structure to be constructed just clear of the existing structures on the south side of the plant. From this structure, the water would then flow in a new canal to the bay. Exhibit 17 shows the layout of this system. The basic requirements considered in the assessment of this system were that the canal should be lined, that the discharge velocity of the water into the bay should be low so as not to disrupt pleasure boating, and fish should not be able to enter the canal. Since a low water velocity discharge would allow fish to enter the discharge canal, a drop structure with its crest set at the high water elevation or above would need to be used. Since the maximum recorded high water level (including wind effect) is +4.5 ft, this arrangement would lead to a relatively high level canal.

A review of the general geology of the area and of the drilling logs of exploration holes at the plant site indicated that all the material likely to be encountered during construction would be fine to medium textured sand with possibly some silt and lenses of clay at greater depths. Although this should make excavation relatively easy, it has been assumed that the material will be highly permeable. Thus, should excavation proceed below the water level in the bay, dewatering problems would probably be encountered, leading to problems in installing the required lining. Additionally, the eastern third of the canal, including the discharge, would have to be constructed through a marsh. In order to avoid these potential dewatering problems as much as possible, it was decided to maintain the floor of the canal at a minimum of 1.5 ft above mean sea level.

The canal lining would be a high proportion of the cost of the canal. Therefore, in order to minimize construction costs, it was decided that a canal cross-section having the least wetted perimeter, but with not less than a 20-ft base width would be considered.

These decisions give the canal profile shown on Exhibit 17. The low point of the canal bottom would be at elevation 1.75 ft and the crest of the drop structure at the bay would be at elevation +9.0 ft. This would give a depth of water in the main part of the canal of 10.75 ft and a water velocity of 4.0 fps. The water surface near the power plant would be at elevation +13.5 ft.

This high water surface would create some problems, i.e., the need for increased pumping head on the system and the question of whether or not sufficient headroom would exist for bridge members where the canal would cross under the railway and Route 9.

A more detailed evaluation of this scheme that gives consideration to the effects of lowering the water surface in the canal, changing the cooling water flow rate and altering means of transferring dilution water to the discharge canal is included in Section IV-G of this report.

An assumption made in this scheme is that excavated material will be suitable for embankment construction.

In selecting a lining material, first consideration was given to concrete. If an unreinforced concrete liner was used, the possibility of differential settlement of the liner after filling with water could lead to extensive cracking of the liner. Also, should the water pressure under the liner build up during operation, further damage due to heave could occur if the canal were dewatered. This leads us to believe that if a concrete liner were used it would have to be reinforced. The recommended minimum concrete cover for reinforcement in concrete structures in contact with sea water is 3 in.. Thus, the liner thickness would be increased to a practical limit of 7 inches.

The alternate liner considered was a flexible liner. Many such materials exist and selection of a particular type depends largely on the particular conditions met at the site. Differential settlement or pressure beneath the liner would present no difficulties and, in addition, installation time should be greatly reduced. Since both types of material would present problems of deterioration, the flexible liner was included due to its substantial cost benefit.

At the power plant end of the canal, connection of the existing discharge tunnels to the canal would present many problems. The pumping head requirement with the discharge canal would be higher than with the existing cooling water system due to the drop structure's high elevation. The possibility of a new impeller installation in the existing vertical circulation water pump case or the necessity for new pumps is subject to further study by the pump manufacturer. In this study it was assumed that new pumps would be installed in the existing intake structure.

As the low point of the bottom of the canal would be well below the crest of the drop structure, a maintenance drain line would be provided. Some dredging in the bay would be required in order to maintain the required low discharge velocities.

The orientation of the drop structure would be based on requirements to minimize environmental impacts and the possibility of water recirculation.

Construction time for this system is estimated to be 20 months.

c. Discharge Pipes to the Bay

Exhibit 18 shows in schematic form the flow diagram for a discharge pipe to the bay. This diagram is almost identical to that for the canal-to-bay system, the only exceptions being that the canal would be replaced by a pipeline and thus the mixing and discharge structure would become a mixing and surge tank structure.

The layout for this system is shown on Exhibit 19. This system is identical to the canal-to-bay system except that two 13 ft diameter pipes sized to carry a total cooling water and dilution water flow of 1 000 000 gpm would carry the water between the mixing structure and the transition section leading to the drop structure at the bay. Problems of crossing under the road and railway would be somewhat simplified, although some work would have to be carried out below mean sea level, thus increasing dewatering problems during construction.

Pumping head requirements would be increased due to the additional friction losses in the long pipelines and the drop structure's high elevation. New circulating water pumps and motors would be required. The existing intake structure could probably be used for the new pump installation.

Fouling of the concrete pipes with marine growths could present a major maintenance problem with this system.

As the low point of the pipeline invert is below the crest of the drop structure, a maintenance drain line would be required.

Some dredging in the bay would be required in order to maintain the required low discharge velocities.

Construction time is estimated to be 30 months.

d. Ocean Intake and Discharge Pipelines with the Existing Single Pressure Condenser

The schematic flow diagram for an ocean intake and discharge system using the existing condenser system is shown on Exhibit 20. Due to the extreme length of the intake and discharge pipelines and the consequent high friction losses in the system, it was not considered possible to circulate the cooling water by the use of only one pump house, as pressure at the condenser would have been far too high for the existing design. This system would, therefore, have both an intake line pump house and a discharge line pump house, and would use the existing cooling water pumps to circulate water through the condenser.

The layout of this system is shown on Exhibit 21. Location of the intake line pump house would present major difficulties. A location on Island Beach State Park would be best, but it was considered very unlikely that permission to build in this location could be obtained. Therefore, three alternate locations have been shown. The open ocean location would present major difficulties of access both during construction and operation. The bay location would avoid the hazards of open sea construction for the pump house but would require construction of a separate intake and pump house while retaining the access problems. The location on the west shore of the bay would simplify access both during construction and operation, but due to the friction losses in the extremely long suction line, the pump house would need to be very deep, probably at least 30 to 40 ft below mean sea level. This assessment is based on using one 12-ft diameter concrete pipe for both intake and discharge lines. The pipes would be designed for a cooling water flow of 460 000 gpm as used in the present cooling system.

Control of fouling by marine growths in this scheme would be extremely difficult and costly. Even if provision were made to dewater the lines for maintenance purposes, investment cost would be greatly increased as even a concrete pipeline would be buoyant; thus, special anchorage devices or deeper burial beneath backfill would be required. This system was not considered to be a viable economic alternative, regardless of engineering details, and attempts to further refine the engineering of the system were not undertaken.

Construction time is estimated to be five years.

e. Ocean Intake and Discharge Pipelines with a Multipressure Condenser

The flow diagram and layout for the ocean system using a multipressure

condenser are similar to those just described and are listed as Exhibits 22 and 23 respectively. The basic difference between the two systems is in water flow quantity and condenser operation. In this system the flow would be reduced to 177 400 gpm and, therefore, the required size of pipe would decrease to 7-ft diameter. Friction loss in the intake and discharge pipe would be higher and thus problems of water hammer during start-up and unscheduled shutdown of the pumps would be magnified.

For this alternative system the condenser would have to be modified for three pressure operation. The cooling water flow through the multipressure condenser would be reduced to 37 percent of the existing single pressure condenser flow rate (See Exhibit 24). However, the total temperature rise across the condenser would increase 2.7 times and would be 50° F or approximately 17° F per shell. This would result in higher turbine back pressure. However, the maximum pressure in the high-pressure condenser shell would be under 5 in. Hga. The cooling water velocity in the condenser tubes would be increased to 7 fps (as opposed to 6.3 fps for the present single pressure condenser). Remodeling the existing condenser for three pressure operation would require relocation and rearrangement of the external and internal condenser piping.

For this system, the head losses through the power plant would increase drastically, i.e., condenser losses would increase from 15 ft to 61 ft. Thus, the existing cooling water intake structure at the plant would require new pumps and motors. The condenser water boxes would have to be replaced and tube sheet firmness would have to be checked.

Potential corrosion hazards, the probability of marine fouling, difficulties of maintenance and the high investment cost are all factors leading to the conclusion that this cooling system would not be a viable alternative.

Construction time is estimated to be three years.

#### f. Helper Cooling Towers with the Existing System

The flow diagram for a once-through cooling water system using helper towers is listed as Exhibit 25. The supplemental mechanical draft cooling towers would be used to cool the heated circulating water before discharging it into the discharge canal. The helper towers would be sized to meet

applicable thermal discharge criteria. The most stringent criterion would be the 4° F temperature rise limit in the canal during winter conditions. The selected design conditions were a wet bulb temperature of 36° F or more and an intake water temperature of 33° F or less.\* The required helper tower discharge temperature was calculated assuming that the 4° F thermal criterion would be met by mixing the cooling tower discharge flow of 462 000 gpm with the flow of three dilution pumps (3 x 260 000 gpm):

$$\frac{T_{ct} \times 462\,000 + (3 \times 260\,000) \times 33^{\circ} \text{ F}}{462\,000 + (3 \times 260\,000)} = 33^{\circ} \text{ F} + 4^{\circ} \text{ F}$$

$$T_{ct} = 43.8^{\circ} \text{ F}$$

Hence, the helper tower design approach temperature (defined as the cooling water temperature leaving the cooling tower, less the ambient air wet bulb temperature of 36° F), is 43.8 - 36 = 7.8° F.

Typical cooling tower designs incorporate a winter approach of greater than 20° F and the minimum water temperature leaving the cooling tower is usually recommended to be not less than 48-50° F. At a lower average water temperature severe local icing may occur in the cooling tower. Therefore the described helper tower system with 60 cooling cells and  $T_{ct} = 43.8^{\circ} \text{ F}$  could not be recommended.

A more reliable helper cooling tower with 26 cooling cells and a minimum tower average outlet water temperature of 50° F was also considered. However, this system would not meet the thermal discharge criteria (see Section III-G-3).

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\*Based on a "10 percent critical winter time occurrence".

The design parameters and performance data of both helper tower systems for turbine full load operation is summarized as follows:

Mechanical Draft Helper Tower Systems

|  |             |             |
|--|-------------|-------------|
| <u>Cooling Tower Minimum Discharge Water Temperature at Winter Conditions °F</u> | <u>43.8</u> | <u>50.0</u> |
| Number of Cooling Towers   | 5           | 3           |
| Total Number of Cells  | 60          | 26          |
| Cooling Tower Width x Length ft x ft   | 64 x 432    | 70 x 540    |
| Cooling Tower Static Head, ft  | 44          | 32          |
| Fan Diameter   | 30          | 40          |
| Fan Exit Diameter  | 33          | 43          |
| Fan, bhp   | 122         | 200         |
| Circulating Water (CW) flow, gpm   | 462 000     | 462 000     |
| CW Temperature at Summer Conditions  |             |             |
| Entering Condenser, °F   | 74          | 74          |
| Leaving Condenser, °F  | 93          | 93          |
| Leaving Cooling Tower, °F  | 78          | 82          |
| After Mixing with Dilution Water, °F   | 75.5        | 77          |
| Temperature Rise in Discharge Canal After Mixing with Dilution Water             |             |             |
| Summer, °F   | 1.5         | 3.0         |
| Winter, °F   | 4.0         | 6.3         |

The assumed location for the five low discharge temperature helper towers is depicted on Exhibit 26. The suggested arrangement would be to locate all the towers to the south of the power plant adjacent to the discharge canal. This arrangement would provide the shortest pipelines. The cooling towers could be located to the north of the power plant. However, the alternate arrangement (which is depicted by dotted lines) would result in increasing pipeline length by approximately 2000 ft and increasing pumping cost by approximately 8 percent due to increased system static head.

The layout for the helper cooling tower alternative with higher discharge temperature (three cooling towers) is shown in Exhibit 27.

For the helper cooling tower system the total differential head (TDH) of the circulating water pumps would be significantly higher (60-80 ft) than the one required with the existing system (24 ft). Therefore new circulating water pumps and motors would have to be installed with the helper towers. Due to the imposed pressure limit of 25 ft on the existing discharge tunnel, two stages of pumping would have to be employed. However, since the circulating water flow rate would remain unchanged it would be possible to employ the existing intake structure with new pumps to pump the water through the condenser. A new four booster pump installation would supply the cooling water from the discharge tunnel to the cooling tower.

Construction time for the helper cooling tower systems is estimated to be 20-23 months.

### 3. Closed Cycle Cooling Water Systems

The total makeup requirement for evaporative closed cycle systems is usually 2-5 percent of the circulating water flow. However, the available freshwater sources would not be sufficient even for makeup requirement, and therefore the evaporative closed cycle systems would be designed for saltwater application. Salt water as a coolant has some specific properties which affect the performance and economics of the closed cycle circulating water systems.

The heat transfer in a saltwater circulating water system differs slightly from that in a freshwater system due to lower saltwater specific heat, lower vapor pressure (at the same temperature) and higher liquid density. For saltwater having on the order of 50,000 ppm total dissolved solids, the above changes in properties result in decreasing the heat transfer rate by approximately 5 percent and increasing required power by 7 percent.

Salt deposition in the vicinity of a saltwater cooling facility due to drift losses is a hazard associated primarily with saltwater cooling towers and spray modules. For all evaporative cooling tower systems the drift loss rate was assumed to be 0.001 percent of circulating water flow in this analysis. This rate is presently considered as the state-of-the art for drift eliminator efficiency and was proved to be achievable during laboratory and industrial tests performed by various manufacturers. The predicted drift loss from a spray module system is highly affected by wind speed.

a. Mechanical Draft Rectangular Cooling Tower System

i. Description

Mechanical draft rectangular cooling towers create the cooling effect by a combination of evaporative and convective processes. As the cooling water from the condenser passes through a flow of air in the cooling tower, a small portion of the water evaporates thereby cooling the remainder of the water. Approximately 80 percent of the total cooling tower heat duty is evaporative. The remaining heat removal is accomplished by sensible heat transfer.

The mechanical draft rectangular cooling tower is composed of a number of individual cells located adjacent to each other in a string. There are several manufacturers of this cooling tower type. Their designs differ in cell size, fan diameter and fill arrangement. For all designs, the tower height usually does not exceed 70 ft and serves only to accommodate the tower equipment. Since all designs provide a low profile saturated air discharge, ground level fogging and icing may occur during adverse meteorological conditions. In addition, recirculation of the saturated hot effluent from one cell into the entrance of other cells can occur if the cooling tower length is too large. This recirculation seriously reduces tower thermal performance. Therefore, the number of cells per tower is limited and the distance between cooling towers has to be not less than one tower length.

The mechanical draft rectangular cooling tower provides flexibility in thermal performance by turning off some of the cooling tower cells or by just shutting down a portion of the fans. In order to melt ice which may form in the tower during extreme cold winter operation the individual cell fans are usually reversible.

Individual cells operate independently to facilitate maintenance, and the cooling tower is noncombustible. Construction time for this scheme was estimated to be 31 months.

In this study the largest available cooling cells were considered. The general arrangement of the cell is depicted on Exhibit 28. The cell width would be 71 ft, length 60 ft, and height 55 ft. The induced draft fan diameter would be 40 ft. Eighteen cells of this size would be required to cool the Oyster Creek Unit circulating water flow of 462 200 gpm. The cells

would form two cooling towers, each 9 x 60 = 540 ft in length. The flow diagram for the mechanical draft cooling tower system is listed as Exhibit 29. A new intake structure with four circulating water pumps would provide the cooling water circulation through the condenser and cooling tower. Maximum evaporation loss would be approximately 7500 gpm. To maintain water quality in the closed cycle with 1.5 cycles of concentration the blowdown rate would be approximately 15 000 gpm. Hence the makeup from the existing intake canal would not exceed 22 500 gpm.

The proposed location of the rectangular towers is shown in Exhibit 30. For optimum thermal performance the longitudinal axes of the towers would be directed along the prevailing summer winds. A common intake structure with four vertical circulating water pumps would be located between the two towers.

The major technical data for the rectangular towers is summarized as follows:

Mechanical Draft Rectangular Cooling Tower System

|  |                    |
|--|--------------------|
| Number of Towers   | 2                  |
| Number of Cells per Tower  | 9                  |
| Approximate Size:  |                    |
| Cell Width x Length, ft  | 70 x 61            |
| Cooling Tower Length, ft   | 540                |
| Cooling Tower Height, ft   | 55                 |
| Fan Diameter, ft   | 40                 |
| Fan Horsepower   | 310                |
| Static Head, ft  | 31                 |
| Design Conditions:   |                    |
| Heat Load, Btu/hr  | $4.44 \times 10^9$ |
| Approach to $T_{wb} = 74^\circ \text{ F}$ , $^\circ \text{ F}$                   | 12                 |
| Cooling Range, $^\circ \text{ F}$  | 19.73              |
| Circulating Water Flow, gpm  | 462 000            |
| CW Temperature Leaving Cooling Tower<br>(Entering Condenser), $^\circ \text{ F}$ | 86                 |

ii. Experience

The mechanical draft rectangular cooling tower is the best known cooling tower type in the U.S. However, almost all of the installations are designed

and operated with fresh water.

Documented experience with saltwater towers is limited. A summary of available information is listed in Exhibit 31.

b. Round Mechanical Draft Cooling Tower System

i. Description

The round mechanical draft tower is a recent development. It was designed to provide better plume discharge characteristics in comparison with the rectangular tower, to exclude effluent recirculation and to provide more flexibility in cooling tower location.

The general arrangement of the tower is depicted on Exhibit 32. All the induced draft fans are located on the upper deck of the tower structure. Each fan has an individual short stack. The cooling tower structure is noncombustible. The columns, beams, deck and basin are reinforced concrete; the fill, drift eliminators and louvers are of asbestos cement.

Due to its circular configuration, the tower's performance is not affected by wind direction. The towers can be built closer to the power plant than rectangular towers. Piping and wiring requirements are reduced.

Due to the clustered location of all the fans on the cooling tower deck, the saturated vapor plumes from the individual fan stacks merge into a common plume. There is a great dilution of vapor and droplets and a lesser tendency to produce fogging and icing than with a mechanical draft rectangular cooling tower. Also, drift droplets travel further from the tower before depositing on the ground than with the rectangular system. Consequently, though salt deposition would affect a greater area, the actual concentrations of salt deposited would be less.

The strong buoyant force of the common plume precludes effluent recirculation to the cooling tower entrance. Flexibility in operation for meeting reduced heat duty and seasonal meteorological variations is provided by sectionalizing the hot water distribution system and shutting off some of the fans. However, during summer shutting off fans might cause some undesirable air recirculation if the fan discharge is not blocked off.

Construction time for this system was estimated to be 31 months.

The flow diagram for the round mechanical draft cooling tower system is similar to that of a rectangular tower. Two cooling towers, each with 19 fans, and an intake structure with four pumps are required (See Exhibit 33).

The assumed location of the round towers is shown in Exhibit 34.

The major technical data for the round towers is summarized as follows:

Round Mechanical Draft Cooling Tower System

|  |                    |
|--|--------------------|
| No. of Towers  | 2                  |
| Approximate Size:  |                    |
| Base Diameter, ft  | 237                |
| Height, ft   | 69                 |
| No. of Fans per tower  | 19                 |
| Fan Horsepower   | 206                |
| Static Head, ft  | 42.4               |
| Design Conditions:   |                    |
| Heat Load, Btu/hr  | $4.44 \times 10^6$ |
| Approach to $T_{wb} = 74^\circ \text{F}$ , $^\circ\text{F}$                    | 10                 |
| Cooling Range, $^\circ\text{F}$  | 21.1               |
| Circulating Water Flow, gpm  | 426 200            |
| CW Temperature Leaving Cooling Tower<br>(Entering Condenser), $^\circ\text{F}$ | 84                 |

ii. Experience

The round cooling towers are designed by Marley, Ecodyne and Zurn. The Marley Company design was introduced into the cooling tower market several years ago while the Ecodyne and Zurn designs were offered for the first time in 1975. The first large (thirteen fan) tower was completed by the Marley Company and started operation in March 1975. Presently, some improvements to the prototype tower design are being developed by the Marley Company. Several other towers of this design are currently under construction or ordered. These towers are listed in Exhibit 35. All of them but one are designed for freshwater operation.

### c. Natural Draft Cooling Tower System

#### i. Description

Natural draft evaporative (wet) cooling towers, sometimes called hyperbolic cooling towers, create their cooling effect in the same way as the mechanical draft towers by a combination of evaporative and convective processes. The difference is that the air flow through the tower to cool the circulating water is provided by the chimney effect of the high tower. The air flow through the natural draft towers varies. It increases at low ambient temperatures and decreases at high temperatures. Therefore, the winter thermal performance of a natural draft tower is better than that of a mechanical draft tower with the same summer design data and a constant air flow.

One natural draft cooling tower would be required to handle the condenser and auxiliary heat duty for OCNGS. Based on the results of an economic optimization, the cooling tower diameter would be approximately 430 ft and its height would be 540 ft.

There are several designs for natural draft towers which differ in fill arrangement and air flow direction through the fill. The difference in thermal performance data for the various designs is not significant. Therefore, consideration was given to one design only - the counterflow natural draft cooling tower. A typical arrangement for this design is shown in Exhibit 36.

The flow diagram for the natural draft cooling tower system is depicted on Exhibit 37. The optimum circulating water flow would be 433 300 gpm. The maximum evaporation rate and blowdown would be almost the same as for a mechanical draft cooling tower system: 7400 gpm and 14 800 gpm.

The assumed location for the natural draft cooling tower is shown in Exhibit 38. The cooling tower is located at a distance of 540 ft (equal to tower height) from important safety-related (Class I) structures.

Construction time was estimated to be 36 months.

The natural draft cooling tower does not provide the flexibility in draft control that is inherent in mechanical draft towers. However, the natural draft towers are presumed to provide better availability and require less maintenance because they do not have rotating parts and consequently there is less that can go wrong.

The major technical data for the natural draft tower is summarized as follows:

Natural Draft Cooling Tower System

|  |   |
|--|---|
| Cooling Tower Design:  | Counterflow, Concrete Structure<br>Asbestos Cement Fill |
| No. of Towers,   | 1   |
| Approximate Size:  |   |
| Base Diameter, ft  | 430   |
| Exit Diameter, ft  | 270   |
| Height, ft   | 540   |
| Static Head, ft  | 49  |
| Design Conditions:   |   |
| Heat Load, Btu/hr  | $4.44 \times 10^6$                                      |
| Approach to $T_{wb} = 74^\circ \text{ F}$ , $^\circ \text{ F}$                   | 14  |
| Cooling Range, $^\circ \text{ F}$  | 21.2  |
| Circulating Water Flow, gpm  | 433 300   |
| CW Temperature Leaving Cooling Tower<br>(Entering Condenser), $^\circ \text{ F}$ | 88  |

ii. Experience

The first natural draft cooling tower on a power plant in the U.S. started operation in 1963. Presently, there are more than 50 natural draft cooling towers in operation and approximately 75 are under construction or ordered for United States utilities. Most of them are assigned for large generating stations (500-1200 MW). These towers are being designed and built by Marley, Research Cottrell, Ecodyne, Zurn, and others. Almost all the towers are designed for fresh water, but a few are for salt and brackish water. A brief description of the B L England Power Plant saltwater natural draft cooling tower is provided in Exhibit 31. This tower was designed and built by Research

Cottrell. The Marley Company has built a brackish water natural draft tower for Chalk Point Unit No. 3.

Exhibit 39 lists the largest freshwater natural draft towers in operation.

d. Fan Assisted Natural Draft Cooling Tower System

i. Description

The fan assisted natural draft cooling tower is a hybrid, combining features of natural draft and mechanical draft design. Depending on shell height, the environmental effects of the fan assisted tower may approach those of a natural draft tower (for high towers) or a round mechanical draft tower (for low towers).

The fan assisted natural draft cooling tower uses forced draft fans which completely encircle the base of the cylindrical shell. The fans may have two speed motors which permit operation at lower speeds during cool ambient air periods, thereby reducing the auxiliary power requirement. Originally, the recommended tower veil height was 180 to 300 ft. To reduce investment cost, a low profile tower was recently developed with a height of a regular mechanical draft tower (60 ft). Both types of fan assisted towers are shown in Exhibit 40.

In this study a fan assisted cooling tower with a height of 300 ft was evaluated. Two cooling towers would be required to cool the circulating water flow. Each tower would be 230 ft in diameter. The cooling tower would have a noncombustible structure of reinforced concrete. The fill and drift eliminators would be made from asbestos cement sheets. The tower may be divided into four quadrants, hydraulically and aerodynamically, to facilitate maintenance and operation at winter conditions.

The flow diagram for this cooling tower type is depicted on Exhibit 41. It is similar to those for other mechanical draft towers.

The assumed location for the fan assisted towers (See Exhibit 42) is the same as for round mechanical draft towers.

For saltwater application it appears that the fan assisted cooling tower may provide higher reliability than the mechanical draft towers. This is

due to the fact that the fan assisted tower's fans would operate in the ambient air environment, whereas the fans in the mechanical draft towers would be exposed to the cooling tower's salt effluent.

Construction time was estimated to be 31 months.

The major technical data for the fan assisted cooling tower system is summarized as follows:

Fan Assisted Cooling Tower System

|   |                    |
|---|--------------------|
| No. of Towers:  | 2                  |
| Approximate Size:   |                    |
| Base Diameter, ft   | 230                |
| Exit Diameter, ft   | 150                |
| Height, ft  | 300                |
| No. of Fans per Tower   | 20                 |
| Fan Diameter, ft  | 24                 |
| Fan Horsepower  | 68                 |
| Static Head, ft   | 37                 |
| Design Conditions:  |                    |
| Heat Load, Btu/hr   | $4.44 \times 10^9$ |
| Approach to $T_{wb} = 74^\circ \text{F}$ , $^\circ \text{F}$                    | 14                 |
| Cooling Range, $^\circ \text{F}$  | 20.0               |
| Circulating Water Flow, gpm   | 458,400            |
| CW Temperature Leaving Cooling Tower<br>(Entering Condenser), $^\circ \text{F}$ | 88                 |

ii. Experience

In the U.S. the fan assisted forced draft round cooling tower design is offered by Research Cottrell, Inc. In Europe this cooling tower type was developed and built by Hamon, Balcke and GEA. There are presently in operation or under construction nine (9) towers of this type in Europe (England and West Germany). A list of available information is shown in Exhibit 43.

e. Wet/Dry Saltwater Mechanical Draft Cooling Tower System

i. Description

Evaporative (wet) cooling towers of both natural and mechanical draft designs produce a visible plume due to the water saturated discharge (100 percent relative humidity) which condenses when mixed with the cooler ambient air. The makeup requirement for the evaporative towers is 2-5 percent of circulating water flow.

To reduce the visibility of the plume and to reduce the makeup requirement, a wet/dry cooling tower design has been developed in two modifications:

- a) Plume abatement cooling tower which reduces the visibility of the plume by providing an undersaturated effluent. This cooling tower type has a relatively small dry section and a large evaporative section and therefore the difference in makeup requirement is not significant when compared with the evaporative (wet) cooling tower. For Cyster Creek NGS this cooling tower type was considered for salt water application.
- b) Water conservation cooling tower. This tower has a larger dry section and a smaller wet section than the plume abatement tower. It will provide an invisible plume and its total annual makeup requirement would be only 20-25 percent of that for an evaporative cooling tower. This cooling tower type is described in Section IV-B-3-f and was considered for freshwater application.

There are several wet/dry plume abatement cooling tower designs. They may be classified according to their air flow. The series air flow arrangement employs dry surface circulating water coolers either preceding or following the evaporative (wet) section. In the parallel path wet-dry tower, the ambient air travels in parallel streams through a dry surface exchanger and an evaporative section as illustrated in Exhibit 44. Water to be cooled is passed through the dry air-cooled section and then through the wet section of the tower. Both sections benefit thermally by receiving the cooler, ambient air with the wet and dry air streams mixing after exiting their respective sections.

The formation of a plume is basically a function of the cooling tower effluent and the ambient air. If this air mixture above the fan plenum does not reach saturation, the result will be little or no visible plume. The amount of visible plume reduction desired dictates the design ratio of the wet and dry surface. The wet section thermal performance is improved for summer operation by dampers located between the dry section and fan. Plume control capability is achieved by modulation of dampers in the dry and wet sections of the cooling tower.

Presently in the United States, two wet/dry mechanical draft cooling tower designs are offered by manufacturers and both are based on the parallel path principle. One of the designs is a round tower similar to a round wet mechanical draft tower, but with a dry section above the wet one. This cooling tower design was developed by the Marley Company, but has not been built or ordered. The other design is a multicell rectangular tower composed of adjacent cells with an individual induced draft fan for each cell. This cooling tower design was evaluated in order to determine whether a plume abatement wet/dry tower design should be considered a preferred alternative.

Three twelve cell cooling towers would be required. Each tower would be 64 ft in width and 432 ft in length. The structure would be noncombustible.

The flow diagram for the plume abatement wet/dry cooling tower system is depicted on Exhibit 45. The circulating water flow rate of 462 000 gpm would be the same as with the existing once-through cooling system. At design conditions the evaporation of 7000 gpm, the blowdown of 14 000 gpm and the make-up requirement of 21 000 gpm would be almost the same as for the evaporative cooling tower systems. However, at low ambient air conditions the above rates would be significantly lower due to an increased cooling ratio in the dry section. The total annual makeup requirement with the plume abatement wet/dry cooling tower would be approximately 20 percent less than with the evaporative cooling tower systems.

Construction time for this system was estimated to be 31 months.

The assumed location for this cooling system is shown in Exhibit 46. For optimum thermal performance the cooling tower longitudinal axes would be directed along the prevailing summer wind direction.

The major technical data for the plume abatement saltwater cooling tower system is summarized as follows:

Wet/Dry Saltwater Mechanical Draft Cooling Tower System

|                          |         |
|--------------------------|---------|
| No. of Towers            | 3       |
| No. of Cells per Tower   | 12      |
| Approximate Size:        |         |
| Cell Width x Length, ft  | 64 x 36 |
| Cooling Tower Length, ft | 432     |
| Cooling Tower Height, ft | 60      |
| Fan Diameter, ft         | 30      |
| Fan Horsepower           | 200     |
| Static Head, ft          | 41      |

Design Conditions:

|   |                    |
|---|--------------------|
| Heat Load, Btu/hr   | $4.44 \times 10^9$ |
| Approach to $T_{wb} = 74^\circ \text{F}$ , $^\circ \text{F}$                    | 16                 |
| Cooling Range, $^\circ \text{F}$  | 19.8               |
| Circulating Water Flow, gpm   | 462 200            |
| CW Temperature Leaving Cooling Tower<br>(Entering Condenser), $^\circ \text{F}$ | 90                 |

ii. Experience

There are four wet/dry cooling towers in operation in the U.S. and all of them are the rectangular multicell towers. They are listed in Exhibit 47. A few more were recently ordered. Three cooling towers were built by the Marley Company and one by Ecodyne Corporation. Other manufacturers have announced their intention of building wet/dry cooling towers. All these towers are designed for freshwater application.

f. Wet/Dry Freshwater Mechanical Draft Cooling Tower System

i. Description

As indicated previously, the water conservation wet/dry tower design was considered for freshwater application at OCNCS; it has a larger dry section and a smaller evaporative section than the saltwater wet/dry tower described above. Therefore, a larger portion of the cooling is accomplished in the dry section without water losses. At winter low ambient air temperature

the cooling tower can be even operated as a completely dry tower. The total annual makeup requirement at Oyster Creek NGS to compensate for evaporation and blowdown loss would be reduced to approximately  $1.2 \times 10^9$  gal/yr as opposed to  $5 \times 10^9$  gal/yr and  $6.4 \times 10^9$  gal/yr with the wet/dry saltwater tower and the evaporative cooling tower systems, respectively. However, at high summer ambient air temperature dry cooling would provide only 30 percent of the total heat duty and the makeup requirement (based on 10 cycles of concentration in the freshwater close cycle) may reach 6500 gpm. Therefore, it would be necessary to build some storage facility for freshwater supply at peak demand periods.

Four freshwater wet/dry cooling towers, each composed of 16 cells, would be required. These towers would be made of noncombustible structure and fill materials.

The flow diagram for this cooling system is depicted on Exhibit 48. The circulating water flow would be 469 200 gpm. At design conditions the evaporation rate would be 5800 gpm and the blowdown would be 650 gpm. The makeup source would be well water.

The assumed location for the freshwater wet/dry cooling tower is shown in Exhibit 49.

Construction time for this system was estimated to be 31 months.

The major technical data for the water conservation freshwater cooling tower system is summarized as follows:

### Wet/Dry Freshwater Mechanical Draft Cooling Tower System

|   |                   |
|---|-------------------|
| No. of Towers   | 4                 |
| No. of Cells per Tower  | 16                |
| Approximate Size:   |                   |
| Cell Width x Length, ft   | 70 x 32           |
| Cooling Tower Length, ft  | 512               |
| Cooling Tower Height, ft  | 60                |
| Fan Diameter, ft  | 28                |
| Fan Horsepower  | 200               |
| Static Head, ft   | 29.2              |
| Design Conditions:  |                   |
| Heat Load, Btu/hr   | $4.4 \times 10^6$ |
| Approach to $T_{wb} = 74^\circ \text{F}$ , $^\circ \text{F}$                    | 18                |
| Cooling Range, $^\circ \text{F}$  | 19                |
| Circulating Water Flow, gpm   | 469 200           |
| CW Temperature Leaving Cooling Tower<br>(Entering Condenser), $^\circ \text{F}$ | 92                |

#### ii. Experience

As indicated previously, there are four freshwater wet/dry plume abatement cooling towers in operation in the U.S. They are listed in Exhibit 47. Since the plume abatement and water conservation towers have the same components and design features, the available experience may be related to both wet/dry cooling tower modifications.

#### g. Dry Mechanical Draft Cooling Towers

##### i. Description

Dry cooling is accomplished in a completely closed cycle and it does not involve water losses since there is no evaporation and no blowdown requirement.

There are several designs for dry cooling systems. All of them utilize ambient air as a coolant. These systems may be classified as:

- direct steam condensing systems with an external air surface condenser
- indirect cooling systems with circulating water or condensate cooled in

fin heat exchanger coils (dry cooling tower).

In the latter case a direct contact condenser (jet condenser) may provide lower turbine backpressure and better plant performance than a regular surface condenser due to elimination of a terminal temperature difference between the circulating water and the condensing steam.

However, a retrofit cooling water system, as is the case with Oyster Creek NGS, does not provide the flexibility usually associated with the selection of a condenser-cooling tower installation for a new plant. The acceptable alternatives are confined to those which can use the existing condenser and the existing circulating water conduit arrangements in the turbine building. Therefore, only an indirect system with a dry cooling tower in conjunction with the existing condenser was considered in this study.

Dry cooling towers are sized relative to the ambient dry bulb temperature whereas wet evaporative cooling towers function in response to the wet bulb temperature. Therefore, at summer conditions, the turbine backpressure is higher with a dry cooling tower system than with an evaporative system. The OCNGS turbine maximum allowable backpressure is limited to 5 in. Hga. Due to this limitation and the maximum circulating water flow limitation with the existing condenser, a dry cooling tower would have to be sized for a relatively low design approach temperature (defined as the difference between circulating water temperature entering cooling tower and the design ambient dry bulb temperature of 89° F). For these conditions a mechanical draft dry tower appears to be more suitable than a natural draft tower and therefore the former was evaluated in this study.

A typical arrangement of a mechanical induced draft multicell rectangular dry tower with an individual fan for each cell is shown in Exhibit 50. Round multifan dry towers with several induced draft fans on the deck of each tower can also be provided.

The dry cooling tower would consist of 52 cells located in 4 rows. The tower width would be approximately 340 ft and its length would be 1300 ft. Each cell would have a fan 60 ft in diameter driven by a 500 hp motor.

The flow diagram for the dry cooling tower system is depicted on Exhibit 51.

At high summer ambient air temperature the water temperature leaving the dry cooling tower would exceed 100° F and therefore it could not be used for the turbine building closed cooling water system. Consequently, it was assumed that the turbine building closed cooling water system would utilize salt water from the existing canal.

A nitrogen system for water replacement in the air coolers of the dry tower would be provided to prevent internal corrosion of the tubes during plant shutdown periods.

Construction time was estimated to be 34 months.

The proposed location of the dry cooling tower and circulating water pumps is shown in Exhibit 52.

The major technical data for the dry mechanical draft cooling tower system is summarized as follows:

Dry Mechanical Draft Rectangular Cooling Tower System

|   |                        |
|---|------------------------|
| No. of Towers   | 1                      |
| No. of Cells  | 52                     |
| Approximate Size:   |                        |
| Cell Width x Length, ft   | 80 x 96                |
| Cooling Tower Width x Length, ft                                | 340 x 1300             |
| Cooling Tower Height, ft  | 120                    |
| Fan Diameter, ft  | 60                     |
| Fan Horsepower  | 446                    |
| Static Head, ft   | 70                     |
| Design Conditions:  |                        |
| Heat Load, Btu/hr   | 4.55 x 10 <sup>9</sup> |
| Approach to T <sub>db</sub> = 89° F, °F                         | 16                     |
| Cooling Range, °F   | 17.7                   |
| Circulating Water Flow  | 502 300                |
| CW Temperature Leaving Cooling Tower<br>(Entering Condenser) °F | 105                    |

## ii. Experience

In the U.S. the mechanical draft dry cooling towers are manufactured by Hudson Products Corporation and the Marley Company. In Europe the major manufacturers of direct and indirect dry cooling systems are GEA, MAN and Hungarian companies. Generating plants with dry cooling installations are listed in Exhibit 53. All of them service relatively small units.

### h. 500 Acre Cooling Pond

#### i. Description

The flow diagram for a 500 acre cooling pond is shown in Exhibit 54. The existing intake and discharge lines would be closed and a new pipeline would be connected to transfer the cooling water to the 500 acre pond. On the new intake pipeline a new pumphouse with four pumps would be constructed to circulate the cooling water flow of 512 300 gpm. The existing cooling water pumps would be modified to supply makeup water and provide for initial filling. Blowdown would be into the existing discharge canal and the existing dilution pumps would be retained to dilute this blowdown. To maintain a maximum of 50 000 ppm total dissolved solids (TDS) at adverse conditions in the saltwater pond system the rate of blowdown would not exceed 19 500 gpm.

Average monthly water temperature leaving the pond (entering condenser) in July would be 95° F. Maximum water temperature would not exceed 102° F. At full unit load the temperature rise across the condenser would be 19.2° F. Hence the cooling water temperature leaving the condenser at adverse conditions would be 121.2° F and the turbine backpressure would be 4.5 in. Hga, i.e., below the allowable limit of 5 in. Hga.

The layout of the system is shown on Exhibit 55. The pond would be located so as to avoid interference with Oyster Creek, Waretown Creek and the surrounding roads and railroad. The required minimum depth of water of 15 ft would be achieved by excavation where the existing ground is high and constructing embankments where it is low. It was assumed that excavated material would be satisfactory for embankment construction.

By setting the water surface at elevation +40.0 and excavating all material in the pond area down to elevation +25.0 a reasonable balance of excavation and required fill would be achieved.

For the purposes of this study, a flexible liner was incorporated into the design. Due to the cost of this material, only a single layer was considered. Other methods of making the pond relatively impermeable exist and have the potential for considerable saving of cost. For example, techniques exist for constructing a cutoff wall through the sand and into the relatively impervious clay layer that appears to exist at depth under the site providing a natural bottom lining to the pond. This possibility was not investigated due to the unknown location of the clay seam at the pond site and its unknown capacity to resist flow of salt water through it.

Both intake and discharge lines would have to be completely buried where they cross under Oyster Creek. After completion of construction, the creek would be restored.

Construction time was estimated to be 30 months.

#### ii. Experience

Flexible liners manufactured from various materials for watertight storage of potable water, industrial wastes, fly ash or cooling ponds have been applied in many installations. However, to the best of our knowledge, the maximum size of a lined pond in operation is on the order of one hundred acres. The major flexible liner manufacturers are Dupont, Exxon and Staff Industries, Inc.

#### i. 1000 Acre Cooling Pond

##### i. Description

The flow diagram shown on Exhibit 56 for the 1000 acre cooling pond is identical to the flow diagram for the 500 acre pond scheme. However, due to the larger cooling surface of the pond the average monthly water temperature leaving the pond (entering condenser) in July would be 85° F, or 10° F less than the temperature in the 500 acre pond. The maximum water temperature leaving the 1000 acre pond would not exceed 92° F as opposed to 102° F in the 500 acre pond. Hence the turbine backpressures with the 1000 acre pond cooling system would be lower and the unit output higher than with the 500 acre pond.

The layout is shown on Exhibit 57. In this case, it would not be possible to avoid all the surrounding roads, railroads and creeks. As a result, it would be necessary to encroach on Oyster Creek. This would make it

necessary to construct a diversion canal to bypass flow in Oyster Creek into the South Branch of the Forked River. For the purpose of this study, it was assumed that this increased flow could be carried in the South Branch without disruption to that stream.

All other features of this system would be the same as for the 500 acre pond with the exception that the best balance of cut and fill would be achieved with the water surface at elevation +45.0 and the bottom of the cut at +30.0 ft.

Construction time is estimated to be 34 months.

ii. Experience

Experience described for the 500 acre pond above is also applicable to the 1000 acre pond.

j. Spray Cooling Module Canal

i. Description

The flow diagram for the cooling canal, shown in Exhibit 58, is essentially identical to that for cooling ponds with the spray canal in lieu of the pond.

The cooling system would consist of a canal in which the discharged condenser water is repetitively sprayed into the air by spray cooling modules. Each spray module would consist of a pump and four spray heads with underwater interconnecting pipelines. The entire unit would float in the water and be moored in place.

There is another design of a powered spray module with a single motor and pump assembly which would float on a polyurethane ring moored in place and discharge the water through a single spray head. Both designs are depicted on Exhibit 59.

During this study the four spray head cooling module design was considered because the other design is presently being changed by the manufacturer and technical data was not available.

The circular spray pattern would be 35-40 ft in diameter and its height would be 13-17 ft. Each cooling module pump would have a 75 hp motor. The actual power requirement would be approximately 65 hp.

At design conditions (ambient wet bulb temperature 74° F) the water temperature leaving the canal (entering condenser) would be 89° F. Maximum water temperature at adverse meteorological conditions would not exceed 92° F.

To maintain a maximum of 50,000 ppm total dissolved solids at adverse conditions in the saltwater spray module canal a maximum blowdown of 18,400 gpm would be discharged to the existing discharge canal.

Exhibit 60 shows the canal required for 184 spray modules. There would be four sprays per pass (across the canal). The spray canal shown would be partly formed by excavation and partly formed by embankment construction. For balanced cut and fill in the canal, the water surface would be at elevation +14.0 ft. The minimum required depth of water would be 7.0 ft, placing the bottom of the canal at elevation 7.0 ft. Again, a flexible liner would be used in the canal. On the basis of four spray modules per pass, the total required width at the bottom of the canal would be 138 ft.

The intake and discharge pipelines are shown as 12.0 ft diameter concrete pipes. Where the spray canal ends and the intake pipeline starts, a new intake structure with four circulating water pumps would be constructed to circulate the required flow of 460,000 gpm.

The pipelines would be required to pass under the road and railroad at two separate locations.

As shown on the drawing, the spray canal would have a minimum clearance from the road of 600 ft. Latest information from the manufacturer indicates that this clearance may have to be substantially increased due to drift problems.

Construction time was estimated to be 20 months.

#### ii. Experience

Both described spray cooling module designs are being manufactured in the United States. The design which employs one pump for four spray heads has been developed by Ceramic Cooling Tower Company. The individually powered module design has been developed by Richards of Rockford, Inc.

Most of the spray module systems in operation are designed for fresh water. Major spray cooling module systems operating and ordered are listed in Exhibit 61.

## C. EVALUATION METHODOLOGY & SELECTION RATIONALE

For purposes of selecting preferred systems, this study initially evaluated each of sixteen (16) alternative cooling water systems with respect to technical and cost data, licensing considerations, and environmental impacts associated with these alternatives. Methodology for making this selection needed to encompass all these aspects of the study. A description of the evaluation methodologies and selection rationale employed follows.

### 1. Cost Evaluation

The cost evaluation in this study is based on the annual system cost method. The best economic choice is the cooling system which requires minimum comparable annual cost (assuming, for the moment, that the environmental impacts of the alternatives are equal). This cost is based on the following levelized expenses:

- i. annual owning expense (annual fixed charges on initial investment cost)
- ii. operating expense (annual energy cost for circulating water system pump and fan motors and chemical cost for water treatment)
- iii. maintenance expense (cooling water system equipment and structures only)
- iv. annual cost adjustments for differential plant net output and net annual generation (to equalize unit performance with various cooling water systems)

The cost evaluation was performed utilizing Ebasco's computer program "Economic Selection of Steam Condensing System," which is described in Appendix A.

### 2. Environmental Evaluation

The licensing requirements and environmental impacts were evaluated by discipline for all of the cooling water systems considered. The evaluation methodology used within each discipline is described in sections E through G and I through M of this chapter.

In addition to evaluating each system's environmental impact, two related studies were conducted. Section H of this chapter discusses the

potential sources of cooling water available at the Oyster Creek site and Section N analyzes the potential radiological effects that would result if effluents from the Oyster Creek NGS stack merged with an elevated plume created by a cooling tower system.

### 3. Selection Rationale

Preferred cooling water systems were selected from the sixteen systems studied on the basis of cost, licensing and environmental factors.

Three general criteria were utilized to eliminate alternatives from selection as preferred alternatives. First, systems which showed evidence of one or more "overriding" environmental impacts were eliminated. Environmental impacts of an overriding nature at the Oyster Creek site were defined to include high salt deposition rates, heavy ground-level fogging and icing conditions and severe aquatic and/or terrestrial stresses. Second, systems were eliminated where adverse, though not overriding, environmental impacts and/or comparatively high costs were involved and were not compensated by sufficient environmental benefits to justify "preferred" status. Third, systems judged to involve significant commercial risk due to potential technical problems were not selected as preferable.

#### D. ECONOMIC EVALUATION

In this section cost data is listed for all evaluated alternative cooling water systems. The technical data for these systems was described in Section III-B and is summarized in Exhibit 62. Depending on a particular manufacturer's design the dimensions of the cooling towers with the selected thermal design parameters may vary from those listed in Section III-B and in Exhibit 62. These deviations would not change the results of the cost analysis.

The cost and performance data for all alternative cooling water systems considered, as well as the design parameters for cooling tower systems, were defined utilizing the Ebasco computer program "Economic Selection of Steam Condensing System." This program enabled a review and evaluation to be made of the following parameters and costs:

- 1) Turbine generator output at various ambient air conditions;
- 2) Optimum cooling tower approach ( $^{\circ}$ F) to ambient air design wet bulb temperature;
- 3) Optimum circulating water flow rate and circulating water conduit size;
- 4) Auxiliary power requirement for the cooling water system;
- 5) Plant net output at various ambient air conditions;
- 6) Total estimated investment cost, including material and installation cost (1976 prices), predicted cost escalation based on 1984 operation, indirect construction cost, engineering expenses, contingency, interest during construction, utility expenses and land cost;
- 7) Total comparable annual cooling system cost, including fixed charges on investment cost, maintenance and water treatment costs, fuel cost for energy consumed by the cooling water system, and adjustments for differential net plant capability (kW) and net annual generation (kWh/yr) (the performance of the existing once-through cooling water system was used as a base in the calculation of the aforementioned adjustments).

The computer program is described in Appendix A.

1. Economic Factors Used in the Evaluation of Alternative Cooling Water Systems

a. Escalation

Escalation was based on the following assumed rates:

Material - 6 percent per year compounded

Labor - 8 percent per year compounded

The escalation period was based on system operation starting in 1984. For each cooling system a construction schedule was developed to define an appropriate number of years of cost escalation for each item considered.

b. Sales/Use Taxes

Sales and use taxes were not treated in the calculation of total direct escalated material costs.

c. Indirect Construction Cost

Indirect construction cost allowances were assumed by adding 10 percent to the total direct escalated installation cost.

d. Contingencies

Percentages added to the total direct and indirect escalated costs for contingencies were 14 percent for evaporative cooling tower systems, 17 percent for the dry tower system, 18 percent for cooling pond and spray canal systems, and 20 percent for the ocean intake and discharge system.

e. Interest During Construction

Interest during construction was calculated based on a 9.3 percent per annum rate as provided by JCP&L.

f. Utility's Expenses

Five percent of total direct costs were added to cover JCP&L administrative, engineering and supervisory costs and taxes during construction, up to a maximum of \$3,000,000.

g. Levelized Maintenance Cost

Maintenance cost was assumed to be 1.0 percent of total investment cost. For mechanical draft towers this was increased to 1.2 percent of investment cost, plus \$2,000 per year per cooling tower fan.

h. Fixed Charge Rate

The fixed charge rate (annual levelized carrying charges as a percent of capital cost to include return, depreciation, Federal income tax, insurance, property taxes and other items) was assumed to be 22.25 percent based on data provided by JCP&L.

i. Rate of Return

The rate of return (discounting factor to discount future worth to present worth) after taxes was assumed to be 11.22 percent based on data provided by JCP&L. This value was used to calculate levelized values for fuel cost, makeup water treatment cost and maintenance cost.

j. Incremental Net Capability Charge

The capability charge accounts for the differential net capability of each of the alternative cooling systems. The present OCNGS maximum dependable net capacity of 620 MW served as a base.

According to the common practice of General Public Utilities (GPU), and as advised by JCP&L, two capability charges were defined and added to the annual cost components for each cooling water system case:

- - The Levelized Installed Capacity Charge (ICC) for the years 1984-2004 was calculated to be \$172.2/MW-day. The calculation is shown in Exhibit 63. In 1975-76 the installed capacity charge was \$50/MW-day. For the 1984-85 period the escalated charge is predicted to be \$111/MW-day. For further projections an escalation rate of 7 percent per annum was applied up to the year 2004, when the plant is supposed to be decommissioned.

- - The Levelized Operating Capacity charge (OCC) was calculated to be \$65.3/MW-period. There are 988 periods per year; 3 periods per week-day and 2 periods per weekend day. Assuming that the unit overhaul and refueling period of 42 days would occur during spring or fall and that there would be a total of 45.6 outage days, the predicted number of periods was defined as:

|               |             |
|---------------|-------------|
| Summer        | 304 periods |
| Spring & Fall | 258 periods |
| Winter        | 191 periods |

The calculation of operating capacity charge is based on JCP&L information that in 1976 this charge was \$23/MW-period. A seven (7) percent escalation was assumed for future projections. The calculation is shown in Exhibit 63.

#### k. Nuclear Fuel Cost

The nuclear fuel cost for Oyster Creek NGS in 1985 will be  $\text{\$}39.43/10^6$  Btu. For future projections an escalation rate of 9 percent per annum compounded was assumed. Applying the above data and an 11.22 percent rate of return the levelized nuclear fuel cost was defined as  $\text{\$}65/10^6$  Btu.

#### l. Replacement Energy Cost

As advised by JCP&L the replacement energy cost in 1976 was 19.1 mills/kWh. The predicted cost for 1980 is 24.8 mills/kWh. The escalation rate for future projections (1981-2004) is 7 percent per annum. Based on this information a levelized replacement energy cost was defined as 53.8 mills/kWh. If the average system net heat rate is 10,400 Btu/kWh, the above replacement energy cost is equivalent to a levelized fuel cost of  $\text{\$}5.17/10^6$  Btu.

The replacement energy cost was utilized for annual system cost adjustments based on the differential annual plant net generation ( kWh/yr) with each of the alternative cooling water systems as compared to the annual generation with the existing cooling system.

m. Makeup Water Treatment

The levelized chlorine cost was assumed to be \$400/t. The predicted chlorine consumption for various systems is listed in Section III-B. Based on those data the makeup water treatment cost was defined as \$25/10<sup>6</sup> gal for cooling tower systems, \$400/day for the cooling pond system and \$1,500/day for the ocean intake and discharge systems.

n. Land Cost

JCP&L provided the following data pertaining to land costs:

| <u>Area</u>                         | <u>Cost per Acre</u> |
|-------------------------------------|----------------------|
| Adjacent to Garden State<br>Parkway | \$ 3,300             |
| Farm east of Route 9                | 4,500                |
| Cooling Tower Sites                 | 0                    |

2. Pricing Information

a. Pricing Data Stored on Computer

Pricing data filed on the computer tape were adjusted to today's prices by means of cost increase rates based on information contained in recent manufacturer's quotations. The sources of the unadjusted price data were:

- i) Vertical Circulating Water Pumps - Byron Jackson pricing dated July 17, 1968; and
- ii) Circulating Water Pump Motors - Westinghouse Price List 6120 dated March 1, 1975.

Cost increase rates used in the computation were:

- Circulating water pumps: 90 percent increase of price; and
- Circulating water pump motors: 18 percent increase of price.

b. Pricing Data Input Directly to Computer

Present pricing data were developed by Ebasco's estimating department or quoted by the vendor for major site development, circulating water intake structures, conduits, cooling ponds, canals, cooling towers, spray cooling

modules, electrical equipment, instrumentation, wiring, local clearing and grading and have been inputed directly to the computer. Pricing data input directly to the computer are listed below in subsections i through xviii as a series of tables:

i. Major Site Development Cost

| Cooling System                                    | Material<br>(\$1,000) | Installa-<br>tion<br>(\$1,000) |
|---|-----------------------|--------------------------------|
| Mechanical Draft Rectangular Cooling Tower (CT)   | 4,150                 | 1,600                          |
| Mechanical Draft Round CT                         | 4,080                 | 1,600                          |
| Natural Draft CT                                  | 4,820                 | 1,635                          |
| Fan-Assisted CT                                   | 4,080                 | 1,600                          |
| Wet/Dry Salt Water CT                             | 4,260                 | 1,973                          |
| Wet/Dry Fresh Water CT                            | 4,260                 | 1,973                          |
| Dry CT  | 4,200                 | 1,850                          |
| 500 Acre Cooling Pond                             | 17,667*               | 24,984*                        |
| 1,000 Acre Cooling Pond                           | 28,518*               | 43,282*                        |
| Spray Module Canal                                | 6,201*                | 9,316*                         |
| Discharge Canal to Bay                            | 6,037*                | 8,044*                         |
| Discharge Pipelines to Bay                        | 12,059*               | 9,962*                         |
| Helper Cooling Towers - 26 cells                  | 3,250                 | 1,355                          |
| Helper Cooling Towers (low discharge temperature) | 3,650                 | 1,510                          |
| Ocean Intake & Discharge )                        | See                   |                                |
| Ocean Intake & Discharge with a Multipressure )   | Section               |                                |
| Condenser )                                       | III-D-2-c             |                                |

\* Includes total present cost of all civil works, and circulating water conduits.

Major site development cost includes capital cost for general clearing and grading, maintenance roads, lighting, cathodic protection, condenser tube cleaning system, condenser water box reinforcement, valving facilities on circulating water conduits auxiliary transformer, and booster circulating water pumps (if necessary). These costs are shown in the following table:

ii. Circulating Water Pump Intake Structure

| System                   | Material    | Installation  |
|--------------------------|-------------|---------------|
| Wet Cooling Tower System | \$4.1/cu ft | \$10.75/cu ft |
| Dry Cooling Tower System | \$348,000   | \$919,000     |

iii. Reinforced Concrete Salt Water Circulating Water Conduits

|                                 |        | Material<br>(lin ft) | Installation<br>(\$/lin ft) |
|---------------------------------|--------|----------------------|-----------------------------|
| One CW Pipe in a Trench         |        |                      |                             |
| <u>Pipe Diam (in.):</u> 48      | lin ft | 68                   | 93                          |
| 60                              | lin ft | 100                  | 124                         |
| 72                              | lin ft | 124                  | 145                         |
| 84                              | lin ft | 188                  | 168                         |
| 96                              | lin ft | 212                  | 187                         |
| 120                             | lin ft | 329                  | 232                         |
| 144                             | lin ft | 473                  | 280                         |
| Two CW Pipes in a Single Trench |        |                      |                             |
| <u>Pipe Diam (in.):</u> 48      | lin ft | 68                   | 87                          |
| 60                              | lin ft | 100                  | 117                         |
| 72                              | lin ft | 124                  | 137                         |
| 84                              | lin ft | 188                  | 159                         |
| 96                              | lin ft | 212                  | 177                         |
| 120                             | lin ft | 329                  | 220                         |
| 144                             | lin ft | 473                  | 266                         |

iv. CW Pump Installation Cost

Ten percent of material cost.

v. CW Pump Motor Installation Cost

Four percent of material cost.

vi. Cooling Tower Basin Excavation, Grading & Backfilling

All types of wet and wet/dry CT - Material \$0.8/cu yd  
 - Installation \$8.2/cu yd

vii. Dry Cooling Tower Foundation

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|              |                |            |
|--------------|----------------|------------|
| For 52 cells | - Material     | \$ 104,000 |
|              | - Installation | \$ 500,000 |

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viii. Supplementary Auxiliary Transformer Cost

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|                                  |                |             |
|----------------------------------|----------------|-------------|
| Base - 20 MVA                    | - Material     | \$ 600,000  |
|                                  | - Installation | \$ 120,000  |
| Differential - $\frac{1}{2}$ MVA | - Material     | \$6,700/MVA |
|                                  | - Installation | \$1,200/MVA |

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ix. Power Wiring

---

|  |                        |       |           |
|--|------------------------|-------|-----------|
| High Voltage Cable to CW System                  | - Material             | 11    | \$/MVA/ft |
| Switchgear                                       | - Installation         | 22    | \$/MVA/ft |
| High Voltage Cable from Switchgear<br>to CW Pump |                        |       |           |
| 2,500 hp Motor                                   | - Material             | 5.5   | \$/MVA/ft |
|  | - Installation         | 16.5  | \$/MVA/ft |
| 3,000 hp Motor                                   | - Material             | 7.0   | \$/MVA/ft |
|  | - Installation         | 16.75 | \$/MVA/ft |
| 4,000 hp Motor                                   | - Material             | 6.25  | \$/MVA/ft |
|  | - Installation         | 18.25 | \$/MVA/ft |
| High Voltage Cable to Motor Power<br>Center      | - Material             | 5.5   | \$/MVA/ft |
|  | - Installation         | 16.5  | \$/MVA/ft |
| Power Center to Fan Motor                        | - Material (460 V)     | 60    | \$/MVA/ft |
|  | (6 kV)                 | 25    | \$/MVA/ft |
|  | - Installation (460 V) | 180   | \$/MVA/ft |
|  | (6 kV)                 | 100   | \$/MVA/ft |

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x. Control Wiring

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|                          |                |              |
|--------------------------|----------------|--------------|
| CW Pump to Control Board | - Material     | \$14/pump/ft |
|                          | - Installation | \$50/pump/ft |
| Cooling Tower Fan        | - Material     | \$ 5/fan/ft  |
|                          | - Installation | \$17/fan/ft  |

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xi. Instrumentation & Control

---

|                           |                |              |
|---------------------------|----------------|--------------|
| CW Pump & Motor           | - Material     | \$2,500/pump |
|                           | - Installation | \$1,200/pump |
| Cooling Tower Fan & Motor | - Material     | \$1,400/fan  |
|                           | - Installation | \$1,000/fan  |

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xii. CW System Switchgear

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|  |                |               |
|--|----------------|---------------|
|  | - Material     | \$42,000 pump |
|  | - Installation | \$18,000 pump |

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xiii. Cooling Tower Fan Motor Power Center

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|                    |                |                  |
|--------------------|----------------|------------------|
| 10 Motors @ 200 hp | - Material     | \$166,000/center |
| 10 Motors @ 500 hp | - Material     | \$426,000/center |
| 10 Motors @ 200 hp | - Installation | \$ 37,000/center |
| 10 Motors @ 500 hp | - Installation | \$ 38,000/center |

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xiv. Spray Modules

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|                                |                |                  |
|--------------------------------|----------------|------------------|
| Powered Spray Module for Salt  | - Material     | \$ 20,000/module |
| Water Application with a 75 hp | - Installation | \$ 4,400/module  |
| Motor                          |                |                  |

---

xv. Dry Cooling Tower

| Approach to Tdb =<br>89° F, ° F | Cooling Range, ° F | Total Estimated Cost,<br>\$1,000,000 |
|---------------------------------|--------------------|--------------------------------------|
| 29                              | 18                 | 34.8                                 |
|                                 | 20                 | 32.4                                 |
| 31                              | 16                 | 34.8                                 |
|                                 | 18                 | 32.4                                 |
|                                 | 20                 | 30.0                                 |

xvi. Evaporative (Wet) Cooling Towers

| Approach<br>to Tw <sub>o</sub> = 74° F<br>° F | Cooling<br>Range<br>° F | Total Estimated Cost \$1,000,000 |       |         |          |
|---|-------------------------|----------------------------------|-------|---------|----------|
|   |                         | Mechanical Draft                 |       | Natural | Fan-     |
|   |                         | Rectangular                      | Round | Draft   | Assisted |
| 10  | 16                      | 12.9                             | 10.5  | -       | -        |
|   | 20                      | 11.7                             | 9.0   | -       | -        |
|   | 25                      | 10.6                             | 7.9   | -       | -        |
| 12  | 16                      | 11.4                             | 9.6   | -       | -        |
|   | 20                      | 10.4                             | 8.2   | 14.7    | 10.2     |
|   | 25                      | 8.6                              | 7.4   | 13.0    | 8.6      |
| 14  | 16                      | 10.0                             | 8.8   | 14.7    | 11.6     |
|   | 18                      | -                                | -     | 13.9    | -        |
|   | 20                      | 8.8                              | 7.8   | 13.0    | 9.8      |
|   | 25                      | 8.2                              | 7.1   | 11.0    | 8.6      |
| 16  | 16                      | 9.0                              | 8.2   | 13.4    | 10.0     |
|   | 18                      | -                                | -     | 12.5    | -        |
|   | 20                      | 8.2                              | 7.4   | 11.5    | 8.7      |
|   | 22                      | -                                | -     | -       | 8.2      |
|   | 25                      | 7.6                              | -     | 9.8     | -        |
| 18  | 16                      | -                                | -     | 12.3    | 9.4      |
|   | 18                      | -                                | -     | 11.2    | -        |
|   | 20                      | -                                | -     | 10.2    | 8.3      |
|   | 22                      | -                                | -     | -       | 7.7      |
|   | 25                      | -                                | -     | 8.8     | -        |
| 20  | 16                      | -                                | -     | 11.3    | -        |
|   | 18                      | -                                | -     | 10.3    | -        |
|   | 20                      | -                                | -     | 9.2     | -        |
|   | 25                      | -                                | -     | 7.9     | -        |

xvii. Wet/Dry Cooling Towers

| Approach<br>to $T_{wb} = 74^{\circ} F$ | Cooling<br>Range<br>$^{\circ} F$ | Total Estimated Cost \$1,000,000 |                              |
|--|----------------------------------|----------------------------------|------------------------------|
|  |                                  | Salt Water<br>Cooling Tower      | Fresh Water<br>Cooling Tower |
| 11                                     | 16                               | 32.0                             | -                            |
|  | 20                               | 29.2                             | -                            |
|  | 25                               | 26.8                             | -                            |
| 16                                     | 16                               | 21.3                             | -                            |
|  | 20                               | 20.1                             | -                            |
|  | 25                               | 18.3                             | -                            |
| 18                                     | 16                               | -                                | 21.8                         |
|  | 20                               | -                                | 20.8                         |
|  | 24                               | -                                | 19.8                         |
| 20                                     | 16                               | -                                | 19.4                         |
|  | 20                               | -                                | 18.5                         |
|  | 24                               | -                                | 17.6                         |
| 22                                     | 16                               | -                                | 16.8                         |
|  | 20                               | -                                | 16.2                         |
|  | 24                               | -                                | 15.5                         |

xviii. Mechanical Draft Helper Towers

|  | Total<br>Estimated Cost<br>\$1,000,000 |
|--|--|
| 3 Towers (for minimum cold water temperature, $50^{\circ} F$ -<br>26 cells   | 9.1                                    |
| 5 Towers (for minimum cold water temperature, $43.8^{\circ} F$ -<br>60 cells | 13.3                                   |

c. Ocean Intake and Ocean Discharge System

A brief review of the ocean intake and discharge alternatives in conjunction with the existing single pressure condenser revealed that the total investment cost would be extremely high. For example, the 1976 cost of purchasing the required pipe (material only) was estimated to be 30 to 40 million dollars. Therefore, no attempt was made to prepare sketch designs and calculate quantities. A previous study for a discharge pipe to the bay for the proposed Forked River NGS was reviewed. The proposed construction methods were considered satisfactory, and it was decided to

use the cost estimate included in that scheme to arrive at an order of magnitude cost estimate for the ocean intake and discharge alternative at Oyster Creek NGS. Numerous methods of calculating costs using this price information were employed. For a reinforced concrete pipeline 12 feet in diameter, the 1976 estimated cost fell in the range of 150 to 200 million dollars. It was considered that an investment cost of this magnitude would be grossly uneconomic, therefore additional work required to make a more refined estimate was not undertaken for this alternative. Extrapolation of the costs for use of two - 12-foot diameter coated steel pipes indicated some savings would be achieved by the use of coated steel, provided the created increased corrosion hazard were acceptable.

A brief review of the ocean intake and discharge system with a modified multipressure condenser also revealed that the required investment costs (1976 prices) would be uneconomically high - approximately 60 million dollars for a 7 foot diameter coated steel pipeline and 90 million dollars for a 9 foot diameter reinforced concrete platform. The cost estimate was extrapolated from the cost estimate discussed above considering the use of coated steel pipe. Therefore, a detailed estimate was not carried out for this alternative.

### 3. Cost Summary

The cost assessment of alternative cooling water systems for the Oyster Creek NGS involved computerized evaluation of many cases for each alternative by varying several technical parameters of the system specified as input data in Section III-A of the report. Following are the results:

#### a. Investment Cost Comparison

The total estimated investment costs and their components for all alternative cooling water systems are listed in ascending order in the tabulation shown on the next page. Although, as discussed above, a range of cost estimates was generated for the ocean intake-discharge alternatives, only single values have been depicted in the tabulation. Together, the values shown for the multipressure and existing condenser ocean intake and discharge alternatives bracket the costs expected for ocean intake and discharge systems.

| Cooling System  | Investment Cost in Million Dollars |            |  |                            |
|---|------------------------------------|------------|--|----------------------------|
|   | Direct Cost                        |            | Indirect,<br>Contingency,<br>IDC,<br>Utilities | Total<br>Estimated<br>Cost |
|   | Material & Installation<br>1976    | Escalation | Expenses,<br>Land Cost                         |                            |
| Existing Once Through System                              | 0                                  | 0          | 0  | 0                          |
| Discharge Canal to the Bay                                | 11.3                               | 7.4        | 11.3   | 30                         |
| Helper Cooling Towers (CT) with min Cold Water Temp 50° F | 22.0                               | 9.7        | 17.3   | 49                         |
| Mechanical Draft Round CT                                 | 24.9                               | 11.2       | 19.9   | 56                         |
| Fan-Assisted CT   | 25.7                               | 11.6       | 20.7   | 58                         |
| Natural Draft CT  | 27.3                               | 12.2       | 21.5   | 61                         |
| Discharge Pipeline to the Bay                             | 22.0                               | 12.2       | 17.8   | 52                         |
| Mechanical Draft Rectangular CT                           | 27.6                               | 12.4       | 22.0   | 62                         |
| Helper Cooling Towers with min Cold Water Temp 43.8° F    | 30.8                               | 13.8       | 24.4   | 69                         |
| Spray Cooling Module Canal                                | 28.7                               | 16.7       | 23.6   | 69                         |
| Wet/Dry Salt Water CT                                     | 41.7                               | 19.1       | 35.2   | 96                         |
| Wet/Dry Fresh Water CT                                    | 44.2                               | 20.4       | 37.4   | 102                        |
| 500 Acre Cooling Pond                                     | 45.2                               | 21.7       | 38.1   | 105                        |
| Dry Cooling Tower   | 51.0                               | 23.6       | 42.4   | 117                        |
| Ocean Intake & Discharge + Multipress Condenser           | 60.0                               | 25.9       | 58.1   | 144                        |
| 1,000 Acre Cooling Pond                                   | 74.0                               | 36.0       | 63.0   | 173                        |
| Ocean Intake & Discharge with Existing Condenser          | 200.0                              | 45.0       | 189.0  | 434                        |

b. Annual System Cost Comparison

The total comparable annual costs, which include investment and operating expenses and adjustments for equalized net capability ( $\Delta kW$ ) and net annual generation ( $\Delta kWh/yr$ ), and differential comparable annual costs for all cooling systems considered are presented in ascending order on Exhibit 1. A bar chart for these costs is listed as Exhibit 3.

The existing cooling water system annual costs are used in this study as a base value. The annual fixed charges on the initial investment cost for this system were excluded from the comparative evaluation because they would be the same with any one of the alternative systems. The levelized operating cost (fuel consumption to develop the power required for the existing circulating water pumps and chlorine consumption for cooling water treatment) and maintenance cost for the existing cooling water system was assumed to be 0.5 million dollars per year.

The lowest comparable annual costs would occur with the Discharge Canal or Pipelines to the Bay, Helper Cooling Tower System with 26 cells (minimum discharge temperature of  $50^{\circ}$  F would not meet thermal discharge criteria) and with Natural Draft, Round Mechanical Draft and Fan-Assisted Cooling Towers.

SECTION III-D

REFERENCES

1. Burns and Roe, Inc., Alternate Cooling Systems Study for Forked River No. 1, Jersey Central Power and Light Company, 1971.

E. LICENSING CONSIDERATIONS

The following paragraphs summarize the permits required or regulations that apply to each of the alternative cooling water systems for the areas of land use, noise, air quality and water quality.

1. Land Use

Any cooling system installation proposed for Oyster Creek NGS must conform to siting and land use guidelines stipulated by the various permits needed for construction. Depending upon the nature of the activity and location, the following tabulation presents land use permits issued by the New Jersey Department of Environmental Protection (NJDEP) which could be required:

| <u>Permit</u>       | <u>Applicable State Regulation</u> |
|---------------------|------------------------------------|
| CAFRA*              | NJSA 13:19-1 <u>et seq.</u>        |
| Wetlands            | NJSA 13:9A-1 <u>et seq.</u>        |
| Riparian            | R.S. 12:5-3                        |
| Stream Encroachment | R.S. 58:1-26                       |

Details regarding these permit programs are briefly described in Appendix B; while their impact on construction of the alternative cooling water systems is discussed in the following paragraphs.

In addition to the above listed permits, certification from the local State Soil Conservation District is also required before construction can begin. It must be demonstrated that construction procedures will comply with the interim rules and regulations promulgated under the Soils Erosion/Sediment Control Act of 1976. It is not expected that this requirement will be a controlling factor in the licensing of any alternative cooling system.

The cooling systems that would have the highest potential for conflict with land use regulations are the cooling ponds. The 1000 acre pond would be located in an area designated as environmentally sensitive<sup>(1)</sup>, and would include white

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\* Coastal Area Facility Review Act

cedar stands as well as Oyster Creek. Thus, portions of the area are earmarked for preservation under CAFRA and therefore, development is discouraged. Protection of the underlying groundwater aquifers from contamination would have to be assured under the Pine Barrens Region Groundwater Regulations, which will be promulgated by NJDEP in the near future. In addition to a CAFRA permit, a stream encroachment permit would be required, since a large segment of Oyster Creek with its attendant drainage areas would be lost. The smaller cooling pond would have somewhat less of an impact on land use because of its reduced area and the fact that most of Oyster Creek could be avoided.

The once-through ocean intake/discharge system alternative would necessitate construction on Island Beach, an area also designated as environmentally sensitive (it is a public open space as well) and termed a preservation area. A CAFRA permit, wetlands permit and riparian permit would be required to construct pipelines and associated pump-houses for the Barnegat Bay and Island Beach crossings.

Construction of a canal or pipe to Barnegat Bay would involve removal of a small wetland area near the shore of Barnegat Bay. Consequently, CAFRA, wetlands and riparian permits would be required for this cooling system.

The cooling tower systems (including the helper towers) and spray canal system would be constructed inland and on primarily nonforested land. As a result, these systems would have only a minimum impact on land use. Under CAFRA, construction would take place on land suitable for development or in the case of the spray canal, suitable for conservation (development allowable, though restricted). A CAFRA permit and Corps of Engineers permit should be required.

In addition to the state permits, an Army Corp of Engineers permit would also be necessary to construct the open-cycle systems and the spray canal system. A Corps permit procedure can include preparation of a National Environmental Policy Act (NEPA) related Environmental Impact Statement (EIS). In addition, depending upon the degree of public interest, a public hearing could be held by the Corps of Engineers.

It is felt that prohibitive difficulties would be encountered if land use permits were requested for the cooling pond systems. The once-through ocean

system would also involve a lengthy and difficult licensing process, but possibly to a somewhat lesser degree than for cooling pond alternatives. The major problem here would be crossing Island Beach and receiving Army Corps of Engineers approval for the massive dredging operation in Barnegat Bay. Fewer problems in regard to land use considerations should arise for permitting the spray canal, canal-to-bay and cooling tower alternatives, since their use of sensitive land is minimal. It should be noted, however, that CAFRA requires a complete environmental review, and therefore, other impacts associated with each alternative in addition to those relating to land use could have bearing on permit approval.

## 2. Noise Control

Operation of each alternative cooling system is subject to New Jersey Noise Regulations. The expected noise levels were analyzed for all alternatives on a preliminary basis and the results are presented in Section J of this chapter. While a number of alternative systems appear to exceed the 50 dB(A) nighttime limitation, this preliminary analysis was not used as a basis for selecting preferred alternatives. A more detailed review of the noise effects of preferred alternatives is contained in Chapter IV.

## 3. Water Quality

Water quality considerations can be divided into the categories of surface water quality, ground water quality, and thermal criteria. Comparison of the resultant Oyster Creek, Barnegat Bay and ocean surface water quality concentrations of each alternative with applicable state and federal limits indicates that these limits would not be exceeded. The dredging operations during construction of the ocean intake/discharge system and canal-to-bay system would require a permit from the Corps of Engineers.

Groundwater pollution, principally through the leaching of saltwater to freshwater aquifers, is not expected to be an important consideration in any of the alternative systems except the cooling ponds. The NJDEP's proposed groundwater non-degradation standards for the pine barrens region (Appendix B) are intended to prevent groundwater contamination of aquifers west of the Garden

State Parkway in the site vicinity. Because of the close proximity of the pond locations to this region (approximately 1000-3000 ft), the potential of seepage from the ponds could be a determining factor in the licensing of such an alternative. The potential for saltwater intrusion resulting from the removal of makeup for freshwater cooling towers also would have to be investigated before the freshwater cooling tower alternative could be recommended.

New Jersey thermal criteria can be met for each of the closed-cycle cooling tower schemes, the spray canal system, cooling ponds and ocean intake/discharge system. A preliminary analysis of the canal (pipe)-to-bay system with respect to the surface criterion in Barnegat Bay was inconclusive (see Section III-G-3). The low temperature helper tower scheme, while designed to meet thermal criteria on an average basis, will exceed the 4<sup>0</sup>F Oyster Creek limits (at the Route 9 bridge with two dilution pumps operating) some percentage of the time during the winter months. The other helper system (with three banks of towers rather than five) will exceed thermal criteria during most of the summer and winter months.

Construction of any alternative cooling water system will require application for a new\* discharge permit under the National Pollution Discharge Elimination System (NPDES) program. The permit must be accompanied by a Section 401 Certification. EPA's review of the application will probably result in a request for a 316(a) demonstration if the cooling system is open-cycle. Where construction of an alternative cooling system involves modification of the intake structure, a 316(b) demonstration will be required as well. The NPDES/316 process is expected to be a lengthy one, regardless of which alternative system is involved. On the state level, a WP-1 wastewater permit would also be required for all options.

#### 4. Air Quality

Allowable emission rates of particulates (i.e. salt particles) from the cooling towers under consideration were determined assuming the towers would be in the manufacturing (not combustion) source category. These air quality regulations are summarized in Appendix B.

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\*"New" is intended to mean a modification of the existing NPDES permit and not the issuance of a "New Source" NPDES permit.

The limit for particulate emissions is governed by both the uncontrolled source emission rate and the exit air flow rate. For the natural draft cooling tower alternative, with an air flow rate (design conditions) of  $30 \times 10^6$  cfm, drift rate of 0.001 percent, circulating flow rate of 433,000 gpm and total dissolved solids concentration of 45,000 ppm, the allowable emission rate is 30 lb/hr of particulate in each category. The emission rate calculated for the natural draft tower is approximately 100 lb/hr, which exceeds the calculated allowable emission rate. Similar results were obtained for the other evaporative cooling tower systems (except for the freshwater wet/dry cooling tower, which is expected to meet the allowable emission standards).

In addition to the emission rate limitations, ambient air quality standards (see Appendix B) for particulate matter could be applied to the tower emissions. The preliminary indication is that only the natural draft, fan-assisted natural draft and the round mechanical draft towers will meet the ambient air standards if salt particle emissions are considered relevant to the standards.

Because an amendment to the particulate emission rate limitation may be available as a possible solution, this problem was not used as a criterion in selecting preferred alternatives for further study.

SECTION III-E

REFERENCES

1. Department of Environmental Protection, State of New Jersey, Interim Land Use and Density Guidelines for the Coastal Area of New Jersey, 1976.

## F. ATMOSPHERIC EFFECTS

### 1. Introduction

Atmospheric effects of cooling system impact were evaluated within the context of site geography and system location with respect to other facilities and topographic characteristics. The Oyster Creek site is part of the New Jersey shore area with relatively flat terrain and extensive marshes. The Oyster Creek Nuclear Generating Station is about two miles inland from Barnegat Bay and the site property extends about 3.5 miles inland from the bay. The general location for the alternative cooling tower systems is about 300-500 feet west of US Route 9, 7,000 feet east of the Garden State Parkway and 4,000 feet northeast of the proposed natural draft tower for the Forked River Nuclear Generating Station.

The primary atmospheric effects associated with cooling system operation are the following:

- a. Elevated Visible Plumes
- b. Ground Level Fogging and Icing
- c. Salt Deposition and Drift
- d. Convective Instability, Cloud Growth and Precipitation Augmentation

As indicated by Ovard, (1) the atmospheric effects of the natural draft and fan-assisted natural draft towers are very similar; consequently, in this section, the term "natural draft tower" will also refer to the fan-assisted natural draft tower, and five basic tower types will be evaluated: rectangular, round, natural draft, wet/dry and dry.

The tower systems would have a circulating water rate ranging between 426,000 gpm and 502,000 gpm with a total dissolved salts (TDS) concentration of about 45,000 ppm. Design summer and winter wet bulb temperatures at the site are 74°F and 30°F, respectively. Engineering descriptions of the alternative tower systems are given in Section B of this chapter.

Most of the effects due to "wet" towers (rectangular, round and natural draft) result from the condensation of water vapor and the entrainment of large water drops from the tower by the exhaust air. Water vapor condensation may lead to fogging, icing or elevated visible plumes, and the large drop entrainment may cause deposition of salts from the tower onto surrounding environs.

Wet/dry towers have a dry heat exchanger in addition to the conventional wet fill section. The amount of vapor leaving the tower can be controlled by changing the proportion of heat rejected in the wet and dry sections. When heat rejection occurs primarily in the wet section, this type of tower has impacts similar to those of wet towers. Dissipation of rejected heat in the dry section, however, is accomplished by conduction of sensible heat to the ambient air with any environmental effects being due to the release of this sensible heat. Such effects are mainly characterized by updrafts and turbulence in the affected area. The possibility exists that these updrafts could enhance or initiate precipitation due to the associated convective instability.

Dry towers dissipate all heat by conduction to the ambient air with the atmospheric effects being entirely due to the release of sensible heat. Most studies of cooling tower impact have concentrated on elevated plumes, ground level fogging and icing, and salt deposition. Very little research has been done regarding the release of sensible heat and the associated convective instability.

Cooling ponds and spray canals are the two other closed-cycle alternatives. The cooling ponds would be southwest of the station and would be about 600 feet from both US Route 9 and the Garden State Parkway at their closest points. The cooling spray canal would be east of the station, about 600 feet east of US Route 9 at its closest point. Steam fog in the vicinity of the pond or spray canal is an important atmospheric effect of both systems, with spray canals also producing some low level, precipitation size (drift) droplets from the spray units.

Open-cycle systems such as canal-to-bay and once-through ocean systems would have little atmospheric impact, except for some very localized steam fog along the canal under conditions of high relative humidity and low ambient

temperatures.

The third alternative open-cycle system entails the use of a helper mechanical-draft rectangular tower. Because a relatively large percentage of cooling would be affected by use of the helper tower and the system would be operated during all seasons of the year, the atmospheric impact of a helper tower system would be very similar to the impact of the closed-cycle rectangular tower alternative.

The relative atmospheric effects of the alternative cooling water systems are tabulated on Exhibit 64 and the major atmospheric effects are discussed in the following section.

## 2. Evaluation of Atmospheric Effects

### a. Elevated Visible Plumes

Elevated plumes are a result of the condensation of water vapor, and are, therefore, relatively free of impurities. They are generally at heights of 1,000-3,000 feet and are fairly permeable to the sun's rays. Shading of the ground due to the plume has been calculated to be less than 20 minutes per day from an 1,800 MW plant utilizing natural draft towers in Switzerland.<sup>(2)</sup> Elevated plumes are considered a significant effect in natural draft and round tower operation. Studies of the Forked River NGS proposed natural draft tower<sup>(3)</sup> predict that during 925 hours each year, elevated plumes will extend more than 3,000 feet from the tower. These plumes are generally less than two miles long but occasionally may extend to distances of several miles. Long plumes are much more frequent in winter than in summer. However, long plumes from natural draft or round towers at OCNGS should not be as frequent as discussed above because the station rating is 670 MW compared to a 1,100 MW rating at FRNGS and would, therefore, be releasing a significantly lower (approximately 61 percent as much) amount of heat to the atmosphere.

Based on measured wind data (400 foot elevation) at Oyster Creek site, the dominant direction of the elevated plumes would be southeast and south-southeast of the tower. During periods of northeast and southwest winds, plumes from the OCNGS and FRNGS natural draft towers could occasionally merge.

Plume merger does not increase plume frequency, but does increase the length of an observed single plume.

Elevated plumes are not considered a significant factor in rectangular tower operation as the effluent from these relatively low towers does not rise to the heights of natural draft and round tower plumes. Furthermore, these low-level plumes are dispersed relatively close to the tower due to the fan operation and tower downwash, and the plumes as such are not as readily observable due to their low heights. Wet/dry towers do not produce significant plumes when primarily operating on the dry mode and have effects similar to rectangular towers when primarily operating in the wet mode.

Elevated plumes are not a significant effect of dry towers, cooling ponds, spray canals, a canal-to-bay system or a once-through ocean system.

#### b. Ground Level Fogging and Icing

Tower-induced fogging at ground level occurs when relatively lower level plumes are brought down to the earth's surface by either dispersive processes or downwash effects due to tower wake. Such fogging is generally evaluated in terms of frequency, exclusive of periods of natural fog. Ground level icing occurs when all criteria are present for tower-induced fogging and the ambient air temperature is 32°F or less.

Studies at Oak Ridge, Tennessee <sup>(4)</sup> indicate that ground-level fogging frequencies from rectangular mechanical draft tower operation have a maximum value of 300 hours per year at distances less than 10,000 feet from the tower. This frequency is probably greater than the fogging that would be associated with the 670 MW Oyster Creek NGS's alternative rectangular tower as the station studied at Oak Ridge had a unit rating of 1,000 MW. The dominant direction of tower-induced fogging at the Oyster Creek site will probably be east and south of the tower. Since US Route 9 is approximately 600-800 feet east of the tower location, tower-induced fogging along this highway is a potentially significant factor associated with rectangular mechanical draft tower operation. Tower-induced fogging along the Garden State Parkway is expected to be much less significant, due to its greater distance from the Oyster Creek Nuclear Generating Station.

Ambient temperatures are 32<sup>o</sup>F or less at Oyster Creek site about 10 percent of the time. If this percentage remains constant during periods of tower-induced fogging, ground-level icing would have an estimated maximum frequency of occurrence of approximately 30 hours per year.

Ground level fogging and icing are generally not considered significant effects of natural draft tower operation because of their low frequencies of occurrence.<sup>(5)</sup> According to Carson,<sup>(6)</sup> ground level fogging from round mechanical towers is greater than that from natural draft towers, but less than the fogging due to rectangular tower operation. Plumes from both natural draft and round mechanical towers will attain greater heights than those from rectangular towers. Considering this additional height and the lack of elevated terrain in the site vicinity which could lead to plume impingement, no significant fogging or icing effects are expected with the natural draft and round towers. Negligible ground-level fogging would be expected from wet/dry tower operation, assuming that the degree of cooling by the dry mode would be maximized during periods of potential fogging problems, an operating mode which is technically feasible with this type of tower.<sup>(7)</sup>

Ground level steam fog over and near cooling ponds and spray canals can be an important meteorological effect of these systems. Generally, the spray canal would have a higher probability of creating dense fog than a cooling pond.<sup>(6)</sup> However, the fogging potential from a spray canal is less than that of a rectangular tower. Fogging from both types of pond systems may impact on roads closer than one-half mile, indicating that fogging impact on Route 9 and the Garden State Parkway is a probability with use of a cooling pond or spray canal.

#### c. Salt Deposition and Drift

The maximum annual tower-induced monthly salt deposition rate for the Forked River Nuclear Generating Station has been estimated to be 89 kg/km<sup>2</sup>/month<sup>(8)</sup>. Deposition from a similar natural draft tower at OCNCS would probably be less than the values for FRNGS; the circulating water rate used in the Forked River study was 570,000 gpm as compared to

about 433,000 gpm at Oyster Creek Nuclear Generating Station. The estimated drift rate is 0.001 percent with an assumed TDS concentration (within the tower) of 45,000 ppm for both stations. The dominant direction of salt deposition is expected to be east-southeast of the tower, with deposition decreasing with distance from the tower. There will be a combined (additive) deposition of salt in the area if both the Forked River NGS and Oyster Creek NGS towers are operating.

The main characteristic of salt deposition resulting from a natural draft tower system operation is that the salts are distributed over a large area and, therefore, have relatively low concentrations in any specific locale.

Salt deposition from rectangular towers occurs over a smaller area than from natural draft towers, but deposition rates are greater in the area of impact. The mechanical draft towers have larger drift droplets than natural draft towers and, due to greater terminal velocities, these larger droplets fall closer to the tower. Based on a comparison of average plume heights and drift rates, the local deposition from rectangular towers is on the order of seven times that of natural draft towers. Therefore, deposition from the rectangular towers will be greater than seven times the natural draft deposition rates close to the towers and much less than the natural draft tower rates at greater distances from the towers.

The salt deposition associated with round tower operation is (like natural draft towers) distributed over a large area, but there is greater deposition close to the tower due to a larger drift droplets size with the round towers. Saltwater wet/dry tower operation would have salt deposition rates similar to rectangular towers when on the wet mode and negligible deposition when on the dry mode (primarily during the winter months). Freshwater wet/dry tower operation is not expected to produce significant salt deposition.

Salt deposition and drift (of precipitation size droplets) are not produced by cooling ponds. Spray canals, however, do produce drift droplets which can have drift rates greater than cooling towers, due to the absence of drift eliminators.<sup>(6)</sup> A study of a 400-module spray module system by Hoffman<sup>(9)</sup>

indicated that, for a fresh water system, significant drift is unlikely to occur at distances greater than 600 feet from the canal and that drift rates should not exceed 0.01 percent of the sprayed water. Experience with salt water spray systems is limited. Available data, however, indicate that salt deposition may be significant at distances in excess of 2,000 feet.<sup>(10)</sup> It is, therefore, expected that drift from the spray canal at its conceived location could have a measurable impact on US Route 9 and nearby residences. However, the determination of accurate estimates for specific deposition rates from spray canal systems is questionable.

d. Convective Instability, Cloud Growth and Precipitation Augmentation

The release of heat from any localized heat source such as a cooling tower produces increased convective instability and has the potential of producing (or enhancing) cloud growth and possibly augmenting precipitation.<sup>(11)</sup> The release of this heat is in the form of sensible heat in the operation of dry cooling towers or wet/dry towers when in the dry mode. Wet towers, cooling ponds and spray canals release most of their heat to the atmosphere through latent heat of evaporation. Although it is not known whether dry or wet towers are more likely to enhance cloud formation with a given rate of heat discharge<sup>(12)</sup>, Carson indicated that the effects of sensible heat are more important than moisture in increasing atmospheric buoyancy and resultant instability.<sup>(13)</sup> Furthermore, a plant of a given size would discharge more heat with dry than with wet towers, due to reduced plant efficiency and the resultant increase in heat rejected.

Enhancement of cloud growth and precipitation augmentation is not considered to be a potential effect of cooling ponds or spray canals.<sup>(14)</sup> Due to the great volume of water involved in the systems and the relatively large area (compared to cooling towers) over which the heat is released, the rate at which it is released to the atmosphere is much slower than for tower systems. This suggests that convective instability, enhancement of cloud growth and precipitation augmentation from these systems is less significant than from cooling towers.

### 3. Summary

Exhibit 64 presents a summary of the atmosphere-related impacts associated with the alternative cooling water systems, and indicates that both full-load and helper rectangular tower operation at the Oyster Creek site would have significant effects (compared to other tower types) regarding ground-level fogging and salt deposition. Tower-induced fogging along US Route 9 is a potentially significant impact associated with operation of rectangular mechanical draft type towers. In addition, the local deposition of salts is also a major consideration with these types of towers, assuming the utilization of salt water for makeup.

The major atmosphere-related effect of natural draft or round towers would be the generation of visible elevated plumes. Possible impacts of such plumes are related to esthetics, ground shading and reduction in visibility to aircraft flying at plume level. Although few studies have been made on the effects of atmospheric heat discharges, the most significant effect of dry towers (and, to a lesser extent, wet/dry towers), is probably convective instability, possibly leading to enhancement of cloud growth and precipitation augmentation.

The major atmosphere-related effect of a cooling pond is ground level fogging. However, the effect would be less than that from mechanical draft towers. The fogging and salt deposition from a spray canal system would impact highways and quite possibly residences in the plant vicinity. The canal (pipe)-to-bay and once-through ocean systems would not be expected to have significant atmospheric effects.

### SECTION III-F

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## G. HYDROTHERMAL EFFECTS

### 1. Introduction

The alternative cooling water systems considered for the Oyster Creek Station were assessed from a hydrothermal standpoint on the basis of whether the systems were open-cycle or closed-cycle systems.

The closed-cycle systems (e.g. cooling towers, cooling ponds) dissipate heat rapidly to the atmosphere to accomplish cooling, and then recirculate the cooling water flow back to the condenser. This type of system requires the withdrawal of water for makeup and the discharge of water as blowdown. These makeup and blowdown water flow rates would be significantly smaller (less than 6 percent as much) than the overall condenser cooling water flow rates of the present once-through system. The hydrothermal effects associated with the closed-cycle system would be predicated on the characteristics of the blowdown discharge, the mode of discharge and the receiving water body.

For all the alternatives, it was assumed that a constant makeup flow rate would be maintained and the blowdown flow rate would be controlled to limit the solids concentration in the system to a maximum of 1.5 times the TDS of the makeup water. The blowdown flow rate at any time is then the difference between that makeup flow rate and the evaporation rate at that time (assuming negligible drift loss). The blowdown temperature was assumed to be the same as the cooling system coldside water temperature. Thus, the heat load of the discharge, which depends on both the flow rate and temperature of the blowdown, is a function of the performance of the cooling system, the meteorological conditions during operation and the physical characteristics of the makeup water. Exhibit 65 presents a tabulation of the estimated blowdown flows, temperature differentials between the blowdown flow and the receiving water temperature, and the heat load that would be discharged from the Oyster Creek Nuclear Generating Station for the various alternative closed-cycle systems. It was estimated that the heat load discharged from the closed-cycle systems would range between three and fifteen percent of the existing open-cycle system heat load discharge.

In addition to the makeup water and blowdown flow rates from the Oyster Creek Nuclear Generating Station, the studies also considered the combination of Forked River NGS blowdown discharge with the Oyster Creek NGS discharge. The blowdown from both the Forked River NGS and Oyster Creek NGS was assumed to be discharged to Oyster Creek, approximately 10,000 feet upstream of the creek mouth at Barnegat Bay.

The following tabulation presents the FRNGS cooling system seasonal operating characteristics that were utilized in the hydrothermal analyses conducted for this study:

FORKED RIVER NUCLEAR GENERATING STATION - COOLING SYSTEM CHARACTERISTICS (1)(2)

|                      | Summer             | Winter             | Spring             |
|----------------------|--------------------|--------------------|--------------------|
| Evaporation (gpm)    | 12,750             | 10,550             | 11,620             |
| Makeup (gpm)         | 36,000             | 36,000             | 36,000             |
| Blowdown (gpm)       | 23,250             | 25,450             | 24,380             |
| Heat Load (Btu/hour) | $1.30 \times 10^8$ | $4.24 \times 10^8$ | $2.50 \times 10^8$ |

The alternative closed-cycle systems can all incorporate the existing service water discharge as a part of the makeup flow, thereby reducing the required makeup water withdrawal rates and eliminating the service water discharge. In addition, it was assumed that dilution flows of either 260,000 gpm or 520,000 gpm, representing either one or two of the existing dilution pumps operating, are available for each alternative.

The once-through alternatives would discharge ultimately to either Barnegat Bay or the Atlantic Ocean. They are characterized by large cooling water withdrawal and discharge flow rates similar to the present mode of operation (460,000 gpm). Those systems must meet applicable thermal limitations at all times, at least when credit is allowed for the utilization of the existing dilution system. Similarly, the systems utilizing supplemental cooling (i.e. helper towers) and dilution must meet applicable thermal criteria in Oyster

Creek. The expected discharge of blowdown from the Forked River Nuclear Generating Station natural draft tower has been considered in the evaluation of all the open-cycle alternatives.

## 2. Average Ambient Water Temperature Data

The State of New Jersey Surface Water Quality Standards (see Appendix B) for TW-1 waters (Oyster Creek and Barnegat Bay) and CW-2 waters (Atlantic Ocean waters more than 1,500 feet offshore and 15 or more feet deep, both with respect to mean low tide) define ambient temperature as "the temperature of a water body unaffected by the localized heated waste discharge or discharge complex."

The only source of water temperature data suitable for computing temporal averages concerning this area of Barnegat Bay were the records of the Oyster Creek NGS intake water temperatures where maximum, minimum and average intake water temperatures are recorded daily. Monthly averages of the daily maximum, minimum and average intake water temperatures have been calculated for the period July, 1975 through August, 1976. These temperatures are presented in Exhibit 66. The seasonal\* average estimates for ambient temperatures are given in the following table:

### ESTIMATED AVERAGE AMBIENT WATER TEMPERATURE

| <u>Season</u> | <u>Temperature</u> |
|---------------|--------------------|
| Summer        | 78.8°F             |
| Winter        | 37.5°F             |
| Spring        | 58.0°F             |
| Fall          | 61.0°F             |

To insure that the intake water temperatures are appropriate for use as ambient, a literature review to ascertain the potential for recirculation of the discharge water back to the intake was conducted. Based upon this review, it was determined that, under conditions of strong southeasterly winds in conjunction with a flooding tide, recirculation of the thermal plume back into the intake can occur (3,4). However, it has been calculated that the threshold wind

\* Seasonal temperature estimates used here differ from those in Section III-A because a given season, as defined in the two sections, does not correspond to the same dates.

speed for this effect is greater than 10 miles per hour and that such wind conditions will not occur more than 4 percent of the time. <sup>(3)</sup> Therefore, 96 percent of the time it could be expected that the intake water temperatures recorded at the station would meet the regulatory definition for ambient temperature.

### 3. System Hydrothermal Effects

#### a. Closed-Cycle Alternatives

The closed-cycle evaporative cooling tower alternatives include cooling towers, cooling ponds, and spray canal systems. These alternatives require makeup water to replenish water lost through evaporation, and to replace blowdown which is required to maintain water quality parameters within acceptable levels. The blowdown for these alternatives would be discharged to Oyster Creek at approximately the same location where the existing condenser cooling water is discharged. This blowdown would be mixed with blowdown from the Forked River Station and flow from the existing dilution pumps.

The blowdown temperatures predicted for the cooling towers were derived from the tower thermal performance data (see Section B of this chapter) based on preliminary manufacturers' data. The predicted blowdown temperatures for the cooling ponds were calculated in accord with accepted methods. <sup>(5)</sup> The discharge temperatures for the spray cooling systems were derived from manufacturer's thermal performance curves, and verified by analytical analyses. <sup>(6)</sup> The makeup, blowdown, and evaporative flow rates for the Oyster Creek NGS, and the discharge heat rate for the combined Oyster Creek NGS and Forked River NGS are summarized in Exhibit 65.

The discharge flow rates and temperature rise above ambient for the Oyster Creek NGS closed-cycle cooling tower alternatives are tabulated in Exhibit 67\*. This tabulation was predicated on estimated Oyster Creek NGS blowdown plus Forked River NGS blowdown, operation of two dilution pumps, average summer, winter and spring conditions, and assuming a completely mixed discharge. Similar data are presented for the cooling pond alternatives in

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\*The fan-assisted natural draft tower is not included in Exhibit 67. However, its discharge is very similar to that of the mechanical draft towers.

Exhibit 68 and for the spray cooling alternatives in Exhibit 69.

A comparison of the resulting temperatures to the applicable thermal standards clearly shows that, in every case, the closed-cycle alternatives would meet the thermal criteria in Oyster Creek with two dilution pumps operating. In those cases in which the criteria would not be met with a single dilution pump running, it appears that the excess would be due to the contribution of the Forked River NGS blowdown which would constitute the majority of the heat load. For those cases involving the use of one dilution pump, thermal criteria are estimated to be exceeded during the winter months by about 0.5°F (i.e. 4.5°F temperatures rise versus 4.0°F criterion) for the saltwater wet/dry towers, the rectangular and round mechanical draft towers, the natural and fan-assisted natural draft towers and the 500 acre cooling pond alternative. Thermal criteria would not be exceeded for the freshwater towers, the 1,000 acre cooling pond alternative and the spray canal alternative, even assuming only one dilution pump operating.

In summary, all of the closed-cycle alternatives would satisfy thermal criteria, assuming the utilization of two dilution pumps. Certain of the systems would exceed thermal criteria during the winter months when only one dilution pump was operating. However, this excess is primarily due to the large heat load contributed by the blowdown from the Forked River NGS. In addition, due to the relative bathymetric, dispersive, convective and dilution-related characteristics of Barnegat Bay as compared to Oyster Creek, all of the alternatives which satisfy thermal criteria in Oyster Creek can be expected to satisfy thermal criteria in Barnegat Bay.

b. Open-Cycle Bay Discharge Systems

In accord with the New Jersey Surface Water Quality Standards for Class TW-1 waters, any discharge to Barnegat Bay must not raise the bay temperature to more than 85°F, and not more than 1.5°F above ambient during June through August, outside a designated heat dissipation area. The heat dissipation area cannot exceed one-fourth of the cross-sectional area and/or flow volume or two-thirds of the surface, at any tidal stage.

As described in Section III-G-2 the intake temperatures measured at the Oyster Creek Station have been used as the average ambient bay temperature. Exhibit 70 presents a plot of the cumulative frequency distribution of summer intake temperatures. Based on maximum daily temperatures, the 85<sup>o</sup>F limit was exceeded naturally on an average of 21 percent of the summer days. Obviously, during such events, the addition of any discharge from the plant would result in exceeding the maximum temperature criterion.

The influence of the existing discharge system on bay temperatures was investigated in order to provide a basis for assessment of the canal (pipe)-to-bay alternative, but the results regarding temperature rise criteria were inconclusive. Available data were limited to a single directly measured temperature profile obtained August 6, 1974<sup>(3)</sup> and a single temperature profile obtained by remote (airborne) sensing without ground confirmation on July 13, 1973<sup>(4)</sup>. The former profile is shown in Exhibit 71, presenting surface temperatures obtained on a line between the mouth of Oyster Creek and Island Beach Park during ebb tide.

While Ebasco believes direct measurement of water temperature to be more reliable than remote sensing, even the interpretation of direct measurements is complicated by the fact that ambient temperatures show large spatial variations throughout Barnegat Bay and are a function of numerous influences such as water depth and the locations of inflowing ocean water. In Exhibit 71, the relevant surface ambient temperature is believed to be 79<sup>o</sup>F; at a point less than two-thirds across the bay surface, the temperature excess of the thermal plume became negligible.

However, this available data base was inadequate to support any general statement about the ability of the open cycle bay discharge alternatives to meet applicable thermal criteria in the bay, though the existing thermal discharges to Oyster Creek would, of course, be eliminated. It was recognized that these options could not be eliminated as preferred alternatives on the basis of hydrothermal effects, but more temperature data would have to be obtained (see Chapter IV) prior to any recommendation to construct a bay discharge system.

Bay discharge alternatives require discharge over a weir into the bay. This mode of discharge results in low discharge velocities to the bay and was not considered conducive to accomplishing rapid mixing and dilution of the discharge water. The temperature rise distribution in the bay could theoretically be improved by optimizing the weir design (e.g. increasing the discharge velocity) to provide for more rapid dilution. However, the shallow depth of the bay could limit entrainment of cooler water into the plume. An alternative mode of discharge which would utilize a subsurface discharge was also considered. Such a system would utilize a multiport diffuser designed to provide the necessary dilution to meet the 1.5°F temperature rise limitation. This system would require a large number of relatively small ports, and would, therefore, be subject to fouling, damage from boating, and possible impairment of hydraulic efficiency. As a result of these potential operational problems, a multiport subaqueous diffuser in Barnegat Bay was not considered as a viable alternative mode for discharge.

c. Open-Cycle Ocean Discharge Systems

The New Jersey Surface Water Quality Standards regulating offshore discharges prohibit the direct discharge of heated effluent within either 1,500 feet of the shoreline, or in water a depth of less than 15 feet (Class CW-1 waters). In addition, no discharge to waters classified as other than Class CW-1 may increase the temperature in CW-1 waters by more than 1.5°F during June through August or 4° during the remainder of the year. The remaining ocean waters (Class CW-2) are subject to the same temperature rise criteria outside a designated heat dissipation area whose dimensions are determined on a case-by-case basis.

The ocean discharge structures would be designed as subsurface, multiport diffuser which would achieve rapid dilution of the effluent and ensure compliance with the applicable thermal criteria. Preliminary analyses were conducted utilizing appropriate computer models<sup>(7)</sup> to establish a conceptual diffuser design that would result in the 1.5°F temperature-rise isotherm not exceeding a height 5/6 of the total depth above the point of effluent discharge. This point is considered the maximum free buoyant jet height before surface

impingement effects begin. (8)

A conceptual diffuser design for a single pressure condenser alternative which was consistent with the existing condenser rise and flow rate was prepared. This diffuser design was predicated on a total design flow rate of 496,000 gpm, which includes 460,000 gpm of circulating water, 12,000 gpm of service water, and 24,000 gpm of blowdown from the Forked River Station cooling tower. The design temperature rise of the combined flow was calculated to be 20°F.

Consistent with the flow and temperature conditions indicated above and in recognition of the applicable thermal criteria, a preliminary conceptual "design" for the diffuser was prepared. A diffuser lying, at its closest point, 2,050 feet offshore in a depth approximately 28.5 feet below mean low water and containing 36 ports 10 feet on center (diffuser length 350 feet), was found to satisfy the thermal criteria. The entire pipeline including the diffuser section would be 12.5 feet in diameter. The actual diffuser ports would be 1.75 feet in diameter and would face alternately north and south along the diffuser length. The exit velocity at each port would be approximately 12.7 fps and the densimetric Froude number would be about 30. Exhibit 72 presents a location plan for the discharge pipeline while Exhibit 73 presents a schematic of the conceptual diffuser design.

In addition to the single pressure condenser alternative, it was necessary to consider the diffuser required for a multipressure condenser alternative. This alternative would entail a reduced flow rate and increased condenser rise resulting in a design flow rate of 177,400 gpm, which includes 167,000 gpm circulating water and 10,000 gpm of service water and a discharge temperature rise of 48°F above ambient. It should be noted that for this alternative, the Forked River NGS cooling tower blowdown was assumed discharged to Oyster Creek. In this regard, the existing dilution system would be required to ensure that the Forked River NGS discharge would meet thermal criteria in Oyster Creek.

As for the case of the previously discussed diffuser, an analysis was conducted to establish a preliminary conceptual design which would satisfy the

applicable thermal criteria. In this regard, the design was planned to achieve essentially the same thermal profiles from both diffusers. The results of this analysis yielded a discharge system which would have the first port of the diffuser approximately 5,500 feet offshore of Island Beach in a water depth approximately 35 feet below mean low water level. The 5,500 feet long pipeline would be 12 feet in diameter. The diffuser would contain a total of 67 ports, 10 feet on center, placed on a 660-foot section of 7 feet diameter manifold pipe. The port diameters would all be 0.67 feet and the ports would face alternately north and south. The velocity through each port would be approximately 17 feet per second. The location of this discharge system is presented on Exhibit 74 while details of the diffuser are presented on Exhibit 75.

d. Open-Cycle Helper Cooling Systems

In the supplemental, or helper cooling systems, the condenser discharge would be pumped to rectangular mechanical draft cooling towers prior to discharge to the receiving water body. After being passed through the towers and cooled by the release of a portion of the heat load to the atmosphere, the cooling water would be discharged to Oyster Creek at a location near the present discharge point. These systems would be subject to the same thermal requirements as the closed-cycle systems in Oyster Creek and Barnegat Bay.

The tower performance was predicted for average seasonal meteorological conditions and average intake water temperatures. The results for the helper system utilizing five banks of towers (60 cells) are tabulated on Exhibit 76. Based upon these results, the discharge would meet thermal criteria for average seasonal conditions in Oyster Creek. However, the winter reliability of this system is questionable due to icing problems and, therefore, compliance with the 4°F temperature rise limit in Oyster Creek may not be possible during certain winter operations.

A smaller helper system ("high temperature discharge"), consisting of three banks of rectangular mechanical draft towers (26 cells) was considered in order to provide an acceptable level of operational reliability. However, the thermal distribution resulting from this system would exceed the Oyster Creek temperature criteria, as shown in Exhibit 77 and, as such, it would not appear to be a viable alternative.

### SECTION III-G

#### REFERENCES

1. Jersey Central Power and Light Company, Environmental Report, Construction Permit Stage, Forked River Nuclear Station, Unit 1, January, 1972.
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3. Woodward-Clyde Consultants, "The Physical Behavior of the Thermal Plume Discharged from the Oyster Creek Nuclear Generating Station", June 9, 1975.
4. U S Atomic Energy Commission, Final Environmental Statement related to Operation of Oyster Creek Nuclear Generating Station, December, 1974.
5. Patterson, W D, Leporati, J L, and Scarpa, M P, "The Capacity of Cooling Ponds to Dissipate Heat", presented at 33rd Annual Meeting of the American Power Conference, April, 1971.
6. Frediani, H A, Jr, and Smith, N, "Mathematical Model for Spray Cooling Systems," Journal of Engineering for Power, ASME (to be published).
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## H. POTENTIAL COOLING WATER SUPPLY SOURCES

### 1. Introduction

Closed-cycle condenser cooling system makeup flow requirements are dependent upon system evaporation. Evaporation varies with climatic conditions and the cycles of concentration (makeup flow divided by blowdown flow, or the number of times a water quality parameter is concentrated) utilized during operation. Makeup requirements for the alternative cooling systems are discussed in Section III-B and that section's accompanying exhibits. The water sources considered for use at the Oyster Creek Nuclear Generating Station were: 1) the fresh surface water resources within the vicinity of the plant; 2) a number of groundwater aquifers underlying the plant area; 3) Barnegat Bay; and 4) the Atlantic Ocean.

### 2. Water Quantity and Quality

#### a. Fresh Surface Water Resources

The fresh water streams considered for use in this study included Oyster Creek, the three branches of Forked River and Toms River (See Exhibit 7).

As shown in Exhibit 78, Oyster Creek is a small freshwater stream into which the existing Oyster Creek NGS cooling water canal discharges before entering Barnegat Bay. This junction between Oyster Creek and the canal is less than a mile southeast of the plant. For a distance of about a mile downstream from this confluence to the mouth of the Bay, the creek has been dredged to accommodate the plant's discharge canal. Oyster Creek's drainage basin is approximately 7.4 square miles. Flow records for 1961-1974 by the United States Geological Survey (USGS) are presented in Exhibit 79 and depict an average discharge of 28.3 cfs near Brookville. At least 70 percent of this creek's flow as well as the others in the plant's vicinity is groundwater base flow derived from the water table aquifer.<sup>(1)</sup>

Forked River is a freshwater stream system consisting of three branches within the vicinity of the plant. The South Branch discharges into

the cooling water intake canal near Route 9, one mile north of the plant. The North and Middle Branches meet about two miles west of Barnegat Bay (i.e., three miles northeast of the plant) where they mix with Barnegat Bay waters flowing inland toward the canal.

The drainage areas for the North, South and Middle Branches are estimated at 12, 1.3 and 1.5 square miles, respectively. The USGS has compiled only partial flow records for the North and South Branches over the period 1961-1974; no data are available for the Middle Branch. A summary of the available flow data appears in Exhibit 79.

Toms River, located about nine miles north of the plant, is the largest freshwater body in the vicinity of the plant site. The drainage area of this stream is approximately 124 square miles and it flows into Barnegat Bay. Flow data obtained over a 46 year period, 1928-1974, near the Town of Toms River, has been compiled by the USGS and is presented in Exhibit 79.

Exhibit 80 presents typical water quality data for Oyster Creek, Forked River and Toms River. All three freshwater streams exhibit similar characteristics. The freshwater reaches are generally acidic and, therefore, this water could be considered corrosive in nature. Most dissolved solids constituents have generally low concentrations, notably calcium, magnesium, chloride, sodium and sulfate. Industrial and/or municipal water use processes do not appear to have exerted a significant influence on water quality, since nutrient (nitrogen forms and phosphate) and metal concentrations are also relatively low. Relatively high concentrations of iron can be expected as this is characteristic of the water table aquifer which provides these streams' base flow<sup>(1)</sup>.

Tidal influences (saltwater intrusion) affect water quality in the eastern reaches of these water bodies. These effects were evident as far upstream as US 9 for both Oyster Creek and the three Forked River branches.

#### b. Groundwater

According to the New Jersey Department of Conservation and Economic Development,<sup>(1)</sup> Ocean County has relatively vast supplies of groundwater available for public and industrial use. This groundwater resource is

found in the Coastal Plain sediments that overlies consolidated bedrock which lies at an average depth of 3,000 feet below the land surface of the site. Generally, the aquifers include continental, near-shore marine, deltaic or beach deposits of sand and gravel. The aquitards (i.e., confining beds) are mainly marine deposits of clay and glauconite.

The geology and hydrology of the geologic formations in the vicinity of the Oyster Creek NGS is presented in Exhibit 81. In Ocean County, all potable groundwater is derived from rainfall<sup>(1)</sup> which falls on the surface areas (See Exhibit 82) of the formations. For some specific aquifers, "leakage" from overlying formations may contribute to the volume of water in storage. About 40 percent of all precipitation infiltrates the highly permeable sandy surface which is characteristic of the region. The actual percentage varies during the year due to changing evapotranspiration rates and seasonal climatic conditions.

Based on information supplied by the USGS<sup>(1)</sup> and test borings conducted for Jersey Central Power and Light,<sup>(2)</sup> three of the aquifers presented in Exhibits 82 and 83 can be considered potential supplies of freshwater for cooling purposes:

- 1) The Raritan and Magothy Formation Aquifer;
- 2) The Kirkwood Formation Aquifer; and
- 3) The undifferentiated water table aquifers.

These aquifers are discussed in the following paragraphs.

#### 1. Raritan and Magothy Formation

The upper surface of the aquifer system in the area of the plant site lies approximately 1,200 to 1,400 feet below sea level and has an aggregate thickness of about 1,000 to 1,400 feet.<sup>(3)</sup> This system contains the largest amount of groundwater in storage in the Coastal Plains in Ocean County.<sup>(1)</sup> It is currently underdeveloped with approximately 5 MGD (7,200 gpm) being withdrawn as of 1962.<sup>(1)</sup> The yields of wells tapping this formation range from 35 to 1,850 gpm and the average is 660 gpm. An average of 70,000 gpd/

sq mi is available for withdrawal based on aquifer recharge estimates. The plant site, however, lies above the saltwater-freshwater interface zone which trends through the Island Beach State Park area <sup>(1,4)</sup> (See Exhibit 84. The groundwater, therefore, would exhibit the influence of saltwater intrusion and high chloride (700 to 1,000 ppm) concentrations.

#### ii. Kirkwood Formation

A geohydrologic cross-section of the upper geologic formations in the vicinity of the Oyster Creek NGS is presented in Exhibit 85, which was developed from available information and a series of test borings performed for JCP&L prior to construction of the Oyster Creek NGS. Recharge to the Kirkwood aquifer occurs principally by leakage from the water-table aquifer in areas of higher elevation inland and in the outcrop area in northwest Ocean County and Monmouth County. Leakage in the vicinity of the plant site is probably insignificant, as indicated by the fact that saltwater in the barrier beach area has not contaminated the Kirkwood aquifer. The physical properties of the aquifer system which have an important bearing on the capacity of an aquifer to transmit and store water are presented in Exhibit 86. The approximate average yield of wells from these aquifers is 417 gpm and on the average, one foot of drawdown is produced for every 11 gpm withdrawn. Recharge of the confined aquifers from areas of higher elevation to the west has resulted in artesian pressures sufficient to cause the water in wells penetrating the aquifers to rise above the elevation at which the aquifers are encountered. <sup>(1,2)</sup> The observed piezometric surfaces for the various pressure aquifers are presented in Exhibit 87.

Exhibit 88 presents a tabulation of expected values of various water quality constituents for the aquifers in the area. The well being used presently at the Oyster Creek NGS obtains water from the Kirkwood Formation. This well's water quality characteristics are presented in Exhibit 89. In general, the Kirkwood aquifer contains water that is soft to moderately hard and low in dissolved solids. <sup>(1,5)</sup> Depending on well location, excessive concentrations of iron (0.04 to 7.2 ppm) and low pH (4.0

to 8.3) can be encountered. The Kirkwood aquifer also contains relatively high concentrations of silica (to 32 ppm).

### iii. The Undifferentiated Water-Table Aquifers

The water-table aquifers are comprised of many geologic formations which vary with location. In the vicinity of the plant site (See Exhibit 85) the water-table aquifer is comprised of: the unconfined Recent and Upper Cape May Formations; the confined Lower Cape May Formations; and the confined Cohansey Sand. Recharge to the water-table in Ocean County occurs normally directly from precipitation, although locally recharge can be induced from nearby streams. The water-table aquifer is also affected by losses from evapotranspiration and baseflow runoff with as much as 50 percent of the precipitation transpired by various land and vegetative forms. Most of the remainder percolates down to the water table and moves in the general direction of the slope of the land surface (from higher ground in the west toward Barnegat Bay). The upper groundwater body intersects the eastward flowing streams in the area and can comprise 70 percent of the stream water flowing to the ocean.<sup>(1,2)</sup> Groundwater baseflow from this aquifer in the Toms River drainage basin is approximately 0.8 mgd per square mile or 100 mgd for the total basin area.<sup>(1)</sup> The physical properties of these aquifers are presented in Exhibit 86 and the elevations of the piezometric surfaces are presented in Exhibit 87. In a recent study performed by the Department of Geology, State of New Jersey,<sup>(6)</sup> the safe yield from the outcropping area of the Cohansey Formation was estimated at 1 mgd/sq mi during a normal year and 0.6 mgd/sq mi during a dry year.

The quality of groundwater in the water-table aquifer is commonly acidic and therefore, corrosive. It may contain excessive iron and may have a hydrogen sulfide odor.<sup>(1)</sup> Exhibit 88 presents the expected concentrations of various water quality constituents for this aquifer.

#### c. Barnegat Bay

Barnegat Bay is a shallow, irregular tidal basin enclosed by the New Jersey mainland on the west and a barrier beach on the east, extending 30

miles from Point Pleasant on the north to Manahawkin Causeway on the south. The maximum width of the Bay is about four miles. The maximum depth of the Bay at local mean low tide is 20 feet, while the average depth is about five feet. The surface area of the Bay is conservatively estimated at over  $1.8 \times 10^9$  square feet and the volume at  $8.5 \times 10^9$  cubic feet. (2)

Surface fresh water inflow is relatively small, about 2 percent of the tidal prism. This results in high salinity throughout the Bay, though salinity is greatest in the vicinity of Barnegat Inlet. The flow component of groundwater seepage has not been determined, but based on a salinity comparison between ocean and Bay waters, it appears to be a significant part of the total fresh water inflow. (2)

Surveys sponsored by JCP&L during 1963 measured salinity as a function of depth in the Bay. Their results suggest a tendency for two-layered circulation with periods of complete vertical mixing. This pattern, which entails a seaward drift in the upper portion of the water column and upstream drift in the lower layer is common in deeper estuaries.

Various water quality parameter data for the Bay are also available from 1966 to 1968 (7) and from a recent study performed for JCP&L during the period June, 1975 to May, 1976. Comparison of the concentrations measured in these studies with concentrations found in typical seawater (8, 9) indicate that the major constituents of the Bay occur in a percentage of total dissolved solids very similar to that experienced in typical seawater. Based on this fact, the estimated water quality characteristics of this water resource were estimated and are presented in Exhibit 90.

#### d. Atlantic Ocean

The Atlantic Ocean shoreline is situated about  $7\frac{1}{2}$  miles east of the plant. It is separated by 2 miles of mainland terrain, Barnegat Bay and a barrier beach. Exhibit 90 lists typical ocean water quality values which have been utilized in the evaluations of cooling system makeup alternatives.

#### e. Oyster Creek NGS Intake Canal

The existing Oyster Creek NGS presently withdraws approximately 460,000 gpm from the intake water canal to satisfy condenser cooling water

system demand. Two dilution water pumps with a total capacity of 520,000 gpm (260,000 gpm each) also operate when necessary to control the temperature of the discharge. The canal flow patterns created by the plant's water demand is such that much of the fresh water from the three branches of the Forked River is mixed with incoming Bay water. This results in an intake water salinity which is less than that of the Bay. Water quality data for the intake canal are available from sampling programs performed for JCP&L and are presented in Exhibit 91. The water quality constituents of the intake water occur in a percentage of total dissolved solids similar to typical seawater. This fact was utilized in estimating the maximum concentrations presented in Exhibit 91.

### 3. Water Availability

This section highlights the constraints from engineering, environmental and licensing related viewpoints that would affect the actual availability of water for withdrawal and use by the OCNGS circulating water system.

#### a. Surface Water Resources

The only fresh surface water body with sufficient flow to possibly meet the requirements of the closed-cycle condenser cooling water system alternatives is Toms River. Plant demand, however, would be equivalent to several percent of the average annual flow in Toms River and a large fraction of the recorded low flow. Direct utilization of this water body would create significant impacts on the aquatic ecology of the river and would be incompatible with existing river use (recreation water supply, etc). Therefore, it was concluded that none of the surface fresh water resources in the vicinity of the OCNGS would be amenable for use as a direct source of condenser cooling water makeup.

Other approaches, however, have been proposed to utilize these water resources by means other than continuous direct withdrawal. The "Alternate Cooling Systems Study"<sup>(10)</sup> for the FRNGS evaluated Toms River as a supply source requiring a 9.5 mile makeup pipeline. A spillway across the river could be utilized for impounding approximately 15 percent of the

average annual flow. It was also anticipated that a storage reservoir in the area would be required to maintain an adequate downstream flow and ensure continuous plant operation.

In another cooling water study,<sup>(11)</sup> it was suggested that consideration be given to a system which would capture part of the surface water runoff of Oyster Creek, the branches of Forked River and other smaller watersheds in the area. This would be accomplished by installing a series of low dams and creating a number of storage areas.

Without discussing the potential operational problems and costs associated with the above alternatives, it is felt that their viability to supply cooling water makeup can be dismissed on environmental and licensing related factors alone. Each of these cooling water system designs would require a CAFRA permit (See Appendix B).<sup>(12)</sup> Under CAFRA, proposals which incorporate features in the preservation category (e.g., streams and wetlands) would be discouraged unless the applicant could provide compelling justification for the proposed facilities. Thus, compelling justification would be needed to gain approval for the construction of dams for water storage. Because the development of surface water resources for plant utilization could create significant environmental impacts on many of the land and water forms in the preservation category, these alternate makeup water sources were not recommended for use.

It should also be noted that any of these water supply alternatives would also require an additional permit from the DEP's Division of Water Policy and Supply for stream encroachment.

#### b. Groundwater

##### i. Raritan - Magothy Formations

Since the plant site is located at the approximate interface of the salt and fresh water in these formations (See Exhibit 84), withdrawal from these aquifers would increase saltwater intrusion. Further inland, this aquifer could be utilized but the yield of this aquifer (70,000 gpd/sq mi) is such that it could not solely satisfy plant cooling water needs

on a long-term basis. Its contribution to a combined groundwater utilization system would also be small. Therefore, it was not recommended for use.

ii. Kirkwood and Water Table Aquifers

The only groundwater aquifers capable of sustaining large long-term yields without creating a significant saltwater intrusion problem in Ocean County are those of the Cohansey Sand and Kirkwood Formations. The safe yields that can be expected from the outcropping areas of these aquifers are as follows:

| Aquifer            | Normal<br>Year<br>(gpd/sq mi) | Dry<br>Year<br>(gpd/sq mi) |
|--------------------|-------------------------------|----------------------------|
| Kirkwood Formation | 1,000,000                     | 600,000                    |
| Cohansey Sand      | 1,000,000                     | 700,000                    |

The State of New Jersey, Division of Water Supply and Policy states, however: <sup>(1)</sup>

"The artesian aquifer of the Kirkwood Formation is approaching its maximum development. Since the turn of the century, water levels have declined more than 30 feet in Long Beach Island and more than 80 feet in Atlantic City, the centers of greatest withdrawals. Further development along the coast would add to the already existent danger of saltwater encroachment. Inland, where the piezometric surface of the Kirkwood formation increases from 20 to 120 feet above sea level, the aquifer can be further developed although aquifer permeabilities and well yields are less than in the 800 foot sand on the coast."

These facts would necessitate a well field development at some location substantially inland from the Oyster Creek NGS. The concept of a well field has previously been explored as a source of condenser cooling water for the Forked River NGS. <sup>(10)</sup> In that study, it was concluded that a twenty square mile well field utilizing 37 wells would be required to meet the maximum makeup requirements of the Forked River NGS. It was also concluded that this makeup alternative was not economically attractive even

ignoring land costs and costs associated with field preparation and maintenance. Our study has verified the need for such an extensive well system and has concluded that it would not be practical from an engineering point of view due to the excessive number of wells required. Land acquisition would also be a severe problem since this large land requirement is not presently available in reasonable proximity to the plant site.

Adverse environmental effects of developing a well field makeup water source could be substantial. The significant depletion of groundwater from these aquifers, independent of location, could drastically affect stream-flow. <sup>(1)</sup> Because streams in the Coastal Plain of New Jersey are placed in the Preservation category under CAFRA, the well field location would have to ensure stream integrity. The use of these aquifers at an inland location might also affect recharge potential and groundwater movement for locations nearer the coast. This could create increased drawdowns for existing water supply wells and enhance a landward movement of the saltwater-fresh water interface. Thus, groundwater is not recommended as a desirable supply source for the "wet" cooling system alternatives.

The freshwater "wet/dry" cooling tower system, however, is a unique case. The winter evaporation rate for this system is negligible and, therefore, substantial makeup water would not be required in winter. The makeup system, therefore, would have only to supply sufficient water to offset maximum summer evaporative conditions.

#### c. Saline Water Sources

Sufficient water would be available from Barnegat Bay (Oyster Creek intake water canal) or the Atlantic Ocean to meet the needs of all applicable condenser cooling water systems presented in this report.

SECTION III-H

REFERENCES

1. Anderson, H R and Appel, C A, Geology and Ground Water Resources of Ocean County, New Jersey, State of New Jersey, Dept of Conservation and Economic Development, and the U S Geological Survey, Special Report #29, 1969.
2. Jersey Central Power & Light Co, Environmental Report, Oyster Creek Nuclear Generating Station, 1969.
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11. Smith, B L, Forked River Unit 1, Fresh Water for Cooling Purposes, Jersey Central Power & Light Co, 1971.
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## I. WATER RESOURCES

The following paragraphs discuss the potential environmental effects on water resources that can be associated with the construction and operation of various alternative condenser cooling water systems. Depending on the specific system chosen, however, these effects can be minimized or eliminated by the proper utilization of construction techniques, operational procedures and environmental controls.

### 1. Construction Impacts

Soil erosion and sediment deposition are the major potential sources of water pollution associated with construction activities on land. Dredging and the subsequent release of bottom sediments is the major source of pollution resulting from the in-water construction of intake and discharge structures and pipelines.

Exposed soil can be carried by rainfall/runoff and deposited in adjacent water bodies causing increased turbidity and subsequent environmental degradation. Both the runoff volume and the associated solids concentration will be variable, being influenced by:

- 1) the intensity and duration of the rainfall event;
- 2) the particle size distribution and the infiltration and percolation rates of the soil types at the plant site;
- 3) the type and extent of vegetation;
- 4) the physical characteristics of the site, e.g., the slope of the land and the total land area affected.

The environmental impacts associated with dredging operations can generally be divided into direct and indirect effects on biological communities. In the first category, the greatest concern is related to the actual destruction of benthic communities by dredging operations. The extent and significance of benthic destruction vary considerably depending on many circumstances including the type of dredge utilized, type of benthic ecosystem, time of dredging in relation to tidal pattern, local current, etc.

The potential for the indirect effects on biological communities is generally attributed to physical alterations including changes in bottom geometry, the creation of deepwater regions, new open water, changes in bottom substrates and habitats, alterations in water velocity and current patterns, changes in future sediment distribution patterns, alteration of the sediment-water interface with subsequent release of biostimulatory or toxic chemicals and the creation of turbidity clouds.

Another significant impact that can be associated with construction is the disruption (e.g. modification, diversion or elimination) of surface water bodies. The impact resulting from these activities will be extremely dependent on the characteristics (e.g. aquatic ecology, water quality regime, drainage function, water use, etc) of the resource.

For alternatives analyzed in this study other than the once-through ocean intake/discharge system alternative and the cooling pond alternative, no significant construction-related impacts on water resources would be anticipated. The once-through ocean system would require the construction of a dredged trench for the intake and discharge pipelines. The intake and discharge pipelines would be approximately 34,000 feet in length. The total volume of dredge spoil created from this alternative would be 300,000 cubic yards. The construction of these pipelines would require several years to complete.

Environmental effects of an increased sediment load in Barnegat Bay due to these construction activities and the water quality effects due to dredge spoil disposal could be substantial. Benthic communities could be extinguished due to sediment deposition, while water quality constituents and planktonic productivity could be altered due to the release of nutrients and/or metal toxins (for a discussion of the aquatic ecological impacts of the dredging, see Section III-L). Extensive sediment characterization studies and dredge spoil treatability studies may have to be performed to comply with the EPA and Corps of Engineers guidelines for open water dredge spoil disposal<sup>(1)</sup> or for an NPDES permit for runoff from dredge spoil disposal on land.

The other cooling water system alternative which would create significant construction-related effects is the cooling pond system. The construction of the 1,000 acre pond would necessitate the diversion of Oyster Creek, eliminate a substantial amount of its drainage area, and thereby reduce the creek's flow. Diversion of Oyster Creek would not be necessary for the 500 acre pond alternate, but the drainage area would still be significantly reduced. Both pond systems could also create saltwater intrusion problems, possibly affecting both groundwater and Oyster Creek water quality. These cooling ponds would impact on natural resources placed in the DEP's "preservation" category and may be in violation of the NJDEP Proposed Groundwater Standards for the Pine Barren Region. (2)

## 2. Operating Impacts

Operation of a condenser cooling water system can affect a water resource through the mechanisms of water withdrawal, consumptive water use and the discharge of "concentrated" water quality constituents and chemical additives.

The major potential impact of water withdrawal is the reduction of stream flow. A significant alteration in stream flow could cause substantial effects upon the ecology downstream and would also affect the amount of water available for downstream users. Downstream water quality may also be affected if the dilution capacity for wastewater discharges or tributary streams is reduced.

The effects of power plant liquid waste discharges upon the receiving water body is an alteration in the water quality and thermal regime in a specific plume area. The magnitude of the plume is dependent upon plant operation and the type of discharge structure utilized. Water quality alteration is due to the discharge of high concentrations of total dissolved solids (usually the concentrating effect of recirculating cooling water governs the overall plant discharge concentration of a particular parameter) which contain undesirable constituents.

The actual significance of these effects is dependent upon the ecological and physical characteristics of the water body, its assimilative capac-

ity and the extent of use of the receiving water body. If the mixing zone encompasses a large area of the water body or if discharge flows are significant in comparison to receiving body flow or volume, then a major alteration in the water quality characteristics of the receiving water body could result. Besides the ecological consequences of this change, other water users could be adversely affected.

Significant environmental effects associated with water withdrawal and consumptive use would not be anticipated for any of the "wet" cooling tower alternatives since the makeup water flows would represent a small percentage of the supply source's (Barnegat Bay or the Atlantic Ocean) water.

As discussed previously, all the closed-cycle condenser cooling water system alternatives were assumed to utilize saline water for makeup and to discharge the blowdown at the existing discharge canal location (See Exhibit 92. The operational mode for these systems was assumed to be 1.5 cycles of concentration which is considered representative of historical saltwater system operation.<sup>(3)</sup> The helper tower system was also assumed to utilize the existing canal intake and discharge locations as depicted in Exhibit 92. Operational characteristics for all of these systems are summarized in Exhibit 93.

Estimated blowdown water quality concentrations for all of the closed-cycle condenser cooling water system alternates (and helper tower system) are presented in Exhibit 94. Utilizing these concentrations as well as the anticipated blowdown water quality of the future Forked River Station (at 1.5 cycles of concentration) and assuming the use of two of the existing dilution water pumps, the resultant water quality concentrations in the discharge canal after complete mixing of all three effluent streams were calculated and are depicted in Exhibit 95. The percentage increase of each parameter above intake water concentrations is also shown in this exhibit. As can be seen, the 1,000 acre cooling pond alternative would produce the largest concentration differential, which would represent an increase of only 3.7 percent above ambient water concentration levels. Assuming only one dilution pump in operation, the maximum increase in con-

centration level would be about 8 percent. All water quality parameters would be within allowable limits according to Class TW-1 New Jersey Surface Water Quality Standards.

In regard to the open-cycle ocean intake/discharge alternative, the utilization of the diffuser discharge would insure compliance with the applicable thermal criteria. In addition, no measurable impact on water quality in the ocean would be expected as a result of this discharge system. The potential water quality impacts associated with the canal-to-bay alternative did not significantly affect the decision to include the canal-to-bay system as a preferred alternative for further consideration. These impacts are considered in detail in Chapter IV.

Other low volume wastewater sources presently being discharged from the Oyster Creek NGS, including demineralizer regeneration wastewater, floor drainage and sanitary wastewater were not included as a component of the Oyster Creek NGS blowdown discharge. Given that these wastewater streams receive appropriate treatment and are in compliance with EPA Effluent Guidelines and Standards, their incremental contribution to the plant's overall discharge characteristics should not be significant.

A chemical of concern which is not discussed above is chlorine. It is presently anticipated that chlorine would be utilized in all systems as a biocidal agent to prevent the biofouling of condenser tubes, spray nozzles, tower surfaces, etc. A number of chlorination practices and control technologies are available to ensure that all chlorine discharges would be in compliance with applicable Federal and State standards. There is no reason to suspect that present chlorination of the cooling water at Oyster Creek NGS has caused significant adverse impacts to the aquatic biota. A chlorination optimization study can be conducted at a later time to determine the minimum chlorine required to achieve satisfactory cooling system operation without the problems of biofouling for any of the alternatives. Minimum chlorine requirements cannot be calculated at present.

### 3. Other Potential Impacts

Additional impacts associated with plant operation that would not be directly related to the quality of the plant's effluent streams, yet that would be dependent on the total flow through the Forked River - Oyster Creek loop are: a) changes in Oyster Creek dissolved oxygen concentrations, and b) changes in silt transport through Oyster Creek, resulting in changes in the deposition rates in Barnegat Bay. These impacts were not viewed as limiting factors for the selection of the preferred alternatives.

Changes in Oyster Creek dissolved oxygen concentrations are discussed further in Chapter IV.

SECTION III-I

REFERENCES

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2. Department of Environmental Protection, State of New Jersey, "Proposed Non-Degradation Water Quality Standards for the Pine Barrens Area", January 19, 1977.
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## J. NOISE EFFECTS

### 1. Introduction

The potential noise impact of alternative cooling water systems was evaluated taking into consideration both the magnitude of the noise and the location of the equipment relative to residential areas. Exhibit 96 shows the plant location, residential areas surrounding the plant and areas zoned for residential uses. The noise levels presented in this chapter are based on the distance between the potential source and the nearest residentially zoned property. Possible mitigating measures were not considered prior to selection of preferred alternatives (See Chapter IV).

Though both Lacey and Ocean townships have local noise ordinances, they do not specify limiting sound levels in decibels. Therefore, this analysis has been based on the New Jersey Noise Control Regulations adopted January 18, 1974 (See Appendix B). These regulations set noise limits both in terms of dB(A) values and also in the form of octave band spectra from 31.5 to 8,000 Hertz. The most restrictive dB(A) limit is 50 dB(A) for nighttime. Each of the alternative cooling systems was evaluated in terms of its ability to meet this limit.

### 2. Evaluation of Alternatives

The noise levels produced by the various cooling systems were estimated using existing literature, vendors' information and in-house analytical methods. (1, 2)

#### a. Cooling Tower Alternatives

The predominate sources of noise in cooling tower installations are associated with the movement of air and water. Noise associated with air movement in towers using fans is created by the turbulence of the air leaving the fan blades and basically varies proportionally to the horsepower input to the fan. Noise associated with water movement is caused by the splashing and dripping of water cascading over the internal fill of the tower and into the basin. Fan noise has a predominately low frequency whereas water noise is of high frequency. At large distances, fan noise dominates water noise. Therefore, in general, at a given distance the

noise level from a mechanical draft tower would be higher than from a natural draft tower.

Preliminary noise level data were not available for the fan-assisted tower during evaluation of the sixteen alternative cooling systems. However, the analyses indicated that each of the other cooling towers (including helper cooling towers) would be expected to exceed the nighttime limit of 50 dB(A) imposed by the New Jersey Noise Control Regulations, provided that mitigating measures could not be taken.

b. Cooling Pond Alternatives

The major source of noise associated with the cooling pond alternative systems would be the circulating water pump-motor assemblies. However, the noise produced by these pump-motor assemblies could be attenuated by conventional means such as enclosures and internal motor design, and therefore, these alternatives would not be expected to create a significant noise impact and should satisfy regulatory requirements.

c. Spray Canal Alternative

The sound level produced by an individual powered spray module (PSM) would be somewhat lower than the sound level produced by a conventional cooling tower. However, because of the great numbers of modules that would be required and the length of the canal, the system propagates sound as a line source rather than a point source. Consequently, the reduction of noise due to distance with the spray canal alternative would be less rapid than the reduction in noise with distance from the cooling tower alternatives.

The unattenuated sound levels produced by the spray canal system in the residential area would be expected to be about 60-62 dB(A), or 10-12 dB(A) above the nighttime limit.

d. Open-Cycle Canal (Pipe)-to-Bay Alternative

Both alternatives discharging to Barnegat Bay would include a sharp-crested weir to regulate the flow of water. This flow of water over the

weir would be the predominant source of noise associated with these alternatives.

A literature search did not reveal any information regarding noise levels generated by waterfalls, and therefore, an analytical model was employed to estimate resultant noise levels. Based on this analysis, the water flowing over the weir would generate noise levels of about 63 dB(A) in the residential area bordering the plant.

e. Open-Cycle Ocean Intake/Discharge Alternatives

The major sources of noise for these alternatives would be the noise generated by the circulating water pumps. Even if the unattenuated noise level should exceed the New Jersey Noise Control Regulations, a suitable enclosure could be utilized to meet the required limits.

3. Summary

The ocean intake/discharge and cooling pond systems appear able to meet the New Jersey Noise Regulations for dB(A) levels. Each of the remaining alternatives would be expected to exceed these criteria unless mitigating measures could be employed. Nevertheless, the potential for exceeding noise limits was not considered as a criterion for elimination from the list of preferred alternatives (due to regulatory non-compliance) because: a) possible mitigating measures had not yet been considered, and b) data on noise levels associated with the fan-assisted tower were not yet available.

SECTION III-J

REFERENCES

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## K. VISUAL/ESTHETIC CONSIDERATIONS

### 1. Introduction

This section presents a qualitative assessment of the visual and esthetic impacts resulting from installation of various alternative cooling systems at the Oyster Creek Nuclear Generating Station. For the purposes of this study, these impacts are categorized into two broad areas - direct and indirect.

Direct visual and esthetic impacts are those resulting from the physical dimensions of the cooling system (the location, extent, height, and shape of the particular cooling system structure or installation) involving the intrusion of that system into the landscape. Also included under the direct impacts category are the effects of visible plumes created by a system, and the extent and nature of fogging, misting, and icing phenomena.

Indirect impacts are those affecting existing vegetation. These impacts are the result of the removal of plant material resources and fall into two categories:

- 1) Impacts which would result from removal of existing vegetation for the construction of the cooling system; and
- 2) The impact which would occur if there would be future loss of vegetative area due to operation of the cooling system, i.e., salt deposition on the leaves. Losses such as these must be postulated from experiences at other installations since only actual operation of a facility can determine the extent of impact.

In the assessment of visual impact of the alternative cooling systems discussed in this report, the following general criteria were employed:

- 1) Cooling systems which can be installed without the removal of existing vegetative cover (or whose installation(s) minimize removal of such cover) are preferred over installations that require large amounts of removal.

- 2) Cooling systems which can be installed in such a manner that vegetative cover can be used for screening purposes are preferred over those where no such cover exists.
- 3) Cooling systems which have a low profile are preferred over those which entail high, broad, or lengthy elements.
- 4) Where structures (as opposed to canals or ponds) are involved, systems which are visible to a small number of potential viewers are preferred to those which expose a large number of potential viewers to the structure.
- 5) Systems which locate cooling structures near existing power plant elements are considered to have visual and esthetic benefits. This concept eliminates the need for intrusion into new areas with attendant loss of cover, and would also allow for grouping of plant site elements tending to minimize further disruption of the landscape.

## 2. Existing Conditions

As discussed previously, the Oyster Creek Nuclear Generating Station Site is located in the Pine Barrens area of New Jersey and is about nine miles south of Toms River. JCP&L owns 1,416 acres in Lacey and Ocean Townships, of which 755 acres are west of State Route 9 and 661 acres east of State Route 9. The westerly portion of this holding is bounded by the Garden State Parkway on the west, State Route 9 on the east, and by land zoned for light industrial uses (in both townships) on the north and south. The easterly portion of the JCP&L owned lands is bounded by State Route 9 on the west, by land zoned for marine commercial uses on the north and south, and by land zoned for residential uses on the east.

The nearest concentrations of population in the area are in Forked River, which is approximately 1.9 miles from the site and had a 1970 population of 1422, and Waretown, which had a 1970 population of 700 and is about 1.7 miles from the site.

The present facility is partially visible from local and state roads in the immediate vicinity and from nearby residences. Viewers of the plant site

would probably not be very aware of the facility as they travel north or south on Route 9 if it were not for the stack which visually pinpoints the facility. The station is set well back from Route 9 and planting has been installed along this road to soften the view. These plantings will tend to provide additional screening in years to come as they become taller.

Travelling south on Route 9, the existing plant elements can first be seen at a point about one mile away. Approaching the site, plant related structures are seen intermittently between commercial and residential areas along this road where extensive strip development has taken place.

Travelling north on Route 9, the stack is visible at a point about 1.4 miles south of the plant location. It reappears intermittently through the intervening visual clutter of shops, restaurants, and industries. It is in full, unimpeded view for about 0.7 of a mile and is seen behind a foreground of planting.

As the traveller proceeds south on the Garden State Parkway (GSP), the power plant is not visible at all since it is hidden from view by existing planting in the median strip. One is aware only of transmission lines and towers which are viewed intermittently paralleling the road.

Proceeding north on this same highway, however, the traveller is aware of the transmission lines and towers for about 2.2 miles, and the transmission towers are close to the road for about 0.6 of a mile. A lateral view (at right angles to the road) is gained of the transmission line towers and station in an opening of about 500-600 ft.

### 3. Cooling Tower System Alternatives

#### a. General

In general, shapes of both round towers and hyperbolic towers are considered more esthetically pleasing than that of rectangular towers since curvilinear surfaces are more eye-appealing and tend to soften the outlines of the form, while rectangular shapes tend to be hard and box-like. While the shape of the hyperbolic cooling tower is thought to be pleasing, the structure would be over 500 feet high, constituting, therefore, a dominant visual impediment in any vista. The round mechanical towers would be only 70 feet tall, allowing for visual integration with other facility elements.

In assessing visual and esthetic impacts of cooling tower systems, consideration must be given not only to the dimensions, shape and location of the towers, but also to those effects resulting from their operation such as elevated plumes and ground level fogging.

Optimal conditions for plume formation would exist when wind speeds were moderate to slow and the atmosphere was very moist. The plumes would be most readily observed when they were not obscured by low-lying clouds. Smaller plumes would occur when the atmosphere was relatively dry. Plumes created by natural draft and fan-assisted towers would tend to have the greatest rise and probably the greatest travel distance of tower systems. It is difficult to assess the esthetic reaction to elevated plumes. Generally, they would not interfere with the scene viewed by the passerby, whether on foot or in a vehicle, since they are above these views. Though these plumes are not intrinsically unpleasant, they may, however, be viewed or imagined by some as conveyers of pollutants.

In contrast to high level plumes, greater potential concern can be associated with the effects and impacts of ground level fogging. Fogging would render the ground level scene less visible and could have adverse effects on the viewer and/or driver. Fogging could reduce driving conditions to potentially dangerous situations in which the driver would be forced to strain to see and where his senses of distance and depth perception would be impaired. Therefore, it has been assumed that minor visual impacts could result from elevated plumes while adverse impacts could result from ground-level fogging and icing.

One advantage to be gained in the location of any cooling towers at the Oyster Creek Nuclear Generating Station, despite their large dimensions, is that they could be placed upon lands already owned by the applicant and within close proximity to established plant elements. The benefits of this arrangement are two-fold: they would be viewed as part of the overall power plant complex, and not as separate intrusive elements in the regional scene; and they would not require further removal of visually important forested lands for their installation. For this reason, impacts would not be as great as they would be if towers were placed in an area disassociated from the other plant facilities.

b. Discussion of Alternatives

Of the cooling tower systems under consideration, the one which would be most acceptable from an esthetic standpoint is the round mechanical tower. This conclusion is based on the tower shape and ability to blend with other low profile elements. Two towers would be required, each about 70 feet high and 230 feet in diameter. Positioned close to the existing plant, they would tend to combine with other facilities of the site complex, and, therefore, not present a significant visual intrusion. The frequency of elevated plumes from this type of installation would be similar to that from the other tower types. It is anticipated that there would be somewhat higher salt deposition from round mechanical towers. Fogging incidences created by these towers would be expected to be similar in frequency to that from a natural draft cooling tower but less than that created by rectangular tower operation. There is a possibility that the plumes from round mechanical towers at Oyster Creek NGS could combine with and augment a plume from the Forked River NGS cooling tower under conditions of northeast or southeast winds.

There appears to be little difference in the atmospheric effects created by the natural draft and fan-assisted natural draft cooling towers; therefore the statements that follow apply to both systems. The natural draft cooling tower would present a pleasing hyperbolic profile and curved surfaces which can intrigue the eye of the observer. Its principal drawbacks would be its large size (370 feet in diameter at the base and 550 feet in height) and the high level plume which would be observable during the colder months and/or when the relative humidity is high.

The fan-assisted natural draft tower would be 300 feet in height. While still a dominant element in the visual scene, it would have a lesser degree of impact than the natural draft tower.

The rectangular mechanical draft tower system would be the latest desirable choice from the esthetic viewpoint. Two towers would be required for

this facility and while they would not be tall (69 feet), they would be about 600 feet long and would present a very long and visually obstructive facade to viewers on Route 9. Ground level fogging which would be expected from this system is considered to be significant, occurring during approximately several hundred hours per year. Therefore, not only would an impact be created by the proximity of these large units to Route 9, but also, under certain atmospheric conditions, fog would impact vision along Route 9.

The last alternative type of tower considered is the installation of salt-water or freshwater wet/dry cooling tower units between the station and the intake canal. These units would each be 500 feet long and would present an almost solid facade to the viewer on Route 9. Furthermore, the installation of these units would entail dislocation and rearrangement of previously installed plant material near the station. Therefore, due to their proximity to a heavily used thoroughfare, it is judged that the physical and esthetic impacts of these systems would be high.

#### 4. Cooling Ponds and Spray Canal Alternatives

While cooling ponds could offer viewers a broad expanse of water, considered by some to be the most appealing of all natural features, water bodies are not unique visual elements in this particular area. There are numerous recreational facilities in the area and the region abounds with inlets, bays, rivers, lakes and marshes. Furthermore, the construction of ponds would necessitate the removal of a significant amount of vegetation which, at present, screens the Oyster Creek NGS from viewers on the Garden State Parkway and the Waretown-Brookville Road. The single most important visual amenity in this vicinity has resulted from the preservation of the stands of hardwood and pine trees and it should be expected that the choice of any alternative which threatens them could meet with local opposition.

Cooling ponds and/or spray canals would have potential for the development of ground level steam which could result in fogging and possible icing effects on Route 9, Waretown-Brookville Road (Rt. 532) and the Garden State Parkway. Since it is estimated that fogging effects from cooling ponds could extend up to one-half mile, impacts due to an increased occurrence of fogging could be a problem. The following table lists the distances from each pond to the major roadways:

| <u>Pond Size</u> | <u>Road Designation</u> | <u>Distance from Pond</u> |
|------------------|-------------------------|---------------------------|
| 1000 acres       | Garden State Parkway    | 500-700' <u>+</u>         |
| 1000 acres       | Route 532               | 350-1500' maximum         |
| 1000 acres       | Route 9                 | 1000' <u>+</u>            |
| 500 acres        | Garden State Parkway    | 2100' at closest point    |
| 500 acres        | Route 532               | 400-1500' maximum         |
| 500 acres        | Route 9                 | 1000' <u>+</u>            |

The distances shown above are not large enough to insure that pond-induced atmospheric effects could not impact traffic on these thoroughfares.

The spray canal would be installed on land which lies between Route 9 on the west and residences on the bay (east) side. This land is bounded on the north and south by the existing Oyster Creek NGS intake and discharge canals and is presently owned by JCP&L. Since the installation would only be 8 feet above grade, there would be little elevational view intrusion except for the necessary pumphouses. Furthermore, when the sprays were in operation, they may be considered visually pleasing and as such, the characteristics of the spray canal system are deemed acceptable from a direct visual standpoint.

As in the case of a cooling pond, the spray canal system could create fogging effects extending to one-half mile from the canal. Since the canal, as envisioned for this project, would be only 600 feet from State Route 9 at the closest point, there would be potential for a negative impact on vehicular traffic resulting from the spray system. Furthermore, there would be increases in salt deposition over the estimated natural salt deposition levels. Since significant salt deposition can be expected to occur within 600 feet of the canal, any new planting near the canal for purposes of screening may be precluded. Therefore, though the spray canal would be of low profile and would furnish an attractive view to the passerby, the direct visual impact of fogging and the potential for vehicular traffic interference are negative attributes of this alternative.

## 5. Open-Cycle System Alternatives

The once-through ocean intake and discharge system would have the least potential for visual impact of all the alternatives. A major problem associated with this alternative is related to land use. Construction of the system would require crossing of Island Beach State Park, which is not only a public open space, but also a "Selected Environmentally Sensitive Area", according to the Interim Land Use and Density Guidelines for the Coastal Area of New Jersey. Proper siting, construction practices, and restoration procedures, however, should result in minimizing long-term impacts on the barrier island park.

This system would probably require a pumphouse building near the discharge canal at the shore of Barnegat Bay. The building would be of modest size (approximately 40 feet by 25 feet) and not over two stories in height. The visual impacts of this structure would be expected to be minimal.

The canal-to-bay and pipe-to-bay systems would require a drop structure that would be seen by viewers on Barnegat Bay as a wide but low waterfall. The view would extend to 400 feet in length and would normally display a waterfall of 4.5 feet based on mean low water level. This alternative would present very little visual intrusion on the landscape. Some nocturnal fogging would be produced, but this should not be a significant visual effect.

The helper tower systems would consist of three to five rectangular mechanical towers located between the station and the discharge canal with the cells located as close as 200 feet from Route 9. The esthetic impacts would be similar to those produced by the rectangular mechanical cooling tower alternative, i.e., impacts due to ground level fog along Route 9 and the presence of a large facade along this route.

## 6. Summary - Visual/Esthetics Evaluations

Exhibit 97 summarizes the qualitative assessments for the visual and esthetic impacts of the alternative cooling water systems. In general, overall high impact ratings were given to high or extensive structures which would create ground fog and/or visible plumes. Low impact ratings were given to systems of low profile which would create lower amounts of fog and entail small amounts of existing vegetative removal. Finally, the capability of the system to accommodate restorative plantings was also factored into these results.

As apparent from Exhibit 97, the once-through systems are considered to have low visual impacts while the cooling tower alternatives, excluding the wet/dry towers, are all rated as having high potential for visual impact. The cooling pond, spray canal, dry tower and wet/dry towers are all considered to have moderate potential for visual impact.

## L. AQUATIC ECOLOGY

### 1. Introduction

In order to make recommendations on preferred alternatives from the viewpoint of aquatic ecology, it was, at a minimum, necessary to compile and understand the following data:

- 1) baseline distribution and abundance of organisms in the Atlantic Ocean offshore of Island Beach and Barnegat Bay;
- 2) life histories of indigenous species;
- 3) environmental requirements of indigenous species (temperature, salinity);
- 4) responses of indigenous species to unnatural levels of water quality variables (temperature, salinity, chlorine);
- 5) importance of indigenous species to man's continued use of the resource, and
- 6) present impact of the Oyster Creek Nuclear Generating Station.

Sufficient information was sought to demonstrate any gross differences among the alternatives under consideration.

The existing Oyster Creek Nuclear Generating Station system employs once-through cooling. The source of cooling water (the intake water body) is a channelized section of the South Branch of Forked River which is connected to Barnegat Bay via the main Forked River channel. The discharge water body is a similarly channelized section of Oyster Creek, flowing into Barnegat Bay. The channelization of these two creeks has extensively altered the original aquatic and riparian habitat. Prior to plant construction and operation, the small tidal creeks had distinct salinity wedges extending approximately to the Route 9 bridges. Where high salinities existed only at the bottom of each creek prior to 1965, presently there exists an isohaline condition, (i.e. high and approximately equal salinities occur throughout the channel from the mouth of Forked River to the mouth of Oyster Creek.)

This isohaline condition and physical modifications have altered the ecology of the streams. Water flow through Forked River and Oyster Creek increased a thousand fold after OCNGS began operation. The stream systems may be viewed as a single canal rather than two separate tidal creeks with their respective watersheds.

The increase in cooling water temperatures after passage through plant condensers has been as much as  $11.6^{\circ}\text{C}$  ( $23^{\circ}\text{F}$ ). In order to reduce the effect of elevated temperatures on biota of Oyster Creek and Barnegat Bay, three dilution pumps have been installed to transport water from the intake water body directly into Oyster Creek, mixing large quantities of ambient water with condenser discharge water. With the operation of the dilution pumps, the temperature elevation in Oyster Creek may range from  $2^{\circ}$  to  $7^{\circ}\text{C}$  ( $3.6^{\circ}$  to  $12.6^{\circ}\text{F}$ ) above ambient.

Over the course of its operational period from 1969 to the present, several unanticipated problems in plant operation have become apparent at the Oyster Creek Nuclear Generating Station. The most visible of these were occurrences of fish kills. These have most often been attributed to a rapid rate of water temperature decrease when the station is shut down in winter. Fishes attracted to the warm discharge plume become acclimatized to the higher water temperatures and are vulnerable to cold shock when they become exposed to rapidly declining water temperatures.

A second problem which has received attention is incidence of shipworm (Teredo spp) damage in the Oyster Creek area. This is a problem which can be related to temperature, salinity, and habitat availability, depending upon specific circumstances. It is treated in detail in sections of this report describing present ecological conditions and advantages and limitations of alternative cooling systems.

Other problems are more generic to the steam electric industry. These are habitat removal, entrainment of small animals and plants through the intake screens and into the cooling water system, impingement of animals on the intake screens and effects of plant effluents. In the present case, the dilution pumps constitute an additional source of plankton and nekton entrainment.

Alternative cooling water systems were evaluated on the basis of four operational characteristics: change in temperature ( $\Delta T$ ), change in salinity ( $\Delta S$ ), impingement (nekton and benthos) mortality, and entrainment mortality.

Although system-specific modifiers such as construction effects, fouling potential, sport-fishing potential and shipworm habitat possibilities augmented the analyses used to select preferred systems, available data bases were less than ideal. This was particularly true of entrainment and impingement estimates, which lacked detailed data on individual species, a complete (which is possibly unattainable) data base on population sizes, and, in the case of the ocean alternative, data on actual operating experience in the geographical area. Approximate methods for comparing water withdrawal impacts on the total biological matter present are developed in Subsection III-L-3 below. More detailed analyses of aquatic ecology impacts of the preferred alternatives are described in Chapter IV.

## 2. Description of the General Study Area

### a. Habitat

#### 1. Atlantic Ocean

The New Jersey coastline is characterized by barrier beaches which separate shallow estuarine bays from the Atlantic Ocean (Exhibit 7). A gently dipping coastal plain forms the coast of New Jersey and continues under water as the continental shelf, extending approximately 90 miles offshore.

The Ocean and bays of southern New Jersey have been described by Ichthyological Associates, Inc. (1). The sea bottom consists of unconsolidated sediments, chiefly sand. Temporary large sand ridges, produced by wave action, are the dominant natural features of the sea bottom. Beaches dominate the coastline; solid substrates are limited to beach stabilization structures such as groins. Water depth increases gradually with distance from shore, at a rate of approximately 5 to 6 feet per mile. The tidal range is approximately four feet. Water temperatures in nearshore waters of the southern New Jersey coast exhibit an annual range of from near 32°F (0°C) to 75°F (24°C). A thermocline stratification usually develops during warmer seasons, resulting in 11-14°F (6-8°C) differences between surface and bottom waters.

The dominant circulation pattern in the coastal waters is a southwestern drift. A narrow northeastern counter-current occurs adjacent to the coast. Gulf Stream eddies may affect coastal waters temporarily. Wind has a strong influence on circulation due to the shallowness of coastal waters. Seasonal shift in surface currents have been linked to wind shifts. Ocean salinities show slight variation off southern New Jersey. Maximum salinities are approximately

32 parts per thousand (ppt) during late summer. Lowest salinities (20-25 ppt) generally occur during winter and spring. Slight variations between surface and bottom salinities have been noted.

#### ii. Barnegat Bay

Barnegat Bay, located between the New Jersey mainland and two barrier beaches (Island Beach and Long Beach Island), has a direct connection with the ocean through Barnegat Inlet, situated between the two beaches. Tidal currents, which may exceed 5 ft/sec, are noticeable a mile away on either side of the inlet.<sup>(1)</sup> The bay is approximately 31 miles long and 3.8 miles across at its widest point. Average depth is 4.9 feet and maximum depth is 19.7 feet. Unconsolidated sediments dominate the bay bottom.

Because land development between 1950 and 1970 occurred at a rapid rate along the coast of New Jersey, marshes along western and eastern bay shores are restricted. The largest wetlands are found at the southern end of Island Beach (State Park) and along mainland areas, especially near rivers and creeks. A number of small rivers and creeks drain the mainland, emptying into the bay along its western shore. Tidal influences are discernable as far as 2.2 miles upstream from small river mouths.<sup>(2)</sup> The largest source of freshwater input to the bay in the area of Oyster Creek is Toms River.

Salinities in Barnegat Bay vary seasonally, with lowest values generally occurring during spring when runoff is high and evaporation is relatively low. Highest values normally occur in summer and early fall. Salinity in northern Barnegat Bay ranges from 8.9 to 30.3 ppt.<sup>(3)</sup> Toms River appears to have a strong influence on salinity in the bay. Water temperatures in the bay vary widely. Documented natural minimum and maximum are 32° and 88° F (0.3° and 29.5° C).<sup>(3)</sup>

#### b. Fish

##### i. Atlantic Ocean

Shoreline areas are used by fish throughout the year, but peak abundance in the surf occurs in summer and fall. Bay anchovy (Anchoa mitchilli) and Atlantic silverside (Menidia menidia), are particularly numerous in the shallow waters off the barrier islands. Killifish (Fundulus spp) and young pompano (Trachinotus carolinus) also are present during the warmer months.

Pelagic fish occurring in New Jersey oceanic waters include Atlantic menhaden,

striped bass, weakfish, bluefish, shad, and sharks. Seasonal shifts in species appearance and dominance have been noted in gill net catches offshore of Long Beach Island (4,5). Prominent demersal fishes in the Atlantic Ocean or offshore of southern New Jersey beaches include hakes, flounders, searobins, dogfish and sand lance. Seasonal variations have been observed. (4, 6)

Commercial landings for various species are shown in Exhibits 98, 99, and 100, helping to illustrate the populations present. Ocean sport fishing from the shoreline to as far as 20 miles offshore of Long Beach Island is important to the local economy, as reflected in sport catches (Exhibits 101 and 102). Summer flounder, Atlantic mackerel, weakfish, bluefish, black sea bass and striped bass are all taken as sport fish.

Information on life stages and the thermal and salinity distribution of fishes found in south New Jersey coastal waters has been previously summarized by Ichthyological Associates, Inc. (4,5)

#### ii. Barnegat Bay

Because Barnegat Bay is shallow and confined, it responds quickly to changes in air temperature and freshwater input. (2) The wide annual temperature and salinity regime of the Bay suits a variety of needs in the life cycle of finfish, including spawning and/or larval development requirements. Hence, the bay is utilized by numerous species at different stages in their life histories. Species normally present in the ocean as adults, may spawn and/or spend part of their early life stages in the Bay. Species which confine themselves to the Bay throughout their life cycle, such as silverside, pipefish and gobies, may shift their location within it in response to changes in temperatures or other seasonal factors, such as vegetation growth. Important fish known to occur in Barnegat Bay include the Atlantic silverside, bay anchovy, fourspine stickleback, flounders (summer/winter), menhaden and bluefish.

Fish are most active in Barnegat Bay from spring to mid-fall when spawning and nursery activity result in greater fish density. (1) March and September/October are periods of much spawning activity.

Sport fishing activities in Barnegat Bay are of major economic importance. Black sea bass, northern kingfish, winter flounder, summer flounder, blue crab and other species are caught in Bay waters (Exhibit 103). Barnegat Inlet is a productive sport fishing ground due to greater fish density resulting from

migration between the ocean and Bay. Eastern Bay waters near the inlet have been productive during warm seasons.<sup>(7)</sup> Western Bay waters from north of Oyster Creek to Waretown Creek have produced larger sport catches in winter than neighboring areas.<sup>(7, 8)</sup> Heated effluent from OCNGS contributes to the congregation of fish in this area. Commercial landings from Bay waters include winter flounder, blue crab, white perch and clams (Exhibit 104). Blue crab is an especially prominent commercially important species.

c. Phytoplankton

Unicellular plants which move with the water that sustains them constitute the phytoplankton. Variation in species size within the general microscopic characterization has resulted in investigators grouping phytoplankters by size. Species with diameters of at least 60 microns are referred to as protoplankton. Organisms less than 60 microns in diameter are called nannoplankton. Phytoplankton are an important ingredient of the ecological system and occur in vast numbers. They are subject to entrainment in power plant intakes.

The phytoplankton community in southern New Jersey offshore coastal waters consists mostly of diatoms.<sup>(9)</sup> Maximum cell densities of the major phytoplankton groups were found to range from 826,380 cells/liter for diatoms in September to 296,000 cells/liter for cyanophytes in January during sampling conducted between August 1972 and January 1973. Seasonal dominance exchanges among diatom and dinoflagellate species characterize waters near the coast. Dinoflagellates (Prorocentrum spp Gymnodinians) are abundant during summer, with up to 530 cells/liter found at the 20 foot depth at the site of the proposed Atlantic Generating Station.<sup>(4, 5)</sup> Remnant diatom populations increase abruptly in January or February. Blue-green (Cyanophyta) unicellular species are present in large numbers at all times, but their minute size reduces their influence on the general phytoplankton population biomass. Protozoa, Tintinnids and silicoflagellates are also present in low density.

Micrcoflagellates (nannoplankton) comprise a major portion of Barnegat Bay phytoplankton through the entire year, but protoplankton abundance follows a seasonal abundance pattern,<sup>(10)</sup> in which dominance varies between diatom and dinoflagellate species.

Minute nannoplankters, especially Nannochloris, are thought to be a numerically dominant species in Bay phytoplankton,<sup>(4)</sup> although size has restricted accurate enumeration per unit of volume. Nannochloris abundance has been taken as an indicator of eutrophication.<sup>(9)</sup>

Phytoplankton density and productivity were found to be greatest in western Bay waters near river and creek mouths.<sup>(10)</sup> Areas of lowest density were those

where water exchange with the ocean was most rapid.

#### d. Zooplankton

Zooplankton is the term given to passively moving animals which inhabit the sea independent of the bottom (at least temporarily). Most plankton are microscopic in size. Diurnal vertical movement is a common feature of zooplankton, but horizontal movement is considered passive. Animals which are exclusively planktonic are referred to as holoplankters. Numerous invertebrate animals have planktonic life stages, usually as larvae. Such temporary plankton are called meroplankton. Species composition of the meroplankton varies seasonally.

The zooplankton population in south Jersey coastal waters is composed of meroplanktonic larval stages of benthic adults and holoplankters. Meroplankton comprise a large portion of the coastal plankton population. The density of the larvae varies through the year, being greatest during spring and summer and lowest during winter <sup>(4, 5)</sup>.

Bivalve, polychaete, crab, and shrimp larvae are prominent meroplankters offshore of southern Long Beach Island. Surf Clam (Spisula solidissima) and ribbed mussel (Modiolis demissus) larvae have been the most abundant of the bivalve larvae in the meroplankton offshore of Little Egg Inlet <sup>(11)</sup>. Holoplankters have been the most numerous zooplankters offshore of Little Egg Inlet <sup>(11)</sup>. These are mainly copepods (nauplii, copepodites, adults). Copepods have been most numerous in bottom waters, while the remaining holoplankters were most dense near the surface <sup>(4, 5)</sup>.

The zooplankton population in the Bay itself consists of meroplankton (larval clams, hydroids, shrimp, crabs) and holoplankton (copepods, protozoans, chaetognaths) which may be further differentiated by size (micro versus macro). Plankton densities vary throughout the year <sup>(10)</sup>. Highest densities occur during warm seasons. Barnegat Bay microplankton density exceeds that of macroplankton.

Bivalve, polychaete and barnacle larvae are prominent meroplanktonic organisms in the Bay. Taken throughout the year at the Oyster Creek NGS, greatest densities of these organisms have been recorded during warm seasons, late spring through early fall <sup>(12)</sup>.

Recently, microplankton densities in the Bay have been higher off Oyster Creek and Forked River than other western Bay areas. <sup>(8)</sup> In most instances, the higher abundances have been due to high naupliar copepod density.

Macro-zooplankton in western Barnegat Bay during recent cool seasons has included chaetognaths, hydromedusae, shrimp, zoeae, polychaete (worm) larvae and

mysids<sup>(7, 8)</sup> While density of these organisms offshore of Oyster Creek and Forked River was generally high, all but polychaete larvae were also abundant in northern Bay areas rather than in southern areas, where the worms were denser.

e. Benthos

Plants and animals living on or in the sea bottom are collectively termed benthos. Animals which burrow into the sediment are referred to as infauna; those living on the sediment surface are called epifauna.

Numerous small invertebrates, bivalves, worms, isopods and amphipods live in the bottom sediments on the continental shelf<sup>(9)</sup>. In nearshore areas off Long Beach Island, capitellid worms (capitellidae), surf clam spat (Spisula solidissima) and the northern dwarf clam (Tellina agilis) are the dominant small invertebrates. Polychaetes, including capitellid worms, are most numerous.

The most important bottom species in nearshore coastal waters off southern New Jersey is the surf clam (Spisula solidissima)<sup>(4)</sup>. Adult Spisula support a major fishery. Most spawning occurs in July and August with minor activity in the fall. Larvae are in the planktonic stage for three weeks or more.

Organisms living on the bottom (epifauna) include moon snails (Polinices spp), sand dollar, horseshoe crab (Limulus), spider crab (Libinia), sand shrimp (Crangon), rock crab (Cancer irroratus), lady crab (Ovalipes ocellatus) and starfish (Asterias). Demersal fish such as flounder and dogfish are also found on the ocean bottom.

Barneget Bay supports abundant floral and faunal growth. Algal growth in central Barneget Bay is seasonal.<sup>(13)</sup> The species composition of the benthic algal community in the Bay has been comparatively stable on an annual basis in recent years. Ulva lactuca has been the most abundant macro-alga in the Bay (25-55% of the total dry weight of all algae collected during the 1969-1973 sampling period), but a limited number of species share dominance from season to season. Species composition differs between central Bay areas north and south of Oyster Creek. Codium fragile has been more abundant to the south (28% of total dry weight of algae), whereas Gracilaria spp has been prominent in areas north of Oyster Creek (33% of total dry weight). The difference has been linked to sediment particle size.<sup>(13)</sup> The prominent sea grass in the Bay is Zostera marina which appears to be present uniformly in central Bay areas. Mainland, Island Beach and Long Beach Island Bay shore areas are dominated by marsh grass (Spartina spp). Mainland river and creek mouths and Bay shores within State Park boundaries on Island Beach are the largest marsh areas.

The benthic invertebrate community in western Barnegat Bay is dominated by the polychaete worm, Pectinaria gouldii and the clam, Mulina lateralis. The isopod Cyathura polita and gem clam Gemma gemma dominate the benthic invertebrate community in eastern Barnegat Bay <sup>(14)</sup>. Hard clams (Mercenaria mercenaria) and bay scallops (Argopecten irradians) are harvested in Barnegat Bay. The clams represent the most valuable New Jersey Bay fishery resource. However, bacterial contamination has resulted in occasional condemnation of clam flats in various parts of the Bay. Scallop abundance is subject to wide fluctuation and, as a result, the commercial fishery is of minor importance.

Artificially formed aquatic habitats have resulted from dredge and fill operations along Barnegat Bay shores. The numerous deadend stream and river branches which are joined to the Bay generally via a single channel have resulted in limited flushing of the lagoon systems. The restricted water circulation leads to anaerobic water conditions near the sediment/water interface in the lagoons. Such conditions exist in the lower reaches of the Forked River and Oyster Creek where real estate development has occurred. Worms dominate the benthic biota in lagoons <sup>(15)</sup>.

#### f. Fouling Organisms

Organisms which attach themselves to firm substrates may become nuisances as fouling organisms. A number of fouling organisms may occur in dense patches offshore of Long Beach Island. Shipworms have penetrated experimental masonite panels submerged offshore of Little Egg Harbor Inlet.

The most abundant fouling organisms along the New Jersey ocean coast is blue mussel (Mytilus edulis). It appears to be limited in distribution to waters with temperatures of less than 80°F. <sup>(16)</sup> Barnacles, especially Balanus eburneus, are also common foulers <sup>(4, 5)</sup>. Barnacles themselves provide substrate suitable for further encrustation by either their own offspring or those of other organisms (e.g., mussels, hydroids or anemones). Additional encrusting foulers which occur outside the barrier islands include barnacles, sea anemones, hydroids, algae, the byozoan Schizoperella unicornis, and stony coral Astrangia danae <sup>(4, 5)</sup>. Fouling organisms such as mussels, oysters, barnacles, hydroids and shipworms also occur throughout Barnegat Bay.

Richards and Bellmore <sup>(17)</sup> recently reviewed the literature on shipworm (Teredo navalis, T. furcifera, T. bartschii, and Bankia gouldi) activity in Barnegat Bay. Ample evidence exists that shipworms have inhabited the Bay since at least the turn of the century. T. furcifera and T. bartschii are considered subtropical species, the latter having been found only in the Oyster Creek area of Barnegat Bay.

Shipworms can have extremely rapid generation times. Turner <sup>(18)</sup> noted that the organisms can settle, grow, and reproduce within six weeks. If suitable substrate is not found after 3 - 30 days, depending on species, the larvae will die. Production occurs in Barnegat Bay typically from May through September, with a peak in July. Release of T. navalis larvae occurs when temperatures are between 56.5° F - 86° F (13° C and 30° C) <sup>(19)</sup>, and optimum temperatures for larvae are from 68° F - 86° F (20° C to 30° C) <sup>(20)</sup>. Lethal temperatures for larvae are below 53° F (11.6° C) and above 35° C (95° F). Adults can apparently tolerate a wider range of temperature. Bankia gouldi reproduces at temperatures of 16° C to 20° or 30° C, and adults can tolerate extremes of 5° C and 23° C <sup>(19)</sup>.

Shipworms are euryhaline (i.e., they survive in a wide range of salinities). Salinity ranges reported in the literature for T. navalis are from 5 - 10% (lower limits) to 32 - 35% (upper limits). Normal larval development depends upon a salinity of at least 12% <sup>(20)</sup>. Apparently shipworms can also withstand very low dissolved oxygen concentrations, and can do quite well in waters such as those typifying estuarine lagoons.

Two isopod species, Limnoria lignorum and L. tripunctatum, are members of the marine wood borer community. These organisms are present in Barnegat Bay where salinities are higher than those at Oyster Creek (e.g., Barnegat Inlet and several other locations). They prefer salinities close to that of normal seawater, and have a lower tolerance of some 14 - 77% <sup>(17)</sup>. They are eurythermal, and can withstand temperatures between 34° F and 86° F. Reproduction takes place optimally between 72° F and 79° F (22° C - 26° C) <sup>(17)</sup>. L. tripunctatum are also tolerant of creosote, <sup>(17)</sup> which is generally used to protect marine structures from damage by most organisms.

### 3. Rationale, Materials and Methods

The following eight (8) types of alternative cooling water systems were evaluated for aquatic ecological effects:

- 1) existing once-through system with Oyster Creek discharge,
- 2) existing once-through system with canal or pipe discharge,
- 3) existing once-through system with helper cooling towers,
- 4) closed-cycle system with salt water mechanical draft or natural draft cooling towers,
- 5) closed-cycle system with fresh water wet/dry or dry cooling towers,
- 6) closed-cycle system with spray canals,
- 7) closed-cycle system with cooling ponds, and
- 8) once-through system with ocean intake and discharge.

Evaluation of the first seven of these systems was conducted for effects with zero, one, two and three dilution pumps operating. The first three systems were examined on the basis of whether or not they would be equipped with Ristroph bucket screens for reducing impingement mortality. Two ocean systems were considered (a high flow, low  $\Delta T$  system and a low flow, high  $\Delta T$  system), and two cooling pond sizes were considered as well. In addition, the effects during each season and the presence or absence of the Forked River Nuclear Generating Station (FRNGS) were included in the analysis.

Results are presented here for two seasons, winter and summer, and under the assumption that the FRNGS would be operating. Thus, flows and changes in temperature and salinity reflect operation of FRNGS and OCNGS. It was also possible to combine several of the closed-cycle salt water cooling systems on the basis of similarities in operational characteristics. For example, salt-water mechanical and natural draft cooling towers would have virtually identical makeup water and blowdown characteristics, hence they were combined for analyzing aquatic impacts. The same is true for spray modules and cooling ponds, although cooling ponds would require significantly greater amounts of land. In terms of intake and discharge (operational) effects, all of the saltwater closed-cycle systems were viewed as a single (generic) alternative.

Changes in temperature, changes in salinity, nekton entrapment and impingement and ichthyoplankton entrainment were the primary factors used to evaluate the various alternative systems (See Exhibit 105).

a. Entrapment/Impingement Methodology

For alternatives using the Forked River as an intake waterbody, entrainment/impingement data were available for the months of September - December, 1975<sup>(7)</sup> and March - April, 1976<sup>(8)</sup>. September and October were considered "warm" months in the analyses reported in this section, and were compared with "summer" operating data. The other months were arbitrarily designated as "winter" months.

To compare impacts of alternatives relying on a Forked River intake waterbody, impingement was scaled by system intake flow. Flow, in itself, is not always a useful scaling factor for predicting impingement rates; site specific abundance of organisms may be the key determinant. However, given some level of organism abundance, then operational characteristics of the power plant serve as secondary determinants. Characteristics of importance could be intake velocity, intake flow, intake area, and intake design. At the OCNGS, impingement has been correlated with intake flow, as discussed in Chapter IV.

Impingement and entrapment mortalities given in Exhibit 105 reflect results seen at OCNGS from September 1975 - April 1976. Ichthyological Associates, Inc.<sup>(7)</sup> found that immediate intake screen and dilution pump mortalities were 17% and 9%, respectively (average all species and time periods). Delayed mortalities based on capture and holding of specimens subject to these stresses were 58% and 37%, respectively. Thus, total mortality rates of 75% and 46% were used here in projecting impingement losses for systems using a Forked River condenser water intake and various levels of incremental dilution. These mortality rates may have an upward bias due to handling of the test organisms. The mortality figure (15%) used for the Ristroph adaptation to the traveling screens was based on total (all species) mortality observed at the Surry Power Station, located on the James River estuary in Virginia. The Surry plant is designed differently than OCNGS, but common species are impinged. The screen system used at Surry is fitted with buckets, which retain fish in pools of water prior to low pressure rinsing. To be effective, the screens must be rotated continuously. No data were available on delayed mortalities after return to the waterbody.

For the ocean intake systems (low and high flow), approximations of nekton entrapment (and ichthyoplankton entrainment) were made using data collected offshore of Long Beach Island, south of the postulated OCNGS intake area off Island Beach. Based on contour definition, habitat similarity, and expected similarity in finfish distribution, it was assumed that these data could be used to make first approximations of fisheries impact at Island Beach.

Entrapment estimates for pelagic fish were based on gill net data presented by Ichthyological Associates, Inc. in Table 81 of their 1975 report <sup>(7)</sup>.

Gill nets are selective for certain species and/or size groups of species, and no methods of estimating waterbody densities from gill net data have, to our knowledge, been published. These data, however, still comprised the best available information on abundance of pelagic fish, and an approximation method was developed for estimating pelagic fish density from this data, as outlined in the following paragraphs.

Consider the situation shown in Exhibit 106 in which a fish is located at point F somewhere near a gill net.

We chose to approximate the probability of gill net capture by the probability that, swimming at a constant speed along a straight path, the fish would intersect the gill net. Assuming the fish swims in any direction with equal probability, it follows that the probability of gill net intersection is  $A/2\pi$  multiplied by  $B/2\pi$ , where A and B are the horizontal and vertical angles, respectively, subtended by the gill net (Exhibit 106).

If  $f(A, B)$  represents the spatial density function of fish by angles subtended to the net, then the expected capture probability is

$$E(P) = \int_0^\pi \int_0^\pi \frac{AB}{4\pi^2} f(A, B) dA dB$$

The value of this double integral is 1/16, when  $F(A, B)$  is uniform ( $= 1/\pi^2$ ). In other words, 1/16 of the fish actually present would be captured under these assumptions. However, this technique is clearly unrealistic if A and B are allowed to assume values without further restriction, since this would permit the capture of fish at infinite distances from the net. A better approach is to apply the 1/16 probability computed above only over a finite

capture region. This capture region was defined as the locus of all points such that the probability of net intersection was not less than .01, i.e., such that  $A \geq .04\pi^2/B$ . Fish located outside this capture region were disregarded.

The shape of this region is complicated, and the volume of the region was difficult to compute directly. It was observed through trial and error that a reasonable approximation to the capture region's volume could be obtained by treating the capture region as a circular disk of thickness  $D/2$  and radius  $L/2$ , where D and L are the depth and length of the gill net in question, respectively. Thus, the volume of the capture region was given by:

$$\text{Volume} = \frac{D}{2} \times \left(\frac{L}{2}\right)^2 \times \pi$$

For the 12 ft. by 900 ft. nets used to collect the data of interest here, the volume was computed to be  $3.8 \times 10^6 \text{ ft}^3$ . Then,

$$\text{gill net catch (fish)} = \frac{1}{16} \times 3.8 \times 10^6 \text{ ft}^3 \times \text{fish density}$$

and the fish density was estimated to be  $\frac{16}{3.8 \times 10^6 \text{ ft}^3} \times$  the gill net catch.

Densities were finally expressed on a metric basis (fish/100  $\text{m}^3$ ).

Since the defined capture region is small, swim speeds of species in the habitat are not a factor in calculating the capture region.

Demersal fish densities were based on trawl data from offshore of Holgate, Long Beach Island (Table 17 of Reference 4). Densities per 100  $\text{m}^3$  were determined in a disaggregate fashion for the appropriate stations. Sample volumes ( $4700 \text{ m}^3$ ) were approximated by multiplying the distance of each haul (92 km) by the effective fishing width of the net (5.1 m) and by the height of the trawl (approximately 1 meter). The total number of specimens per 100  $\text{m}^3$  was then determined from the disaggregated densities for each station. Arithmetic monthly means were then calculated.

To estimate total densities of fish available for entrapment, densities of fish based on gill nets and trawls were added. This appears valid because the two pieces of gear sampled different fish species, with trawls catching a large number of hake, blueback herring, pipefish, silverside, anchovy, and windowpane flounder, and gill nets taking dogfish, menhaden, and weakfish.

## b. Ichthyoplankton Entrainment Methodology

Condenser entrainment mortalities were assumed to be 100% for ichthyoplankton. Marcy<sup>(21)</sup> has demonstrated high levels of mechanical damage for ichthyoplankton entrained at the Haddam Neck (Connecticut) nuclear power plant, and it is not unreasonable to assume 100% mortality considering the combined effects of temperature shock and mechanical stresses.

Estimates of ichthyoplankton entrainment with an offshore intake were based on collections made offshore of Holgate and Brant Beach, New Jersey. Total counts and volumes for each sample except TRT-74-114 (see Reference 5) were used to calculate monthly and seasonal mean densities. Forked River estimates were derived from ichthyoplankton entrainment data (total fish eggs and larvae) presented in References 7 and 8.

May - October, and November - April data were designated as "summer," and "winter" data, respectively. Entrainment was considered strictly flow dependent, and densities were multiplied by water withdrawal rates to quantify losses to the cooling water system.

## c. Additional Considerations

The methodology for determining changes in temperature and salinity are described in Sections III-G and III-I respectively.

In addition to considering the quantitative values of the four differentiating factors, the assessment of impact was modified in some cases by additional considerations: potential for increases of fouling organisms in the habitat or engineering systems; possible construction effects, impacts on sport fishing; etc.

## 4. Results - Comparison of Alternatives

### a. Overview

#### 1. Differentiating Factors

Quantitative values assigned to the four differentiating factors listed in Exhibit 105 are shown in Exhibits 107 and 108. Changes shown for temperature and salinity ( $\Delta T$  and  $\Delta S$ ) assume both OCNGS and FRNGS operation and would change if the FRNGS was inoperative.

Impingement estimates employed flow-adjusted impingement rate values and the estimated mortality rates shown on Exhibit 105. The canal-to-bay or existing system without Ristroph bucket screens was estimated to impinge 14,000 fish per week in summer. Of this total, 75% or 10,500 fish would be expected to die. With one dilution pump operating, an additional 1000 deaths would be predicted; with two dilution pumps, 2000 additional deaths would be predicted. With the bucket screens, mortalities could drop to 2000 fish per week without dilution, assuming that the system would work as well at OCNGS as it appears to work at Surry. The salt water closed-cycle alternatives would impinge  $14000 \times 75\% \times (22,000 \text{ gpm}/460,000 \text{ gpm})$  fish plus produce incremental dilution mortalities, and the fresh water wet/dry towers would impinge nothing when used without dilution pumps (dilution pumping would represent the only direct population losses).

Entrainment estimates were also flow-adjusted, and results were expressed on the basis of equivalent adult losses<sup>(22)</sup> using an assumed rate of natural mortality through the entrainable life stages of 90%. Corresponding ocean impingement/entrapment rates and entrainment rates are discussed subsequently in this section.

Data presented in Exhibits 107 and 108 illustrate some important results:

- 1) If the assumptions used in this section are correct, Ristroph bucket screens on the existing system may reduce impingement losses to within the same order of magnitude as the closed cycle alternatives;
- 2)  $\Delta T$ 's associated with closed cycle alternatives are such that dilution pump operation would still be required, particularly in winter;
- 3)  $\Delta S$ 's associated with closed cycle alternatives could cause substantial increases in salinity, which is important when considering proliferation of nuisance species and resulting socio-economic penalties;
- 4) Use of a third dilution pump would not decrease either temperature or salinity significantly, relative to the increased penalty of causing greater entrainment and impingement losses.

Information in Exhibits 107 and 108 was used as input to a cluster analysis algorithm. Clustering is used for grouping like objects, a major purpose being data reduction. Clustering can only discover sets of data which are similar to each other<sup>(23)</sup>. The model used to assess similarities among alternative cooling systems and dilution pump combinations involved a general coefficient of similarity described by Gower<sup>(24)</sup>. In this procedure, impact variables were normalized to a scale of 0 to 1.0, based on the range over each variable. Then, similarity coefficients for each pair of cooling system X dilution pump alternatives were computed as the sum, over all variables, of 1 minus the absolute difference in the values of a given variable for the pair of alternatives being compared. Variables received equal weight.

Results of this analysis, for both summer and winter (as defined previously), are shown in Exhibit 109. The values shown under "First Order Similarity" are the average values of the similarity coefficients for all pairs of alternatives in a given cluster. Higher order columns contain analogous average values with increasing numbers of clusters combined into larger groupings. Major differences in clusters can be identified as being due to flow rate, operation of a dilution pump, and presence of fish buckets on the traveling screens. No statistical significance is attached to clusters of systems shown; they serve only to illustrate gross differences among alternatives subject to conditions and assumptions described previously.

#### ii. Wood Borers

In Oyster Creek, where the operation of OCNGS can raise temperatures to 70° F in November, shipworm reproduction activity can be extended. This has been documented by gonadal studies<sup>(25)</sup>. An extended period of OCNGS plant shut-down in the winter of 1975-1976 may have caused heavy mortality of shipworms and a corresponding reduction in boring activity during 1976. In addition, two other factors - the severe cold temperatures in that winter and the removal of wood habitat earlier - served to reduce borer activity throughout Barnegat Bay in 1976. Possible influences on shipworm populations are discussed subsequently in this section.

#### iii. Temperature and Cold Shock

Each species (and often each distinct life-stage of a species) has a characteristic temperature tolerance range. The specific limits of this range are usually influenced by the acclimation temperature experienced by the

organism. Living systems respond to changes of temperature. (26)

Organisms possess upper and lower thermal tolerance limits, an optimum temperature for growth, and preferred temperature for life functions such as migration, spawning, and egg incubation. Organisms can also be affected by changes in physical characteristics of water during temperature changes. Viscosity, degree of ice cover, and gas saturation limits are some of the characteristics influenced by temperature.

With few exceptions aquatic organisms have body temperatures the same as the water in which they reside. These waters are normally stable in that temperatures change slowly over a year's time, although rapid fluctuations do occur from time to time due to local storms or unusual meteorological conditions. The overall result is that aquatic organisms over the millennia have adapted to these relatively stable conditions.

The temperatures typical of an area will dictate the species composition of the area's ecological system. Temperature changes of a permanent nature will allow a shift in this species composition. For the Barnegat Bay area, natural temperature changes (as occur via seasonal periods) are in equilibrium with the present species composition and with present life histories of indigenous species. Variations of this temperature regime would be expected to cause a change in the species composition.

Large day-to-day temperature fluctuations can be detrimental to local species, with mortality as a common result. Each degree of temperature change from an ambient level has varying significance for an organism depending upon where the ambient level lies within its tolerance range. (2)

A few terms need to be defined before proceeding. Lethal thresholds of temperature are referred to as "incipient lethal temperatures". This is defined by the survival of 50 percent of a sample of individuals. Survival depends not only on temperature but also on duration of exposure, salinity of water, and condition of the organism, to mention a few. Bliss<sup>(27)</sup> indicates that organisms respond to extreme high and low temperatures in a manner similar to the dosage - response pattern common to toxicants and pharmaceuticals.

The tolerance range of an organism can be adjusted to a limited extent if time is available for acclimation. The ultimate incipient lethal temperature is the limit to which an animal can be acclimated. Organisms function somewhere between these upper and lower limits, doing best in terms of growth, overall metabolism, reproduction, and other ecological factors at some optimum temperature.

During winter months, artificially-produced temperature increases may create conditions expected by migrating fish, such as bluefish and menhaden. Thus, instead of migrating to warmer climates, these fish remain in the artificial area and experience the temperatures they are initially seeking. This condition will restrict movement and make it unsafe for these fish to return to ambient temperatures should the artificial heating stop.

Loss of access to the warm water causes an organism to go through "cold-shock". The difference in temperature will determine the degree of stress the animal will suffer. This will affect the organism's ability to deal satisfactorily with its environment. Sublethal physiological problems may be incurred. If the change in temperature is large enough, mortality will occur. Records of cold-shock mortality discussed in Section III-L-1 and, in greater detail, in Exhibit 110 bear this hypothesis out. Species of fish involved in cold-shock mortality at OCNGS are predominantly bluefish (Pomatomus saltatrix) and menhaden (Brevoortia tyrannus).

#### b. Existing System

The OCNGS system as it exists and operates today is a necessary point of reference for comparing alternative systems. This is particularly true of impingement and entrainment estimates.

The OCNGS draws 460,000 gpm water from the Forked River to cool its condensers. Dilution pumps pass 260,000 gpm each. With or without FRNGS blowdown in summer, winter or spring, the T's are 20° F at zero dilution; 13° F with 1 dilution pump; 9° - 10° F with 2 dilution pumps; and 7° - 8° F with 3 dilution pumps. Salinity increases due to actual condenser cooling are negligible, but a general increase in creek salinity has occurred because of the way the system was constructed (i.e., channelization).

## 1. Wood Borers

Local increases in wood borer activity could have occurred in Oyster Creek as a result of lengthening of the reproductive season due to discharge of heated water. The extent of such increase has been amplified by abundance of wood in the area. Removal of wood by JCP&L has apparently alleviated some of the problem in Oyster Creek, and recent extended cold waves along the New Jersey shore have reduced shipworm populations. The potential for seasonal growth and reproduction of shipworms remains real unless two dilution pumps are operated from September through April. Summer operation without dilution could have beneficial effects in limiting Teredo success in Oyster Creek (i.e., raise the temperature above 95° F), but could have detrimental effects on the ecosystem as a whole.

Limnoria has not been found to date in Oyster Creek; it is apparently restricted by suboptimal salinities.

## ii. Cold Shock

As mentioned in the introduction to aquatic ecological effects, menhaden and bluefish have been killed at OCNGS as a result of cold shock. Fish attracted to the heated effluent in cold months and acclimatized to the increased temperature of the creek have not been able to tolerate sudden decreases in temperature. Since the dilution pumps have been operating, fish kills have been few. Experience during the winter of 1975-1976 was of limited predictive value since the plant was either not operating or operating at restricted capacity. Dilution pumps can cause greater stress to occur if they remain in operation during reactor shutdowns than would be the case if they were turned off. This can occur because the addition and mixing of the dilution water to the discharge, which is already falling in temperature, increases the rate of temperature decline in the volume occupied by the thermal plume.

The Environmental Protection Agency "Blue Book"<sup>(26)</sup> states that:

"Important species should be protected if the maximum weekly average temperature during winter months in any area to which they have access does not exceed the acclimation temperature (minus a 2° C safety factor) that raises the lower lethal threshold temperature of such species above the normal ambient water temperature for that season, and the criteria for short-term exposure is not exceeded"

For bluefish, lower lethal thresholds appear (from laboratory observations) greater than ambient temperature at all acclimation temperatures tested. Except for larvae, we have not found data on lower thresholds of Atlantic menhaden. Recent experience at OCNGS suggests that with extended and gradual acclimatization, menhaden can withstand temperatures of 38° F.

If two dilution pumps are operated at OCNGS during the time when menhaden and bluefish might ordinarily emigrate from Barnegat Bay,  $\Delta T$ 's of 10° F could still serve to attract these fish to the discharge, creating a potential for subsequent cold shock.

### iii. Entrainment

With the existing system, there is no proven mechanical method of reducing the rate at which plankton is entrained. The only means of reducing the total number of organisms entrained would be to operate the FRNGS, OCNGS and dilution pumps in such a way as to minimize total water withdrawal when plankton were most dense (seasonally or diurnally). This may not be practical.

The rate of entrainment is maximized with once-through systems (existing, canal or pipe, helper towers). Only the ocean system would have a potential for entraining more ichthyoplankton than the present once-through system. Although mortality of ichthyoplankton was assumed to be 100% with any once-through Forked River system, the present design may actually have a slight advantage over the other designs. The organisms which pass through the condenser cooling system are exposed to high temperatures for a shorter period of time with the present once-through design than with the alternative once-through designs.

### iv. Entrapment/Impingement

The present rate of impingement at OCNGS is probably maximum relative to possible closed-cycle alternatives considered in this report. In selecting preferred alternatives, a linear relationship between capacity and impingement was assumed.

Approximately 50 percent of the more than 36,000 impinged organisms sampled and examined at the intake screens from September, 1975 through April, 1976 appeared dead or damaged<sup>(7)</sup>. The plant was shut down during January and February. Of approximately 7,000 bay anchovies whose condition was evaluated, 90 percent were dead or damaged. Sand shrimp showed less injury due to impingement. Of approximately 10,400 sand shrimp examined after collection, only

24 percent were dead or damaged. Delayed mortality was estimated to be 58% of the total number of organisms impinged, but handling stress may have inflated the real figures. Blue crab showed no delayed mortality and adults appeared to be active near the discharge outfall, even when effluent temperatures were over 35° C.

Passage through the dilution pumps appears to be less stressing than impingement on the screens, but delicate species like anchovy, menhaden, or herring are vulnerable to damage and mortality. Bay anchovy, generally the most abundant fish species in the region, showed high injury and mortality. A combined total of 64 percent of the 61 specimens sampled from October, 1975 through April, 1976 was affected. Sand shrimp showed a low percentage of injury (4 percent dead or damaged out of 566 specimens examined). The dilution pumps were operated while the plant was shut down in January and February.

The design of the intake and discharge canals offers little opportunity for escape from screen impingement and dilution pump entrainment. The only means of escape from the plant intake of the dilution pumps is movement against the current in the intake canal in order to gain passage to the Bay or other Forked River tributaries.

While methods of diverting fishes from power plant intakes have been demonstrated using louvers and bubble screens, such precautions would be of little benefit to OCNGS unless located in a way that would prevent fishes from entering the south branch of the Forked River.

As discussed previously, the Ristroph bucket concept of screen design would probably reduce mortality of impinged organisms (see Exhibit 107 and 108)

#### v. Other Impacts

The existing system provides an opportunity for sport fishing along parts of Route 9, and at the mouth of Oyster Creek. Finfish attracted to the plume apparently provide for good fishing success.

#### c. Canal (Pipe)-to-Bay System

##### 1. Wood Borers

Since the heated effluent would be contained in the canal, the amount of borer habitat exposed to high  $\Delta T$ 's would be minimized. However, a canal or

pipe discharge closer to the mouth of Forked River could cause an increase in the amount of effluent recirculation in an area where borer habitat is substantial. Recirculation to Forked River is estimated to be about 4%. In addition, flow augmentation of Oyster Creek would be necessary to prevent recirculation into that water body (see Chapter IV).

#### ii. Cold Shock

Cold shock potential with the canal (pipe)-to-bay system is limited to a small area near the point of discharge. With less habitable water volume (due primarily to mixing directly with Barnegat Bay water), and discharging into a relatively unconfined area, fish concentration should be reduced and habitat temperature diversity increased. The canal system is preferable to a pipe, but neither system should develop its own indigenous fish community because a weir, or waterfall structure, is located at the point of discharge. Organisms washed from the travelling screens and/or passed through the dilution pumps could conceivably take up residence in the canal, however.

#### iii. Entrapment/Impingement

Impingement rates described for the existing system are applicable to the Bay discharge alternative. However, delayed mortalities of organisms washed from the screens may increase because of mechanical stresses and longer time-excess temperature experience in the discharge canal. This may be true despite an expected doubling in transport rates back to the bay (i.e., velocities double those in Oyster Creek). Oyster Creek may provide refuges for these animals.

#### iv. Entrainment

Since 100% condenser entrainment mortality was assumed, the discussion of entrainment associated with the existing system is applicable for the canal (pipe)-to-bay system.

#### v. Construction

Construction effects on aquatic ecology would be expected to be insignificant. Care would be required to minimize physical and chemical effects of total suspended solids and dredge-spoil extract on local areas of Barnegat Bay. Potential wetland losses are discussed in Section III-M.

#### vi. Other Impacts

With a pipe discharge system, a potential for system biofouling exists

(Barnacles). This is particularly acute during and after construction, but prior to operation. If invertebrate larvae survive passage through condenser cooling system pipes or dilution pumps, the velocities expected in the discharge pipes (0.6 - 1.2m/sec) are insufficient to prevent settlement. Maintenance of 3 m/sec velocities is generally considered to be the only effective means of limiting biological fouling in coastal region cooling systems.

If a canal or pipe were to replace the present Oyster Creek discharge channel, downstream flow in the creek would be substantially reduced. Freshwater flow from Oyster Creek would be the only upstream input, as it was pre-1965. Because of the dredging, bay and tidal influence would have a much greater effect than pre-1965. Extensive habitat work (e.g. fill) would be required to produce the original watershed characteristics. However, these modifications probably would not be sufficient to insure acceptable water quality in Oyster Creek (see Section IV-F).

#### d. Low Discharge Temperature Helper Tower System

This system utilizes the same circulating water flow (460,000 gpm) as that of the existing system. Supplemental cooling is provided by passing the condenser cooling water through cooling towers prior to discharge. Oyster Creek salinity would be increased by only 3-4 percent without dilution. Temperature increases with this system\* would be less than 1° Fahrenheit in summer, without dilution. In winter, operation of two dilution pumps would result in a mixed  $\Delta T$  of 4.7° F. Operation with no dilution would cause a 9.8° F mixed  $\Delta T$  in winter.

#### i. Wood Borers

In terms of temperature reduction, the helper tower system is attractive. In spring, summer and fall, the  $\Delta T$ 's in Oyster Creek would probably be insignificant (roughly 3° F in spring and fall). Accentuated reproduction of shipworms is not expected at those  $\Delta T$ 's. Likewise, recirculation of the heated effluent will have an insignificant effect on Forked River water temperature. With the once-through operation, a net flow into Forked River and out of Oyster Creek would be maintained.

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\*For combined OCNGS, FRNGS discharges.

Limnoria attack is not predicted because of the marginally acceptable salinities involved.

ii. Cold Shock

The potential for cold shock would be significantly reduced if two dilution pumps were operated from approximately October through March. Temperature increases with this system would be half those of the existing once-through system.

iii. Entrapment/Impingement

With regard to entrapment and impingement effects, this alternative is similar to the existing system with or without bucket screens. A possible reduction in delayed mortality could result from returning all of the individuals impinged on the screens and displacing all pumped (by dilution) individuals in water of ambient temperature (i.e., upstream of the point of discharge of the helper towers).

iv. Entrainment

Entrainment rates would be similar to that observed in the existing system. However, the mortality rate of all organisms (regardless of type) may be 100%.

v. Other Impacts

The increased chlorination that may be required for biofouling control in the cooling towers could result in higher total residual chlorine (TRC) concentrations in Oyster Creek.

e. Salt Water Cooling Towers

The various mechanical and natural draft alternatives utilizing saltwater makeup from Forked River would have similar blowdown flow rates and qualities. Temperature rises above ambient would also be similar, though not identical.

As shown in Exhibit 65, Oyster Creek water temperature rise without dilution, and with FRNGS blowdown, would be approximately 9° F in summer, 30° F in winter, and 18° F in spring/fall. Without FRNGS,  $\Delta T$ 's are predicted to be about 4° F lower. With two dilution pumps, and FRNGS operating,  $\Delta T$ 's would be less than 1° F in summer and less than 3° F in winter.

Salinity increases of 50 percent in summer and 30 percent in winter are estimated with no dilution. With two dilution pumps, salinity increases due to discharge of cold side blowdown would be minimal (3 percent as compared with 1 percent with the existing system).

#### i. Wood Borers

Closed-cycle saltwater cooling towers (mechanical or natural draft) would discharge blowdown which has a salinity of 40-45 ppt and, in winter, a temperature rise of 30° F. Thus, operation of at least one dilution pump would be required to achieve acceptable water quality.

Without dilution, Teredinid activity could increase given acceptable substrate, and Limnoria infestation is possible. Success of Limnoria and Teredo in a competitive situation is not clearly understood. Nevertheless, increase in colonization by either organism would be unacceptable. With two dilution pumps operating, temperatures and salinity would not alter the balanced indigenous community.

Cooling tower operation would produce approximately a 50 percent reduction of flow in the South Branch of Forked River if two dilution pumps were utilized. There is an abundance of wood in Forked River, and shipworms occur there in some abundance. The possibility that the OCNGS acts as a predator on their larvae, by continually extracting them from the system and passing them through the condensers, is an important concept. The OCNGS and FRNGS would require makeup water of only 1/10 the amount currently withdrawn by OCNGS, if both stations utilized closed-cycle cooling. If condenser mortality of Teredinid larvae were 100 percent, and that source of predation were decreased significantly (by reducing intake flows), one could conceive of a situation whereby settlement in Forked River would increase over that presently occurring. This possibility is also discussed in Chapter IV.

#### ii. Cold Shock

The cold shock potential with closed-cycle saltwater cooling towers would be minimal, provided that the dilution pump system operates continuously.

### iii. Entrapment/Impingement

Dilution pump entrapment would be expected to remain the same as that of the existing system. Reduced water velocities and flows would be expected to cause a reduction in screen impingement. The relationship may not be linear (as assumed here) but some reduction would occur. Prediction is complicated by the nature of the intake canal system and environmental factors. Additionally, the feeling has been expressed that if fish were not screened, they would be passed through the dilution pumps. There is also the possibility that fish or crustaceans can simply reside in the area longer without being either pumped or screened.

### iv. Entrainment

Entrainment of plankton should be a function of flow rate. Reduction in velocity would be expected to enhance the survival of motile forms (fish post-larvae or young-of-the-year) which may resist velocities of 0.5 to 1.0 fps but would still be able to pass through the 3/8-inch traveling screen mesh.

With the closed cycle system, dilution pumping would account for the greatest rate of entrainment, but actual mortality through those pumps would probably be less than that through the condensers.

### v. Other Impacts

The potential would exist for increased residual chlorine concentrations in Oyster Creek.

### f. Spray Canal

The spray canal system has aquatic ecological impacts similar, if not identical, to those of the saltwater cooling tower systems discussed above.

### g. Cooling Ponds

The cooling ponds (500 acre and 1000 acre) have makeup and blowdown characteristics essentially the same as those of the saltwater cooling towers and, therefore, entrainment, impingement, wood borer and cold shock impacts would be similar.

Pond construction would require a commitment of large amounts of land, much of it infringing upon other, presently unaffected watershed. This impact, and

the fact that effects on downstream users in Forked River or Waretown Creek are unclear (but possibly significant), would render these alternatives unacceptable from the viewpoint of aquatic ecology.

#### h. Fresh Water Wet/Dry Towers and Dry Cooling Towers

Fresh water wet/dry and dry cooling towers are basically the only alternatives for which a clear line of demarcation exists, depending on whether FRNGS is in operation. Dilution pumping and FRNGS pumping and blowdown would dominate the aquatic system.

Temperature and salinity increases would be substantial without dilution, as with the salt water towers. However, since the blowdown volume would be so small, compliance with aquatic ecological water quality requirements would be possible with only one dilution pump operating.

##### i. Wood Borers

When operating with one dilution pump, the probability of enhancing borer activity would be minimal. The increase in salinity with FRNGS operating is predicted to be approximately 1 percent. Salinities would still be expected to be marginal for Limnoria.

##### ii. Cold Shock

With one dilution pump in operation, the cold shock problem is expected to be insignificant.

##### iii. Entrapment/Impingement

Since groundwater would be utilized as a makeup source, dilution pump mortality would constitute the only source of entrapment impact. Pump mortality should be much lower than that of the existing system.

##### iv. Entrainment

Dilution pumping would be the only cause of entrainment. Mortality and population effects are expected to be insignificant. With FRNGS operating, condenser entrainment would also occur, but significant impacts would not be expected.

##### v. Other Impacts

The potential exists for increased residual chlorine concentration in Oyster Creek.

### 1. Ocean Intake and Discharge

The two alternatives considered for ocean intake and discharge systems were a single pressure condenser with a flow rate of 496,000 gpm discharging water at a  $\Delta T$  of 20° F and a multi-pressure design with a flow rate of 177,400 gpm, resulting in a  $\Delta T$  of 48° F.

Based on preliminary thermal plume models, and the expected density and importance of organisms offshore of Island Beach, the multi-pressure (low - flow/high  $\Delta T$ ) system should result in a lower impact than the high-flow design.

#### i. Entrapment/Impingement

Estimates of nekton entrapment based on the highly presumptive methods outlined in Section III-L-3 range from 1 million fish per week (May - October) to 5 million fish per week (November - April). Actually, rates as high as these should only be expected during some four weeks of each year, when anchovies are in greatest abundance offshore. Weekly rates during more than 80% of the calendar year should be much less than the above estimates suggest, since these estimates were derived from raw (untransformed) sampling data and conservative assumptions regarding susceptibility to entrapment.

#### ii. Entrainment

Ichthyoplankton entrainment estimates for the multi-pressure system are 2300-3500 organisms per minute. Mechanical and time - excess temperature histories of organisms in such a system ensure 100 percent mortality.

#### iii. Other Effects

An important aspect of the ocean system from the standpoint of aquatic ecology is construction impact, particularly in Barnegat Bay. Benthic habitat and biological productivity would be lost while the pipe is being laid. It is estimated that approximately 175,000 cu. yd. of ocean substrate and 150,000 cu. yd. of bay substrate would be dredged. In addition, approximately 32,300 sq. ft. of marsh habitat inside of Island Beach would be destroyed. At this time, only the particle size composition of Bay sediments is known. Toxic

substances and oil and grease are certain to be present in bay sediments due to boating activity. The combination of direct habitat loss and possible effects of dredge spoil extract could constitute a serious source of impact on bay productivity.

Biological fouling in the circulating cooling water system is a factor which must be considered in the choice of an alternative system. Mussels, in particular, would constitute a threat to the system's viability. Nevertheless, experience at other utilities (Carolina Power & Light, Long Island Lighting Co., United Illuminating Co., Pacific Gas & Electric) suggest that control would be possible if in-pipe current velocities are maintained at 10 fps throughout the system. Thermal backwashing can be used in conjunction with high velocities as a technique to limit mussel attachment and growth. Antifoulant coatings are also available, but primary success is usually achieved by high velocities in the pipes.

A heated effluent has, theoretically, some probability of attracting organisms and thus interrupting the normal migratory behavior of populations utilizing the route. This potential would probably be very low with the diffuser discharge, but may be a controversial topic. Time - excess temperature exposure for organisms entrained into the discharge plume would be short (no quantitative estimates were made).

#### 5. Summary

Exhibit 111 summarizes the aquatic ecology results for each cooling system type. Entries in the table refer to the existence of an overriding environmental impact for the particular combination of cooling system and dilution pump scheme.

The exhibit shows that only the cooling pond systems and helper cooling tower systems would have an overriding impact, based on a preliminary evaluation. The cooling ponds require that a large amount of watershed be disrupted or destroyed. The helper towers offer no advantages over the closed-cycle systems and exhibit much greater rates of impingement and entrainment. These systems were eliminated from the list of preferred alternatives on the basis of overriding aquatic environmental impact.

The preliminary evaluation of the ocean intake/discharge system did not yield any overriding impacts in aquatic ecology. However, this system would

have the potential for high impacts in the areas of construction effects (e.g. toxins released by dredged material in Barnegat Bay, and loss of benthic organisms in dredging operations) impingement and entrainment.

The remaining cooling systems were acceptable for one or two dilution pump operation. Three pump operation produces excessive increases in entrainment/impingement rates in return for a given level of water temperature reduction in Oyster Creek. Operation of the cooling tower or cooling pond systems with no dilution pumps would produce unsatisfactory increases in Oyster Creek salinity.

SECTION III-L

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M. TERRESTRIAL ECOLOGY

1. Introduction

Mixed hardwood pine forest forms the most extensive habitat type within a five-mile radius of the Oyster Creek Site, covering 32 percent of the area. Exhibit 112 presents a vegetation map for the site area. Dominant plant species in the region are pitch pine (Pinus rigida) and several oaks (Quercus spp). Understory species common to several habitat types include sassafras (Sassafras albidum), mountain and sheep laurel (Kalmia latifolia and K. angustifolia) and bracken fern (Pteridium latiusculum). The occurrence, distribution and abundance of faunal species are consistent with the variety of habitats in the site region (i.e., shore, marsh, swamp, river bottom and upland forests).

Impacts of the alternative cooling systems on the site's terrestrial ecosystems would be primarily related to the land requirements, effluent characteristics, and structural design of the systems. Impacts resulting from land requirements would depend on acreage required and the ecological sensitivity of the affected areas. Depending on the type of cooling system, effluent effects may be caused by the atmospheric emission of salts and their ultimate deposition on the surrounding environs or as a result of heat discharged into man-made water bodies. Structural design-related impacts could be associated with the potential for facility encroachment into bird flyways, etc.

The alternative cooling water systems were evaluated to consider their physical and chemical characteristics in relation to the terrestrial ecological characteristics of the site environs. Relevant research findings reported in site-related reports and scientific literature were used to rate the type and severity of impact on a qualitative basis as high, medium, low or not applicable. The several (e.g., land, flora, fauna) impact "ratings" for each cooling system alternative were then used to derive a summary rating which represented an estimate of the total system's impact on the site's terrestrial ecosystems, relative to the other alternative cooling systems.

## 2. Results and Discussion

### a. Land Requirements

The alternative cooling systems vary in their permanent acreage requirements from approximately 10 acres (cooling towers) to 1,000 acres (largest cooling pond). The impacts due to the land requirements of the alternative cooling water system would essentially be related to construction of the systems. The clearing of vegetation would eliminate or displace fauna which may utilize the area as a habitat, and emigrating organisms may be subject to stresses as a result of displacement from their home ranges. Based upon studies conducted by others, <sup>(1)</sup> mammals dispersed into unfamiliar surroundings are considered more vulnerable to predators and other causes of death.

Sensitive terrestrial ecological areas which should be avoided include white cedar swamp forests, saltwater marshes and barrier island beaches. White cedar forests and saltwater marshes are relatively rare vegetation types in the study region. Within a five mile radius of the site, these types occupy only 1.2 percent and 3.5 percent of the area, respectively. <sup>(2)</sup> The southwestern section, Island Beach State Park, is basically a pristine example of a barrier island beach.

The alternative cooling water systems which could have the most significant impact on sensitive areas are the 1,000 acre cooling pond, the canal (pipe)-to-bay, and the once-through ocean systems. If the 1,000 acre cooling pond were built, cedar swamp forest would be lost. The canal (pipe)-to-bay system would damage portions of the saltwater marsh, while the once-through ocean system would require a pipeline crossing in the undisturbed island beach habitat of Island Beach State Park.

Ratings for impact due to land requirements reflected the extreme difference in acreage required between the two cooling ponds and the other alternative cooling systems. Loss of 500 or 1,000 acres of terrestrial habitat due to cooling pond construction was considered a high-level impact. The remaining cooling systems, which all would require less than 25 acres, would have minimal (low) impact on the site's terrestrial eco-

system, from the viewpoint of land requirements.

b. Atmospheric Effluents

i. Vapor Emissions

Ground level fog produced by any of the alternative cooling systems is not expected to impact offsite terrestrial ecosystems.

Ice deposited from freezing steam fog from any cooling system source, including cooling ponds and towers, would be light and friable, similar to that deposited by natural freezing fog.<sup>(3)</sup> This type of ice, termed rime, does not damage woody vegetation as would dense glaze ice formed by freezing rain and drizzle. The spray system, however, may well deposit a dense glaze on objects or vegetation near the canal during freezing weather conditions. Since the area within about 2,000 feet of the canal is primarily unforested (See Exhibit 112), any impact due to icing from this system would be minor in terms of area affected. The pine forest near the northeastern portion of the spray canal, however, may experience some damage due to icing.

The exhaust heat from a dry cooling tower is not expected to affect terrestrial ecosystems in the region of the Oyster Creek site. The warm air plume would disperse before it reaches offsite vegetation.

ii. Salt Emissions

Spray canal systems and wet cooling towers using saline water sources deposit salt on their surrounding environment. The amount and areal extent of deposition varies for these cooling systems, depending on factors such as the height of the air/cooling water interface, the salt concentration of the cooling water, and the size distribution of water droplets released from the cooling system.

Salt deposition from cooling systems can affect vegetation through soil contamination or direct foliar contact. There is, however, a major difference in effects between these two pathways. Soil contamination can produce a chronically deteriorating biota over the life of the facility while foliar contamination could result in a series of damaging episodes largely independent of one another.<sup>(4)</sup> While salt crystals impacted on leaf blades are

washed off during periods of rain, salts accumulated on leaf surfaces between rainfalls may be rapidly absorbed by foliar tissues when relative humidity is sufficient to maintain salts in the dissolved state (5, 1).

Chloride has been the major focus of saltwater cooling tower studies because this ion represents a major component of emitted salts, and because it has been identified as the toxic agent in experiments where foliar damage resulted from applications of sea spray or road salt. (6, 7) Through foliar absorption, plants may achieve relatively high chloride ( $\text{Cl}^-$ ) levels which would not normally result from soil uptake.

Spray canal systems and mechanical draft cooling towers would produce maximum deposition rates close to the source while a natural draft tower may deposit maximum salt loads up to several miles distant.

Deposition from the Oyster Creek NGS would need to be viewed in the context of natural salt deposition rates for coastal areas. Salt becomes airborne naturally by the bursting of air bubbles at the surface of the sea and the subsequent transport of saltwater droplets in air. Wind, waves and surf action all contribute to this process. Storms can increase natural levels of airborne salt because of increased sea turbulence. The action of surf on beaches is responsible for large amounts of salt in a narrow band of air near the shoreline. Wave action on the ocean distributes lower concentrations of airborne salt over a greater area, including significant distances inland. (8) In nearshore areas, these two processes interact to cause high airborne salt concentrations which quickly decrease a short distance inland to relatively constant low-level concentrations. In the Barnegat Bay area near the site, this decrease occurred less than four miles from the outer beaches of the barrier islands. (8)

Measurements at the Forked River Nuclear Generating Station, taken near the alternative cooling systems locations, showed naturally occurring short-term peak salt concentrations in air of about  $20 \text{ ug/m}^3$  ten miles inland and 500 to  $1,000 \text{ ug/m}^3$  near the ocean shore. (9) In the same study, average annual concentrations of airborne salt were predicted to be  $0.9 \text{ ug/m}^3$  at ten miles inland to  $72 \text{ ug/m}^3$  at the ocean shore. The study also estimated that long-term average deposition rates of natural sea salt ranged from  $300 \text{ kg/km}^2/\text{mo}$  ten miles inland to  $3,500 \text{ kg/km}^2/\text{mo}$

at the ocean shore. Long-term average deposition in the vicinity of the Oyster Creek Site was estimated to be between 300-600 kg/km<sup>2</sup>/mo. (2)

Looking initially at the assimilative capacity of the soils to accept the additional salt deposition resulting from the alternative cooling water systems, it would appear that, despite the high leaching rates of the site's soils, the spray canal system and the mechanical draft cooling towers (including helper towers) may significantly contaminate the soils within a few thousand feet of these cooling systems. The soils within five miles of the site are sands and gravelly sands. (10) According to Toth, leaching is rapid because of the soils' sandy nature and high percolation rates. Because the spray canal system and mechanical draft cooling towers would be expected to deposit large amounts of salt close to the facility, salt deposition within 1,000 to 2,000 feet of these cooling systems could increase to a level which might be greater than could be removed by leaching. Based upon existing studies (10) regarding the potential for soil contamination from natural draft cooling tower salt emissions at the Forked River NGS a natural draft cooling tower system at Oyster Creek NGS would not pose a significant potential for soil contamination.

Studies on the effects of airborne sea salt on vegetation in the region of the Oyster Creek Site have estimated detrimental concentrations. (8) For the principal indigenous species, no visible leaf scorch or injury occurs when long-term average values of airborne salt concentrations are about 40 ug/m<sup>3</sup>. Short-term (several hours) exposure at 100 ug/m<sup>3</sup> would produce foliar injury, while short-term airborne salt concentrations below 60 ug/m<sup>3</sup> would not. (1) At levels above 10 ug/m<sup>3</sup>, salt concentration appears to play a role in the distribution and growth of plants. Vegetation within about 2,000 feet of the rectangular mechanical draft cooling towers (including helper towers) or the spray canal system would probably experience salt damage due to soil contamination and/or direct foliar contact.

Salt deposition concentrations from a natural draft cooling tower would be, on the average, several times less than that from the mechanical draft cooling tower and spray canal systems. A natural draft cooling tower

at the Oyster Creek Site would be estimated to produce maximum deposition in an ESE direction close to the tower. The increased deposition of salt from a natural draft cooling tower on an estuarine area which experiences natural deposition rates near  $3,500 \text{ kg/km}^2/\text{mo}$ , would not be expected to affect the terrestrial system. Within 10 miles of the site, long-term average salt deposition was estimated to be about  $300 \text{ kg/km}^2/\text{mo}$ .<sup>(2)</sup> At most, a natural draft cooling tower could result in some increase in long-term salt deposition over background levels. While this increase would not be expected to damage vegetation, long-term effects on plant distribution are unknown.

c. Impacts of Water Impoundments

During migration, waterfowl flying along the Atlantic Coast in the region of the site may be attracted to the warmer waters of either the cooling ponds or spray canal systems and diverted or delayed from their usual migration flights. Following an unusually severe ice and snow storm, a reduction in waterfowl abundance and species richness in an unheated area of a 2,767 acre reservoir in South Carolina was observed. No such decline in either abundance or species diversity of waterfowl was observed in the heated area. This raises the possibility that the heated section of the reservoir became "unusually attractive to waterfowl during this period" because of the warmer waters (Brisbin).<sup>(11)</sup>

Any diversion or delay in waterfowl migration due to the proposed cooling ponds or spray canal should not be extensive because of the lack of food available in these water bodies. A pond lining, coupled with the warm, hypersaline water, may inhibit plant growth, thus making the pond and canal alternatives attractive only as a temporary resting habitat.

d. Structural Design-Associated Impacts

Because of their height, cooling towers can obstruct migrating birds.<sup>(12)</sup> The hazard exists primarily at night, especially during adverse conditions, (e.g., low and thick cloud cover, fog or precipitation, or frontal passages) when birds are forced to fly at lower than normal altitudes.<sup>(13)</sup> Many bird species are nocturnal migrants, including shorebirds, rails, flycatchers, orioles and most sparrows, warblers, vireos and thrushes.<sup>(14)</sup> It is these

species which are most likely to strike cooling towers. Furthermore, because birds prefer to migrate along major topographic features, such as the seacoast, a greater potential hazard exists in this case because of the site's proximity to the shore. (12)

While cooling tower systems at the Oyster Creek site would be potentially hazardous for migrating birds, selective night lighting should reduce the impact to a minimal level. Early observations concerning bird collisions with high structures, e.g., Washington Monument (555 feet), indicated that bright lights attracted migrating birds, especially under adverse weather conditions. (15) In this case, extinguishing the lights did much to eliminate, or at least, reduce the problem. When floodlights were used at the Perry Monument, a 352 foot monument on an island a few miles offshore on Lake Erie, "hundreds of birds were killed in a single night; more than eighty were estimated killed or injured within fifteen minutes on one occasion". (16) Without night lighting (floodlights), mortalities were minimal.

The Federal Aviation Administration requires that either red or high intensity white lights be used to mark structures over 200 feet. (17) Since high intensity white lights are more penetrating in fog and tend to distract migrating birds caught in inclement weather more than red lights would, red lights, on any cooling tower requiring lighting, would be the preferred choice. (18) Use of red lights and the avoidance of high intensity white lights should reduce bird collision impact to a minimum. Since the natural draft and fan-assisted natural draft cooling towers would be much taller than the other types of cooling towers considered, these cooling towers would have a greater potential to obstruct nocturnal migrants. (16)

### 3. Summary

Exhibit 113 summarizes cooling alternative characteristics which have a bearing on terrestrial ecological impact analysis. The results of this impact analysis are summarized in Exhibit 114. Each alternative cooling system is rated on the basis of land requirements, fogging and icing, salt deposition and structure height. A relative summary rating is also provided.

The cooling ponds exhibit the highest impact regarding land requirements because of the quantity of land which would be committed. The canal (pipe)-to-bay and ocean systems are rated moderate, since the land disrupted during construction of these systems, while comparatively low in total area, would affect sensitive habitat (wetlands).

Only the spray canal system would have the potential for damaging surrounding vegetation due to fogging or icing effects.

Vegetation damage (through foliar contact or soil contamination) would be a potential problem with the rectangular mechanical cooling tower systems (this includes the helper towers), spray canal system, and, to a lesser degree, the salt water wet/dry cooling tower system. The spray canal would have the highest potential for vegetative damage because of its proximity to surrounding vegetation and high variability in reported deposition rate estimates.

Bird impaction would be a potential problem concerning the natural draft and fan-assisted natural draft cooling tower systems.

The summary impact rating gives the cooling pond systems the highest (worst) relative rating, and assigns a moderate rating to the spray canal and ocean intake-discharge systems. Each of the cooling tower alternatives is given a low (favorable) impact rating. It should be noted, however, that the rectangular mechanical towers (including helper towers) may adversely affect vegetation close to the towers.

## SECTION III-M

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## N. STACK GAS/COOLING TOWER PLUME INTERACTION STUDY

### 1. Introduction

Federal regulations require that the design of a nuclear power facility provide assurance that the average annual release rate of radioiodines in the gaseous effluent will not result in thyroid gland exposures in excess of 15 mrem/yr per nuclear power unit. Compliance is assessed via standardized calculational techniques which include: 1) the evaluation of the release rate of radionuclides based on system design, 2) the evaluation of atmospheric dispersion and deposition of these radionuclides using site specific meteorological data, 3) the determination of the reconcentration of these radionuclides via various pathways, and 4) the calculation of the uptake of these radionuclides by members of the public and the resulting doses.

At present, the technique used to determine the deposition of airborne radionuclides routinely includes consideration only of dry deposition processes (i.e. fallout and impaction). Wet deposition processes (i.e., rain-out and washout) are in most cases of little significance due to their infrequent occurrence. However, cooling towers for large generating stations can produce continual drift in the vicinity of the tower which could potentially result in the enhancement of wet deposition.

As a first step in evaluating the potential significance of such a process on the choice of alternative cooling systems at Oyster Creek NGS, the following tasks were performed:

- (1) define the wet and dry deposition process;
- (2) evaluate the possible magnitude of wet deposition effects relative to dry deposition effects, and
- (3) discuss the possible licensing significance of the findings.

Dose estimation using the standardized techniques discussed above was deferred until preferred alternatives were selected, since it was judged that dose estimates were unlikely to themselves be important in preferred alternative selection. A selection of the most preferred alternative

could not, of course, be made prior to examination of other radiological issues.

## 2. Discussion

Ground deposition of radioiodines from nuclear power plants has long been recognized as a potentially significant source of radioiodine in the diet of people who consume vegetables and milk produced in the vicinity of the plant. The rate at which airborne effluents are removed from the atmosphere and deposited on the ground depends on many factors. Among them are the physical and chemical properties of the effluent, and such properties of the deposition surface as surface roughness, previous loading history and chemical affinity for the effluent. The deposition rate depends also on the properties of the airflow field in the vicinity of the deposition surface and on the characteristics of any precipitation which might be occurring at the time of deposition. The various mechanisms cannot yet be specified precisely. A recent review of the subject<sup>(1)</sup> has resulted in the conclusion that only order-of-magnitude estimates of the importance of these processes are appropriate given present state-of-the-art knowledge.

### a. Dry Deposition

Dry deposition of gases takes place by turbulent diffusion to the air/ground interface, molecular diffusion across a laminar sublayer and sorption onto the surface. Dry deposition of particulate matter may occur as a result of gravitational settling (for particles with a diameter of at least 15 microns) and by impaction on objects at or near the deposition surface.

Deposition of gases and particulates can be described by a deposition velocity, which is the ratio of the deposition flux to the concentration at some reference height above the surface, typically 1 meter. Thus, the deposition rate can be obtained by multiplying the concentration at the reference height by an appropriate deposition velocity. This approach is particularly suited to calculating deposition rates from plumes which are assumed to be Gaussian distributed. Since the concentration distribution is given explicitly by the Gaussian function, analytical solutions for the

deposition flux can readily be obtained. In addition, it is relatively easy to account for plume depletion caused by the deposition process. However, this method suffers from several drawbacks. Since the deposition process is assumed to result in depletion of the entire plume, the shape of the Gaussian distribution in the vertical direction is unaffected. Thus, this method tends to overestimate deposition because depletion of the plume in the vicinity of the deposition surface is neglected. More fundamentally, the deposition velocity defined in the above manner is clearly a purely empirical parameter and has little relationship to the actual process of deposition. Since this process is governed primarily by diffusion, the concentration gradient near the deposition surface, not the concentration at some reference height, is the important quantity. As a result of the influence of diffusion on deposition rate, the flux-gradient form of the diffusion equation <sup>(2, 3)</sup> has been found to provide a more physically realistic description of the deposition process. In solving the diffusion equation the deposition velocity is used as a boundary condition at the air-ground interface. Following this approach Markee <sup>(3)</sup> was able to demonstrate not only depletion of the plume near the deposition surface, but also obtained a marked increase of the height of maximum concentration with distance from the point of release. His results have been incorporated in Nuclear Regulatory Commission (NRC) Regulatory Guide 1.111 <sup>(4)</sup>, and serve as the basis for the approach which has been recommended by the NRC for treating dry deposition of gases and particulates.

#### b. Wet Deposition

Wet deposition processes include 1) scavenging below-cloud by falling precipitation and 2) scavenging in-cloud by incorporation into cloud elements and by precipitation occurring within the cloud. The first process is called washout and the second process is called rainout.

In below-cloud scavenging, washout of particulates is caused by impaction and collection of the suspended material by a falling waterdrop. When a drop of rain falls, it sweeps out a volume of air. The air in front of the falling object must separate to let the object pass, and particles suspended in it will tend to follow the movement of the air. However, due to

inertia, electrical attraction and Brownian motion, some particles will cross the air-waterdrop interface and collide with it. Of those particles which undergo a collision some will escape and others will be retained. The product of the collision probability, or efficiency, and the retention efficiency determines the overall collection efficiency, E, of the drop for the particles considered. The fraction of material washed out per unit of time is called the washout coefficient, A. When E is known as a function of drop size, the washout coefficient for a particular aerosol size and density can be obtained from (5):

$$A = \int_0^{\infty} FEA \, dD$$

where A is the cross-sectional area of drops of diameter D and F is the drop flux density (drops/area-time-diameter interval). The washout coefficient for the entire aerosol can be obtained by integrating the above equation over the particle size distribution.

Washout of gases takes place by vapor diffusion to the drop surface, rapid equilibration with the surface liquid and subsequent diffusion into and possible chemical reaction with the drop. The equation which describes this process is similar to that which describes washout of particles. The main difference lies in the fact that the significant parameter is no longer collection efficiency, but vapor diffusivity in air.

Usually, it can be assumed that all of the material which is washed out from below a cloud will be deposited on the ground below. However, under some conditions, such as low humidity, high temperature and small drop size, evaporation of the falling drops can result in resuspension of some scavenged material.

If snow is the scavenging agent, the removal of particulates from air is similar to scavenging by drops. However, the snow-out of gases is no longer governed by molecular diffusion, but by adsorption on ice surfaces. Data cited by Engelmann<sup>(5)</sup> indicates that at comparable precipitation rates, the washout coefficients in snow are lower than in rain.

Within-cloud scavenging of airborne effluents can occur as a result of two processes. The first of these is precipitation occurring within a cloud. This process is basically the same as below-cloud scavenging. However, since precipitation flux can be expected to vary with height within the cloud, the washout coefficient is also a function of height.

In addition to rain-out by falling precipitation, in-cloud scavenging also occurs due to incorporation of particulate effluents into the cloud structure. Scavenging within a cloud may be the result of adhesion of particulate material to suspended cloud particles. It may also be caused by cloud droplet formation around particulate nuclei. Deposition occurs when the cloud material is precipitated. Indeed the airborne material often stimulates precipitation by acting as condensation nuclei within the cloud. This scavenging process appears to be rather inefficient for small particles, and due to the absence of condensation nuclei, it can be considered negligible for gases.

### 3. Results

The residence nearest to the Oyster Creek Nuclear Generating Station is located approximately 2/3 of a mile north of the 112m stack. This is a distance at which maximum drift deposition may be expected to occur. Our evaluation indicated that even at that location, the deposition of iodine due to drift would be lower by at least a factor of 40 for a natural draft, and a factor of 20 for a mechanical draft cooling tower than that which might occur due to dry deposition processes.

In reality, the importance of wet deposition, relative to dry deposition might even be lower than indicated above. This is due to the possibility that the effective halflife of radioiodine on vegetation may be significantly less than under dry conditions. For example, the physical halflife of radioiodine on vegetation under dry conditions is accepted as 14 days in current NRC models. At least one study<sup>(6)</sup> has shown that under wet conditions the physical half-life may be considerably less (i.e., 2.7 days).

This study thus presents an upper estimate of the wet deposition rate

of radioiodines which can be associated with drift from either a mechanical draft or natural draft cooling tower. The values are an upper estimate because they reflect the iodine deposition rate which would occur at the location of maximum drift deposition, because it was assumed that the drift is falling from above the iodine plume, and because a drift rate of .002 percent of coolant flow was used (See Section III-F).

The calculated maximum wet deposition rate is on the order of  $1 \times 10^{-6} \text{ m}^{-1}$  for both types of cooling towers, as compared to a dry deposition rate of  $2.4 \times 10^{-5} \text{ m}^{-1}$ . Consequently, the potential incremental impact of drift-deposited radioiodines on doses to humans is judged to be negligible compared to the doses to be anticipated from dry deposition.

Discussions with NRC personnel have revealed that the NRC has not yet formally addressed on a generic basis the question of the significance of cooling tower wet deposition on iodine dispersion. However, this issue was recently raised as a contention at environmental hearings and NRC staff testimony on this subject is in substantial agreement with these conclusions<sup>(7)</sup>.

In summary, the results of this study indicate that the potential interaction between stack gases and cooling tower drift should have no effect on the choice of a cooling tower design. Furthermore, it is judged that any such interaction will make a negligibly small contribution to the overall radiological impact of a nuclear facility.

## SECTION III-N

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## O. COMPARATIVE ANALYSIS OF ALTERNATIVE COOLING WATER SYSTEMS

The comparative technical, cost and environmental merits of each cooling system alternative are analyzed in this section.

### 1. Technical and Economic Analysis

#### a. Investment and Annual System Cost Comparison

A major economic factor is the total system estimated investment cost. These costs for all sixteen alternatives considered were tabulated in Section III-D-3-a.

However, in the annual system cost method which is used in this study, the least costly choice is the cooling water system which would require minimum total comparable annual cost. These costs for optimized cases of all cooling systems considered were tabulated in Section III-D-3-b and are plotted in Exhibit 3. The costs include the owning and operating expenses and adjustments for equalized net plant capability and net annual generation. The lowest annual comparable costs would occur with the discharge canal or discharge pipeline to bay, helper cooling tower with 26 cells (minimum water temperature of 50<sup>o</sup> F), natural draft cooling tower, round mechanical draft cooling tower, and fan assisted (forced draft) cooling tower systems.

The discharge canal to bay system would be the least costly choice. However, when compared with the existing cooling water system, it would require differential annual expenses of \$5,700,000/yr. The investment cost for the discharge pipeline to bay would be higher than the discharge canal by approximately \$22,000,000 and the annual expenses would increase by \$5,200,000/yr. The other once-through cooling water systems considered would result in even higher annual costs (Exhibit 3). Therefore, the discharge canal to bay system is the preferred alternative once-through cooling water system when considering the financial aspect only.

Among the closed cycle cooling water systems the natural draft cooling tower system would require the least annual expenses and would be the next least costly choice. However, the investment and annual costs for the natural draft cooling tower system would be significantly higher than those for the discharge canal to bay.

The round mechanical draft and the fan assisted (forced draft) cooling tower systems would result in approximately the same investment and comparable annual costs. These costs would be only marginally higher than those of the proposed natural draft cooling tower systems. The plant net output with these three systems would be almost the same. Therefore, the choice among these systems, to an even greater extent than is normally the case, cannot be based on costs only and is subject to a precise evaluation of various technical and environmental aspects.

b. Plant Net Capability and Net Annual Generation

The assessment of plant net capability at average seasonal conditions with each of the cooling system alternatives was used in the economic evaluation as an adjustment described in previous sections of this report. However, those data are of particular importance and therefore are listed in ascending order in Exhibit 115. The substitution of any alternative cooling water system but the ocean intake and discharge pipelines for the existing cooling water system would result in plant derating.

A bar chart depicting turbine generator output and plant net output with each of the cooling water systems considered at average summer conditions is listed as Exhibit 4.

Minimum plant derating would occur with the discharge canal to bay system. For average summer conditions it would be 1.6 MW. The natural draft, mechanical draft and fan assisted cooling tower systems would cause an average summer plant net derating of 20-23 MW or approximately 3 percent of net output with the existing cooling water system.

The ocean intake and discharge system would provide an increase in plant net output of 14 MW at summer conditions. However, at lower ambient temperatures the existing system would provide higher output due to lower water temperature in the existing intake canal as opposed to the ocean intake water temperature. Significantly increased power requirements for cooling water pumping would also contribute to reduced net output. Therefore, the net annual plant generation (kWh/yr) with any one of the alternatives would be less than with the existing system.

## 2. Environmental Analysis

Exhibit 116 summarizes the environmental effects for each alternative cooling system, the existing system, and the existing system with Ristroph bucket screens.

### a. Atmospheric Effects

Of the four types of atmospheric effects discussed in Section III-F, salt deposition and ground level fogging were the effects most influencing preferred alternative selection for the Oyster Creek NGS. Significant salt deposition and fogging would be produced by the wet rectangular mechanical draft cooling tower, helper cooling tower, and spray canal systems.

### b. Water Quality

Effects of construction on water quality would be significant for the ocean intake-discharge and cooling pond systems. Effects of operation would not be significant for any of the alternatives considered.

### c. Hydrothermal Effects

Increases in temperature above ambient for the canal or pipe-to-bay systems would be similar to those of the existing system, although the discharge would not occur at the same location. Increases from the helper tower system would be substantially less than those of the existing system; however, such a system could not meet winter reliability requirements and still avoid exceeding thermal criteria within Oyster Creek. Thermal discharges from the remaining alternatives would satisfy applicable limits.

### d. Noise Effects

The following alternative cooling systems would be expected to exceed New Jersey nighttime noise criteria, unless mitigating measures could be found to reduce noise levels to acceptable limits: all cooling tower alternatives, canal (pipe)-to-bay system, spray canal system. Mitigating measures are discussed in Chapter IV.

The remaining alternatives would produce noise emissions which would not be in excess of applicable standards.

e. Visual and Esthetic Effects

The cooling tower alternatives would produce the most significant visual and esthetic effects due to the towers' physical size and, in the case of the rectangular mechanical draft and helper towers, the potential for ground level fogging. As stated earlier, the spray canal system would also have a fogging potential.

f. Land Use

The cooling pond, ocean intake-discharge and canal-to-bay systems would involve the use of land classified as environmentally sensitive by the State of New Jersey. The cooling pond system would commit 500 or 1000 acres of watershed, and the ocean intake-discharge system would disturb approximately 25 acres of sensitive barrier beach land in Island Beach State Park. The canal-to-bay cooling system would disturb an environmentally sensitive marsh area near the shore of Barnegat Bay.

g. Terrestrial Ecology

The most important terrestrial ecological impact would be that resulting from salt deposition. The wet rectangular mechanical draft cooling tower, helper tower, and spray canal alternatives would produce the highest concentrations of deposited salt. Deposition from the round mechanical draft and saltwater wet/dry towers would be somewhat less. The remaining alternatives would produce relatively little or, in some cases, no concentration of deposited salt.

h. Aquatic Ecology

The most significant impacts from the standpoint of aquatic ecology lie in the areas of impingement, entrainment, cold shock, and shipworm populations.

Impingement losses for the ocean intake-discharge, canal (pipe)-to-bay and helper tower systems would be similar to that of the existing system. Closed cycle alternatives would produce much smaller losses, and losses from the existing system and the other open cycle alternatives

could be reduced by a substantial amount through the use of Ristroph bucket screens. The freshwater wet/dry cooling tower system would have very low impingement losses.

The discussion on impingement in the previous paragraph also generally applies to the issue of entrainment, except that the use of Ristroph bucket screens would not be an effective mitigating measure.

Each of the alternative cooling systems would reduce the overall potential for wood borer infestation and cold shock losses.

i. Water Supply Availability and Quality

Freshwater wet cooling tower alternatives would not be viable due to lack of a suitable water supply.

j. Combined Environmental Impacts

Comparison of overall environmental effects shows that the closed cycle cooling tower systems, with the exception of the wet rectangular mechanical draft tower system, would probably have the lowest environmental impact at Oyster Creek. These systems include:

- 1) Natural draft tower;
- 2) Fan-assisted natural draft tower;
- 3) Round mechanical draft tower;
- 4) Wet/dry freshwater mechanical draft tower; and
- 5) Dry tower.

**IV. DISCUSSION OF PREFERRED  
COOLING WATER SYSTEMS**

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A. INTRODUCTION

Sixteen alternative cooling water systems were described and analyzed in Chapter III of this report. Four of them, namely the natural draft cooling tower system, the round mechanical draft cooling tower system, the fan-assisted natural draft cooling tower system, and the open cycle canal-to-bay system were selected as the preferred ones for a more detailed evaluation in terms of their cost, licensing and environmental aspects. Such an evaluation was performed and the methodology used by each discipline is described in the following section. The remainder of this chapter discusses the results of the evaluation for each individual preferred system and then concludes with a comparison of their relative merits.

## B. METHODOLOGY

### 1. Economic Evaluation

The cost evaluation of the 4 preferred alternatives is based on the same annual cost method that was described in Subsection III-C-1 and in Appendix A.

### 2. Licensing Evaluation

The four preferred alternatives were evaluated in light of the regulatory and permit requirements discussed in Section III-E and in Appendix B. Licensing considerations which were important in the evaluation of any or all of the alternatives are discussed in those sections (Sections IV-C through IV-F) containing the evaluation of the individual alternatives.

### 3. Atmospheric Effects Evaluation

#### a. Fogging and Elevated Plume Analysis

The following paragraphs give the data base, tower characteristics and an abbreviated description of the models used for the fogging and elevated plume analyses for the alternate cooling towers. A complete description of the fogging and elevated plume models is given in Appendix C.

#### i. Data Base

The fogging and elevated plume analyses for the cooling towers were based on hourly meteorological data from the Atlantic City Airport located about 31 miles southwest of the site. A computer program was used to select a single conservative year for these analyses from the base periods 1959-1969. The program calculated the annual frequencies of "low saturation deficits", which are differences between the mass of water vapor required to saturate a unit volume of air and the mass of water vapor actually present in the air. The program indicated that the year 1960 would be a conservative data year for the cooling tower analyses to be performed.

#### ii. Tower Characteristics

Exhibit 117 presents the cooling tower characteristics assumed in the fogging and elevated plume analyses performed for the natural draft (ND), fan-assisted natural draft (FAND) and round mechanical draft (RMD) towers.

### iii. Description of Fogging and Icing Model

The modeling of cooling tower induced ground level fogging and icing was based on the following assumptions:

- 1) The cooling system was assumed to saturate the ambient air that is drawn through the cooling tower;
- 2) The effective height of the vapor plume was assumed to be a function of cooling tower height and plume buoyancy (which included the effect of latent heat);
- 3) The plume spread was assumed to have a Gaussian distribution in both the horizontal and vertical planes;
- 4) Periods with visibilities less than 0.5 miles due to naturally occurring fog were not counted as periods of cooling tower induced fogging;
- 5) Downwash was assumed to occur when the plume exit velocity was less than 1.5 times the wind speed; and
- 6) Tower induced icing was assumed to occur if the model predicted ground level fogging and the temperature was  $32^{\circ}$  F or less.

The rise of the tower vapor effluent was calculated by Briggs' plume rise equation <sup>(1)</sup> as modified by Hanna. <sup>(2)</sup> For each hour, stability conditions were determined (neutral, stable, or unstable), and the appropriate plume rise equation was utilized. The model converted surface wind speeds to wind speeds at the top of the cooling tower; calm conditions were assigned a wind speed of one knot and the same wind direction reported during the previous hour.

The model calculated plume downwash when the plume exit velocity was less than 1.5 times the wind speed. The magnitude of the downwash was estimated using the relationship given by Briggs. <sup>(3)</sup> Such high wind speed downwash generally occurs in the low pressure zone on the lee side of the tower and is a function of wind and plume exit speeds and tower diameter.

The Gaussian diffusion equation <sup>(4)</sup> was used to calculate the transport of cooling tower vapor to ground level, downwind from the tower. The vapor concentrations for each of 16 wind directions were calculated for twenty

downwind points spaced at 500 meter intervals for each hour of meteorological data. Tower induced fogging was assumed to form at a point if cooling tower concentrations equalled or exceeded the atmospheric saturation deficit.

The computerized model tabulated the tower induced fogging and icing occurrences on a seasonal and annual basis for the year 1960 and also determined natural fog frequencies.

#### iv. Description of Elevated Plume Model

The modeling of elevated visible plumes emitted from the three preferred cooling tower systems were calculated by use of Baker's Equation.<sup>(5)</sup> Plume lengths predicted by the equation are based on cooling tower vapor emission rate, wind speed, ambient air temperature and temperature at the source and end of plume. The temperature at the end of the plume was calculated by an iterative procedure based on Tetens' Equation<sup>(6)</sup> for calculating saturation vapor pressure and also by assuming that the plume behaved according to a linear psychrometric mixing process. The temperature at the source of the plume (at exit of cooling tower) was calculated by a heat-and-mass balance method<sup>(7)</sup> based on the law of conservation of mass and energy.

The computerized elevated plume frequency program calculated the length and areal distribution of the plumes from the ND, FAND and RMD towers for one year (1960) of hourly meteorological data.

#### b. Salt Deposition

The following paragraphs give the data base, tower characteristics and an abbreviated description of the salt drift model used to determine the ground level salt deposition rates and near ground air concentrations of salt associated with cooling tower operation. The salt drift computer modeling and analyses for the preferred cooling towers were performed by Pickard, Lowe and Garrick, Inc.

#### i. Data Base<sup>(8)</sup>

The meteorological data base used for the salt analysis consisted of hourly measurements of wind direction, wind speed and vertical temperature

differences which were recorded at the OCNGS 400 foot meteorological tower from January 1, 1968 through December 31, 1968. Wind measurements were taken at the 400 foot (above grade) level and the vertical temperature difference measurements were taken between the 400 foot and 12 foot levels. Since no moisture measurements were available from Oyster Creek NGS, relative humidity data were obtained from the Atlantic City Airport, located about 31 miles southwest of the site.

ii. Tower Characteristics and Drift Drop Size Distribution<sup>(8)</sup>

Exhibit 117 gives the cooling tower characteristics and Exhibit 118 the drop size distributions assumed in the salt drift analyses performed for the three cooling towers.

iii. Description of Salt Drift Model<sup>(8)</sup>

A very small fraction of the brackish water circulating through the cooling tower would be carried from the tower as small droplets in the rising vapor plume. This drift rate fraction (defined as kg of salt per second leaving the tower top divided by the kg of salt per second circulating through the tower heat exchange section) averages about 1 to 2 x 10<sup>-5</sup> (or .001 to .002 percent) for large natural draft towers with the state-of-the-art drift control systems. The rate at which drift salt would deposit on the ground outside the tower (e.g., as kg/km<sup>2</sup>/month) and the near ground air concentration of such salt (e.g., as g/m<sup>3</sup>) would be a function of distance from the tower and depend on:

- 1) Tower geometry and operating conditions (as given in Exhibit 117);
- 2) Mass drift rate of salt emitted from the tower (as given in Exhibit 117), which is a fraction of the circulating water rate;
- 3) The drift droplet size distribution (as given in Exhibit 118), which is representative of tower conditions downstream from the eliminators; and
- 4) The ambient atmospheric conditions, including wind direction and speed, relative humidity and stability.

As previously indicated, the atmospheric conditions used for the study were Oyster Creek NGS hourly tower measurements collected during the period January 1 through December 31, 1968. The stratification of these data into groups is shown in Exhibit 119, and the representative values for each group are given in Exhibit 120. The calculations were made assuming that every hour during the base period was dry (without precipitation).

Using the parameters discussed above, computer calculations simulated the history of representative drift droplets of selected initial size and salinity from the time they left the drift eliminators in the tower to the point of deposition on the ground. The model took account of accretion and evaporation of the droplets; calculated the effects of gravity, aerodynamic tower wake and vertical turbulence on the average motion of the droplet, and also determined the statistical distribution of the droplets (due to turbulent dispersion) relative to the average droplet trajectories.

The model was used to estimate both salt deposition rates at ground level and near ground air concentrations of salt as a function of direction and distance out to 15 miles from each of the three preferred tower systems. Calculations were made for tower operation at Oyster Creek NGS alone and for the simultaneous operation of both the Oyster Creek and Forked River Nuclear Generating Stations. Calculations were made for the following time periods:

- 1) Average monthly deposition rates and airborne concentrations based on a complete annual cycle;
- 2) Average monthly deposition rates and airborne concentrations for the summer (June - August) period; and
- 3) Short-term (e.g., several hour) airborne salt concentrations associated with persistent wind conditions.

A complete description of the mathematical computer model used to calculate the salt drift is given in Appendix C.

(8)

c. Ice Formation Due to Drift

The accumulation of ice on the ground and on surfaces in the site area would be a function of distance and direction from the tower and would depend on the same parameters that influence salt deposition rate by drift.

In addition, ice accumulation on structures would depend on the drift drop collection efficiency of the object. The collection efficiency as a function of wind speed and drift droplet diameter for selected object shapes and dimensions is given in Exhibit 121. These relationships have been characterized in the mathematical model described in Appendix C and were utilized in the studies performed for this report.

The computer model discussed in the previous paragraph was used to estimate potential ice accumulation on the ground and on various structures as a function of time at selected distances for each of the alternate tower systems for each of the 16 discrete sectors used to represent the entire compass ( $360^{\circ}$ ) for the winter month of January.

#### 4. Hydrothermal Effects Evaluation

##### a. Ambient Water Temperature Data

As discussed in Section III-G, the intake temperature data recorded at the Oyster Creek NGS were assumed to represent the ambient temperatures at Oyster Creek and Barnegat Bay. However, the period of record used for the analysis of the preferred cooling systems described in this chapter was extended to include the data from June 1975, through March 1977.

The cumulative frequency distribution of daily maximum, average and minimum intake temperatures was calculated on a monthly basis and the resulting values are presented in Exhibit 122.

##### b. Assumptions

The analysis of hydrothermal effects is based on several assumptions. Although neither the Oyster Creek NGS nor the Forked River NGS is expected to operate at 100 percent load at all times, the assumption of 100 percent load factor was made for this study. The Forked River NGS was assumed operating with a natural draft cooling tower. A constant make-up flow rate for each cooling tower system was assumed, as well as continued use of the existing dilution system.

Discharge flows, temperatures and heat loads have been evaluated on a monthly basis for average and extreme conditions. Average conditions refer to monthly average wet bulb temperatures and monthly averages of daily

average intake water temperatures. The extreme condition has been assumed to occur during periods of the highest predicted temperature rise of the combined discharge flows (Oyster Creek NGS and Forked River NGS), coinciding with high wet bulb temperature (monthly wet bulb not exceeded during the period of record) and low ambient water temperature (monthly average of daily minimum intake water temperature).

The highest discharge temperatures would occur for cooling tower systems when wet bulb temperatures were highest. The canal-to-bay system would be characterized by a constant temperature rise and discharge heat load for the Oyster Creek NGS. Thus, the combined temperature rise and heat load would be at a maximum when the Forked River NGS cooling tower discharge is at its maximum, or, in other words, when a cooling tower at OCNGS would also be producing its maximum discharge temperature. For this reason, the same wet bulb and ambient water temperatures have been assumed for all four preferred alternatives in defining both average and extreme conditions. The wet bulb and ambient water temperatures utilized for this analysis are presented in Exhibit 123.

c. Operating Conditions

i. Discharge Temperatures

The discharge temperatures for each cooling tower alternative are the cold side or basin temperatures for each tower. These temperatures are a function of the meteorology, the cooling tower characteristics, and the heat load on the tower. Manufacturer's curves relating cold water temperature to wet bulb temperature were utilized for each tower. Representative values from the curves used are presented in Exhibit 124 for each preferred cooling tower considered and for the Forked River NGS cooling tower.

The discharge temperatures for the canal-to-bay system were calculated using a constant temperature rise through the condenser of  $19.4^{\circ}$  F above the intake water temperature.

ii. Discharge Flows

The blowdown flow rates from each cooling tower were calculated as the difference between the makeup flow rate (21,000 gpm for the Oyster Creek NGS

Station and 36,000 gpm for the Forked River NGS) and the evaporation rate of that tower.

The evaporation rate of each cooling tower, like the discharge temperature, was taken as a function of the wet bulb temperature from manufacturer's curves of evaporation rate versus wet bulb temperature (Exhibit 124).

The discharge location for each cooling tower scheme would be in approximately the same location as the existing condenser cooling water discharge point. The dilution flow available for each of these schemes would be either 260,000 gpm (one dilution pump operating) or 520,000 gpm (two dilution pumps operating).

As a mitigating measure to preserve water quality in Oyster Creek, the canal-to-bay alternative was revised during its assessment as a preferred alternative (see Section IV-F) by the addition of new dilution pumps. The present dilution pumps would continue to bypass water (without going through the condenser) from the intake to Oyster Creek. This would provide acceptable water quality in the portions of the creek where natural flows would not be sufficient to do so. The new dilution pumps would be located near the mouth of Oyster Creek and would convey most of the flow released into Oyster Creek from the present dilution pumps into the new discharge canal, where it would reduce the temperature of the condenser discharge water prior to release into Barnegat Bay. Exhibit 125, discussed more fully in Section IV-F, shows a schematic flow diagram of the revised alternative.

A primary constraint on the transfer of water from Oyster Creek to the discharge canal would be the requirement to maintain a sufficient flow through the mouth of Oyster Creek to prevent tidal recirculation of the discharge back into the creek. The minimum flow required to prevent recirculation was calculated by superimposing the flow induced by the tidal action at the mouth of Oyster Creek and the total dilution flow, based on a linear harmonic method.<sup>(9)</sup> The resultant minimum flow was estimated as 65,000 gpm, corresponding to a tidal range of 1.0 ft near the mouth of Oyster Creek.

Thus, approximately 544,000 gpm (520,000 gpm of dilution water and 24,000 gpm of Forked River NGS blowdown) would be discharged into the

upstream end of Oyster Creek and approximately 480,000 gpm would be withdrawn near the creek mouth by the additional dilution pumps. The net flow from Oyster Creek into Barnegat Bay would range approximately between 0 and 130,000 gpm over the tidal cycle, under normal tidal conditions (tidal range of one foot).

d. Temperature Distribution

i. Canal-to-Bay Alternative

As described in Section III-G, the temperature distribution in Barnegat Bay for the canal-to-bay system would be expected to be somewhat different from that of the existing system. There are several reasons for this difference. Relocating the discharge point approximately 600 feet closer to the intake at the mouth of the Forked River would alter the flow distribution in the bay. The existing system has been run with either one or two dilution pumps operating. The canal-to-bay system would run with two dilution pumps operating at all times. Also, the anticipated discharge of the Forked River Station cooling tower blowdown would increase the total heat load over that of the existing station. A mathematical model previously applied to the Oyster Creek site<sup>(10)</sup> was utilized to predict the difference in temperature distribution between the existing system and the canal-to-bay alternative.

The model uses a "potential" flow solution to represent the flow pattern in Barnegat Bay caused by the plant intake and discharge. The heat exchange processes are included through the use of an exchange coefficient. Effects of heat loss to the atmosphere and of dispersion are included in the model. The model predicts an exponential decay of temperature with respect to travel time, which can be expressed as:

$$T - E = (T_0 - E)e^{-(k + \lambda)t/D}$$

where,

T is the temperature of heated water,

E is the ambient temperature of water,

T<sub>0</sub> is the initial temperature of heated water,

k is the atmospheric heat transfer coefficient,  
 $\lambda$  is the entrainment coefficient,  
t is the travel time, and  
D is the depth of water.

The entrainment coefficient ( $\lambda$ ) has been estimated from dye experiments to be 0.4 ft/hr.<sup>(9)</sup> The atmospheric heat transfer coefficient (k) has been calculated for each case in accordance with methods given in Reference (11).

The model was verified by using it to simulate a known temperature distribution. The condition chosen was the plume surveyed on August 6, 1974.<sup>(12)</sup> This condition represents an extreme summertime plume configuration. The heat load on that date was approximately 20 percent above that for normal full station load, presumably due to problems experienced with leaking in the condenser that caused inefficient heat transfer. As shown in Exhibit 126, the model was found to be in good agreement with the data with respect to the surface temperature isotherms of 5 °F or less temperature excess.

Jersey Central Power and Light Company has provided data from twenty thermal surveys conducted between August 1974 and December 1976.<sup>(13, 14)</sup> The surveys simultaneously measured temperatures at depths of one, two and a half, and five feet. These data were assumed representative of the temperature distribution in the bay produced by the operation of the existing station. The thermal model was then used to simulate discharges from both the existing station and the canal-to-bay system for four selected months (January, April, July and October) for which field data were available. The observed differences between predicted and actual surface temperature distribution for the existing system were used to adjust predictions for the canal-to-bay alternative.

#### ii. Cooling Tower Alternatives

The mathematical model described in the preceding paragraphs was also used to predict the thermal effects of the blowdown discharge from each of the preferred cooling tower alternatives in combination with that from the Forked River Station cooling tower.

## 5. Water Supply Evaluation

As described in Section III-H, adequate sources of intake water would be available for each of the preferred alternatives. Additional evaluation beyond that described in Section III-H was not judged to be warranted.

## 6. Water Resources Impact Evaluation

Water quality is often described by a tabulation of parameters including the concentration of various chemical constituents and physical properties. The evaluation of water quality impacts due to operation of any of the preferred alternatives consisted of calculating the incremental changes of these parameters. The existing cooling water system was used as a baseline from which the preferred cooling systems were compared. Exhibit 127 shows the estimated chemical releases to the discharge canal from the existing system. The Exhibit indicates that the incremental changes in concentration are negligible when compared to the natural variation of water quality in Barnegat Bay.

## 7. Noise Effects Evaluation

The noise impact of each of the alternative cooling water systems was evaluated by taking into consideration both the magnitude of the noise and the location of the noise sources relative to the nearest residential areas. This analysis was based on the New Jersey Noise Control Regulations, which set noise limits in terms of dB(A) values and in the form of octave band spectra (see Appendix B).

The noise levels produced by the preferred cooling tower systems were estimated using existing literature<sup>(15,16,17)</sup> and sound level data provided by various manufacturers (see Exhibit 128).

The noise levels produced by the drop structure associated with the canal-to-bay system were calculated using an analytical model for falling water. The noise level was determined as a function of potential energy rate (the product of water flow rate and fall height).

For the preferred cooling tower systems, the closest residential area would lie to the northeast of the site and to the east of Route 9. For the canal-to-bay system, the closest residential areas are located to the north

and south of the drop structure. The noise levels for each of the preferred systems were evaluated based upon their distances to the boundaries of these closest residential areas.

## 8. Visual/Esthetic Impact Evaluation

### a. Introduction

The four preferred cooling systems were assessed on strictly physical and visual characteristics, with the intent of presenting the esthetics analyses on as objective a basis as possible. No attempt was made to assess viewer reactions to shapes or configurations of various cooling alternatives.

Certain basic premises were established for this analysis and they are listed below:

- 1) Any above-ground structure constitutes an additional intrusive element into the existing scene. Its intrusiveness varies with its physical dimensions; therefore, the taller or longer or wider a structure is, the more intrusive it is.
- 2) Since the three tower schemes considered here would all involve structures which are either round or hyperbolic in shape, they would all be approximately equal in possessing shapes which would be more amenable to shapes occurring in nature than, for example, the rigid shapes found in square or rectangular structures. Because of this fact, physical size becomes the dominant esthetic evaluative element and shape is subordinated.
- 3) It was assumed that visible elevated plumes generated by the cooling towers would have the greatest impact when the plumes were directly overhead of the observer. Therefore, frequency of occurrence of overhead visible plumes was calculated for the summertime, when the local population is at a maximum, and these frequencies were used in assessing the visual impact of elevated plumes.

### b. Photographic Analysis

In addition to considering the physical size and shape of the cooling systems and their interaction with meteorological phenomena, an evaluation

was made of the visual impacts which the entire complex -- existing power plant elements together with preferred cooling tower systems -- would have upon the human population in the area. In order to accomplish this, photographs were taken from several representative areas in the affected vicinity (areas such as backyards of residences, local and through roads, and shore and Barnegat Bay locations). These photographs were enlarged and the various cooling tower systems were superimposed upon them, as they would appear to the observer if they were constructed.

The locations from which the photographs depicting a natural draft cooling tower were taken are shown in Exhibit 129. The natural draft cooling tower photographs themselves are shown in Exhibit 130-134. The locations from which the photographs depicting a round mechanical draft cooling tower system were taken are shown in Exhibit 135. The round mechanical draft cooling tower photographs themselves are shown in Exhibits 136-138. The locations from which the photographs depicting a fan-assisted natural draft tower system were taken are given in Exhibit 139, and the corresponding photographs are given in Exhibits 140-144.

The canal-to-bay system, which has a relatively low profile, has not been shown photographically, but its visual impact is discussed in Section IV-F.

#### c. Analysis of Visual Exposure

A field survey was conducted to further determine the visibility of the existing station in the surrounding area. This survey, in which the visibility of the existing Oyster Creek NGS was used as a basis for judgment about the potential visibility of the preferred alternatives, allowed delineation of approximate areas of high, medium, or low visual exposure to high elements at the plant site. The areas of potential visual exposure and population concentrations are shown in Exhibit 145.

Areas of high potential visual exposure were defined as those in which power plant elements (stack and cooling towers) would be dominant in the view available to the observer when he faced in the direction of the plant. In other words, in these areas the observer would be forced to look at the high elements because of their overriding importance in the scene.

Areas of medium potential visual exposure were defined as locations where the view of the plant elements would be lessened by one or more of the following:

- 1) Distance,
- 2) Elevational differences,
- 3) Natural vegetation, or
- 4) Intervening structures.

In areas of medium exposure, the plant would be viewable but not as obviously dominant for observation as in the "high" category. An example of these areas of medium exposure are roads (with trees or treeless) which are located in the direction of the facility. Most roads in the area which run approximately north-south would afford some glimpses of the facility. Another example of this type of exposure is the high ground on the north side of the Deer Head Lake - Lake Barnegat complex, where the observer would be looking across the lakes toward the plant site, and the natural vegetation is some distance away.

Areas of low potential visual exposure were defined as areas where the plant is either a great distance away, or there are many intervening structures and/or much vegetation between the observer and the plant facilities. An example of an area of low exposure is the most northerly subdivision in Ocean Township, which is immediately adjacent to the JCP&L property line. Because of stands of existing trees, this residential area is protected from exposure to views of the plant despite the fact that it is very close to the plant. The only areas where observers would normally see the plant are those along Oyster Creek, where there are no trees. The interior of the subdivision is very well protected by intervening homes and existing intervening vegetation.

It should be noted that the single most important visual modifier in this region is the presence or absence of existing vegetation. In situations where vegetation is close to the viewer, it will have a maximum screening and blocking effect. Where it is some distance from the viewer, it will have a lessened screening effect but will still serve as a partial screen and softening element. Vegetation also gives scale to scenes because

the observer has some intuitive "feel" for the height of a tree (six times a man's height, as high as a five story building, etc.). No such comparison is possible with high tower structures since they lack scalar references.

References 18 through 21 provide background information on methodologies used for visual assessment.

## 9. Aquatic Ecology Impact Evaluation

### a. Introduction

Four areas of aquatic biological concern were addressed: shipworm infestation, cold shock, entrainment, and impingement. These subjects, which were defined in Section III-L, are important because they are, or are perceived to be, perturbed by operation of OCNGS.

Considerable emphasis has been placed on identifying and understanding the mechanics of estuarine ecological systems, but they are at best crudely understood. Because of this, the basic approach used in evaluating the effects of alternative cooling systems relied primarily on the relative effects of each system with respect to the others. In only a few instances could the change induced by a particular cooling system be related to the aquatic environment as a whole. Where this is possible, it was done.

To deal with the effects of the four preferred alternative cooling systems for the OCNGS, it was necessary to simplify species-environment cause-and-effect relationships by identifying those parameters which have a dominant effect on an organism's life. In doing this, it was important to guard against oversimplification since this could lead to descriptions of unrealistic, or spurious, relationships. For some species of concern here, much basic life history data are lacking so that attempts to bring into play all of the complex interrelationships between these organisms and their environment are futile. In this evaluation available literature was utilized to describe those aspects of each species that may in some significant way be affected by operation of the OCNGS.

### b. Shipworms

Many environmental factors determine the level of success a given population will experience. In the case of shipworms, some of the

important parameters are water temperature, salinity, dissolved oxygen (DO), pH, water flow, and Gelbstoff (humic material suspended in the water column). Exhibit 146 compares species of teredinids found in Barnegat Bay in terms of environmental tolerances and development characteristics.

To understand the relationship between the preferred alternative cooling water systems and shipworm populations, we began by assuming that all conditions other than water temperature were ideal for wood-borer breeding (i.e., the ideal environmental conditions for optimum growth, reproduction, etc. existed). Under this assumption, breeding conditions would be optimum as long as water temperature remained in the optimum range, and any change in temperature beyond this range (or, of course, any change to sub-optimum values for other parameters) might cause a breeding reduction.

Under normal conditions in Barnegat Bay the changes in season would limit the duration of these ideal conditions. Assuming that other conditions were ideal, extension of the time during which water temperatures were optimum might increase length of breeding activity. The operation of each preferred cooling system would establish an increased thermal load in a limited portion of the receiving waters.

To view the relative influence of the temperature rise produced by the preferred alternatives, ambient water temperatures were superimposed on a plot of optimum and suboptimum breeding temperature ranges for the two most active teredinids in the Bay. These defined the expected period of time available to each species for successful reproduction. Each cooling alternative's effect on ambient temperature could then be added to the ambient water temperature in order to depict the increased period during which water temperatures would be optimum for breeding. The existence of this period would not necessarily mean that breeding changes would occur. However, use of this technique allows depiction of a maximum potential breeding season. For the purposes of this study, it was not necessary to know absolute changes in teredo breeding season, but rather, only the relative changes.

Richards et al<sup>(22)</sup> have attempted to determine if water velocity can be correlated to successful siting by teredo larvae. Results are inconclusive at this time. However, it is generally accepted that local breeding

populations produce young that infect nearby wood habitat. Also, the greater the distance between any given source of larvae and potential habitat, the more difficult it is for an individual larva to locate a site. There are primarily two reasons for this. First, larvae are essentially pelagic, though it is known that they can influence their motion by swimming. Larvae tend to be found in greater density in the vicinity of wood. This is believed to demonstrate selection of location by the larvae. Second, larva life span is limited to about 4 to 25 days depending on the species.

The dissolved oxygen and pH of the Oyster Creek NGS discharge canal appear to be in a range suitable to wood-borers.<sup>(22)</sup> The effect of salinity can best be measured by indicating the area which is suitable or unsuitable as shipworm habitat. In this case, areas of low salinity (< 10 ppt) are excluded from some species' range. By increasing the salinity, these areas would become available habitat.

Without habitat, shipworms would be little noticed. In the Oyster Creek area the Jersey Central Power and Light Company has removed many of the old docks, piers and bulkheads, reducing habitat. Habitat in this instance is determined by the amount of wood available to these organisms. The methods by which new generations of shipworms are distributed from breeding locations are important factors in determining the effect of OCNCS on shipworm populations and in assessing the effectiveness of alternative systems in mitigating any such effect. Unfortunately, available data are less than ideal for these purposes.

Four species of borers have been identified in Barnegat Bay. These are Teredo navalis, T furcifera, T bartschi and Bankia gouldi. T furcifera and T bartschi are subtropical and appear in small numbers in the Oyster Creek portion of this estuary. The remaining two species (T navalis and B gouldi) are historically common to the New Jersey coast and are considered the primary culprits when shipworm damage becomes apparent. Even though the teredinids have a complex life history, they are considered to have no "weak link" which might allow humans to control them.<sup>(23)</sup> The teredo is protandrous.<sup>(24)</sup> However, it is not clear whether this characteristic enhances its success over that of a nonprotandrous species.

T navalis is dominant in the outer parts of Barnegat Bay where salinity is greater and Gelbstoff (humic material) is reduced. Sharp drops in numbers of T navalis larvae, in the presence of large amounts of humic material, have been documented. (25)

B gouldi is more common in the inner areas of the bay. All temperate and cold water species of the genus Bankia are somewhat restricted in their range. (26) Part of the reason for this is that the species is known to be oviparous (egg-laying). Marine species that are larviparous (larva-bearing), have the ability to become widely distributed. Because of the advanced stage of development of the young in larviparous species, the larvae can settle immediately after emergence from the mothers. The advantage of this is that the young are not subjected to the predation that would occur if they were carried in the water column over long distances and periods of time and the probability of wood contact is increased.

Teredo navalis, a short-term larviparous species, is widely distributed. This is due in part to its larvipricity and in part to the wide range of salinity and temperature it can tolerate. (26)

c. Cold Shock

Bluefish and Atlantic menhaden are historically susceptible to cold shock at the OCNGS. The nature and history of this problem have previously been described in Section III-L.

If the discharge  $\Delta T$ 's are kept below  $3^{\circ}\text{C}$ , fish delaying migration to remain in the station's thermal plume would experience  $12^{\circ}\text{C}$  (the approximate temperature when migration is observed to commence away from the influence of OCNGS) in the discharge while water away from the discharge had a temperature ( $12^{\circ} - 3^{\circ} = 9^{\circ}\text{C}$ ) well above their lethal level. Being oceanadromous fish there would be no other alternative but to follow their natural migratory behavior. These fish normally leave the Barnegat Bay area over a period of time. The fish in Oyster Creek would end up being the rear guard of the emigrating summer population.

To illustrate the relative influence of each alternative cooling system on the Oyster Creek water temperatures, schematics were developed for

each species (bluefish and menhaden) in reference to the cooling tower system (Exhibits 147 and 148).

These exhibits show the upper and lower lethal temperature limits as given in the available scientific literature. These limits account for each species' prior temperature experience (acclimation or acclimatization as the case may be). By combining this information with information on plant operating conditions and weather statistics, the conditions under which biological problems might occur can be predicted and the probability of having unsuitable water temperature can be quantified (the particular plant operating conditions shown in the exhibits are discussed in Section IV-C).

Exhibits 149 and 150 also summarize temperature limit experience for these two species.

d. Entrainment

Entrainment data at the OCNGS are available through collections made by Ichthyological Associates. Representative important species (RIS) are listed in Exhibit 151. These organisms for which sufficient data are available were dealt with quantitatively. Otherwise, the treatment was on a relative basis.

Entrainment rates estimated from field data for the existing cooling water system were scaled as a function of circulating flow rate (or makeup flow rate) to develop approximate entrainment rates for the alternative cooling systems.

e. Impingement

During a 42-week monitoring program, between September 1975 and September 1976, impinged organisms were sampled at OCNGS by Ichthyological Associates. Specimens were counted, weighted and taxonomically identified, and information regarding their age, maturity, condition and sex was recorded. Concurrent water chemistry measurements were made, and meteorological, physical and plant operating conditions noted. Field sampling programs, conducted between September 1975 and August 1976, included use of trawls, beach seines and gill nets in order to determine the extent of fisheries resources near the Oyster Creek NGS. With varying intensities, fisheries

data were collected in Forked River, in Oyster Creek, in Barnegat Bay at various creek mouths and in Barnegat Bay at Waretown. In addition, monitoring was conducted at the OCNGS dilution pump discharge. The relative abundance of eight important species in these fish collections for the spring and summer of 1976 is summarized in Exhibit 152. The right column lists the relative abundance of these species in the impingement collections.

These data were correlated with the abundance and relative abundance of several RIS in the impingement collections to provide insights on some of the causative factors of impingement at OCNGS.

For the four preferred cooling systems to be evaluated, the only operating factors which may influence the impingement of organisms are total plant flow, intake velocity, and flow in the intake canal induced by plant water withdrawal and dilution pump operation. When all four circulating pumps are in service, the present system withdraws approximately 460,000 gpm. During the year of impingement sampling (September 1975 to September 1976), water withdrawal was at or near full capacity from April 28, 1976 to September 4, 1976, and, except for the plant outage in January and February 1976, flows were about 75 percent of that figure (i.e.,  $3,479 \times 10^6$  gal/week) for most of the remaining weeks.

The canal-to-bay cooling system would operate at approximately the same water withdrawal rates as the present system. The three cooling tower systems being studied would have design flow rates of about five percent of these figures, with a maximum withdrawal of about 23,000 gpm. It is expected that impingement rates would be reduced as water withdrawal rates are reduced. (27) Regression analyses during various time periods were used to estimate the expected reduction in impingement rates due to a reduction in intake water flow. In this regard, evaluation of the alternative cooling system was based upon the designed differences in intake water flow. Impingement mortality rates by species, observed during the sampling year, were used to estimate the expected number of organisms killed. Methods of reducing mortality further were considered, and quantitatively evaluated for a Ristroph bucket system.

Monthly impingement rates at OCNCS were compared to that experienced at other power stations located on estuaries along the New Jersey to Maine coast. The relationships of season, intake flow and impingement rates were investigated by regression analysis and comparisons of time series.

#### 10. Terrestrial Ecology Impact Evaluation

Effects of preferred alternative cooling systems on terrestrial communities were evaluated through consideration of land requirements, effluents, and structural features. Impacts attending the preemption of land are a function of acreage required and the ecological sensitivity of affected areas. Effluent-related effects result from potential icing or salt deposition attributable to cooling tower plume. The impacts of structural features were analyzed in terms of tower height.

The major informational sources consulted for this study were publications in the scientific literature; relevant literature survey and biological investigations performed for JCP&L and other eastern seaboard utilities; and physical parameters provided by JCP&L. Comparison of system impacts was summarized with a rating scheme. Effects associated with land requirements, effluents and structural features were separately assigned a rank of high, medium, or low (or not applicable) for each alternative system.

##### a. Land Requirements

The potential effects of land clearing were evaluated in terms of amount of land required and the quality of the affected area as vegetation and wildlife habitat. It was ascertained early in the effort that differences in acreage requirements for the four alternate cooling systems were relatively minor. Further consideration of the differential impacts of vegetation removal was consequentially restricted to analysis of habitat value. This was conducted with the use of the vegetation map of the site area, Exhibit 112, Wetlands Maps prepared by the New Jersey Department of Environmental Protection, and engineering plans for the preferred systems.

##### b. Effluents

Effluent impact on terrestrial communities was considered an issue only in evaluation of cooling tower systems and not in evaluation of a canal-to

bay system. Cooling tower drift may affect vegetation through increased ice accumulation or through deposition of substances dissolved in the escaped water droplets. Ice accumulation was eliminated as a consideration when it was recognized that, for any of the preferred cooling tower alternatives, additional icing occurrences would not be expected to exceed four hours per year. This increase would be unlikely to affect vegetation.

i. Salt Accumulation in Soil

Evaluation of possible toxic concentrations of salt occurring in soils of the site area was based on comparison of predicted cooling tower inputs with salt deposition rates which represent background conditions or injury thresholds. Scientists at the University of Maryland attempted to identify a minimum salt deposition rate sufficient to produce toxic soil salinities. For soils in the vicinity of the Brandon Shores site, they concluded that annual inputs of NaCl as high as  $56,000 \text{ kg/km}^2$  (or  $65,800 \text{ kg sea salt/km}^2$ ) would not result in toxic levels. (28)

Salt deposition rates sufficient to produce toxic soil salinities are probably much higher than those sufficient to cause injury from foliar impaction. In reference to cooling tower effects, Bernstein<sup>(29)</sup> noted that "Because of the low annual rate of salt deposition by such salt drifts ( $13,175 - 26,355 \text{ kg sea salt/km}^2$ , or  $1100-2200 \text{ kg/km}^2/\text{month}$ ), soil salinity would usually be a minor factor compared to foliar salt deposition". For this analysis, the annual deposition rate of  $65,880 \text{ kg/km}^2$  ( $5490 \text{ kg/km}^2/\text{month}$ ) derived by the University of Maryland team was adopted as the criteria for considering potential development of toxic soil salinities.

ii. Foliar Impaction of Salt

Salts accumulated on leaf surfaces between rainfalls may be rapidly absorbed by foliar tissues when relative humidity is sufficient to maintain salts in the dissolved state. (30,31,32) If the salt ions are accumulated, toxic concentrations of specific ions absorbed in this manner may result.

Effects of foliar impaction were evaluated through comparison of predicted deposition rates and air concentrations with natural background levels and known injury thresholds. Background levels had been previously measured for the area near the Oyster Creek site, as described in Subsection III-M-2.

Identification of injury threshold deposition rates requires consideration of the ionic composition of the emitted salt, as well as the varying sensitivities of plant species to any potentially injurious salt ions. Of the substances emitted from salt water cooling towers, sodium chloride (NaCl) is the one of most concern. While any ionic constituents of tower salt may be toxic when present in plant tissues in excessive concentrations,  $\text{Cl}^-$  has been identified as the likely toxic agent in incidences of sea salt injury<sup>(33)</sup> and, together with  $\text{Na}^+$ , has been the subject of recent investigations of cooling tower salt deposition effects on plants.<sup>(31,32,34)</sup> The salt referred to in the deposition rates and air concentrations discussed below are, unless noted otherwise, comparable to both sea salt (approximately 85 percent by weight NaCl) and cooling tower salt (also 85 percent by weight NaCl). A summary of thresholds applicable to cooling system selection may be found in Exhibit 153.

Investigations of the effects of airborne sea salt on vegetation native to Island Beach State Park provide an estimate of potentially injurious concentrations<sup>(33)</sup>. Of the species studied and occurring on the mainland, the most sensitive were highbush blueberry, poison ivy, Virginia creeper, wild black cherry, red maple, and shadblow service berry. For these species, no obvious leaf scorch or injury occurred when monthly (summer season) airborne sea salt concentrations ranged from  $80 \text{ ug/m}^3$  near the surf to  $14 \text{ ug/m}^3$  at the leeward side of the island. Moser estimates that the average monthly concentration for the "island in general" was about  $40 \text{ ug/m}^3$ . During the same study it was observed that short-term (several hours) exposure to  $100 \text{ ug/m}^3$  produced foliar injury, while short-term airborne sea salt concentrations below  $60 \text{ ug/m}^3$  did not.

The investigation conducted by Dr Moser at Island Beach State Park was part of a series of studies addressing the potential impact of a proposed natural draft cooling tower at the Forked River site. The field observations forming the basis of identification of airborne salt levels causing injury referred to native species of Island Beach which presumably are adapted to a maritime environment. The injurious salt levels identified by Dr Moser are probably not applicable to many ornamental plants, for which apparently no threshold salt deposition rate or concentration data are available.

It should also be noted that the Island Beach studies reflected mostly one season's data, and were not designed to address, in any great detail, long-term effects of airborne salt. For example, Moser refers to several literature reports which suggest that long-term levels of atmospheric sea salt above  $10 \text{ ug/m}^3$  may influence the distribution and growth of plants. Since the literature reports arose from observations recorded in Israel, Wales and citrus plantations, they may or may not be applicable to the Jersey Shore. Moser concluded "that even though the average levels of airborne sea salt on Island Beach do not result in dramatic injury symptoms, they may have more subtle long-term effects such as a decline in general vigor of the plants growing there".

At the University of Maryland, scientists reviewed information in an attempt to identify cooling tower impact on vegetation of the proposed Brandon Shores facility. They concluded that insufficient data existed to determine a threshold deposition rate for vegetation injury, but sufficient data existed to "indicate that caution should be exercised regarding the potential for acute or chronic foliar damage to vegetation in areas receiving in excess of 100 lbs NaCl/acre/year" (approximately  $13,200 \text{ kg/km}^2/\text{year}$ , or  $1100 \text{ kg/km}^2/\text{month}$ ).<sup>(28)</sup> This deposition rate apparently refers to salt crystals and aerial spray, and does not include NaCl contained in rainwater.

Yields of soybeans and corn have been examined following experimental exposure to solution sprays.<sup>(32)</sup> Both species were exposed at deposition rates ranging from 1.82 to 14.56 kg NaCl/ha/week on a weekly basis for 8 weeks. Soybeans showed a significant decrease in yield at 7.28 kg/ha/week. Decreases in corn yield appeared consistent with increases in salt application throughout the entire range of treatments, with significant and most severe decreases occurring at 7.28 and 14.56 kg/ha/week. A deposition rate of 7.28 kg NaCl/ha/week is equivalent to  $2912 \text{ kg NaCl/km}^2/\text{month}$  or  $1766 \text{ kg Cl}^-/\text{km}^2/\text{month}$ , and would be approximately comparable to a monthly sea salt (or cooling tower) deposition rate of  $3200 \text{ kg/km}^2$  (assuming 55 percent as the contribution by weight of  $\text{Cl}^-$  to salt derived from sea water or cooling tower plume). Soybeans evidenced injury on less than 5 percent of trifoliolate leaf (first three sets) area, after laboratory exposure for 5 hours/day, 5 days/week for 4 weeks, to sea salt aerosol con-

centrations as low as  $5 \text{ ug/m}^3$ .<sup>(35)</sup> Leaves 5 weeks old at initiation of exposure showed greater injury than leaves initially exposed when 3 weeks or 1 week old. The 1 week old bean plants, however, exhibited decreased pod productivity at aerosol concentrations of  $25 \text{ ug/m}^3$ , while the 3 week and 5 week old plants evidenced no decrease.

In investigations conducted in the Boyce Thompson Laboratories,<sup>(36)</sup> pinto beans evidenced foliar lesions following one hour exposure to a deposition rate of  $0.35 \text{ ug Cl}^-/\text{cm}^2/\text{minute}$ . With the same assumptions as above, this is equivalent to a deposition of  $387 \text{ kg sea salt/km}^2$  after 1 hour.

Relative humidity is a critical factor affecting the degree of salt injury to vegetation. McCune et al found that pinto beans subjected to 50 percent relative humidity during and following exposure to salt aerosol, required twice the dose to produce injury equivalent to that observed on bean plants exposed at 85 percent relative humidity. Since foliar uptake occurs only when ions are in solution, deposition of dry salt crystals on leaf surfaces is not likely to cause injury unless a moisture film develops (dew or light rainfall) or the salts deliquesce. For NaCl, the latter process occurs at a relative humidity between 70 and 80 percent.

### c. Structural Features

Structural design features are important in regard to natural draft cooling towers of sufficient height to pose potential obstructions to nocturnal migrating birds. Evaluation of this potential impact was based on the considerations discussed below.

In clear weather, most nocturnal bird migration occurs at heights from 400 to 8000 feet above ground level (AGL). The largest concentrations usually occur between 500 feet and 5400 feet (AGL).<sup>(37,38)</sup> When clouds are encountered, birds tend to fly either above or below the cloud formation with very few actually penetrating it. The available air space for those individuals flying below the ceiling may become compressed, forcing large number of birds much closer to ground level. Akin to the change in flight altitudes, flight orientation is also impaired. When celestial clues are lost, birds may orient to lights or arrangements of lights on the ground.

Bright lights, as found on tall structures, attract birds during adverse weather conditions. (37,39,40,41) IGL Limited additionally speculate that, although birds migrate as a broad front at night, celestial orientation may be replaced by terrestrial orientation to ground lighting arrangements. They suggest, for example, that the unusually large autumn bird impact problem associated with the Ontario Hydro Nanticoke Plant along Lake Erie was caused in part by a shift from north-south celestial orientation to an east-west shoreline orientation. The cluster of lighting along the shoreline with the attendant lighting void in the lake may effect this orientation shift in poor weather.

Small passerine birds appear to be most affected by the presence of illuminated towers. Bird impact studies at the natural draft cooling towers of Toledo Edison's Davis-Besse Plant<sup>(42)</sup>; Metropolitan Edison's Three Mile Island facility<sup>(43)</sup>; the stack at the Nanticoke Plant<sup>(44)</sup>; and many TV and radiotowers collectively indicate that warblers, vireos, thrushes and fringillids are most susceptible to bird-tower collisions. Large-bird or game-bird collisions, in contrast, are infrequent.

#### 11. Radiological Impact Evaluation

Operation of an alternative cooling water system at the Oyster Creek NGS would not significantly affect the impact of radioactive gaseous effluents from the station. However, the doses to individuals exposed, directly or indirectly, to liquid releases in the nearfield would change since the total quantity of water available for dilution in the nearfield would change. Consequently, individual radiological doses to man due to liquid effluents from OCNGS were calculated for each preferred alternative to demonstrate compliance with applicable Nuclear Regulatory Commission regulations.<sup>(45)</sup>

Yearly doses which might be received by the whole body and highest organ (GI tract) were calculated using the NRC's estimate of radioactive materials contained in OCNGS liquid effluents and the NRC's definition of the critical individual. Bioaccumulation factors for chemical elements in marine organisms that are specified in NRC Regulatory Guide 1.109 were used to develop these dose estimates.

## SECTION IV-B

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## C. NATURAL DRAFT COOLING TOWER SYSTEM

### 1. Performance Data

The optimum natural draft cooling tower system is described in Section III-B. Its flow diagram is depicted in Exhibit 37, and the layout is shown in Exhibit 38.

The optimum cooling tower design parameters and approximate dimensions are as follows:

|  |                                    |
|--|------------------------------------|
| Design Approach to $T_{wb} = 74^{\circ}\text{F}$             | $14^{\circ}\text{F}$               |
| Cooling Range  | $21.2^{\circ}\text{F}$             |
| Circulating Water Flow                                       | 433 300 gpm                        |
| Circulating Water Temperature Entering/Leaving Cooling Tower | $109.2^{\circ}/88^{\circ}\text{F}$ |
| Base Diameter/Height   | 430 ft/540 ft                      |

Depending on a particular manufacturer's design, the dimensions of the cooling tower with the selected thermal design parameters may vary from those described in this report. These dimension deviations would not affect the optimum choice of the cooling tower design parameters or the results of this analysis.

The lowest design approach considered was  $12^{\circ}\text{F}$ . At lower values two natural draft cooling towers would be required instead of a single tower due to shell height and diameter limitations. A two tower installation would be significantly more expensive in terms of investment cost and annual costs and, therefore, was not considered. For the same reason the lowest cooling range considered was  $16^{\circ}\text{F}$ . An additional limitation for minimum cooling range was the maximum allowable water velocity in existing condenser water boxes and tubes. At a cooling range of  $16^{\circ}\text{F}$ , the circulating water flow through the condenser would be 560 000 gpm and the velocity in tubes would reach 7.8 fps or approximately 25 percent higher than that with the existing once-through cooling water system. The highest acceptable cooling range was defined to be  $21.2^{\circ}\text{F}$ . At this cooling range the design circulating water flow through the condenser would be 423 000 gpm and the water velocity in condenser tubes 5.9 fps. If one of the four circulating water pumps failed, the water flow would decrease to 360 000 gpm.

Accordingly, the water velocity in the condenser tubes would drop to 5 fps, which was assumed to be the minimum allowable velocity for a tube cleaning system operation.

The design data for the optimum case is listed in Exhibit 62. For comparison, the present once-through cooling water system data are listed in the same Exhibit.

Exhibit 154 depicts system costs as functions of cooling tower approach. The least costly choice for this system is a tower with a design approach of 14°F and a height of 540 ft. Such a tower would be larger than any built or on order for salt water application. However, natural draft cooling towers of similar size for fresh water are in operation, under construction and on order.

The natural draft cooling tower thermal performance curve at full load operation is plotted in Exhibit 155.

The predicted effluent data at design conditions are as follows:

|                          |                      |
|--------------------------|----------------------|
| Exit Air Temperature, °F | 101°                 |
| Exit Air Volume, cfm     | 30 x 10 <sup>6</sup> |
| Exit Air Velocity, fpm   | 720                  |

The drift rate at design conditions is 0.001 percent of circulating water flow or 4.33 gpm.

Predicted evaporation rates at full load operation are:

|   | <u>gpm</u> |
|---|------------|
| Design Conditions ( $T_{wb} = 74^{\circ}\text{F}$ ) | 7 000      |
| Average Summer                                      | 6 550      |
| Average Spring/Fall                                 | 5 700      |
| Average Winter                                      | 5 900      |
| Maximum   | 7 400      |

Based on the aforementioned evaporation rates, the blowdown rates would be approximately 10,000 - 14,800 gpm in the closed cycle cooling water system to maintain water quality with total dissolved solids not exceeding 50,000 ppm. Hence, makeup requirements would be 15,000 - 22,200 gpm.

Condenser pressure, turbine generator output and plant net output at full load operation with the proposed natural draft cooling tower system were calculated to be as follows:

| <u>Ambient Conditions</u> | <u>Condenser Pressure<br/>in. HgA</u> | <u>Turbine-Generator<br/>MW</u> | <u>Net Plant<br/>Output, MW</u> |
|---------------------------|---------------------------------------|---------------------------------|---------------------------------|
| Maximum Meteorological    | 3.86                                  | 608.6                           | 581.9                           |
| Design                    | 3.61                                  | 613.7                           | 587.0                           |
| Average Summer            | 3.02                                  | 625.8                           | 599.1                           |
| Average Spring/Fall       | 2.03                                  | 648.1                           | 621.4                           |
| Average Winter            | 1.52                                  | 655.2                           | 628.5                           |

## 2. Condenser Tube Cleaning System

A cooling tower system would be operated with significantly higher cooling water temperature than the existing system, and would provide favorable conditions for bio-fouling. Therefore, a chlorination system (twice a day application for 20-30 minutes each application) was included for the alternative cooling tower systems. For the purposes of this study, a chlorine demand of 3000 lb/day was applied in the economic evaluation of the evaporative cooling tower systems.

To prevent condenser tube fouling, a continuous mechanical cleaning system (Anertap) was assumed for the cooling system and its cost was included in estimated investment cost. A recently developed short screen mechanism would probably fit in the existing vertical circulating water discharge pipes above condenser floor level, and therefore, it was assumed that the installation of tube cleaning equipment could be accomplished during plant shutdown for refueling and would not require additional unit outage time.

## 3. Circulating Water Pumps and Water Conduits

Use of the natural draft cooling tower system would require a much higher circulating water pumping head than does the present system due to significantly increased cooling system static head. However, due to limited pressure rating of the existing underground circulating water

tunnels in the turbine generator building and in the plant yard, pumps with a much higher design head than the existing pumps could not be employed. Therefore, two stages of cooling water pumping were included as shown in Exhibit 37. A new intake structure with four vertical circulating water pumps would be installed close to the cooling tower. The head of these pumps would be approximately 30 ft, which is sufficient to pump the cooling water through the condenser to the suction of a set of four horizontal booster pumps with a design head of approximately 60 ft. These pumps would transfer the cooling water to the cooling tower hot water distribution system. The installation of the booster pumps is shown in Exhibit 156.

An optimization of the number of circulating water pumps and their mode of operation was beyond the scope of this study. A four capacity pump installation was assumed, each with 25 percent of full load capacity, the same as used for the existing cooling water system.

The existing turbine generator design pressure is one inch HgA. Plant operation with the proposed natural draft cooling tower system would always be at higher pressure and would involve plant derating and additional fuel consumption, as opposed to the existing system. A circulating water pump failure would result in increased economic penalties and therefore, it seems justified to have at least a four pump installation in spite of some extra investment cost.

Based on a cost evaluation the new reinforced concrete circulating water conduit diameter would be 10 feet.

#### 4. Connection to Existing System

It was assumed that the interconnection of new circulating water pipelines with the existing circulating water tunnels could be accomplished during plant shutdown for refueling (6 weeks).

There would be two pipe connections (126 in. diameter), one to the existing intake tunnel and one to the discharge tunnel. A plug or stop logs would have to be installed in each existing tunnel to cut off the new cooling tower closed cycle system from the existing intake structure and discharge canal.

A sketch of the proposed interconnection is listed as Exhibit 157. The existing discharge tunnel is located well below ground water level and therefore, the above construction may encounter some difficulties. Consequently, work would need to commence well ahead of unit outage.

#### 5. Construction Schedule

A construction schedule for the natural draft cooling tower system is depicted in Exhibit 158. The construction period would be 36 months, including 6 weeks for final new pipeline interconnection with the existing circulating water tunnels and for cut over from the existing once-through cooling water system to the closed cooling tower cycle. The cooling tower shell construction is shown in the Exhibit as a continuous process. Actually, depending on weather conditions, there may be a winter stoppage. The assumed shell construction period is sufficient to incorporate such a stoppage. If system engineering, equipment purchasing, design and fabrication are included the total time required for the natural draft cooling tower system installation would be 45 months.

#### 6. Results of Cost Evaluation

Exhibit 159 is a computer printout showing the cost evaluation for the natural draft cooling tower alternative. The printout consists of three sheets: (1) "Basic Input Data" (2) "Sort in Ascending Order of Annual Cost" and (3) "Optimum Case Specification." The costs of the optimum system are summarized as follows:

##### Optimum Natural Draft Cooling Tower System

|   |                 |
|---|-----------------|
| Total Estimated Investment Cost   | \$60,602,000    |
| Total Comparable Annual System Cost including Adjustments for Differential Net Capability & Net Annual Generation | \$20,368,000/yr |

The performance of the existing once-through cooling water system was used as a base for above annual cost adjustments. Costs for noise abatement (i.e. additional land costs) were not included.

#### 7. Licensing Considerations

The permits required for construction of the natural draft cooling tower systems are described in Section III-E and Appendix B.

Approximate processing times and licensing fees for these permits are summarized in Exhibit 160.

A review of the federal and state environmental regulations, permit requirements and engineering and environmental data did not reveal any instances of regulatory noncompliance in the areas of land use or water quality.

Noise emissions from the natural draft cooling tower would exceed the New Jersey regulations during nighttime hours (see Subsection IV-C-11). The noise regulations could be met by enlarging the buffer zone surrounding the tower until the noise level at the boundary drops below the nighttime limit of 50 dB(A). For the natural draft cooling tower, approximately 30 acres of residentially zoned land would have to be acquired northeast of the site to achieve compliance with noise regulations. A few residences are located on these 30 acres.

Particulate emissions from the natural draft cooling tower would exceed the New Jersey air emission standards. The emission rate calculated for the natural draft tower is approximately 101 lb/hr; the maximum allowable emission rate is 30 lb/hr. The discussion of this issue contained in Section III-E should be borne in mind in interpreting the significance of this emission rate. The New Jersey primary and secondary ambient air quality standards would not be exceeded.

## 8. Atmospheric Effects

### a. Introduction

The elevated plume model and the salt deposition model discussed in Subsection IV-B-3 and in Appendix C were used to estimate the elevated plume frequencies and salt deposition rates that would be associated with the operation of a natural draft tower at Oyster Creek NGS. These estimates were based upon the tower characteristics shown in Exhibit 161. The analysis of icing due to drift is also discussed in Subsection IV-B-3 and Appendix C. No analysis was performed for tower-induced ground level fogging and icing due to fog at temperatures below freezing as these phenomena are not associated with the operation of tall natural draft towers.

#### b. Elevated Visible Plumes

Exhibit 162, Table 1 presents the predicted annual frequencies of elevated plumes that would be associated with the operation of a natural draft tower at Oyster Creek NGS. The analysis indicated that the plumes would generally be found at heights of 1500 - 2500 feet above grade and thus ground level impacts would not be anticipated. As shown in Exhibit 162, Table 1, plumes would rarely extend to distances beyond one and one-half miles from the tower. The predicted predominant directions of the elevated visible plumes would be east and east-southeast. Plume lengths greater than 5,500 feet in these directions should occur less than 10 hours per year.

Elevated visible plumes would also be created by the operation of the proposed Forked River Nuclear Generating Station tower. The plumes from the two stations would remain separate and distinct during most of the year; in many cases, even if the wind direction was proper for plume merger the downwind end of the plumes would disappear (evaporate) before merger of the two plumes could occur. It was estimated that about 1% of the time, plumes from the two stations would merge, resulting in a combined plume that would persist for a longer distance than would the plume from a single tower.

#### c. Salt Deposition

Exhibit 162, Table 2 presents the maximum short-term, near ground, airborne concentrations of salt that would result from the operation of a natural draft tower at the Oyster Creek Nuclear Generating Station. Exhibit 162, Table 3 presents similar information but also includes the effects of the proposed Forked River NGS natural draft tower. The calculated peak values are similar in both tables with the summer season definitely showing the lowest maximum values.

The estimated maximum summer and annual near-ground air concentration of salt that would result from the operation of the Oyster Creek NGS natural draft tower (with and without consideration of the Forked River Nuclear Generating Station) can be summarized as follows:

|                                   | <u>LOCATION</u><br>(miles in stated direction) | <u>CONCENTRATION</u><br>( $\mu\text{g}/\text{m}^3$ ) |
|-----------------------------------|--|--|
| <u>Annual</u>                     |  |  |
| Oyster Creek                      | 1.0 East-southeast                             | .07  |
| Oyster Creek plus<br>Forked River | 3.0 North                                      | .09  |
| <u>Summer</u>                     |  |  |
| Oyster Creek                      | 3.0 North                                      | .08  |
| Oyster Creek plus<br>Forked River | 3.0 North                                      | .13  |

The impact of salts released during the operation of a cooling tower can also be estimated in terms of the amount of salt deposited on a unit square area in a given time period. Estimates of the maximum amount of salt that would be deposited by a natural draft tower at OCNGS can be summarized as follows:

|                                   | <u>LOCATION</u><br>(miles in stated direction) | <u>DEPOSITION RATE</u><br>( $\text{kg}/\text{km}^2$ -month) |
|-----------------------------------|--|---|
| <u>Annual</u>                     |  |   |
| Oyster Creek                      | .50 East-southeast                             | 80  |
| Oyster Creek plus<br>Forked River | .75 Southeast                                  | 109   |
| <u>Summer</u>                     |  |   |
| Oyster Creek                      | .50 North                                      | 73  |
| Oyster Creek plus<br>Forked River | .50 North-northwest                            | 125   |

Exhibits 163 - 166 indicate the spatial distribution of the near-ground air salt concentrations (summer season) and salt deposition rates (annual) that would be associated with the operation of a natural draft tower at OCNGS. Exhibits 164 and 166 include the effect of the Forked River NGS tower while Exhibits 163 and 165 exclude those additional impacts. The patterns presented in the four figures are basically similar in that maximum impacts are generally shown to the north of the plant sites. As would be expected, the joint consideration of towers at FRNGS and OCNGS causes a substantial increase in deposition levels over those which would occur from the OCNGS tower alone.

## 9. Hydrothermal Effects

### a. Compliance with Thermal Criteria

Assuming use of the natural draft tower alternative, the discharge

flow rate from both the Oyster Creek and Forked River facilities, the dilution flow required for the combined flow to meet thermal criteria for temperature rise in Oyster Creek, the magnitude of the total combined flow and its resultant temperature rise have been predicted for each month and tabulated in Exhibits 167 and 168 for average conditions and for extreme conditions respectively.

The natural draft tower for the Oyster Creek Station would operate at lower temperatures than the natural draft tower for the Forked River Station. Under average conditions, operation of only one dilution pump would be sufficient for the discharge to meet New Jersey thermal criteria in every month except January, during which two dilution pumps would be required. During extreme conditions, the thermal criteria could be met by operating only one dilution pump during May, September and October, and by operating two dilution pumps during the remaining nine months.

b. Temperature Distribution

Because of the relatively low temperature rise and short retention time in Oyster Creek, it is predicted that there would not be any appreciable temperature decay in the creek and the temperature rise at the point of discharge into Barnegat Bay would be the same as the temperature rises presented in Exhibits 167 and 168. Because these temperature rises would satisfy the thermal criteria, no mixing zone in the bay would be required.

10. Impacts on Water Resources

a. Construction Effects

The construction of a natural draft cooling tower would involve the excavation of approximately five acres of land west of US Route 9. The effects of such construction on the quality of water flowing through the Forked River-Oyster Creek system are expected to be minor. The potential impacts can be minimized by using proper construction practices as discussed in Reference 1.

b. Operational Effects

Operational effects upon water quality associated with a natural draft cooling tower system at Oyster Creek NGS can be divided into four categories: changes to intake water quality resulting from cooling system operation, effects due to biocide additions, effects due to corrosion inhibitors and effects due to plant wastewater discharges.

### i. Water Quality Effects

The major water quality effect due to operation of a natural draft cooling tower at OCNCS would be an increase in the total dissolved solids of the cooling tower blowdown. The tower would dissipate up to 99% of the thermal discharge to the atmosphere via evaporation. The process of evaporation increases the salinity, total dissolved solids and the concentration of dissolved substances in the cooling water that remains. This increase in salinity is limited by maintaining a blowdown flow, and the blowdown, evaporation and drift losses are replenished by the makeup pumps at an average rate of approximately 21,000 gpm. The evaporation rate would vary as a function of ambient temperature and humidity, plant loading and the efficiency of the cooling system; thus, the rate of blowdown would also be variable. Exhibit 169 lists the daily average and maximum concentration factors, blowdown flows and rates of evaporation expected during each month for natural draft tower operation, assuming operation of either one or two dilution pumps. As discussed in Section III-I, most chemical constituents in the intake water are proportional to salinity, (ie, TDS) and, therefore, will also increase by these concentration factors. The resulting impact on water quality of Oyster Creek and Barnegat Bay would be expected to be negligible for either one or two dilution pump operation.

### ii. Scale Inhibitors

Sulfuric acid may be added at a rate of 0.25 gpm for the control of scaling in the cooling water system. This would increase the blowdown sulfate ( $\text{SO}_4$ ) concentration above the makeup water  $\text{SO}_4$  concentration by 20 ppm. This increase would be negligible (1.1%) when compared to the average  $\text{SO}_4$  concentration of 1820 ppm found in the intake water.

### iii. Biocides

Chlorine would be added at the condenser intake to inhibit biological fouling on the condenser tube walls, cooling tower surfaces and system piping, etc. There would be an average free chlorine residual of

less than 0.2 ppm and a maximum of less than 0.5 ppm in the blowdown for less than two hours per day. After the blowdown mixes with the dilution flow, which initially has zero residual, the resultant total or free chlorine residual for the overall discharge should be negligible.

The average daily addition of chlorine to the existing system is 1000 pounds per day.<sup>(2)</sup> This dosage should have to be increased for the draft cooling tower system. A chlorination optimization study can be conducted to determine the minimum chlorine required to achieve satisfactory cooling system operation without the problems of biofouling. Reliable results, however, are obtainable only when the particular system in question is operational.<sup>(3)</sup>

#### iv. Wastewater Discharges

The wastewater discharges from the Oyster Creek Nuclear Generating Station equipped with a natural draft cooling tower would be similar to those from the existing station. Therefore, negligible water quality changes would be expected to occur in Oyster Creek as a result of natural draft cooling tower system operation.

#### 11. Noise Effects

As indicated in Exhibit 170, the nearest residential area is located approximately 1200 feet northeast of the cooling tower. The estimated unattenuated sound level produced by the natural draft cooling tower would be 54 dB(A) at a distance of 1200 feet from the tower. The following are the equivalent octave band sound levels that would be produced by the tower at the same distance:

| Octave Band<br>Center Frequency<br>(Hz)                    | 31.5 | 63 | 125 | 250 | 500 | 1K | 2K | 4K | 8K | A Scale |
|--|------|----|-----|-----|-----|----|----|----|----|---------|
| Sound Pressure<br>Level (dB)<br>Re - 0.0002 Micro-<br>bars | 51   | 55 | 52  | 46  | 48  | 50 | 48 | 43 | 31 | 54      |

The above values are compared with New Jersey nighttime noise limitations in Exhibit 171. As can be seen from this exhibit, the sound levels of the tower would be expected to exceed both the dB(A) values and the octave band limits of the New Jersey Regulations.

Exhibit 171 also shows the noise that would be produced by the natural draft tower at a distance of 2500 feet. At this distance, the tower would be expected to produce about 46 dB(A) and would meet New Jersey A-weighted and octave band noise limitations. It should be noted that at a distance of 2500 ft from the tower there would be a slight margin in the tower's sound levels to account for possible additive noise effects of the Oyster Creek Nuclear Generating Station.

The circulating water pump and booster pump motors would be expected to produce about 40 dB(A) at the property line, but because of this disparity in acoustical performance of the various motors, the noise emissions of this equipment would need to be reevaluated when, and if, the equipment is actually selected.

In summary, the natural draft cooling tower would meet New Jersey noise regulations if an acoustical buffer zone of 2500 ft is provided. The tower would exceed the nighttime limit by about 3 dB(A) with the existing 1200 ft buffer zone.

## 12. Visual Effects

### a. Introduction - Visual Exposure

The natural draft cooling tower would be approximately 540 ft in height and would have a base diameter of 430 feet. At the closest point, this tower would be about 370 ft from the right-of-way of Route 9. For comparison with existing plant elements, the existing turbine building is about 265 ft by 180 ft by 88 ft in height, and the existing reactor building is 145 ft by 140 ft by 146 ft in height. The existing stack is tall (368 ft), but is a slender element and has an exit diameter of about 18 feet.

Exhibit 145 shows the area surrounding the Oyster Creek station in terms of relative potential exposure to high elements at the site. The areas which would be most heavily impacted are those with high exposure and a high population density; such areas are indicated in Exhibit 145.

b. Photographic Analysis

A structure 540 ft high with an average diameter of 330 ft would have a large impact on the visual aspects of the region, and this is demonstrated by photographs in Exhibits 130 through 134. The locations where these photographs were taken are shown in Exhibit 129. As might be expected, the natural draft tower would have a large visual impact upon the viewer who is travelling on Route 9, as shown in Exhibit 132, location 6 and Exhibit 133, location 7. It would have a lesser visual impact upon the viewer who is on the waters of Barnegat Bay, as shown in Exhibit 130, location 1. (This photograph was taken at a point approximately one mile offshore in Barnegat Bay or about three miles from the tower location adjacent to the Oyster Creek Station). This tower and other high plant elements would also be seen from Island Beach State Park, some six miles from the facility, where it would be apparent on the bay side, from the Sedge Island area, and from the top of the dunes on the ocean side of this island. However, since most of the visitors to Island Beach Park pursue recreational activities at the ocean shore and in its waters, the visual impacts from the plant structures can be considered minimal for recreational visitors.

c. Visible Plumes

Analysis to determine the impact which would result from elevated plumes from this type of tower upon nearby residential areas concentrated on the summer months of June, July and August, since there will be more outdoor activities of all types during this period than at other times of the year. During approximately one hour per summer, an elevated plume from the natural draft cooling tower would be visible directly overhead in the residential areas around Lake Barnegat (about 6,500 ft north of the site). The home owners living 4,500 ft north-northeast (on the east side of Route 9 of the cooling tower would see an elevated plume overhead for approximately three hours per summer. The residents living about 8,000 ft due east (in the sub-

division bounded by Forked River on the north and Barnegat Bay on the east) of the tower site would see an elevated plume overhead for approximately one hour per summer.

These frequencies indicate that the visual impact due to elevated visible plumes from the natural draft tower would be minimal.

d. Ground Level Fogging

Ground fogging effects from the natural draft cooling tower would be negligible.

13. Aquatic Ecology Effects

a. Shipworms

i. Temperature

Cooling tower operating conditions were determined for average and extreme temperatures. Increases over ambient temperature ( $\Delta T$ ), with two dilution pumps operating would range from 0.6 - 2.3°C under average conditions and 1.3 - 3.5°C under extreme conditions. Exhibits 172 and 173 show ambient water temperatures plotted on a monthly basis with reference to optimum, suboptimum, and lethal zones for two species of teredinid molluscs, Teredo navalis and Bankia gouldi. Lethal temperatures were obtained from Turner<sup>(4)</sup>, and breeding temperatures from Culliney<sup>(5)</sup> for B gouldi. For T navalis temperature limits were based on the work of Bulatov.<sup>(6)</sup>

These Exhibits also include a plot of normal operating conditions for the natural draft cooling tower system with two dilution pumps under extreme conditions. To achieve conservative estimates of breeding extension over natural conditions (prior to OCNCS), we assumed that extreme conditions were reached although, in practice, these conditions are never observed. For T navalis, under these conditions the optimum breeding time would be extended by about 10 days and for B gouldi, approximately 10 - 11 days provided that all other conditions were ideal. However, since the OCNCS would not always be operating at maximum output, both species would most likely have only one to three days added to their optimum breeding season, yielding a one to two percent increase in the

annual breeding season. A difference of this size would be difficult to measure with the present state of aquatic sampling techniques.

Turner<sup>(4)</sup> feels that the primary reason for the increase in shipworm activity in Oyster Creek is that water temperature and salinity, once unsuitable, are now in concert with the requirements of these species. With the reduced temperatures in the discharge area resulting from operation of a closed-cycle cooling system, the shipworm activity should decrease to more natural levels.

#### ii. Salinity

Both B gouldi and T navalis can tolerate a wide range of salinities. The salinity range for the former is 9-35 ppt<sup>(4, 7)</sup>, and for the latter it is 5-32 ppt<sup>(8)</sup>. For optimum growth the salinity needs are somewhat narrowed with concentrations no lower than 19 ppt for B gouldi and 15 ppt for T navalis being required.<sup>(7)</sup> Little else is known about the effects of salinity on these species. The synergistic effect of salinity with other environmental parameters is yet to be studied.

Turner<sup>(9)</sup> suggests that certain species of shipworm are restricted to a narrow geographical range. She describes Nausitora dunlopei as being most active, and only breeding when the salinity is below 10 parts per thousand. In order to relocate to a new area, this species would have to first move into the higher salinities of the open sea. Under these conditions the animal would perish, thus effectively restricting its range. If this concept is valid, then only euryhaline species of borers would be of primary concern in Oyster Creek. Salinities associated with operation of closed cycle cooling towers would not be expected either to enhance or detract from the population of euryhaline species.

#### iii. Water Volume and Velocity

The amount of water flowing past a point inhibited by shipworms may have some effect on Teredinid settling success. If the current is extremely fast, larvae settlement will be inhibited. However, flows of this magnitude (>2 ft/s or 60 cm/s) do not exist in the Oyster Creek-Forked River-Barnegat Bay system. The major concern about current speed

is its effect on Gelbstoff concentrations since teredinid larvae appear to be particularly sensitive to concentrations of humic material.<sup>(5)</sup> Little is known about the relationship of Gelbstoff to teredinid adults.

While there may be a relationship between the water volume and velocity of discharges entering the bay from Oyster Creek and the settlement pattern of shipworm larvae, the nature of the relationship can not be determined from the available data. Thus, no prediction can be made about how or whether volume and velocity changes resulting from a closed-cycle system might also influence shipworm settlement.

#### iv. Dissolved Oxygen and pH

Adult teredos are thought to continue normal activity even when dissolved oxygen (DO) levels are below one part per million<sup>(8, 10, 11)</sup>, although the relationship between DO and teredo remains somewhat unclear<sup>(12)</sup>. Measured DO levels in Oyster Creek have always been at or near saturation<sup>(13, 14)</sup>. DO levels have never been measured below one part per million so it is believed that this parameter plays a subordinate role in teredo life history in Oyster Creek. Measurements of pH vary around neutral (range of 6.7 to 7.3 pH)<sup>(14)</sup>. Changes of this magnitude are not considered significant in being able to cause drastic changes in teredo population. Larger pH changes lasting only a few hours would not be expected to sharply alter teredo populations.

#### v. Other Factors

The most useful technique for preserving wood has been to impregnate the material with creosote although other additives have been used. Creosoted wood (at 20 lb/sq in.) remains impervious to most shipworm damage for up to 20 years. Creosote is leached out of the wood slowly over time, and, as the concentration diminishes, the wood becomes more vulnerable to successful teredo settlement. Untreated wood has been known to come under wood-borer attack and destroyed within a few months of its placement.<sup>(15)</sup>

Field and map determinations indicate that approximately 84,000 linear feet of wood bulkheading, dockage, and piers exist in the vicinity of the OCNCS<sup>(16)</sup>. Exhibit 174 shows where this wood is located, and the

following table summarizes the quantities involved:

| <u>Location</u> | <u>Linear Feet</u> | <u>Notes</u>   |
|-----------------|--------------------|--|
| A               | 1,330              |  |
| B               | 1,160              |  |
| C               | 1,670              | 833 ft of untreated wood in Area C.                    |
| D               | 6,225              |  |
| E               | 2,500              | Bulkheads treated, piles untreated.                    |
| F               | 3,665              |  |
| G               | 23,450             |  |
| H               | 16,740             | Up to 25 percent of Area H consists of untreated wood. |
| I               | 15,670             |  |
| J               | <u>11,550</u>      |  |
| Total           | 83,960             |  |

All wood except where indicated in the table is creosote treated. Approximately 6 percent of the wood is untreated and thus susceptible to normal teredo activity. Only the depth of wood below mean low-water is the portion subject to teredo attack. Any wood remaining above the water, even for a short time, apparently is unsuitable for teredo habitat.

If a natural draft cooling tower operates at OCNGS, water temperatures in the vicinity of wood would be expected to be at or within 1-2<sup>o</sup>C of ambient. Because of the small temperature differential and the small amount of untreated wood habitat, it is expected that there would be no measurable difference in teredinid settlement from that occurring under natural conditions.

b. Cold Shock

i. Temperature

Exhibits 147 and 148 show that operation of a natural draft cooling tower either with two, one, or no dilution pumps, would not, under average conditions, cause discharge water temperatures to exceed acceptable

ranges for bluefish and menhaden. Water temperatures would remain within acceptable ranges during plant shutdowns except during December, January or February regardless of whether zero, one or two dilution pumps are operating. If the natural draft tower system operated with two dilution pumps, water temperatures during the months of December, January and February (as well as November) would be below the temperatures normally eliciting migration even with the station operating, and the fish will have left the river system. Thus, even if the plant shuts down during cold water periods, there should be no bluefish or menhaden mortality.

Concern would exist only if the plant operates with no dilution pumps and under extreme conditions. These conditions have a low probability of occurring simultaneously. First, a backup dilution pump is available. Secondly, the likelihood of near extreme conditions occurring for more than a few days each year is very low.

Elevated water temperatures resulting from cooling tower blowdown would occur in a small zone (1,000-1,500 m<sup>3</sup>) at the head of the discharge canal. This small area may act as an attractant to bluefish and menhaden. Currents would be swift and there would be considerable water turbulence. It is possible that a small population of fish might take up residence at this location. Operation of the OCNCS with a natural draft cooling tower would be required to determine the actual attractant effect for bluefish and menhaden. Based on water temperature, the size of the area, the magnitude of currents and turbulence, and characteristics of bluefish and menhaden, one could expect at most several hundred individual fish in this area. In 1973, 154,483,000 pounds of menhaden were taken commercially in New Jersey waters. At two or three pounds per fish, this represents 51 to 77 million menhaden. The loss of 500 menhaden at the Oyster Creek plant would affect less than one one-hundred thousandth of the New Jersey commercial take. Equally low percentages of reduced availability of bluefish would occur as a result of potential thermal-kills from operation of the natural draft cooling tower system.

#### ii. Other Factors

Bluefish and menhaden are euryhaline species. Salinities of mixed

waters of the Oyster Creek discharge canal will be within suitable ranges for these fish.

Water velocities in the Oyster Creek discharge would be well within the ranges acceptable to bluefish and menhaden for natural draft cooling tower system operation.

No unusual concentrations or levels of DO or pH are expected to cause problems for bluefish and menhaden in Oyster Creek.

c. Entrainment

i. Temperature

Temperature is a major environmental factor affecting the number of organisms available for entrainment. Population growth normally occurs during the warmer months for populations of both invertebrates and vertebrates near the OCNGS. Thus, most of the entrainment occurs during the warmer months of the year when these organisms are available for entrainment. Short-term temperature fluctuations appear not to be related to daily entrainment.

The number of organisms predicted to be entrained with the use of the natural draft cooling tower was based primarily on the amount of water withdrawn by the station, assuming that the organisms are present in the Barnegat Bay system.

ii. Salinity

Most of the source water for the OCNGS is from Barnegat Bay, although a small percentage of water is derived from Forked River. It is expected that those forms indigenous to bay salinity would be the organisms entrained, and discharge salinities of the particular alternative chosen would be irrelevant.

iii. Water Volume and Velocity

Entrainment estimates are available for the existing OCNGS operation<sup>(14)</sup>. Prediction of entrainment, based on a withdrawal rate of 21,000 gpm for the natural draft tower, was made assuming a linear relationship between entrainment and flow. Entrainment rates and mortalities are presented by

month for selected important species in Exhibit 175.

iv. Other Factors

Both DO and pH levels would be expected to remain within ranges that now exist. Therefore, no basic changes in availability or organisms would be expected.

d. Impingement

i. Fish Movement

Impingement data collected at OCNGS during the months of April, May, June and July were compared to abundance data from the field collections in order to investigate possible causative factors for impingement at OCNGS. Because of the differences in sampling gear (the intake being considered as a point collector of organisms), only similarities in species relative abundance in terms of location and gear type were analyzed. During the four month period of sampling, species composition in the trawl collection had high similarity, with correlation coefficients ( $r$ ) ranging between .89 and .99. The highest similarity was between the hauls taken in Barnegat Bay at the creek mouths and near Waretown, which is not surprising considering that the Barnegat Bay-creek system is an open system in which, over an extended sampling period, species composition would be inherently similar. Furthermore, the selectivity of this active gear is biased towards slower moving or smaller members of the fish population, so that a subpopulation (eg, Bay anchovy) is more effectively sampled.

Seining collections have shown less consistency in relative abundance. The Forked River seining stations were similar to the Barnegat Bay seining station near Waretown ( $r = .84$ ), but the other stations showed considerably smaller correlation coefficients. A disparity occurred between gill net sampling locations, as well.

Species composition in the impingement collections correlated best with that found in the discharge end of the dilution pumps ( $r = .89$ ). This is not unexpected because of similarity in sampling mode, and because both intakes are located in the southern-most portion of the intake canal.

Among all other field sampling modes, however, relative abundance in the impingement collections correlated best with that found in the gill net samples.

In particular, the impingement composition was most similar to that in the gill net samples in Forked River ( $r = .82$ ) and Oyster Creek ( $r = .42$ ). This may be due, in part, to the infrequency of the gill net sampling program, resulting in possible spurious correlations. Nevertheless, since impingement/gill net correlations increased as the sampling location moved towards the intake canal a real correlation is likely. Seining data accounted for considerably less species composition variability in the impingement collections ( $r = .27$  at the Forked River stations,  $r = .17$  at the Oyster Creek stations and  $r < .03$  at all of the Barnegat Bay stations) than did the gill net data. Correlations with trawl data were negligible ( $-.02 < r < .07$ ).

Disregarding samples taken at the dilution pumps, a stepwise multiple regression showed that relative abundance in the impingement collections could be best represented ( $r = .86$ ) by the gill net samples in Forked River and Oyster Creek and seining samples in Forked River. This suggested that the selectivity of the intake, as a collection of organisms, is somewhat similar to that of the gill nets, and, consequently, depends upon the movement of fish (and invertebrates) for a successful capture. This observation has been directly noted in other investigations<sup>(17)</sup> and indirectly noted elsewhere through the use of intermediary variables such as temperature changes and tidal movements<sup>(18, 19)</sup>.

Impingement data for the OCNCS, taken during 1975 and 1976, were analyzed for other relationships between fish movement and impingement. A pattern of peak abundance during periods of expected fish movement appeared. In weeks when water temperatures dropped and warm water species were migrating out of the Bay, fall impingement collections were at their highest. Similarly, increasing temperatures during the spring marked Bay immigration of warm water species and an associated rise of these species in the impingement collections.

The OCNGS impingement data demonstrated a substantial diel fluctuation, especially during the period between September and December, 1975. At these times, the collections were dominated by macroinvertebrates, particularly blue crab (Callinectes sapidus) and sand shrimp (Crangon septemspinosa).

The literature has indicated that there are different day-night distributions of these organisms, and that these species tend to move towards bayward canal areas after dark <sup>(20)</sup>. The increased concentration and movement of these species in the intake canal at night could account for such diel differences (96 percent of the sand shrimp and 89 percent of the blue crab were taken at night).

Higher impingement rates may be induced when the movement of fish and invertebrates is influenced by water turbulence. On October 9 and November 24, 1975, when northeasterly winds were high, impingement increased an order of magnitude above what had been recorded in previous sampling periods. Further, over the four months sampled in 1975, while only 15 percent of the collections were made during northeast storms, approximately 30 percent (by number and weight) of the specimens were taken during such periods. These responses may be behavioral (the organisms may disperse to the calmer waters of the intake canal), or environmental (organisms, especially the smaller or weaker members of the population, may be swept to the canal by high currents).

#### ii. Circulating Water Flow

A plot of impingement rates versus circulating water flow for the OCNGS appears in Exhibit 176. Although the Exhibit shows a large impingement variability for any given flow rate, the maximum impingement rates appear to increase linearly with plant flow. This observation involves two separate issues, however, and such a result should be viewed with these issues in mind.

For one, weekly plant flows were not sufficiently variable to allow for meaningful interpolation between data points. As a consequence, the relationship between maximum impingement and plant flow is only based upon a minimum of information. The second issue is more intuitive, but of greater significance. During the course of the 42 week sampling program, fish and invertebrate densities in Barnegat Bay underwent large fluctuations which depended upon the seasonal movement of organisms into and out

of the area. It is likely that impingement rates depend as much upon the density of organisms in the entrainable water as they do upon the plant flow. This is supported by noting that between March 28 and September 4, 1976 impingement rates varied between 51,641 and 1,176,875 organisms per week while flow remained constant (Exhibit 177). Because the low flows occurred during periods of high fish density, Exhibit 176 most likely exaggerates the dependency of impingement on flow.

### iii. Extrapolation to Low Circulating Water Flows

A stepwise multiple regression was performed for the most common fish and invertebrate species impinged during the sampling period between September, 1975 and September, 1976. The regression equations attempted to explain the variation in impingement rates (using log transformation) in terms of the observed variations in water temperature, salinity, dissolved oxygen, pH, wind speed, wind direction, time of day, intake water flow and number of travelling screens in operation. The last variable inversely related to the average intake velocity was expected to be inversely related to impingement. Exhibit 178 shows correlation coefficients computed in this analysis. For four of the seven species considered, impingement rates and number of screens were related inversely; the impingement rate of two species (Atlantic menhaden and sand shrimp) showed no significant relationship and one (Northern pipefish) demonstrated a positive relationship. Ranges were not calculated for any of these coefficients, so that it is possible that they were not significantly different from zero. However, given that the coefficients were calculated from between 275 and 752 nonzero samples (depending upon species), they represent the best annual estimates of the dependency of impingement rates on plant operating characteristics at OCNGS.

If the number of screens at OCNGS remains the same for the natural draft cooling tower system, the percentage decrease in impingement due to a 95% reduction in circulating water flow (typical of the cooling tower systems) can be calculated. Let

$x$  = regression coefficient of flow (from Exhibit 178).

$I_o$  = impingement rate with existing open cycle system,

$I_c$  = impingement rate with cooling tower system, and,

$f$  = open cycle flow rate (gpm).

then,

$$\begin{aligned}\text{Log } (I_c) - \text{Log } (I_o) &= - .95 \text{ xf}/115,000 \\ &= -3.8 \text{ x at maximum flow.}\end{aligned}$$

The correction factor is that fraction of the present impingement rate expected with the operation of any of the cooling tower systems, and is given by

$$\frac{I_c}{I_o} = 10^{-3.8x}$$

For each species, annual impingement rates at 5% of the percent water flow were calculated by multiplying the present rate by the following correction factors: Atlantic silverside (95.7%), bay anchovy (77.6%), blue crab (89.2%), blue fish (94.1%) and sand shrimp (92.4%). Results are shown in Exhibit 179.

An additional limitation to these calculations is that a statistical extrapolation to flows well below that for the period of record could yield sizeable errors. These errors could increase nonlinearly (eg, exponentially) as we move further from the average flow (approximately 400,000 gpm). The standard error for any extrapolated value depends upon the variation in rates for each fixed flow, and as illustrated in Exhibit 176, is likely to be high.

Alternative regression analyses were executed on a monthly basis in order to obtain an idea of the variability of these correction factors. Only the months of May, June and September provided enough information to do so. Correction factors computed on both annual and monthly bases are presented in Exhibit 180. In May, when peak impingement rates were reached, a reduction in water flow would have the greatest effect.

#### iv. Mortality

The existing OCNGS travelling screens collect debris from the inflowing circulating water and lift it upward into a sluiceway where it is transported to the discharge canal. This system is efficient for the removal of trash, but may result in high fish and invertebrate mortality rates. Several factors may exacerbate this problem. The screens are

operated in a pressure differential mode, so that fish or invertebrates may be impinged up to three hours before being removed. Here they are subject to suffocation and collision injury from debris and other organisms. As the screens are rotated, active specimens drop off the screens as the bottom ledge clears the water line. These specimens are then recycled until they are either killed or weak enough to remain on the narrow ledge of the screens. The screen wash water pressure is high (80 psi) in order to effectively clear the screens of debris, aquatic plants and jellyfish. Water at this pressure is highly injurious to fish.

Mortality data taken on OCNGS during the 42-week sampling interval showed that mortality rates remained relatively constant over time, although they differed widely depending upon species.

Many efforts to reduce impingement mortality at other intakes through the use of bubble screens, rubble mounds and multi-frequency vibrations proved ineffective for most species (19, 21). However, in 1974, VEPCO's Surry Power Station installed a series of modified travelling screens (Ristroph bucket screens). These new screens operate on a continuous mode, use a low pressure screen wash system (20 psi) and have a bucket compartment capable of maintaining two inches of water depth during rotation. Data taken during May, 1975 at Surry, indicated that fish survival greatly increased for all species impinged.

Exhibit 179 also presents monthly mortality estimates for the seven dominant fin and shellfish species in the OCNGS collections for the natural draft cooling tower system, utilizing both the existing intake screens and Ristroph screens.

#### v. Impingement Rates at Other Power Stations

Impingement field data from 15 generating stations located along the North Atlantic were also compiled in order to investigate impingement rates under a greater range of plant operating flows. Each of these stations is composed of between one and five units, and each had up to two years of impingement sampling data. Exhibit 181 describes the operating characteristics and impingement sampling frequencies for these stations. The plants, located on estuaries between Cape May, New Jersey to the south and Casco Bay, Maine to the north, were chosen on the basis of recent (1974-1976) impingement data availability.

Fish impingement rates peaked in different months, depending upon location. For example, plants located on or near Long Island Sound had their highest rates during October or November; stations located in more brackish waters demonstrated twin peaks, one during late spring and one during late fall. The preponderance of fish impingement (about  $8 \times 10^5$  fish/month) at OCNGS occurred during April and May, and bay anchovy (Anchoa mitchilli) comprised more than 95% of these collections.

Most time-series records of impingement demonstrate annual cycle patterns, in which large numbers of one or two species dominate the collections during a short time period. Such collections often account for more than three-fourths of the annual impingement. It is thought that the influence of intake flow on impingement rates is greatest during these periods. An analysis of flow versus maximum impingement rates was made for the plants listed in Exhibit 181. For each unit and sampling year, the maximum monthly impingement was extracted. To account for multiple peaks other data points were taken if they were at least 80% of that maximum or above 100,000 organisms. A plot of these rates versus flow appears in Exhibit 182 (see Exhibit 183 for legend). In general, low flows of 5% to 10% of that occurring at OCNGS showed impingement rates of about 1% to 2% of the maximum OCNGS impingement rate. The data showed that, to a first approximation, maximum impingement is linearly related to intake flow (ie, the slope of the regression line,  $\log \text{ impingement} = m \log \text{ flow} + b$ , was about 1.0). In other words, these results indicate that the average maximum impingement rates, over all power plants considered, decrease linearly with circulating water withdrawal. Because environmental differences dictate the magnitude of maximum fish abundance near the intakes, it is the linearly decreasing trend, and not the absolute values of impingement predicted by the regression equation, which is important for forecasting at any one site. For example, the regression line (Exhibit 182) indicates that a maximum of approximately 2,000 fish per month would be impinged at a plant operating around 23,000 gpm. Due to the high fish concentrations near OCNGS during certain months, it is more likely that the maximum impingement rates would decrease from about 800,000 fish per month to 40,000 fish per month, a decrease of 95 percent.

A similar regression of impingement rates on intake flow for the plants was executed on a monthly basis. The results (Exhibit 184) were less significant than that for the maximum impingement rates; only for January, March, April and May did the correlation coefficients exceed 0.5. Here again, the relationship between impingement rates and intake flow was confounded by the patchiness of fish abundance near the intakes.

A corresponding plant-to-plant comparison for macro-invertebrate impingement rates was impossible because most plants did not report detailed data.

#### vi. Impingement Summary

The forecasted impingement rates presented in Exhibit 179 were based upon the data collected at OCNGS over the ten-month sampling period. Water quality variability and plant operating variability both influenced the selection of proper regression coefficients in the predictive equations. As a consequence, there is a reasonable assurance that these equations adequately modelled the impingement phenomenon over the present range of operating variability. The equations can be interpreted as a sufficient predictor of impingement rates for flows between 345,000 and 460,000 gpm. However, for flows well outside this range this predictive capability declines rapidly.

An additional predictive technique utilized data from other power stations; here the flow range was increased at the expense of ignoring water quality and site specific information. Regression over short time periods partially accounted for water quality variables which change slowly over time (eg, water temperature). During most of the critical months, correlation coefficients compared favorably to those computed from OCNGS data directly. The predictive advantage of the alternative technique was that extrapolations of low flow conditions were more precisely estimated. In particular, the analysis indicated that a 95 percent decrease in condenser flow would likely be accompanied by a similar decrease in fish impingement rates. This, of course, is an average figure which may vary widely depending upon species and subsequent

environmental conditions. Macro-invertebrate impingement rates, on the other hand, may not decrease as much as those for fish, especially since behavioral responses (eg, feeding off screens and diel movements) may still attract organisms to the intake canal.

#### 14. Terrestrial Ecology Effects

Features of a natural draft cooling tower system which are discussed in the following paragraphs are limited to salt drift (producing salt deposition) and tower height (as an obstacle to flying birds). The acreage requirement of this system would be a relatively unimportant aspect of its potential environmental impact. Less than five acres would be preempted for the construction and operation activities and these would be located adjacent to the facility in low value vegetation and wildlife habitat.

##### a. Salt Deposition

Salt deposition rates and airborne concentrations predicted for combined operation of a natural draft tower at Oyster Creek and a natural draft tower at the Forked River Station are presented as isopleths in Exhibits 164 and 166 respectively. Associated maximum values are noted in Subsection IV-C-8, while maximum short-term values calculated for the Oyster Creek tower alone, and with a natural draft tower at the Forked River Site, are included in Exhibit 162, Tables 2 and 3 respectively.

The predicted maximum deposition rate relevant to long-term effects from the combined operation of a tower at each site would be  $109 \text{ kg/km}^2/\text{month}$ . Based on estimates discussed in Reference 22, existing background (including both wet and dry deposition) annual deposition of sea salt in the area where this maximum would occur, 0.75 miles southeast of the Oyster Creek tower, is in the range of 600 to  $1,000 \text{ kg/km}^2/\text{month}$ . The combined contribution of both towers in this area would constitute a likely increase in background rates of 10 to 17 percent. The total resulting salt deposition of 700 to  $1,100 \text{ kg/km}^2/\text{month}$  would still be well below the threshold for toxic soil salinity,  $4,670 \text{ kg/km}^2/\text{month}$ . In regard to selection of a cooling system, the potential salt deposition effect on soil was not considered an important factor of natural draft tower impact.

Sea salt deposition rates and airborne concentrations useful for considering the potential for direct salt injury to vegetation, are summarized in Exhibit 153. A background dry deposition rate of 250 -  $410 \text{ kg/km}^2/\text{month}$

(Reference 22, p 35) plus a maximum cooling tower contribution of  $109 \text{ kg/km}^2$  / month would mean a maximum annual total deposition rate of  $360 - 520 \text{ kg/km}^2$  / month. Studies at the University of Maryland have identified a dry deposition rate of  $1,100 \text{ kg/km}^2$  / month as one at which "caution should be exercised". This cautionary level is more than twice the level which would be expected in the vicinity of OCNCS.

The predicted maximum summer season concentration from combined operation of Oyster Creek and Forked River cooling towers would be  $0.13 \text{ } \mu\text{g/m}^3$ . Background concentrations in the vicinity of this maximum average near  $2-3 \text{ } \mu\text{g/m}^3$  (see Figure 23 of Reference 22). By comparison, average summer concentrations of  $40 \text{ } \mu\text{g/m}^3$  are not likely to injure sensitive species observed at Island Beach State Park (see Exhibit 153).

Predicted short-term cooling tower airborne salt concentrations would be well below levels identified by Moser<sup>(23)</sup> as injurious to sensitive vegetation of Island Beach State Park. Moser found that concentrations of  $50 \text{ } \mu\text{g/m}^3$ , maintained for several hours, were not sufficient to cause visible injury. Maximum peak concentrations predicted for operation of natural draft towers at the Oyster Creek and Forked River sites would not raise background concentrations to levels where the possibility of foliar injury would be considered an important factor in selection of a cooling water system.

In summary, short-term and long-term salt deposition rates and airborne concentrations predicted for operation of natural draft cooling towers at the Forked River and Oyster Creek sites would be lower than postulated injury thresholds. While these thresholds apply to natural vegetation, presumably adapted to a coastal environment, and may not be directly applicable to landscape or garden plants, it appears unlikely that these species would be affected by the small increments in background levels attributable to combined tower operation. Potential salt effect on vegetation is not considered an important aspect of natural draft cooling tower impact.

#### b. Hazard to Birds

The natural draft tower would be 540 ft tall and extend into airspace utilized by migrating birds during bad weather. Location of the tower in a shoreline environment where there is considerable night illumination, may contribute to the severity of a bird-collision problem. While this problem cannot be eliminated, selection of an appropriate lighting system should

minimize levels of bird mortality, Potential for bird mortality was not considered a major adverse impact.

15. Radiological Effects

Radiological doses to the critical individual from liquid effluents released by OCNGS equipped with a natural draft cooling tower system were estimated to be 0.27 mrem/year to the whole body and 9.6 mrem/year to the GI tract. These estimates, which are based on an annual average dilution flow of 717 cfs (322,000 gpm) meet the "as low as reasonably achievable" objectives of 3 and 10 mrem/year for the whole body and highest organ, respectively.

The 717 cfs annual average flow is based on dilution flow required to meet thermal criteria in Oyster Creek (see Exhibit 167). If two dilution pumps were used for the entire year, the whole body and GI tract doses would be similar to those for the canal-to-bay system and existing system.

Radioactive effluents from the Forked River Nuclear Generating Station have not been considered.

## SECTION IV-C

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## D. ROUND MECHANICAL DRAFT COOLING TOWER SYSTEM

### 1. Performance Data

The optimum round mechanical draft cooling tower system is described in Section III-B. The flow diagram for this system is depicted in Exhibit 33 and the layout is shown in Exhibit 34.

Two cooling towers of this type would be required to handle plant heat rejection. The optimum cooling tower design parameters and approximate dimensions would be as follows:

|  |                             |
|--|-----------------------------|
| Design Approach to $T_{wb} = 74^{\circ}F$                    | $10^{\circ}F$               |
| Cooling Range  | $21.1^{\circ}F$             |
| Circulating Water Flow                                       | 433 300 gpm                 |
| Circulating Water Temperature Entering/Leaving Cooling Tower | $105.1^{\circ}/84^{\circ}F$ |
| Base Diameter/Height   | 237 ft/69 ft                |
| No. of Fans per Tower  | 19                          |
| Fan hp   | 200                         |

Depending on a particular manufacturer's design, the dimensions of the cooling tower with the selected thermal design parameters may vary from those described in this report. These dimension deviations would not affect the optimum choice of the cooling tower design parameters and the results of the analysis.

An appropriate series of cooling tower approaches and ranges were established and evaluated. The lowest design approach considered was  $10^{\circ}F$ . The use of lower approach values would require three mechanical draft round cooling towers instead of two towers. A three tower installation would be more expensive in terms of both investment cost and annual cost. It would also require a larger area, more complicated piping and would cause more severe noise problems. Therefore, such an installation was not considered. The values considered for cooling ranges were  $16^{\circ}F$  to  $21.2^{\circ}F$  due to cooling tower and condenser tube water velocity limitations, as described in detail in the previous Section IV-C for the natural draft cooling tower system.

The design data for the optimum case is listed in Exhibit 62. Based on the economic analysis described in the following Subsection IV-D-6, the least costly choice for this alternative is a system of two mechanical draft round cooling towers with a design approach of  $10^{\circ}F$  and a cooling range of  $21.1^{\circ}F$ . It should be noted that this system would be the first built for salt water

application if constructed.

The thermal performance curve for the proposed system at full load operation is plotted in Exhibit 185. The predicted effluent data at design conditions were as follows:

|                              |                         |
|------------------------------|-------------------------|
| Exit Air Temperature, °F     | 96°                     |
| Exit Air Volume per Fan, cfm | 1.026 x 10 <sup>6</sup> |
| Exit Air Velocity, fpm       | 1317                    |

Predicted total evaporation rates for both cooling towers at full load operation are almost the same as for the natural draft cooling tower system:

|  | <u>gpm</u> |
|--|------------|
| Design Conditions (T <sub>wb</sub> = 74°F) | 7 000      |
| Average Summer                             | 6 550      |
| Average Spring/Fall                        | 5 700      |
| Average Winter                             | 4 800      |
| Maximum                                    | 7 400      |

Blowdown and makeup requirements would approximately be the same as for the natural draft cooling tower system, namely:

|           |                     |
|-----------|---------------------|
| Blowdown: | 9 600 - 14 800 gpm  |
| Makeup:   | 14 000 - 22 200 gpm |

The guaranteed drift rate at design conditions would be 0.001 percent of circulating water flow or 4.33 gpm.

Condenser pressure, turbine generator output and plant net output at full load operation with the round mechanical draft cooling tower system were calculated to be as follows:

| <u>Ambient Conditions</u> | <u>Condenser Pressure in. HgA</u> | <u>Turbine-Generator MW</u> | <u>Net Plant Output, MW</u> |
|---------------------------|-----------------------------------|-----------------------------|-----------------------------|
| Maximum Meteorological    | 3.41                              | 617.6                       | 585.0                       |
| Design                    | 3.23                              | 621.4                       | 588.8                       |
| Average Summer            | 2.73                              | 632.6                       | 600.0                       |
| Average Spring/Fall       | 2.04                              | 647.9                       | 615.3                       |
| Average Winter            | 1.70                              | 652.7                       | 620.1                       |

## 2. Condenser Tube Cleaning System

To prevent condenser tube fouling a continuous mechanical cleaning

system was assumed for the cooling system and its cost included in estimated investment cost, just as for the natural draft cooling tower system (see Subsection IV-C-2).

### 3. Circulating Water Pumps and Water Conduits

The cooling system total differential head with the optimum mechanical draft cooling tower system would be approximately 5 ft less than for the natural draft cooling tower system. However, when compared with the existing once-through system, it would require increased pump head by 60 ft. Due to pressure limitations in the existing tunnels, a two stage pumping scheme was assumed with four booster pumps similar to the installation described for the natural draft cooling tower system (Exhibit 156).

The main reinforced concrete circulating water conduit diameter from the cooling tower intake structure to the condenser and back would be 10 ft. Close to the cooling towers the conduit would be divided into two 8 ft ID conduits with valving facilities to provide independent operation of each of the two cooling towers.

### 4. Connection to Existing System

The interconnection of new circulating water conduits with the existing circulating water tunnels is shown in Exhibit 157.

### 5. Construction Schedule

A construction schedule for the round mechanical draft cooling tower system is depicted in Exhibit 186. The construction period would be 31 months, including 6 weeks for final pipeline interconnection with the existing circulating tunnels during plant shutdown for refueling. If system engineering, equipment purchasing, design and fabrication are included, the total time required for the mechanical draft cooling tower system installation would be 36 months.

### 6. Results of Cost Evaluation

The cost for the best cooling system cases at various approach temperatures is plotted in Exhibit 187. The performance data for the optimum case, which has an approach of 10<sup>o</sup>F, is tabulated in Exhibit 62. The computer printout for the optimum case is listed as Exhibit 188.

A summary of the costs follows:

Optimum Round Mechanical Draft  
Cooling Tower System

|   |                 |
|---|-----------------|
| Total Estimated Investment Cost   | \$56,015,000    |
| Total Comparable Annual System Cost including<br>Adjustments for Differential Net Capability &<br>Net Annual Generation | \$20,808,000/yr |

The performance of the existing once-through cooling water system is used as a basis for the above annual cost adjustments. Costs for noise abatement were not included.

7. Licensing Considerations

The permits required for construction of the round mechanical draft cooling tower system are described in Section III-E and Appendix B. Approximate processing times and licensing fees for these permits are summarized in Exhibit 160.

A review of the federal and state environmental regulations, permit requirements and engineering and environmental data did not reveal any instances of regulatory non-compliance in the areas of land use or water quality.

Noise emissions from the round mechanical draft cooling towers would exceed the New Jersey regulations during nighttime hours (see Subsection IV-D-11). A 5,000 ft. buffer zone would be necessary to meet the noise regulations. Approximately 220 acres of additional land area would be needed for this buffer. The land primarily consists of developed residential properties.

Particulate emissions from the round mechanical draft cooling towers would exceed the New Jersey air emission standards. The emission rate calculated for the round mechanical towers is approximately 106 lb./hr.; the maximum allowable emission rate is 30 lb./hr. The discussion of this issue in Section III-E should be borne in mind in interpreting the significance of this emission rate. The New Jersey primary and secondary ambient air quality standards would not be exceeded.

## 8. Atmospheric Effects

### a. Introduction

The ground level fogging and elevated plume models and the salt deposition model discussed in Subsection IV-B-3 and Appendix C were used to determine the atmospheric effects associated with use of the round mechanical tower. These analyses were based upon the tower characteristics shown in Exhibit 161. The analysis of icing due to drift is also given in Subsection IV-B-3 and Appendix C.

### b. Ground Level Fogging

Tower induced ground level fogging was estimated to occur only two hours per year (within a distance of 1640 ft from the towers) and therefore, can be considered to be only a minor effect of round mechanical draft tower operation.

### c. Elevated Visible Plumes

The predicted annual frequencies of elevated plumes that would be produced by the operation of two round towers at OCNCS are presented in Exhibit 189, Table 1. The dominant directions of these plumes would be east and east-southeast of the towers and the predicted plumes (for all directions) would be generally 500 to 1,500 feet in length.

Elevated visible plumes would also be created by the operation of the natural draft tower at the proposed Forked River Station. The plumes from the two stations would generally remain distinct and separate. During some small fraction of the year plumes from the two stations would merge resulting in a combined plume that would persist for a longer distance than would the plumes from separate stations.

### d. Salt Deposition

Exhibit 189, Table 2 presents by month the maximum, short-term, near ground, airborne concentrations of salt that would result from the operation of two round mechanical draft cooling towers at the Oyster Creek Station. Exhibit 189, Table 3 presents similar information but also includes the effects of the proposed Forked River NGS natural draft tower. As is readily apparent, the effects of the round towers would overshadow the additional impacts of the FRNGS tower.

The estimated maximum summer and annual near ground concentrations of salt that would result from the operation of Oyster Creek round mechanical draft cooling towers (with and without consideration of the Forked River Nuclear Generating Station) can be summarized as follows:

|                                   | <u>LOCATION</u><br>(miles in stated direction) | <u>CONCENTRATION</u><br>( $\mu\text{g}/\text{m}^3$ ) |
|-----------------------------------|--|--|
| <u>Annual</u>                     |  |  |
| Oyster Creek                      | 1.0 East-southeast                             | 0.80   |
| Oyster Creek plus<br>Forked River | 1.0 East-southeast                             | 0.86   |
| <u>Summer</u>                     |  |  |
| Oyster Creek                      | 1.5 North-northeast                            | 0.68   |
| Oyster Creek plus<br>Forked River | 1.5 North                                      | 0.72   |

The impact of salts released during the operation of a cooling tower can also be estimated in terms of the amount of salt deposited on a unit square area in a given time period. Estimates of the maximum amount of salt that would be deposited by round towers at Oyster Creek NGS can be summarized as follows:

|                                   | <u>LOCATION</u><br>(miles in stated direction) | <u>DEPOSITION RATE</u><br>( $\text{kg}/\text{km}^2$ - month) |
|-----------------------------------|--|--|
| <u>Annual</u>                     |  |  |
| Oyster Creek                      | 1.0 East-southeast                             | 511  |
| Oyster Creek plus<br>Forked River | 1.0 East-southeast                             | 570  |
| <u>Summer</u>                     |  |  |
| Oyster Creek                      | 1.5 North-northeast                            | 502  |
| Oyster Creek plus<br>Forked River | 1.5 North                                      | 534  |

Exhibits 190-193 indicate the spatial distribution of the near ground salt concentrations (summer season) and salt deposition rates (annual) that would be associated with the operation of round mechanical draft towers at the Oyster Creek Station. Exhibits 191 and 193 include the effects of the FRNGS tower while Exhibits 190 and 192 exclude these additional impacts. The addition of the FRNGS impacts does not have a major effect upon the patterns of salt impacts shown in the Exhibit; but, as would be expected, there is a resulting increase in the values of the salt impacts at individual locations.

## 9. Hydrothermal Effects

### a. Compliance with Temperature Criteria

Assuming use of the round mechanical draft cooling tower alternative, the discharge flow rate from both the Oyster Creek and Forked River stations, the dilution flow required for the combined flow to meet thermal criteria for temperature rise in Oyster Creek, the magnitude of the total combined flow and its resultant temperature rise were predicted for each month and are tabulated in Exhibit 194 for average conditions and Exhibit 195 for extreme conditions.

The round mechanical draft towers for the Oyster Creek Station would operate at lower temperature than the natural draft tower for the Forked River Station. Under average conditions, operation of one dilution pump would be sufficient for the discharge to meet New Jersey thermal criteria in every month except January, during which two dilution pumps would be required. During extreme conditions, the thermal criteria could be met by operating one dilution pump during the months of April, May, September and October, and by operating two dilution pumps during the remaining eight months.

### b. Temperature Distribution

Because of the relatively low temperature rise and short retention time in Oyster Creek, it is predicted that there would not be any appreciable temperature decay in the creek and the temperature rise at the point of discharge into Barnegat Bay would be the same as the combined temperature rises presented in Exhibits 194 and 195. Because these temperature rises would satisfy the thermal criteria, no mixing zone in the bay would be required.

## 10. Impacts on Water Resources

### a. Construction Effects

Construction effects would be similar to those for the natural draft cooling tower system discussed in Subsection IV-C-10.

b. Operational Effects

Water quality effects of the round mechanical draft tower system would be essentially the same as those described in Subsection IV-C-10. Exhibit 169 lists the daily average and maximum concentration factors, blowdown flows and rates of evaporation expected during each month for the round mechanical draft cooling tower system. Included are the concentration factors of the discharge TDS above the makeup as a function of operating one or two dilution pumps. As discussed in Section III-I, most chemical constituent concentrations in the intake water are proportional to salinity, ie, - TDS and, therefore, would also increase by these concentration factors. (1, 2) The resulting impact on water quality of Oyster Creek and Barnegat Bay is expected to be negligible for either one or two dilution pump operation.

Discussion in Subsection IV-C-10 relating to the use of corrosion inhibitors and biocides and to wastewater discharges is also applicable to the round mechanical draft cooling tower alternative.

11. Noise Effects

As indicated in Exhibit 196, the nearest residential area would be located approximately 1600 ft northeast of the round mechanical towers. The estimated unattenuated sound level produced by the round towers would be 60 dB(A) at a distance of 1600 ft from the towers. The following are the equivalent octave band sound levels that would be produced by the towers at the same distance:

| Octave Band<br>Center Frequency<br>(Hz)             | 31.5 | 63 | 125 | 250 | 500 | 1K | 2K | 4K | 8K | A Scale |
|---|------|----|-----|-----|-----|----|----|----|----|---------|
| Sound Pressure<br>Level (dB)<br>Re-0.0002 Microbars | 67   | 67 | 66  | 63  | 59  | 54 | 47 | 34 | 19 | 60      |

The above values are compared with New Jersey nighttime noise limitations in Exhibit 197. As can be seen from this exhibit, the sound emissions of the towers would be expected to exceed both the dB(A) values and also the octave band limits of the New Jersey Regulations.

Exhibit 197 also shows the noise produced by the towers at a distance of 5000 ft. At this distance the two towers would be expected to produce about 48 dB(A); in addition, the octave band levels would be below New Jersey limitations. Thus, a buffer zone of about 5000 ft between the towers and the residential area would be sufficient for noise emissions control. No other practical noise abatement techniques were identified for this cooling tower system. The circulating water pump motors would be expected to produce about 40 dB(A) at the property line, but because of the disparity in acoustical performance of the various motors, the noise emissions of this equipment should be re-evaluated if this alternative were chosen.

## 12. Visual Effects

### a. Photographic Analysis

The two round mechanical draft cooling towers would be 69 feet in height and would have a base diameter of 237 feet. The tower closest to Route 9 would be approximately 670 feet from the pavement of this thoroughfare. Because of their relatively low profiles, these towers would have low to medium impact upon the viewer, even in a close view such as that presented in Exhibit 137, location 3. Exhibit 135 indicates the locations from which the photographs were taken. There would be positions from where the towers could be viewed as a single massive unit of approximately 470 feet in diameter, but the effect would be minimized by the low profile of the units. Exhibit 136, location 1, and Exhibit 138, location 5, show the cooling towers as seen from two other locations. These Exhibits show that the round mechanical towers would have the ability to blend in with other elements at the Oyster Creek Station.

### b. Visible Plumes

An analysis was conducted to determine the impact which would result from elevated plumes arising from this type of tower upon nearby residential areas. The summer months of June, July and August were chosen, since there would be more outdoor activities of all kinds during this period than at other seasons of the year. During approximately one hour per summer, an elevated plume from the round mechanical draft cooling tower would be visible directly overhead in the residential areas around Lower Lake and Lake Barnegat (about 6,500 feet north of the site). This frequency would be the same as that

for a natural draft tower. Residents in the subdivision lying 4,500 - 5,500 feet north-northeast of the towers would observe an elevated plume overhead for approximately three hours per summer. Persons residing in the development which is 8,000 - 8,500 feet due east of the towers would observe an elevated plume overhead for approximately one hour per summer. This frequency would be comparable to that for a natural draft tower.

These frequencies indicate that the visual impact due to visible plumes from the round mechanical tower would be minimal.

c. Ground Level Fogging

The plume emitted from the round mechanical cooling tower would be expected to reach ground level only about two hours per year (with maximum frequency occurring 1,500 feet east-southeast of the towers). Thus, the impact due to ground fogging would be negligible.

13. Aquatic Ecology Effects

Aquatic ecological effects for the round mechanical draft alternative would be similar to those described for the natural draft cooling tower system. There would be four months (January, February, April, and September) in which discharge temperatures would be expected to be about 0.1<sup>o</sup>C lower than the temperatures associated with a natural draft tower.

14. Terrestrial Ecology Effects

Operation of round mechanical draft cooling towers at OCNGS may potentially impact terrestrial biota through increasing the existing airborne salt concentrations and deposition rates. The towers would be less than 70 feet tall and would not interfere with migrating birds. Less than five acres would be preempted for tower construction and this land would be located adjacent to the plant island. This land is probably of little value as vegetation and wildlife habitat, and its clearing would be a minor aspect of this cooling system's terrestrial impact.

a. Salt Deposition

Salt deposition rates and airborne concentrations predicted for combined operation of two round mechanical draft towers at the Oyster Creek Site, and

a natural draft tower at the Forked River site, are presented as isopleths in Exhibits 191 and 193, respectively. Associated maximum values are noted in Subsection IV-D-8 while maximum short-term values calculated for the Oyster Creek tower alone, and with a natural draft tower at the Forked River site, are included in Exhibit 189, Tables 2 and 3, respectively.

The predicted maximum deposition rate, relevant to long-term effects from the combined operation of towers at each site, would be  $570 \text{ kg/km}^2/\text{month}$ . Background annual deposition of sea salt (including both wet and dry deposition) in the area where the tower maximum occurs, 1.1 miles ESE of the Oyster Creek towers, is in the range of 600 to  $1,000 \text{ kg/km}^2/\text{month}$ , as stated in Section IV-C. Addition of cooling tower contributions from both sites to the background levels would yield an anticipated total salt deposition of 1,170 to  $1,570 \text{ kg/km}^2/\text{month}$ . While tower salt could increase background by as much as 95 percent, the total salt deposition would still be well below the suggested threshold for toxic soil salinity,  $4,670 \text{ kg/km}^2/\text{month}$ . It would also be within the range ( $1,100\text{-}2,200 \text{ kg/km}^2/\text{month}$ ) identified by Bernstein<sup>(3)</sup> as likely to cause minor effects on soil relative to potential effects on vegetation from foliar impaction and injury. For these reasons salt deposition effects on soil are not considered an important aspect of round mechanical draft tower evaluation.

As stated in Section IV-C, background annual rates for dry deposition fall somewhere between 250 and  $400 \text{ kg/km}^2/\text{month}$ , yielding an expected maximum total deposition rate between 820 and  $970 \text{ kg/km}^2/\text{month}$ . These values, while higher than the analogous values for the natural draft cooling tower system, would still be less than the cautionary value of  $1,100 \text{ kg/km}^2/\text{month}$  discussed in Section IV-C in regard to foliar injury.

The maximum summer month concentration predicted for combined operation of two round towers at the Oyster Creek, and one natural draft tower at the Forked River, sites would be  $0.7 \text{ } \mu\text{g/m}^3$ . Background sea salt concentration occurring in the area of the maximum is about  $2 \text{ } \mu\text{g/m}^3$ , indicating that total airborne salt concentrations would be roughly  $3 \text{ } \mu\text{g/m}^3$ . These levels would be well below levels which have been observed to cause no apparent damage to sensitive species at Island Beach State Park, as previously described.

Predicted maximum peak (5-15 hours intervals) near ground airborne concentrations of salt from round mechanical towers at the Oyster Creek site and from a natural draft tower at Forked River are presented by month in Exhibit 189, Table 3. For three of the months corresponding background short-term concentrations may be roughly estimated from Figures 25 and 26 of Reference 4, which show natural sea salt concentrations measured while winds blew from directions ranging from NNE, through E, to SSW. Maxima during the remaining nine months would be associated with winds blowing toward the ocean, for which no background concentrations have been reported. For these nine months, background levels were derived from Figure 26 of Reference 4. This approach would be expected to yield an overestimate since the wind directions used would be more favorable for bringing sea salt inland than would the wind directions actually expected. With background levels estimated in this manner, combined tower and natural short-term salt concentrations still do not appear to exceed 30-55  $\mu\text{g}/\text{m}^3$ .

The 30 - 55  $\mu\text{g}/\text{m}^3$  short term peak concentration should be compared to a threshold level of 60 - 100  $\mu\text{g}/\text{m}^3$  (Exhibit 153). Predicted maximum short-term peak concentrations appear insufficient to directly injure sensitive plants native to Island Beach State Park.

There is some indication that mechanical draft cooling tower contributions to short-term airborne salt concentrations could promote increased severity or incidence of naturally occurring salt-damage episodes. While the concentrations predicted are below the level identified as likely to injure sensitive species native to Island Beach (Exhibit 153) there are several factors which preclude eliminating the possibility of damage. The most important of these is the lack of information pertaining to species not growing on Island Beach, particularly oramental plants. Another factor is the limited duration (1 year) of the study which provides the basis for most of the thresholds considered. The meteorological data used in predicting salt deposition rates and concentrations are also based on one year's experience. Finally, it should be noted that plant responses to both long-term exposures and repeated short-term high salt concentration episodes are not known.

## 15. Radiological Effects

Radiological doses to the critical individual from liquid effluents released by OCNGS equipped with a round mechanical draft cooling tower system were estimated to be 0.27 mrem/year to the whole body and 9.6 mrem/year to the GI tract. These estimates, which were based on an annual average dilution flow of 717 cfs (322,000 gpm) would meet the "as low as reasonably achievable" objectives of 3 and 10 mrem/year for the whole body and highest organ, respectively, specified by the NRC.

The 717 cfs annual average flow was based on dilution flow required to meet thermal criteria in Oyster Creek (see Exhibit 167). If two dilution pumps were used for the entire year, the whole body and GI tract doses would be similar to those for the canal-to-bay system and existing system.

Radioactive effluents from the Forked River Nuclear Generating Station have not been considered.

SECTION IV-D

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E. FAN-ASSISTED NATURAL DRAFT COOLING TOWER SYSTEM

1. Performance Data

The optimum fan assisted natural draft cooling tower system is described in Section III-B. The flow diagram is depicted in Exhibit 41 and the layout is shown in Exhibit 42.

Two cooling towers of this type would be required to handle plant heat rejection. The optimized cooling tower design parameters and approximate dimensions would be as follows:

|  |                           |
|--|---------------------------|
| Design Approach to $T_{wb} = 74^{\circ}F$                    | $14^{\circ}F$             |
| Cooling Range  | $20.0^{\circ}F$           |
| Circulating Water Flow                                       | 458 400 gpm               |
| Circulating Water Temperature Entering/Leaving Cooling Tower | $108^{\circ}/88^{\circ}F$ |
| Base Diameter/Height   | 230 ft/300 ft             |
| No. of Fans per Tower  | 24                        |
| Fan hp   | 70                        |

The selection of these cooling tower design parameters was based on an evaluation of a series of cooling tower approaches and ranges. The lowest design approach considered was  $14^{\circ}F$ . Due to limited vendors' information, lower approach values could not be evaluated, although they would probably provide slightly improved economics. Acceptable cooling range values would be  $16^{\circ}F$  to  $21.2^{\circ}F$ . The imposed limitations would be the same as described in Subsection IV-C-1 for the natural draft cooling tower system.

The design data for the optimum case are tabulated in Exhibit 62. Based on the analysis described in Subsection IV-E-6 the least costly choice for this alternative would be the installation of two fan assisted natural draft cooling towers with a design approach of  $14^{\circ}F$  and a cooling range of  $20^{\circ}F$ .

It should be noted that this system would be the largest fan-assisted tower ever built and the first for salt water application, if constructed.

The thermal performance curve for the optimum system at full load operation is plotted in Exhibit 198. The predicted effluent data at design conditions were as follows:

|                                |                        |
|--------------------------------|------------------------|
| Exit Air Temperature, °F       | 100°F                  |
| Exit Air Volume per Tower, cfm | 15.8 x 10 <sup>6</sup> |
| Exit Air Velocity, fpm         | 700                    |

Predicted total evaporation rates for both cooling towers at full load operation would be almost the same as for the other two cooling tower systems discussed in this Chapter.

|   | <u>gpm</u> |
|---|------------|
| Design Conditions ( $T_{wb} = 74^{\circ}\text{F}$ ) | 7 000      |
| Average Summer                                      | 6 600      |
| Average Spring/Fall                                 | 5 700      |
| Average Winter                                      | 5 000      |
| Maximum   | 7 400      |

Blowdown and makeup requirements would approximately be the same as for the natural draft cooling tower system, namely:

|           |                     |
|-----------|---------------------|
| Blowdown: | 10 000 - 14 800 gpm |
| Makeup:   | 15 000 - 22 200 gpm |

The guaranteed drift rate at design conditions is 0.001 percent of circulating water flow or 4.58 gpm.

Condenser pressure, turbine generator output and plant net output at full load operation with the fan assisted natural draft cooling tower system were calculated to be as follows:

| <u>Ambient Conditions</u> | <u>Condenser<br/>Pressure<br/>in HgA</u> | <u>Turbine-Generator<br/>MW</u> | <u>Net Plant<br/>Output, MW</u> |
|---------------------------|--|---------------------------------|---------------------------------|
| Maximum Meteorological    | 3.67                                     | 612.5                           | 582.6                           |
| Design                    | 3.47                                     | 616.5                           | 586.6                           |
| Average Summer            | 3.00                                     | 626.0                           | 597.1                           |
| Average Spring/Fall       | 2.22                                     | 644.1                           | 615.2                           |
| Average Winter            | 1.81                                     | 651.2                           | 622.3                           |

## 2. Condenser Tube Cleaning System

To prevent condenser tube fouling a continuous mechanical cleaning system was assumed for the cooling system and its cost was included in estimated investment cost, just as for the natural draft cooling tower system (see Sub-section IV-C-2).

## 3. Circulating Water Pumps & Water Conduits

The cooling system total differential head with the fan-assisted natural draft cooling tower system would be approximately 10 ft less than for the natural draft cooling tower system. However, when compared with the existing once-through system, it would require an increased pump head of 55 ft. Due to pressure limitations in the existing tunnels, a two stage pumping scheme was assumed with four booster pumps similar to the installation for the natural draft cooling tower system (Exhibit 156).

The main reinforced concrete circulating water conduit diameter from the cooling tower intake structure to the condenser and back would be 10.5 ft. Close to the cooling towers, the conduit would be divided into two 8 ft ID conduits with valving facilities to provide independent operation of each of the two cooling towers.

## 4. Connection to Existing System

The interconnection of new circulating water conduits with the existing circulating water tunnels is shown in Exhibit 157.

## 5. Construction Schedule

A construction schedule for the fan assisted natural draft cooling tower system is depicted in Exhibit 199. The construction period would be 34 months, including 6 weeks for final pipeline interconnection with the existing circulating tunnels during plant shutdown for refueling. If system engineering, equipment purchasing, design and fabrication were included, the total time required for the fan assisted cooling tower system installation would be 41½ months.

## 6. Results of Cost Evaluation

The cost for the best cooling system cases at various approach temperatures is plotted in Exhibit 200. The performance data for the optimum case, which has an approach of 14°F, is tabulated in Exhibit 62 and is listed in Section III-B. The computer printout for the optimum case is listed as Exhibit 201.

The cost analysis results are summarized as follows:

### Optimum Fan-Assisted Natural Draft Cooling Tower System

|   |                 |
|---|-----------------|
| Total Estimated Investment Cost   | \$57,632,000    |
| Total Comparable Annual System Cost including<br>Adjustments for Differential Net Capability &<br>Net Annual Generation | \$21,305,000/yr |

The performance of the existing once-through cooling water systems is used as a base for above annual cost adjustments. Costs for noise abatement were not included.

## 7. Licensing Considerations

The permits required for construction of the fan-assisted natural draft cooling tower system are described in Section III-E and Appendix B. Approximate processing times and licensing fees for these permits are summarized in Exhibit 160.

A review of the federal and state environmental regulations, permit requirements and engineering and environmental data did not reveal any instances of regulatory non-compliance in the areas of land use or water quality.

Noise emissions from the fan-assisted natural draft cooling tower would exceed the New Jersey regulations during nighttime hours (see Subsection IV-D-11). The noise regulations could be met by enlarging the buffer zone surrounding the tower and providing the tower with special noise reducing equipment. With the noise reduction modifications, approximately 3½ acres of residentially-zoned land would have to be acquired northeast of the site to achieve compliance with the noise regulations.

Particulate emissions from the fan-assisted natural draft cooling towers would exceed the New Jersey air emissions standards. The emission rate calculated for the natural draft tower is approximately 101 lb./hr.; the maximum allowable emission rate is 30 lb./hr. The discussion of this issue in Section III-E should be borne in mind in interpreting the significance of this emission rate. The New Jersey primary and secondary ambient air quality standards would not be exceeded.

## 8. Atmospheric Effects

### a. Introduction

The ground level fogging and elevated plume models and the salt deposition model discussed in Subsection IV-B-3 and in Appendix C were used for the analyses of the atmospheric effects associated with operation of a fan-assisted tower. These analyses were based upon the tower characteristics shown in Exhibit 161. The analysis of icing due to drift is also discussed in Subsection IV-B-3 and in Appendix C.

### b. Ground Level Fogging

Tower induced ground level fogging and icing were estimated to have a very low frequency of occurrence for the fan-assisted natural draft towers. The greatest amount of fogging was predicted to occur in the west-southwest direction twelve hours per year at 1,650 ft, two hours per year at 3,300 ft in the east-southeast direction and one hour per year at 4,900 ft in the east-southeast direction. The maximum amount of tower induced icing predicted by the model was four hours per year at a location 1,650 ft south-east of the two towers.

### c. Elevated Visible Plumes

Exhibit 203, Table 1 presents the predicted annual frequencies of elevated plumes that would be associated with the operation of two fan-assisted natural draft towers at OCNGS. As with natural draft towers, the dominant direction of elevated plumes would be east and east-southeast of the towers; the most frequent plumes (in all directions) would be those 1,000 to 2,500 feet in length. The longest predicted plume lengths would be 12,500 - 13,000 feet, with an east-northeast direction (4 hours per year).

Elevated visible plumes will also be created by the operation of the natural draft tower at the proposed Forked River Nuclear Generating Station. The plumes from the two stations would generally remain distinct and separate. During some small fraction of the year plumes from the two stations would merge resulting in a combined plume that would persist for a longer distance than would the plumes from the separate stations.

d. Salt Deposition

Exhibit 203, Table 2 presents by month the maximum, short-term, near-ground airborne concentrations of salt that would result from the operation of two fan-assisted natural draft cooling towers at the Oyster Creek Station. Exhibit 203, Table 3 presents similar information but also includes the effects of the proposed Forked River NGS natural draft tower. As is readily apparent, the effects of the fan-assisted towers would overshadow the additional impacts of the FRNGS tower.

The estimated maximum summer and annual near-ground concentrations of salt that would result from the operation of Oyster Creek fan-assisted natural draft cooling towers (with and without consideration of the Forked River Station) can be summarized as follows:

|                                   | <u>LOCATION</u><br>(mi in stated direction) | <u>CONCENTRATION</u><br>( $\mu\text{g}/\text{m}^3$ -month) |
|-----------------------------------|---|--|
| <u>Annual</u>                     |   |  |
| Oyster Creek                      | 2.5 East-southeast                          | 0.20   |
| Oyster Creek plus<br>Forked River | 3.5 East-southeast                          | 0.25   |
| <u>Summer</u>                     |   |  |
| Oyster Creek                      | 2.5 North                                   | 0.22   |
| Oyster Creek plus<br>Forked River | 3.0 North                                   | 0.25   |

The impact of salts released during the operation of a cooling tower can also be estimated in terms of the amount of salt deposited on a unit square area in a given time period. Estimates of the maximum amount of salt that would be deposited by fan-assisted towers operating at Oyster Creek Nuclear Generating Station can be summarized as follows:

|                                   | <u>LOCATION</u><br>(mi in stated direction) | <u>DEPOSITION</u><br>(kg-km <sup>2</sup> -month) |
|-----------------------------------|---|--|
| <u>Annual</u>                     |   |  |
| Oyster Creek                      | .75 East-southeast                          | 110  |
| Oyster Creek plus<br>Forked River | 3.5 East-southeast                          | 110  |
| <u>Summer</u>                     |   |  |
| Oyster Creek                      | 2.5 North                                   | 110  |
| Oyster Creek plus<br>Forked River | 3.0 North                                   | 120  |

Exhibits 204-207 indicate the spatial distribution of the near ground salt concentrations (summer season) and salt deposition rates (annual) that would be associated with the operation of fan-assisted natural draft towers at the Oyster Creek Station. Exhibits 205 and 207 include the effects of the Forked River NGS tower while Exhibits 204 and 206 exclude these additional impacts. The addition of the Forked River NGS impacts does not have a major effect upon the patterns of salt impacts shown in the Exhibits; but, as would be expected, there is a resulting increase in the values of the salt impacts at individual locations.

## 9. Hydrothermal Effects

### a. Compliance with Temperature Criteria

Assuming use of the fan-assisted natural draft cooling tower alternative, the discharge flow rate from both the Oyster Creek and Forked River Nuclear Generating Stations, the dilution flow required for the combined flow to meet thermal criteria for temperature rise in Oyster Creek, the magnitude of the total combined flow and its resultant temperature rise have been predicted for each month and are tabulated in Exhibits 207 and 208 for average conditions and for extreme conditions, respectively.

The fan-assisted cooling towers for OCNGS would operate at lower temperature than the natural draft tower for the Forked River Station. Under average conditions, operation of one dilution pump would be sufficient for the discharge to meet New Jersey thermal criteria in every month except January and February, during which two dilution pumps

would be required. During extreme conditions, the thermal criteria could be met by operating one dilution pump during the months of May, September, and October, and by operating two dilution pumps during the remaining nine months.

b. Temperature Distribution

Because of the relatively low temperature rise and short retention time in Oyster Creek, it is predicted that there would not be any appreciable temperature decay in the creek and the temperature rise at the point of discharge into Barnegat Bay would be the same as the combined temperature rise presented in Exhibits 207 and 208. Because these temperature rises would satisfy the thermal criteria, no mixing zone in the bay would be required.

10. Impacts on Water Resources

a. Construction Effects

Construction effects would be similar to those for the natural draft cooling tower system discussed in Subsection IV-C-10.

b. Operational Effects

Water quality effects of the fan-assisted natural draft tower system would be essentially the same as those described in Subsection IV-C-10. Exhibit 169 lists the daily average and maximum concentration factors, blowdown flows and rates of evaporation expected during each month for the fan-assisted cooling towers system. Included are the concentration factors of the discharge TDS above the makeup as a function of operating one or two dilution pumps. As discussed in Section III-I, most chemical constituent concentrations in the intake water are proportional to salinity, ie, - TDS and, therefore, would also increase by these concentration factors. (1, 2) The resulting impact on water quality of Oyster Creek and Barnegat Bay is expected to be negligible for either one or two dilution pump operation.

Discussion in Subsection IV-C-10 relating to the use of corrosion inhibitors and biocides and to wastewater discharges is also applicable to the fan-assisted natural draft cooling tower alternative.

## 11. Noise Effects

As indicated in Exhibit 209, the nearest residential area would be located approximately 1,600 feet northeast of the fan-assisted tower locations. The estimated unattenuated sound level produced by the fan-assisted natural draft cooling tower would be 61.5 dB(A) at a distance of 1,600 feet from the tower. Also, following are the equivalent octave band sound levels that would be produced by the two towers at 1,800 ft distance:

| Octave Band Center<br>Frequency (Hz)                | 31.5 | 63   | 125  | 250  | 500 | 1K   | 2K   | 4K   | 8K  | A<br>Scale |
|---|------|------|------|------|-----|------|------|------|-----|------------|
| Sound Pressure<br>Level (dB)<br>Re-0.0002 Microbars | 67   | 67.5 | 63.5 | 62.5 | 58  | 54.5 | 49.5 | 38.5 | 6.5 | 60         |

The above values are compared with New Jersey nighttime noise limitations in Exhibit 210. As can be seen from this exhibit, the unattenuated sound emissions of the towers would be expected to exceed both the dB(A) values and the octave band limits of the New Jersey Regulations.

Exhibit 210 also shows the noise produced by the fan-assisted towers, if equipped with special low speed fans supplemented by inlet silencers, at a distance of 1,800 feet. At this distance, the towers would be expected to produce about 45 dB(A). Thus, a buffer radius of 1,800 feet (extending approximately 200 feet beyond the existing JCP&L property line) would be sufficient to meet the New Jersey noise limitations when utilizing these special low-noise tower modifications.

Without the use of noise abatement equipment, the fan-assisted natural draft cooling tower would require a buffer radius similar to that for the round mechanical cooling towers (5,000 ft).

Noise reduction could also be achieved through nighttime shutdown of the circulating water flow and fans in the north-northeast quadrant of the cooling tower. However, such operation would involve significantly higher costs and would still require a buffer zone similar to that required for the natural draft tower.

The circulating water pump and booster pump motors would be expected to produce about 40 dB(A) at the property line, but because of the disparity in acoustical performance of the various motors, the noise emissions of specific equipment chosen should be re-evaluated if this alternative is selected.

## 12. Visual Effects

### a. Visual Exposure

The pair of 300 feet high fan-assisted towers would be approximately 200 feet apart and aligned at right angles to Route 9. The closest tower to Route 9 would be about 690 feet from the pavement. Due to the tower alignment and distance, the two towers would appear as one tower to the viewer who was directly opposite them. From other angular viewing points they would appear as a 300 foot high mass, varying from an average diameter of 260 feet to a maximum possible 520 feet in diameter, depending upon the position of the observer. For a comparison with existing plant elements, it should be noted that the existing turbine building is approximately 265 feet by 180 feet by 88 feet in height, and the existing reactor building is 145 feet by 140 feet by 146 feet in height. The existing stack is tall (368 feet) but it is a slender element and has an exit diameter of about 18 feet.

Exhibit 145 shows the area surrounding the Oyster Creek Nuclear Generating Station in terms of relative potential exposure to high elements on the site. The areas which would be most heavily impacted are those with high exposure and a high population density; such areas are indicated in Exhibit 145.

### b. Photographic Analysis

A visual mass 300 feet high and about 400 feet in diameter would have a large visual impact on the scene. The towers, as they would appear, are shown in Exhibits 140 through 144. The locations where the photographs were taken are shown in Exhibit 139. As expected, there would be a large visual impact upon the viewer who was traveling along Route 9, as indicated by Exhibit 142. Exhibits 140 and 143 show the towers as seen from residential areas. The two towers would have a lesser impact upon the viewer who is on the waters of Oyster Creek, as shown in Exhibit 141, location 4. These towers and other existing high plant elements would also be seen from Island Beach State Park. They would be apparent on the bay side from the Sedge Islands north to about Tices Shoal (at this point, the Sunrise Beach housing development complex would impede the view). The towers would also be visible to viewers on top of the dunes on the ocean side of this barrier island. However, since most of the visitors to this park would be pursuing recreational activities on the beaches and in the ocean waters, the visual impact from plant structures is considered minimal for recreational visitors.

### c. Visible Plumes

An analysis was undertaken to determine the impact of elevated plumes from this type of tower upon nearby residential areas. The summer months of June, July and August were selected, since there would be more outdoor activities of all kinds during this period than at other times of the year.

During approximately two hours per summer, an elevated plume from the fan-assisted cooling tower would be visible directly overhead in the residential area around Lower Lake and Lake Barnegat (about 6,500 feet north of the site). Residents living in the homes lying 4,500 feet north-northeast (on the east side of Route 9) of the cooling towers would see an elevated plume overhead for approximately 22 hours per summer. This is seven times the frequency of summer elevated plumes for the natural draft and round mechanical towers. Residents of the subdivision lying 8,000 feet due east (bounded by the bay on the east and Forked River on the north) of the towers would see an elevated plume overhead for approximately one hour per summer. This is the same as the summer frequency for the two other preferred tower types. These results indicate that the visual impact due to elevated visible plumes from the fan-assisted cooling tower would be low.

### d. Ground Level Fogging

The highest frequencies of fog would occur west-southwest, east, and southeast of the tower locations; frequencies in these directions would be 12 hours, 11 hours, and 9 hours per year, respectively, at a distance of about 1,500 feet from the towers. Natural fog occurs at a frequency of approximately 140 hours/year (as measured at Atlantic City).

## 13. Aquatic Ecology Effects

Aquatic ecology effects produced by use of the fan-assisted natural draft cooling tower would be very similar to those of the other preferred cooling tower systems previously discussed. Discharge water temperature for this system would be only slightly different than for the natural draft cooling tower. Under extreme meteorological conditions, with two dilution pumps operating, the only month showing a different discharge temperature from the natural draft system would be November, and the difference would only be about  $0.1^{\circ}$  C. No other parameters of significance to aquatic ecology effects would differ from those seen with the natural draft tower.

#### 14. Terrestrial Ecology Effects

Employment of a fan-assisted natural draft cooling tower system may potentially affect terrestrial biota through tower emission of salt and tower interference with bird flights. Acreage requirements of this system would not represent a significant impact on terrestrial communities: the less than five acres required would be located adjacent to facility structures and are not considered valuable as vegetation or wildlife habitat.

##### a. Salt Deposition

Salt deposition rates and airborne concentrations predicted for combined operation of two fan-assisted natural draft towers at OCNGS and a natural draft tower at the Forked River Site are presented as isopleths in Exhibits 204 and 206, respectively. Associated maximum values are noted in Subsection IV-E-8, while maximum short-term values calculated for the OCNGS towers alone, and in combination with a natural draft tower at the Forked River site, are included in Exhibit 202, Tables 2 and 3, respectively.

An annual salt deposition rate of  $4,670 \text{ kg/km}^2/\text{month}$  is identified in Exhibit 153 as a threshold value for development of toxic soil salinity. The maximum annual salt deposition rate predicted for operation of two fan-assisted towers at OCNGS and one natural draft tower at FRNGS is  $110 \text{ kg/km}^2/\text{month}$ . This maximum occurs over Barnegat Bay approximately 3.5 miles east-southeast of the Oyster Creek NGS tower, where background sea salt deposition is expected to contribute an amount between 1,000 and 3,500  $\text{kg/km}^2/\text{month}$  (including both wet and dry deposition). On land, at those locations where predicted levels are almost as high as  $110 \text{ kg/km}^2/\text{month}$ , background rates are expected to range from 300 to  $1,000 \text{ kg/km}^2/\text{month}$ . Total salt deposition, background and tower, is not expected to exceed  $1,100 \text{ kg/km}^2/\text{month}$  on land. Consequently, potential salt deposition effect on soil is not considered an important factor of fan-assisted towers impact.

The annual dry deposition rate identified in Exhibit 153 as the level at which "caution should be exercised" regarding direct foliar injury is  $1,100 \text{ kg/km}^2/\text{month}$ . Total annual dry deposition, summing together the fan-assisted tower and background contribution would range approximately up to this level at the west shoreline of Barnegat Bay. Total dry deposition rates would be less inland since naturally occurring salt deposition declines with distance from the bay.

The maximum summer month airborne salt concentration predicted for fan-assisted tower at OCNGS, in combination with a natural draft tower at Forked River, is  $0.25 \mu\text{g}/\text{m}^3$ . This maximum would not significantly increase background summer month concentrations, which in the locale of the maximum are expected to be between 2 and  $3 \mu\text{g}/\text{m}^3$ . These levels would be well below levels which have been observed to cause no apparent damage to sensitive species at Island Beach State Park, as previously described.

Maximum peak concentrations (5-15 hour intervals) predicted for fan-assisted towers at OCNGS combined with a natural draft tower at FRNGS are presented by month in Exhibit 202, Table 3. Associated background sea salt concentrations were estimated as described in Subsection IV-D-14. In no case would peak concentrations reach  $50 \mu\text{g}/\text{m}^3$ , which is below the short-term threshold level of 50-100  $\mu\text{g}/\text{m}^3$  shown in Exhibit 153.

In summary, comparison of critical concentrations and deposition rates listed in Exhibit 153 with predicted levels suggests that salt deposition from fan-assisted cooling towers is not likely to cause significant impact to natural vegetation, although a cautionary level for direct foliar injury could be approached at points along the western shore of Barnegat Bay. Because of the uncertainties discussed in Subsection IV-D-14, the possibility of foliar injury or long-term deleterious effects to vegetation, especially species not studied in Island Beach investigations, should not be excluded from the factors considered in selection of a cooling water system.

b. Hazard to Birds

The fan-assisted natural draft towers would be 300 feet tall and could extend into airspaces utilized by migrating birds during bad weather. Location of the tower in a shoreline environment where there is considerable night illumination may contribute to the severity of a bird-collision problem. While this problem could not be limited, selection of an appropriate lighting system should minimize levels of bird mortality. Potential for bird mortality was not considered a major adverse impact.

The predicted annual frequencies of elevated plumes that would be produced by the operation of two round towers at OCNGS are presented in Exhibit 189, Table 1. The dominant directions of these plumes would be east and east-southeast of the towers and the predicted plumes (for all directions) would be generally 500 to 1,500 feet in length.

#### 15. Radiological Effects

Radiological doses to the critical individual from liquid effluents released from the OCNGS equipped with a fan-assisted natural draft cooling tower system were estimated to be 0.24 mrem/year to the whole body and 8.5 mrem/year to the GI tract. These estimates, which were based on an annual average dilution flow of 813 cfs (365,000 gpm) would meet the "as low as reasonably achievable" objectives of 3 and 10 mrem/year for the whole body and highest organ, respectively, specified by the NRC.

The 813 cfs annual average flow was based on dilution flow required to meet thermal criteria in Oyster Creek (see Exhibit 167). If two dilution pumps were used for the entire year, the whole body and GI tract doses would be similar to those for the canal-to-bay system and existing system.

Radioactive effluents from the Forked River Nuclear Generating Station have not been considered.

Section IV-E

REFERENCES

1. Von Arx, W S, An Introduction to Physical Oceanography, Addison-Wesley Publishing Company, Don Mills, Ontario, 1962.
2. Neumann, G, and Pierson, W J, Principles of Physical Oceanography, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1966.

## F. CANAL-TO-BAY SYSTEM

### 1. Design Alternatives

#### a. Introduction

The canal-to-bay system which was described in Chapter III was selected as a preferred alternative from the point of view of design, construction, operation, maintenance, cost and environmental effects. Certain environmental design constraints were evident prior to that selection and had already been incorporated into the canal-to-bay system described in Chapter III. Among these constraints were included the following: the canal must be lined and as watertight as possible; the discharge velocity of water into the bay must be low enough to avoid interfering with pleasure boating; fish should be prevented from entering the discharge canal.

During the evaluation described in the present Chapter, however, an additional important environmental constraint became apparent: natural flows (unsupplemented by OCNGS discharges) would not be adequate to maintain acceptable water quality in portions of Oyster Creek, given the present level of development in the watershed. Mitigating measures were, consequently, "built" into a substantially revised canal-to-bay alternative, described below. All parameters discussed in this Section and its accompanying Exhibits refer to this revised canal-to-bay scheme and may, therefore, differ from those parameters as specified in Chapter III.

#### b. General System Description

A new pumphouse could have been added to increase flow in the intake canal and transfer the increase to the existing discharge canal (while the bulk of the intake flow was used for condenser cooling and discharges by a new canal directly to Barnegat Bay). The cost of the addition would have been relatively small. However, the increased total flow to the intake canal could have increased sand transport in the intake canal, possibly eventually leading to sand deposition problems in Oyster Creek and Barnegat Bay at the discharge structure. Therefore, methods of maintaining the required minimum flow in Oyster Creek without increasing the flow in the intake canal were sought. Two methods were evaluated - either reduce the quantity of dilution water added to the new canal or, alternately, allow the entire dilution flow to pass down Oyster Creek and devise a means of mixing the condenser cooling water and dilution water at the bay. Since reduction of dilution flow would have had undesirable hydrothermal consequences, the

revised canal-to-bay system was designed to pass all the dilution water down Oyster Creek using the existing dilution pumps, and then using an additional set of pumps, transfer the dilution water to the mouth of the discharge canal for mixture with condenser cooling water and discharge.

The canal cross section required to give the least practical wetted perimeter (i.e., minimum linear area and a minimum practical base width of 20 feet for construction and maintenance purposes) would have a depth of flow in excess of 6.5 feet (for a flow velocity of 4.0 feet per second). Either most of the excavation would have to be made beneath mean sea level, or else the height of the discharge structure at the bay would have to be increased, this increasing noise impact, pumping head on the cooling water pumps, and decreasing available space above the free water surface to construct a new bridge required for Route 9. Reducing the depth of flow by increasing the velocity of flow was found to be unacceptable due to the increased pumping head it would require for the cooling water pumps.

The new canal would carry only the condenser cooling water from the power plant to a discharge drop structure at the bay. The connection between the canal and the existing discharge tunnel would be made using a 12 foot internal diameter reinforced concrete pipe. At the station end of the connection pipe some demolition of existing concrete would be required and the connection would be made by use of a prefabricated steel transition section embedded in concrete. At the canal end of the connection, a transition discharge structure would be required to change from a circular section to the canal cross section and to reduce the velocity of flow from approximately 9.0 feet per second to 4.0 feet per second. From the transition discharge structure, the water would then flow down a fully lined canal, under a new road bridge at Route 9, to the drop structure at the shore of Barnegat Bay.

The existing dilution water pumps would continue to operate exactly as in the existing station with the dilution water flow of about 545,000 gpm, including FRNGS discharges, passing down Oyster Creek. Near the bay, a new channel would be constructed leading to a new pumphouse. At this new pumphouse, about 480,000 gpm would be pumped in a pipeline to the drop structure at the bay where the condenser cooling water and dilution water would be mixed. About 65,000 gpm would be allowed to flow out the existing mouth of Oyster Creek to Barnegat Bay in order to prevent recirculation of heated water through the new dilution pumphouse when the tide is rising.

#### i. Canal

The canal itself would be built partially in cut and partially constructed with embankments. It was assumed that excavated material would be suitable for use in compacted embankment construction. Confirmation of this fact would be required prior to proceeding with design. Side slopes of 3 (horizontal) to 1 (vertical) were assumed for both excavated and compacted fill slopes. The depth of flow in the main part of the canal would be 4 feet and a liberal freeboard of 3 feet was allowed for the lining. On the south embankment, an access road between Route 9 and the new pumphouse would be required. In a wind blown high tide situation, the exterior slopes of the embankment could be exposed to the action of waves. To resist such wave action, the exterior slopes of the embankment would be flattened by spoiling uncompacted surplus excavation material in these areas. Topsoil stripped from the excavation area between Route 9 and the marsh could be used to attempt to grow grass on those flattened slopes.

#### ii. Canal Lining

The discharge canal lining would consist of a 7 inch thick reinforced concrete slab having contraction joints on an approximately 20 foot grid. Foundation material under the slab in the area of the embankment would be well compacted to minimize subsequent differential settlement. Under this slab would be laid an impervious flexible liner together with filter and drainage layers of material. These drainage layers would lead water to 18 inch diameter pipes which would be drained into Oyster Creek, relieving any buildup of groundwater pressure under the concrete liner and preventing heavy damage when the canal is unwatered. The flexible membrane would also be fully protected against the elements. Some special precautions would be required during construction to guard against water pressure buildup under the slab under exceptional high tide conditions.

#### iii. Discharge Drop Structure

The discharge drop structure design would serve three purposes: it would elevate the discharge so that fish are prevented from swimming up the canal; it would enable the discharge velocity in the bay to be held below 1 foot per second so that pleasure boating will not be disrupted, and it would act as a diffuser for the dilution water, achieving reasonably uniform mixing of the condenser cooling water and the dilution water pumped from Oyster Creek.

The drop structure would be built so that cold dilution water would be carried internally in a pipe while only the heated discharge water would flow over the crest. Numerous orifices could be constructed in the dilution piping so that the hot and cold water would mix in the turbulent zone at the foot of the drop structure. Such an arrangement would give the least total pumping head on the new dilution pumphouse and minimize the quantity of water flowing over the drop structure, minimizing noise emissions. In order to further minimize noise while preventing fish from entering the discharge canal, the crest of the drop structure would be set at elevation +4.5 ft, the maximum recorded high water level.

Should the canal-to-bay system be chosen for construction at OCNGS, it would be necessary to carry out a further study of the drop structure design to ensure that it would permit uniform mixing and stable pump operation.

#### iv. Connection to Existing System

In order to connect the existing cooling water discharge tunnel to the new canal, consideration was initially given to using a pipeline or to creating an elevated pond near the discharge structure. Such a pond would raise the water to an elevation of +8.0 feet so that the water could flow directly into the canal. This pond would be created by building walls (by slurry trench methods similar to those used in the original station construction) down into the underlying clay layer so as to form a watertight barrier. The need to maintain the minimum flow down Oyster Creek would make this pond difficult to construct. Consequently, a pipeline should be used instead.

The existing diesel generator vault would be the main obstruction to such a pipeline since it would be uneconomical to interfere with this structure in any way. If the pipeline were constructed on land with its invert above sea level, a substantial increase in pumping head would be required if the pipe were to maintain a positive internal pressure. In order to maintain the pipe below the hydraulic gradient, the top of the pipe would need to be at approximately +6.0 feet elevation or below. This would place the invert of the pipe at approximate elevation -8.0 feet or below. In order to eliminate excavation close to existing structures, the new pipeline should be laid directly in the existing discharge canal.

Construction of this canal-to-bay system would interfere with an existing, though out-of-service, railroad. Since the track has been dismantled south of the point where it crosses Oyster Creek, a complete realignment and provision of a runaround siding for the locomotive, using salvaged material as much as possible, would be the least costly solution to this potential conflict.

## 2. System Layout

The selected layout of this revised canal-to-bay system is shown in Exhibits 211 and 212. A schematic flow diagram is shown in Exhibit 125.

## 3. Construction Schedule

The construction schedule would require a total construction time of 20 months (see Exhibit 213). The most critical work in the schedule would be the connection to the existing system, which must take place in the plant refueling periods. Due to the total length of the schedule, two refueling periods would be available for this critical work. Careful scheduling and advance supply of all required materials would be essential to ensure that the plant outage was not extended. The planned construction sequence to meet this tight schedule would be as follows:

- a) Carry out necessary excavation prior to refueling period;
- b) Immediately after power plant is shut down, install the stoplogs and unwater the existing discharge tunnel;
- c) Demolish the existing concrete in the roof of the existing discharge tunnel and as much of the internal partition walls as possible while still retaining support for the stoplogs;
- d) Install a prefabricated steel transition section to make a transition from a 10.5 foot by 12 foot rectangular section to a 12 foot diameter circular section and embed this steel transition in concrete;
- e) Remove stoplogs;
- f) Demolish remainder of roof, partition walls and sill concrete underwater, as required to install a 12 foot diameter pipe;
- g) Make pipeline to transition connection and embed joint and first part of pipeline in concrete;
- h) Commence operation; and
- i) Backfill as required above the new connection.

#### 4. Plant Performance Data

The canal-to-bay system would produce a slightly smaller net electrical output than the existing system due to increased pumping power requirements. The derating would be much less severe than in the cases of the preferred closed cycle alternatives. Deratings and losses in annual net generation for the four preferred alternatives are compared in Subsection IV-G-4.

#### 5. Results of Cost Evaluation

The economic evaluation for the discharge canal to bay system involved the review of the effect of varying parameters such as flow volume, flow velocity and canal cross section. Changing these parameters made no significant difference in the results of the economic evaluation.

The total investment cost for this alternative was estimated to be \$33,813,000 and the total comparable annual system cost, including adjustments for differential net capability and net annual generation, was estimated to be \$ 9,131,000. Costs for noise abatement will not be included.

#### 6. Licensing Considerations

The permits required for construction of the canal-to-bay system are described in Section III-E and Appendix B. Approximate processing times and licensing fees are summarized in Exhibit 160.

Construction of the canal-to-bay system would require removal of a small wetland area near the shore of Barnegat Bay. Under CAFRA, and the Wetlands Act, wetland areas are classified as environmentally sensitive and suitable for preservation.

Based upon available data, water quality regulations regarding thermal criteria would be satisfied. Estimates of other water quality parameter concentrations in the discharge show that all values would be well below allowable limits.

The expected noise levels produced by the drop structure would exceed the New Jersey nighttime noise regulations unless mitigating measures were taken. However, the regulations could be met if the embankment on each end of the drop structure were 11 feet in height and a wall was constructed at the shoreline on the south side of the structure so that it extended a short distance into the bay and blocked any line of sight between the source of noise and potential receivers in nearby residential areas.

## 7. Atmospheric Effects

Use of a canal-to-bay system would not produce any significant atmospheric effects.

## 8. Hydrothermal Effects

### a. Compliance with Thermal Criteria

The design configuration of the canal-to-bay alternative for the Oyster Creek Station will result in a different discharge location for the OCNGS discharge than for the discharge of the Forked River Station. The Forked River Station blowdown would be discharged to Oyster Creek while the Oyster Creek Station condenser discharge would be directed to Barnegat Bay through a discharge canal. The preferred mode of operation for the Oyster Creek Station would pass the flow of two of the existing dilution pumps (520,000 gpm) into Oyster Creek where it would mix with natural flow and the FRNGS blowdown to protect water quality in the creek. Most of this Oyster Creek flow would be repumped by the additional dilution pumps near the mouth of Oyster Creek and combined with OCNGS's condenser discharge flow at the discharge point at Barnegat Bay.

Exhibits 214 and 215 present the discharge flow rate from each station, the required dilution flow (existing dilution system), the magnitude of the total combined flow to Barnegat Bay and the resultant temperature rise at the canal outlet during average and extreme monthly conditions, respectively. During extreme monthly conditions, the canal-to-bay alternative would operate at lower temperatures than the natural draft tower for the Forked River Station, although the effect would be less pronounced during the summer months than during the remainder of the year. During average monthly conditions, the canal-to-bay system would operate at higher temperatures than the Forked River Station tower from the months of April through September and at lower temperatures during the rest of the year. The temperature rise of the diluted Forked River blowdown would always satisfy thermal criteria in Oyster Creek and no heat dissipation area would be required for this blowdown in Barnegat Bay.

Because of the relatively low temperature rise and short retention time in Oyster Creek, it was predicted that there would not be any appreciable temperature decay in the creek. The temperature rise in the creek would be

as predicted in Exhibit 216 which assumed a Forked River Station blowdown flow and the flow from two existing dilution pumps.

The analysis did indicate that a heat dissipation zone would be required in Barnegat Bay to allow reduction from the temperature rise that would be associated with the new Oyster Creek Station discharge canal.

b. Temperature Distribution and Heat Dissipation Area

Because a heat dissipation zone would be required in Barnegat Bay, an investigation of the expected extent of the thermal plume was conducted. As described in Section IV-B, the predicted temperature distribution in the bay was based on data collected for the existing cooling water system. Examination of these data indicates that meeting thermal criteria will be most difficult during June, July and August when the temperature excess would be limited to 1.5<sup>o</sup>F. The affected surface extents and cross-sections of the five summertime thermal surveys available for the existing discharge are presented in Exhibit 217 along with information about the concurrent wind and tide conditions. From this data it appears that the existing plume satisfies the surface criterion and approximates the cross-section criterion.

In order to predict the temperature distribution in Barnegat Bay for the new discharge canal for the Oyster Creek Station, including the contribution from the natural draft tower for the Forked River Station, base isothermal maps for the existing station discharge were prepared. The thermal survey data for January 8, 1975, April 28, 1976, July 11, 1975 and October 14, 1976 were utilized. To these base isothermal maps, the predicted effects of adding the Forked River Station blowdown flow and relocating discharge to the mouth of the new canal were added. The resulting predicted isothermal maps for the combined discharge at both stations are presented in Exhibits 218 through 223 and indicate that the applicable Barnegat Bay thermal criteria would be met.

9. Impacts on Water Resources

a. Construction Effects

The construction of the canal-to-bay system could potentially cause adverse water quality impacts to Barnegat Bay and Oyster Creek. Suspended

solids concentrations could be increased significantly during excavation and dredging operations near or at the shoreline of Barnegat Bay. However, these impacts could be minimized through proper construction practices and should be of short duration.

Another potential impact during construction of this alternative cooling system would be runoff from disposal of dredge spoils in the areas shown in Exhibit 212. Experience with disposing dredge spoils on the site of the Oyster Creek NCS has already verified that no severe water quality impacts to Barnegat Bay have resulted.<sup>(1)</sup> None should occur if the canal-to-bay system is constructed, presuming that proper soil erosion and sediment control practices would be used.

b. Operational Effects

The canal-to-bay alternative should have operational water quality characteristics similar to the existing once-through cooling system. Essentially, this system would differ in only one hydrothermal consideration; that is, it would release the thermal discharge to Barnegat Bay directly, instead of via Oyster Creek. The existing dilution pumps would continue to direct 520,000 gpm to Oyster Creek. Near the creek's mouth approximately 480,000 gpm would be withdrawn through a new dredged channel, a pumphouse and two diffuser pipes and transferred into the discharge structure to cool the thermal discharge as it enters Barnegat Bay.

The intent of directing the dilution flow through Oyster Creek before mixing with the condenser flow at the discharge structure is to prevent anaerobic or septic conditions from occurring in Oyster Creek. Fecal coliform density and dissolved oxygen (DO) records taken prior to the construction of the nuclear facility have documented periodic septic conditions within the creek.<sup>(2)</sup> This generally occurred under low flow and high temperature conditions during the summer time. The residential community south of Oyster Creek utilizes cesspools for domestic sewage disposal, which very probably exerts a BOD on the creek via groundwater seepage. At present, there are more residences near the creek than before the construction of the nuclear plant and most of these use cesspools. Also, substantial dredging within the creek's natural boundaries and the excavation and dredging of the existing discharge canal have increased Oyster Creek's volume and detention time.<sup>(1, 3)</sup> These factors have raised the potential for septic condition to reoccur, unless the dilution flow is maintained.

Chemical, biocide and sanitary wastes from the station would be discharged to Oyster Creek after treatment. The dilution flow would mix with these effluents prior to entering the natural boundaries of Oyster Creek or Barnegat Bay. In comparison to the concentration of the chemical constituents in Barnegat Bay, these wastewater discharges would cause negligible incremental water quality changes.

10. Noise Effects

The important sources of noise in the canal-to-bay cooling water system would be the drop structure and the dilution pump motors located near the mouth of Oyster Creek.

The estimated sound level produced by the fall of water in the drop structure would be 63 DB(A) at the nearest residential property line (Exhibit 224) approximately 600 ft north of the structure. However, the level of noise reduction necessary to meet the 50 dB(A) limit could be achieved by raising the height of the embankment near the drop structure to 11 ft and extending a wall of the same height into the bay on the south side of the structure. These structural modifications would intercept the line of sight between the source of noise and potential receivers to the north and south, creating an effective noise barrier. With these mitigating measures, the estimated sound level at the nearest residential property line would be reduced to 48 dB(A). The following would be the equivalent octave band sound levels emitted by the drop structure and evaluated at 600 ft (with noise reduction modifications):

| Octave Band<br>Center Frequency<br>(Hz)             | 31.5 | 63 | 125 | 250 | 500 | 1K | 2K | 4K | 8K | A Scale |
|---|------|----|-----|-----|-----|----|----|----|----|---------|
| Sound Pressure<br>Level (dB)<br>Re-0.0002 Microbars | 48   | 48 | 48  | 48  | 46  | 43 | 39 | 39 | 31 | 48      |

The above values are depicted in Exhibit 225 along with the New Jersey octave band limits. As can be seen from this Exhibit, the sound level produced by the modified drop structure would be expected to be below the noise regulations.

## 11. Visual Effects

The canal-to-bay system would involve the installation of a new canal extending from the plant, under Route 9, and eastward to a weir at the shore of Barnegat Bay. The length of the canal would be a little less than two miles and the canal would be contained by dikes throughout its length. The dikes would be three feet above the elevation of the water in the canal and 20 feet wide, with side slopes of 3:1. The water surface in the canal would be 76 feet in width. The weir would be approximately 400 feet long and the exposed vertical portion of it would be only a few feet above mean sea level.

This cooling system would have an extremely low visual impact since there would be virtually no elevational aspects attached to it. Observers on Barnegat Bay would see what would appear to be a long, low waterfall and a small pumphouse in the vicinity of the weir. The only other views available to the general public would be those gained from Route 9 by motorists and fishermen at the bridge over the canal. Motorists would have a very fleeting glimpse of the canal, if they were aware of it at all, since it would lie below the road. Fishermen would find it to be another body of water, much like Oyster Creek, in an area which abounds in canals, creeks, rivers, and bays.

There may be some tendency for this system to augment nocturnal ground fog when conditions are favorable for its formation, but the impact would be expected to be minimal.

## 12. Aquatic Ecology Effects

### a. Shipworms

#### i. Temperature

Barnegat Bay water temperatures with use of the canal-to-bay alternative would be similar to those of the present OCNGS system, where  $\Delta T$ 's range from  $4^{\circ}$  to  $11^{\circ}\text{C}$ . The basic difference would be the location of the heated discharge. The conditions in Oyster Creek essentially would be as described for the natural draft cooling tower system. Depending on the time of year, heated water flowing through the lined discharge canal of the canal-to-bay system would consist of undiluted circulating water flow with  $\Delta T$ 's of  $20\text{-}30^{\circ}\text{C}$ .

Larvae of entrained shipworms would not likely survive these high water temperatures (Exhibit 146).

The confluence of the canal with the bay is nearer to Forked River than the Oyster Creek outlet. This difference in discharge location would cause a small increase in recirculation to Forked River. Area G (Exhibit 174) in Forked River could incur conditions enhancing borer population increases, although the potential change, because of the small difference in  $\Delta T$ , is not possible to quantify. Moreover, if wood-borer reproduction were enhanced in Forked River, the possibility of larvae going through the dilution pumps and into Oyster Creek could increase. Since larvae movement over distances of this magnitude is not well understood, the possible consequences could not be evaluated.

Much of the area in Barnegat Bay that would be influenced by the heated discharge would contain water warm enough to possibly enhance wood-borer population growth. Habitat, however, would also be required. The amount of habitat available to the borers in the areas within the elevated temperature isotherms is considered to be severely limited and, thus, would be a restrictive factor in determining shipworm success. In any event, shipworm success in Barnegat Bay with the canal-to-bay system would be similar to that for the existing system since the thermal distribution for these systems are similar.

#### ii. Salinity

No significant differences in salinity distribution between the present system and the canal-to-bay system would be expected.

#### iii. Water Volume and Velocity

For the canal-to-bay system, the current velocity at the mouth of Oyster Creek would be less than presently exists. No changes in shipworm distribution or successful setting of larvae would be expected in this area since the low  $\Delta T$ 's in Oyster Creek would curtail any increased borer reproduction. Water velocity from the canal into Barnegat Bay would be a new phenomenon, but, with little habitat available, would not be expected to influence borer success at this location.

#### iv. Dissolved Oxygen and pH

Mixing of dilution water with the heated discharge water would assure

oxygen concentrations near saturation for the water entering Barnegat Bay. Dissolved oxygen in the other parts of the Forked River, Oyster Creek, Barnegat Bay system would not be expected to vary from that existing in the present system. The pH values also would not be expected to differ from those of the existing system.

b. Cold Shock

i. Temperature

A comparison of the discharge temperature distribution between the existing system and the canal-to-bay discharge indicates only minor changes. Fish presently attracted to the Barnegat Bay plume areas would continue to behave as they do now with respect to temperature. Oyster Creek water temperatures would be similar to temperature regimes described for the natural draft cooling tower. Thus, it is expected that cold shock problems would be essentially eliminated in Oyster Creek for bluefish and menhaden.

No change in temperature structure is predicted in Forked River for operation of the canal-to-bay system. This suggests that present modes of ecological interactions would continue with the canal-to-bay system.

The lagoon system designated as G in Exhibit 174 is of special interest for the canal-to-bay system. The discharge location for the canal-to-bay system would be closer to this lagoon system than is the existing discharge, and, consequently, slightly higher  $\Delta T$ 's would be experienced at the mouth of the lagoon system should the canal-to-bay alternative be chosen. A comparison of the temperature distributions for the two systems under sample identical conditions can be seen in Exhibits 218 and 226. With the possible exception of springs and rain runoff, this body of water, which is totally artificial, has been designed as a dead-end system. That is, the only effective flushing potential exists through tidal action. In this case, the lagoon water would tend to be warmer than the bay water. This promises excellent attraction water to hold fish such as bluefish and menhaden past their expected migration time in the fall.

ii. Salinity

No difference in salinity from that of the existing system would be expected.

iii. Water Volume and Velocity

Construction of a new canal and addition of dilution pumps near the mouth of Barnegat Bay would not be expected to affect cold shock losses.

iv. Dissolved Oxygen and pH

Dissolved oxygen levels, which might be slightly higher in Oyster Creek as a result of the lower  $\Delta T$ 's, would not significantly affect the cold shock problem. Oxygen concentration in other areas would not be expected to change from that now existing. Levels of pH would not vary over those now present.

c. Entrainment

Condenser entrainment for the canal-to-bay system would be the same as that for the existing system. Dilution pump entrainment would double because of the additional pumps near the mouth of Oyster Creek. Pump mortality, and time-excess temperature mortality in particular, would constitute additional stress on population affected.

d. Impingement

Impingement at the circulating cooling water intake would be similar to present rates. Impingement would not be a factor at the dilution pumps at the mouth of Oyster Creek, since screens would not be required.

13. Terrestrial Ecology Effects

A canal-to-bay system could potentially affect terrestrial and wetland communities through land clearing and the consequential removal of vegetation and wildlife habitat. The canal would traverse approximately 3 kilometers of mostly natural habitat, which is classified as nonforested and marsh.<sup>(4)</sup> The stretch of the canal which would traverse salt water marsh is approximately 600-700 meters long.

Dredging for the canal would displace at least 15 acres of marsh habitat. Wetland maps prepared by the New Jersey Department of Environmental Protection clarify most of this habitat lost as "Phragmites (common reed)/predominantly open ground". Most of the wetland component is potentially valuable wildlife and waterfowl habitat. The canal-to-bay system alternative, therefore, may result in moderate impacts to waterfowl and wildlife resources.

14. Radiological Effects

Radiological doses to the critical individual from liquid effluents released by OCNCS equipped with the canal-to-bay cooling system were esti-

mated to be 0.17 mrem/year to the whole body and 6.0 mrem/year to the GI tract. These estimates, which were based on an annual average dilution flow of 1,160 cfs (520,000 gpm) would meet the "as low as reasonably achievable" objectives of 3 and 10 mrem/year for the whole body and highest organ, respectively, specified by the NRC.

The doses given above are similar to those for the existing cooling water system at Oyster Creek Nuclear Generating Station.

Radioactive effluents from the Forked River Nuclear Generating Station have not been considered.

SECTION IV-F

REFERENCES

1. Jersey Central Power and Light Company, Environmental Report, Oyster Creek Nuclear Generating Station, 1969.
2. New Jersey Department of Environmental Protection, Studies of the Upper Barnegat System, Project Report 3-137-R-2, 1972.
3. Burns and Roe, Inc., Alternative Cooling Systems Study for Forked River No. 1, Jersey Central Power and Light Company, 1971.
4. Jersey Central Power and Light Company, Environmental Report, Construction Permit Stage, Forked River Nuclear Generating Station, Unit No. 1, 1972.

G. COMPARATIVE ANALYSIS OF PREFERRED COOLING WATER SYSTEMS

1. Cost Comparison

The total estimated investment cost and total comparable annual costs for the four preferred systems are summarized in the following table along with their differential as compared to the existing cooling water system :

|  | <u>All Sums in Millions of Dollars</u>      |   |                     |
|--|---|---|---------------------|
|  | <u>Total Estimated</u>                      | <u>Comparable Annual</u>                |                     |
|  | <u>Investment Cost, \$ x 10<sup>6</sup></u> | <u>System Cost, \$ x 10<sup>6</sup></u> | <u>Differential</u> |
|  |   | <u>Total</u>                            | <u>Differential</u> |
| Existing Cooling System                    | -   | 0.5                                     | Base                |
| Discharge Canal-to-Bay                     | 34  | 9.1                                     | 8.6                 |
| Natural Draft Cooling Tower                | 61  | 20.4                                    | 19.9                |
| Round Mechanical Draft Cooling Towers      | 56  | 20.8                                    | 20.3                |
| Fan Assisted (Forced Draft) Cooling Towers | 58  | 21.3                                    | 20.8                |

Based on the above annual costs, the discharge canal-to-bay would be the least costly choice. However, when compared with the existing cooling water system, it would require additional annual expenses of \$9,300,000/yr. The natural draft cooling tower system is the next least costly choice, followed by the mechanical draft and fan-assisted natural draft cooling tower systems. Noise abatement costs were not included in the cost evaluation.

2. Technical Features of Cooling Towers

In the following paragraphs those technical features of each preferred cooling tower system are identified which cannot be readily evaluated economically but which nevertheless could affect a decision regarding the best alternative.

a. Performance, Predictions of Performance, and Performance Flexibility

Natural draft cooling towers have better thermal performance at low ambient air temperatures than other tower types. This improved performance arises from the increased induced flow of cold air through the tower. Alternatively, with high summer air temperature, which may exceed the selected design conditions, the natural draft cooling tower induced air flow would

be less, and its performance would degrade. The mechanical draft tower fans would provide an approximately constant flow of air regardless of ambient air temperatures.

The natural draft cooling tower would not provide the flexibility in draft control that is inherent to mechanical draft or fan-assisted cooling towers by shutting off fans or reducing their speed. However, it can be assumed that the natural draft cooling tower would provide better availability and require less maintenance because it would not have rotating parts and there is less which could go wrong.

Predictions of the performance of natural draft towers can be made with greater confidence than predictions for the other preferred cooling towers because of the greater base of operating experience with natural draft towers. However, during the plant lifetime it may become necessary or desirable to adjust the required performance. For the mechanical draft and fan-assisted cooling tower systems the entire thermal performance can be modified by increasing the fan horsepower. These systems also provide flexibility in thermal performance since one could turn off a portion of the cooling tower fans or reduce their speed. With a portion of the fans turned off, the performance of the round towers would experience more deterioration than the fan-assisted towers due to some recirculation of the air flow. To provide analogous flexibility, a natural draft cooling tower would have to be designed with provision for additional fill and with excessive shell height.

#### b. Maintenance Requirements

The natural draft cooling tower would not require placing any rotating equipment into and out of service on start-up and shutdown. This tower type would have the least number of valves on conduits. The manpower required for its maintenance would be the lowest among all cooling tower systems. However, yearly inspection of the tall concrete tower would be more complicated than that for other tower types.

The round mechanical draft cooling tower usually does not have provisions for hydraulic and aerodynamic division of the tower into independent cells and therefore some of the maintenance jobs have to be performed when the tower is shutdown. If requested, these tower types could be divided into two or more sections at an additional cost. The fan-assisted cooling tower would

normally be divided into four independent quadrants.

#### c. Winter Operation

All cooling tower designs have provisions for tower protection from icing during winter operation. Natural draft cooling towers utilizing the crossflow principle usually have louvers on the air inlet. At low ambient air temperatures these louvers would be flooded with warm water to defeat ice buildup. The warm water distribution basin for this cooling tower type may be divided into two rings. During winter operation most of the warm water flow would be directed to the outer ring. Natural draft cooling towers utilizing the counterflow design have a warm water distribution system composed of flumes and pipes fitted with spray nozzles. The warm water distribution system is designed to allow sectionalizing. During winter operation most of the warm water flow would be distributed around the peripheral part of the tower. In addition, special peripheral deicing warm water piping rings may be provided. Round mechanical draft towers and fan-assisted towers would use the same methods for winter operations as the natural draft towers plus the method of partial fan shutdown.

#### d. Drift Losses

All three cooling tower types would be designed for a drift rate of 0.001 percent of circulating water flow at design conditions (ambient wet bulb 74<sup>o</sup>F at 50% relative humidity). For the mechanical draft and the fan-assisted cooling towers the drift loss would not vary seasonally since the air flow through the tower would be constant. However, for a natural draft cooling tower an increase in relative humidity or a decrease in ambient wet bulb temperature would result in increased air flow and would cause some increase in drift losses.

At high wind velocities there is a possibility that drift could be blown through the air inlet of the natural draft or round mechanical draft cooling towers. The fan-assisted (forced draft) cooling tower does not have air inlet openings but, instead, fan inlet sleeves. When the fans are in operation drift losses through air inlet could not occur. This feature favors the fan-assisted tower.

#### e. Mechanical Equipment Reliability

The reliability of fan-assisted cooling tower mechanical equipment appears to be higher than that for the round mechanical draft towers since

fans in the former would operate in the ambient air environment whereas the fans in the round mechanical draft towers would be subject to the cooling tower salt effluent.

f. Experience and Suppliers

There is very limited experience with any type of salt water cooling tower. Almost all of the cooling towers in operation or ordered are for fresh water application. However, the round mechanical draft cooling tower and the fan-assisted cooling tower is a relatively recent development with just a few units in operation. The number of large natural draft towers in operation exceeds 50 and at least 75 more are under construction or ordered. From this standpoint the natural draft cooling tower system is preferable.

The natural draft cooling tower is offered by several cooling tower manufacturers. Conversely, the fan-assisted cooling tower is presently offered by only one manufacturer in the United States, though it may be offered by some European manufacturers. The round mechanical draft cooling tower is offered by three manufacturers in the U.S.

3. Construction Schedule

The total required time for construction for the three preferred alternative tower systems is summarized as follows:

| <u>Cooling Tower Type</u> | <u>Construction Time, Months</u> |
|---------------------------|----------------------------------|
| Mechanical Draft Round    | 31 (38)                          |
| Fan-Assisted              | 34 (41½)                         |
| Natural Draft             | 36 (45)                          |

Numbers in brackets include engineering and factory manufacturing.

By comparison, the canal-to-bay system could be constructed in 20 months.

4. Capability and Generation Comparison

Exhibit 227 gives the plant net capability (during average summer conditions), the annual heat rate and the net annual generation for the preferred alternative and existing systems. Use of any of the preferred

alternatives would result in a loss of net annual generation. However, the loss would be only about 17,000 Mwh/yr for the canal-to-bay system; losses with use of any of the preferred cooling tower systems would be on the order of 100,000 Mwh/yr.

#### 5. Environmental Comparison

The environmental effects associated with the preferred cooling systems are summarized in Exhibit 5 and compared in the following paragraphs.

##### a. Natural Draft Cooling Tower System

The primary advantages of a natural draft cooling tower system over the existing system or canal-to-bay system at Oyster Creek would be related to reduced thermal plume effects and lower intake water requirements. The smaller plume area would reduce cold shock and wood borer problems and the lower intake flow would reduce impingement and entrainment losses.

Natural draft cooling tower operation would produce a number of environmental effects that have not been associated with the present cooling system. For example, there would be salt deposition on surrounding land and vegetation, the visual impact of a 540 ft high structure and noise levels that would require mitigative measures to meet noise criteria.

In comparison to the environmental effects of other preferred cooling tower systems, the natural draft tower would be similar in most respects. The major differences would concern tower height (visual impact) and noise. The natural draft tower would be the tallest of the preferred cooling towers. It would require the acquisition of less additional land as a noise buffer than the round mechanical draft or unmodified fan-assisted natural draft towers, but more land than would a fan-assisted tower modified for noise reduction.

##### b. Round Mechanical Draft Cooling Tower System

Comparisons of the round mechanical draft cooling system to the canal-to-bay system and existing system are essentially the same as those given above for the natural draft cooling tower system. The round tower would exhibit a relatively low profile, (70 ft in height) but would produce higher noise levels than the other towers. It would not be practical to attempt to acquire land or modify the tower system design to meet noise criteria. The airborne salt concentration and salt deposition rate within several thousand feet of the towers would be somewhat higher than that of the natural draft or fan-assisted tower systems. These rates would be less than the cautionary values discussed in regard to foliar injury.

c. Fan-Assisted Natural Draft Cooling Tower System

Comparisons of the fan-assisted natural draft tower system to the canal-to-bay and existing systems are essentially the same as those given above for the natural draft cooling tower system. If design modifications were used to reduce the tower noise, less additional land would need to be acquired to meet noise standards than would be the case using a natural draft or round mechanical draft system. However, without such design changes (with their accompanying comparable annual system costs) sound levels would be higher than with the natural draft system. Salt deposition near the shore of Barnegat Bay would approach levels of caution regarding foliar injury to vegetation.

d. Canal-to-Bay System

The important environmental effects of the canal-to-bay cooling water system would be related to thermal plume distribution and aquatic ecology. The areal extent of the thermal plume would be similar to that of the existing system. Regarding aquatic ecological effects, impingement mortalities would be similar to those of the existing system. Condenser entrainment would be the same as that of the existing system. Dilution pump entrainment would double because of the additional pumps near the mouth of Oyster Creek. However, a reduction in wood borer population would be expected because the station's heated discharge would be routed directly to Barnegat Bay, a less ideal reproductive environment, circumventing Oyster Creek. Cold shock effects would be reduced in Oyster Creek, but would remain the same in Barnegat Bay.

Some modifications to the drop structure would be necessary for the system to meet noise criteria. Atmospheric, water quality, and visual effects would be similar to those of the existing system. Construction in the marsh near Barnegat Bay would create a disturbance to the terrestrial ecosystem along with loss of habitat.

When compared with the closed-cycle cooling tower alternatives, the canal-to-bay system would produce a much larger thermal plume. In addition, impingement and entrainment mortalities would be substantially higher than would be expected for the cooling tower alternatives.

## 6. Recommendation

Any decision to construct and operate an alternative cooling system at the Oyster Creek Nuclear Generating Station must be based on a judgment that increased annual system costs would be justified in light of environmental benefits to be gained. Such judgments can be difficult to make because the costs and benefits involved are not routinely expressed in commensurate terms. In addition, questions of socio-economic impacts may also figure in the decision.

Questions of socio-economic impacts, and the equivalent dollar value of environmental benefits have not been addressed within the scope of this report. Subject to this constraint, should an alternative cooling water system be judged appropriate for the Oyster Creek Nuclear Generating Station, Ebasco believes, based on its evaluation of technical, cost, licensing and environmental factors, that the natural draft cooling tower system would be the best choice.

The decision to recommend the natural draft cooling tower system was influenced primarily by the following considerations:

- 1) Aquatic ecological effects were viewed as the most important environmental impact associated with the existing cooling water system; the closed cycle preferred alternatives would offer significant reduction in overall aquatic ecological impact of OCNGS, whereas the canal-to-bay system would produce only marginal reduction.
- 2) It would be impractical to meet applicable noise criteria with a round mechanical tower since a buffer zone of 5,000 feet would be required; the significant modifications required to bring a fan-assisted tower alternative into compliance with noise criteria seem unwarranted as long as the 1,300 ft buffer zone extension needed to bring a natural draft tower into compliance can be expected to be obtainable; and
- 3) There are several suppliers of large natural draft cooling towers in the U S, but only one manufacturer offers the fan-

assisted cooling tower. There is considerable operating experience with natural draft towers in the U S; however, fan-assisted towers are a relatively recent development, and none of these towers are operational or under construction in the U S. Experience in noise-control for fan-assisted towers is extremely limited (none in U.S.).

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APPENDICES

LIST OF EXHIBITS

| <u>No. of Exhibits</u> | <u>Title</u>   |
|------------------------|--|
| B-1                    | Chemical Effluent Limitations For Steam Electric Generating Sources  |
| B-2                    | Excerpts From State of New Jersey Surface Water Quality Criteria <ul style="list-style-type: none"><li>. FW-3 Waters</li><li>. TW-1 Waters</li><li>. CW-1 Waters</li><li>. CW-2 Waters</li></ul> |
| B-3                    | New Jersey Regulations on Air Pollution from Manufacturing Processes   |

APPENDIX A

COMPUTER PROGRAM FOR  
COOLING WATER SYSTEM SIZING  
AND ECONOMIC EVALUATION

#### A. INTRODUCTION

The input data to the computerized optimization program for the selection of a steam condensing system based on costs is comprised of the equipment design variables, the heat rates, layout information, and system loads as well as equipment, material and labor pricing information. The program, utilizing these inputs together with mathematical, theoretical and design assumptions, selects and develops cooling system features and components including concrete or earth structures (such as intake structures or cooling tower basins), circulating water main and branch conduits, circulating water pumps and motors (and condenser shells and tubes, if necessary). The cost impact of the differential unit transformers' (main, auxiliary and startup) size, which depends on the cooling water system power requirements, is also considered.

#### B. COMPUTER PROGRAM

The program selects, analyzes and prices all the system components as follows:

- (1) The size of the circulating water pumps, motors and condensers (if necessary) is determined from design formulas and the costs calculated based on the latest pricing lists available assuming reasonable discounts.
- (2) The intake structure size is calculated from general design relationships and priced volumetrically (\$/cu ft of structure).
- (3) Cooling tower data is calculated as a function of approach to the wet bulb temperature and the cooling range based on the input data.
- (4) The optimum size of the circulating water conduits is selected based on a cost analysis of fixed and annual charges (investment and fuel cost)
- (5) The auxiliary power demand and annual energy consumption for the cooling water system are determined from the units loading schedule, circulating water pump and cooling tower fan design and mode of operation data.

- (6) Makeup water consumption and water treatment chemical cost is calculated as a function of evaporation rate, drift losses and cycles of concentration in the circulating water circuit.

For each case the economic analysis includes the determination of initial investment cost and annual system cost (fixed charges on the investment cost plus the annual operating and maintenance costs). These costs include items related to condenser cooling systems only and do not represent total plant costs.

1. Investment Costs

The total investment cost consists of estimated major site development cost associated with each alternative cooling system plus computerized variable costs. The major site development cost, included in the overall computerized optimization program for each of the alternative cooling systems, is estimated based on information shown on plot plans and the specific quantities required for the following:

- Clearing - general area,
- Grading - general area,
- Makeup, blowdown system and water treatment -  
equipment, piping, structures,
- Maintenance roads,
- Condenser tube cleaning system, and
- Cathodic protection and lighting.

For the cooling pond and spray canal systems, the total civil work cost was included in major site development cost.

Computerized variable investment costs are developed by the computer to make up the remaining investment cost items which are added to the major site development cost for the total direct cost of material and installation.

Included in the computerized variable costs are:

- Local improvement to site-clearing,
- Local grading,
- Circulating water intake structure,
- Spray cooling modules,
- Circulating water pumps and motors,
- Circulating water main and branch water conduits,

Cooling tower basin and superstructure,  
 Condenser shells and condenser tubes (if necessary),  
 Instrumentation and control for circulating water pumps,  
 Unit main power transformer (differential),  
 Unit auxiliary transformer (differential),  
 Start-up and stand-by transformer (differential),  
 Circulating water system switchgear, and  
 Wiring for circulating water system.

The size and cost of turbine generator equipment, pedestal and building for an existing plant is assumed fixed for all cases considered.

## 2. Comparable Annual Costs

The estimated "Comparable Annual Costs" is developed using the computerized program and the results are recorded in the following manner:

| <u>Description of Cooling System</u>   | <u>Comment</u>   |
|--|--|
| Type of Cooling System   | - A controlled variable identifying the specific type of Cooling Water System.   |
| Maximum Cooling Water Temperature  | - Cooling water temperature entering condenser at maximum meteorological conditions is used for unit capability calculation at adverse conditions. |
| Degrees of Approach at Design Conditions   | - A controlled variable within the typical range of values for the type of cooling water system.   |
| Plant Net Capability at Maximum Meteorological, Design and Average Seasonal Conditions |  |
| (1) Turbine Generator  | - Energy generated operating at condenser pressure coincident with the appropriate meteorological conditions.                                      |

| <u>Description of Cooling System</u>                                   | <u>Comment</u>   |
|--|--|
| (2) Estimated Plant Auxiliary Power Excluding Cooling Water System, kW | - A set of constant values for each of the various loads common to all cooling water system alternatives studied.  |
| (3) CW System Auxiliary Power, kW                                      | - Calculation and Summation of circulating water pump motor and cooling tower fan motor or of spray module motor input power.  |
| (4) Plant Net Capability at Various Conditions, kW                     | - These calculation values reflect the restraint or limit in plant capability at various conditions. The value at average seasonal conditions is the basis for monetary evaluation of differential net capability. |
| Plant Net Annual Generation kWh/yr                                     | - Integrate (Net Plant Capacity x Period Hours) for three (3) periods per year and three (3) values of turbine generator loads.  |
| Differential Plant Net Capability, kW                                  | - Base value is the maximum dependable plant net output of 620 MW. Any value smaller is penalized for this loss of capability. As instructed by JCP&L larger values were not credited.                             |
| Differential Plant Net Generation, kWh/yr                              | - Base value is a preselected specified value. Any value smaller is penalized for this loss of kilowatt hours generation. A value larger is credited on the same basis.  |

| <u>Description of Cooling System</u>                    | <u>Comment</u>  |
|---|---|
| Annual Fixed Charges, \$/yr                             | <p>Plant Net Generation with the existing cooling system was used as base value.</p> <p>- The total Estimated Investment Cost has been defined. This cost multiplied by an Annual Fixed Charge Rate is equal to the Annual Fixed Charges.</p>   |
| Annual Plant and Cooling Water System Fuel Costs, \$/yr | <p>- It is assumed that the Nuclear Reactor annual fuel consumption and hence the thermal output is the same for all alternative cooling water systems. The total plant annual fuel cost is calculated based on the integral of three (3) periods per year, the percent loading regimen per period, the thermal rating of the nuclear reactor and a specified fuel cost. This cost is the same for all alternatives. A variable is the fuel cost related to the cooling water system. This cost is calculated based on circulating water pump motor and cooling tower fan motor energy requirements (kWh/yr) and is included in the comparable annual system costs.</p> |

| <u>Description of Cooling System</u>   | <u>Comment</u>  |
|--|---|
| Water Consumption  | - Evaporation plus Drift Loss plus blowdown equals makeup.  |
| Water Costs, \$/yr   | - Makeup x Unit Cost of water treatment.  |
| Maintenance, \$/yr   | - A Calculated Cost as a percentage of Investment Cost. For mechanical draft towers, a maintenance charge per fan is added.   |
| Subtotal Annual Cost, \$/yr  | - A summation of above costs.   |
| Net Unit Production Cost, mills/kWh  | - This cost is based on the above annual costs divided by net annual generation.  |
| Adjustment for Differential Plant Net Capability, \$/yr  | - This differential capability cost is calculated at a rate of incremental net capability leveled cost times the leveled Fixed Annual Charge Rate times the differential net capability (see next comment). |
| Adjustment for Differential Plant Net Annual Generation, \$/yr                                   | - This differential generation cost adjustment is calculated assuming a fixed leveled charge per kWh times the differential plant net annual generation.  |
| Total Comparable Annual Cost Including Adjustment for Equalized Capability and Generation, \$/yr | - A Summation of Subtotal Annual Cost and Adjustment.   |
| Comparable Net Unit Production Cost, mills/kWh   | - This cost is based on Total Comparable Annual Cost Including Adjustments for Equalized Capability and Generation divided by base net generation.  |

The above computation is repeated for each condensing system using various values for the water velocity in condenser tubes and cooling tower approach (the latter is defined as the difference between the circulating water temperature entering the condenser and the ambient wet bulb temperature). Then all the cooling system costs are sorted and results printed in ascending order of annual cost with capability and generation adjustments, the least costly being first on the list.

APPENDIX B

APPLICABLE FEDERAL AND  
STATE ENVIRONMENTAL REGULATIONS

A. FEDERAL REGULATIONS

1. Activities in Waterways

Under the Federal Water Pollution Control Act of 1972 and the Marine Protection, Research and Sanctuaries Act of 1972, the U S Army Corps of Engineers requires a permit be issued for any construction or dredging activities in navigable waterways. The Corps will prepare or review the EIS associated with the project and will hold a public hearing if requested by any party affected by issuance of the permit.

2. Chemical Effluent Limitations

The U S Environmental Protection Agency on October 8, 1974 promulgated Effluent Guidelines and Standards for the Steam Electric Power Generating Point Source Category (40 CFR Part 423), as required by the Federal Water Pollution Control Act Amendments (FWPCA) of 1972 (PL92-500). The FWPCA requires that existing sources must meet the standards set by the Best Practicable Control Technology Currently Available (BPCTCA) no later than July 1, 1977 and the standards set by the Best Available Technology Economically Achievable (BATEA) no later than July 1, 1983. A summary of the chemical effluent limitations and guidelines for cooling water and blowdown streams is presented in Exhibit B-1. Limitations for low volume wastes are not included.

B. STATE REGULATIONS

1. Land Use

The State of New Jersey Department of Environmental Protection (DEP) regulates land use in the coastal zone through the following programs:

- (1) Coastal Area Facility Review Act (CAFRA) Permit
- (2) Riparian Construction Permit
- (3) Wetlands Construction Permit
- (4) Stream Encroachment Permit

Since construction of an alternative cooling water system would most likely require one or more of these permits, each of the programs is discussed below:

### Coastal Area Facility Review Act

The CAFRA Act augments existing state statutes, such as the Wetlands Act of 1970, and provides for protection of the coastal environment. Under CAFRA, the State has issued Interim Land Use and Density Guidelines, which serve as DEP policy until a final coastal management program is developed.

The guidelines classify land in the coastal area as to suitability for preservation, conservation and development. Applications which involve construction in the preservation areas (i.e., prime agricultural land, flood-prone land, park lands) will be restricted. According to the guidelines, development would be allowed in discouraged areas "...only under conditions where the department determines that overriding State economic or social values are to be served...". While these guidelines do not include policies for siting energy facilities, it is expected that applications with proposed construction in preservation areas will meet with strong opposition.

An Environmental Report and a public hearing are required.

### Riparian Construction Permit

Any land now or formerly covered by the mean high tide is owned by the State of New Jersey unless it has been divested through a grant, lease or license. Any construction on riparian land must be authorized by the DEP via issuance of a riparian construction permit. Permits are denied for development found to be in conflict with the public interest. A public hearing is held if sufficient public interest is demonstrated.

### Wetlands Construction Permit

The Wetlands Act of 1970 charges the DEP with promoting the public safety, health and welfare, and protecting public and private property, wildlife and marine fisheries in designated coastal wetlands. A permit is required to construct any facilities in these areas. The permit application must be accompanied by an environmental impact statement. A public hearing is held if sufficient public interest is demonstrated.

### Stream Encroachment Permit

Construction within the natural high water mark of any stream requires a Stream Encroachment Permit. The emphasis in the permit review process is on the portion of available drainage area affected and proposed soil erosion control methods. For major projects, an environmental impact statement is also

required. A public hearing is held if sufficient public interest is demonstrated.

## 2. Noise Control

New Jersey noise control regulations (NJAC Chapter 20) specify maximum allowable noise levels from industrial or commercial operations, measured at the nearest residential property line. The regulations limit continuous airborne sound and impulsive sound in two time periods. From 7:00 A M to 10:00 P M, the maximum sound level is 65 dB(A), whereas from 10:00 P M to 7:00 A M, the limit decreases to 50 dB(A). Impulsive sound may not exceed 80 dB(A) at any time of day.

Limits have also been established for continuous airborne sound by octave band and for sound levels measured at the nearest property line of any other commercial operation.

## 3. Water Quality

### a. Surface Water Quality

The State of New Jersey, through the State Department of Environmental Protection, Division of Water Resources, has promulgated surface water quality standards (NJAC 7:9-4 et seq) to preserve and enhance the quality of the State's waters consistent with their intended use. The surface classifications that are applicable to the various cooling system alternates discussed in this study are the following:

- (1) Class FW-1 is applicable to Oyster Creek and Forked River branches upstream of the head of tide.
- (2) Class TW-1 is applicable to Barnegat Bay, Oyster Creek and the branches of Forked River from the head of tide to surf waters.
- (3) Class CW-1 is applicable to the Atlantic Ocean within 1500 feet, whichever is more distant from the mean low tide line, from Sandy Hook to Cape May Point.
- (4) Class CW-2 is applicable to the Atlantic Ocean from the CW-1 boundary to the three-mile limit.

The definitions and quality criteria of these classifications are presented in Exhibit B-2. It should be noted that all criteria are applicable outside of an appropriate designated mixing zone.

#### b. Ground Water Quality

The New Jersey Department of Environmental Protection has issued Proposed Non-Degradation Water Quality Standards for the Pine Barrens Area (Proposed Amendment to Surface Water Quality Standards and Proposed Adoption of Ground Water Quality Standards, Docket No. DEP 002-77-01, dated January 19, 1977). In the Oyster Creek site vicinity, the Pine Barrens region includes only the land west of the Garden State Parkway. The ground water standards are designated to prevent degradation of ground water supplies in the Pine Barrens region. Thus, activities outside this area that could potentially affect aquifers in the Pine Barrens will be within jurisdiction of this regulation.

#### 4. Air Quality

New Jersey Regulation on Air Pollution from Manufacturing Processes, Paragraph 7:27-6.2 (NJAC, Chapter 27, Subchapter 6) lists standards for particulate emissions from any manufacturing process. The list is reproduced in Exhibit B-3 and includes two limits. The first limit (columns 1 and 2) sets a maximum allowable emission rate based on the uncontrolled source emission rate. The second limit (columns 3 and 4) regulates the emission rate on the basis of total exit airflow. In order to comply with these standards, both limits must not be exceeded.

New Jersey Ambient Air Quality Standards, Paragraph 7:27-13:3 (NJAC, Chapter 27, Subchapter 13) defines ambient air quality standards for suspended particulate matter. The secondary (most stringent) standards limit suspended particulate concentrations in ambient air, during any 12 consecutive months, to 60 micrograms per cubic meter, and not to exceed 150 micrograms per cubic meter more than once.

APPENDIX C

MODELS USED IN  
ASSESSMENT OF ATMOSPHERIC  
EFFECTS

## A. INTRODUCTION

This appendix presents the mathematical models used to calculate tower induced ground level fogging and icing, and elevated plumes.

## B. TOWER INDUCED GROUND LEVEL FOGGING AND ICING MATHEMATICAL MODEL

The modeling of cooling-tower induced ground level fogging and icing was based on the following assumptions:

1. The cooling system is assumed to saturate the ambient air that is drawn through the cooling towers;
2. The effective height of the vapor plume is a function of cooling tower height and plume buoyancy (which includes the effect of latent heat);
3. The plume spread has a Gaussian distribution in both the horizontal and vertical planes;
4. Periods with visibilities less than 0.5 miles due to naturally occurring fog are not counted as periods of cooling-tower induced fogging;
5. Downwash will occur when the plume exit velocity is less than 1.5 times the wind speed;
6. Tower-induced icing will occur if the model predicts ground level fogging and the temperature is 32°F or less.

The rise of the moist buoyant tower effluent was calculated using the Briggs<sup>(1)</sup> plume rise equation for a dry gas as modified by Hanna<sup>(2)</sup> to account for the additional buoyancy due to the release of latent heat of condensation. During neutral or unstable conditions the plume rise was calculated by:

$$h_r = 1.6 F_o^{1/3} (3.5 X^*)^{2/3} / U \quad (1)$$

where:

$h_r$  is the plume rise (m),

$F_o$  is the initial flux of buoyancy ( $m^4/sec^3$ ),

$U$  is the wind speed at top of cooling tower (m/sec),

and:  $X^* = 34F_o^{5/8}$ , for  $F_o$  less than 55, (2)

$X^* = 34F_o^{2/5}$ , for  $F_o$  equal to or greater than 55. (3)

The buoyancy flux in the plume is given by Hanna as:

$$F_o = g_o W_o R_o^2 \left[ \frac{T_{vpo} - T_{veo}}{T_{vpo}} \left( q_{po} - q_{eo} \right) \frac{L}{C_p T_{po}} \right] \quad (4)$$

where:

- $g$  is the acceleration due to gravity ( $m/sec^2$ ),
- $W_o$  is the initial vertical velocity of the plume ( $m/sec^2$ ),
- $R_o$  is the initial radius of plume (m),
- $T_{vpo}$  is the initial virtual temperature of plume ( $^{\circ}K$ ),
- $T_{veo}$  is the initial virtual temperature of environment ( $^{\circ}K$ ),
- $q_{po}$  is the initial specific humidity of the plume (gm vapor/gm air),
- $q_{eo}$  is the initial specific humidity of the environment (gm vapor/gm air)
- $L$  is the latent heat required to evaporate one gram of water (cal/gm vapor),
- $C_p$  is the specific heat of air at constant pressure (cal/gm air  $^{\circ}K$ ), and
- $T_{po}$  is the initial temperature of plume ( $^{\circ}K$ ).

The virtual temperature is given by the following relationship:

$$T_v = T(1.00 + 0.61q)$$

where:

- $T_v$  is the virtual temperature of plume or environment (K), and
- $q$  is the specific humidity of plume or environment (percent).

The buoyancy flux considers the increase in buoyancy due to the condensation of excess water vapor. For the purpose of these calculations it was assumed that one-half of the available excess water vapor condenses during the plume rise; the second term in the brackets in Equation (4) was therefore multiplied by 0.5.

Equation (1) only applies at distances equal to or greater than  $X_f$

where:

$$X_f = 3.5X^* \text{ (m)} \quad (5)$$

At distances closer than  $X_f$ , the plume rise was defined by:

$$h_r = 1.6 F_o^{1/3} X^{2/3} / U \quad (6)$$

where:

$X$  is the downwind distance (m).

During stable conditions, the final plume rise was determined by calculating the plume rise by both of the following two equations (Equations 7 and 8). These equations were developed by Briggs<sup>(1)</sup> and modified by Hanna<sup>(2)</sup>. For other than very low wind speeds, the plume rise can be calculated by:

$$h_r = 2.9 (F_o / US)^{1/3} \quad (7)$$

where:

$h_r$  = is the plume rise (m),  
 $F_o$  = is the initial flux of buoyancy ( $m^4/sec^3$ ),  
 $U$  = is the wind speed at tower top (m/sec), and  
 $S$  = is a stability parameter ( $sec^{-2}$ );

where:

$$S = \frac{g}{T_p} \left( \frac{d\theta}{dz} \right);$$

and:  $g$  is the acceleration of gravity ( $m/sec^2$ ),  
 $T_p$  is the temperature of the plume, and  
 $\frac{d\theta}{dz}$  is the potential temperature gradient ( $^{\circ}K/m$ ).

The following potential temperature gradients were used in Equation (7):

| <u>Stability Class</u> | <u>Potential Temperature Gradient (<math>^{\circ}K/m</math>)</u> |
|------------------------|--|
| E                      | 0.020  |
| F                      | 0.035  |
| G                      | 0.050  |

As wind speeds approach calm conditions, however, plume rises calculated by Equation (7) become unrealistically high. Plume rises are therefore also calculated by:

$$h_r = 5.0 F_o^{1/4} / X_f^{3/8} \quad (8)$$

and the minimum plume rise from Equations (7) and (8) is used as the final plume rise if receptor distances are greater than or equal to:

$$X_f = 3.14 \left( \frac{U}{S} \right)^{1/2} \quad (9)$$

For receptor distances less than  $X_f$ , the final plume rise used in the model is the minimum rise calculated from Equations (6), (7) and (8).

For all calculations, surface wind speeds were converted to cooling tower top wind speeds using the equation:

$$U = U_s \left( \frac{h_t}{h_s} \right)^p \quad (10)$$

where:

- $U$  is the wind speed at top of tower (m/sec),
- $U_s$  is the surface wind speed (m/sec),
- $h_t$  is the height of cooling tower (m),
- $h_s$  is the height of surface wind sensor (m), and
- $p$  is a power law exponent ( $p$  ranges from 0.111 for extremely unstable conditions to 0.333 for extremely stable conditions).

Calm conditions were assigned a surface wind speed of one knot and were assumed to have the same wind direction as that of the previous hour.

During periods of high wind speed, plume downwash will occur in the low pressure zone on the lee side of the tower <sup>(3)</sup>. Downwash is assumed to occur only when the plume exit velocity is less than 1.5 times the wind

speed. During such conditions, the magnitude of the downwash effect is estimated using the relationship given by Briggs<sup>(1)</sup>:

$$h_d = 3(15 - W_o/U)D \quad (11)$$

where:

$W_o$  is the initial vertical plume speed (m/sec),

$h_d$  is the downwash correction factor (m), and

$D$  is the length parameter which is related to the cross section of the tower normal to the wind direction (m).

Plume downwash for round or natural draft towers is independent of wind direction. The magnitude of downwash is related to:

- Wind Speed
- Tower Diameter
- Plume Exit Velocity

and the value of  $D$  in Equation (11) is the diameter of the tower.

The height of the vapor plume above any downwind point was calculated in the following manner:

$$h = h_t + h_r - h_d \quad (12)$$

where:

$h$  is the plume height above ground (m),

$h_t$  is the height of cooling tower (m),

$h_r$  is the plume rise relative to the top of this cooling tower (m), and

$h_d$  is the downwash correction (m).

The transport of cooling tower water vapor is primarily governed by the horizontal wind velocity and the stability of the atmosphere. Ground level

concentrations of water vapor directly downwind of a tower were estimated by the Gaussian diffusion equation <sup>(4)</sup>:

$$X = \frac{Q}{\pi \sigma_y \sigma_z U} \exp \left[ -0.5 \left( \frac{h}{\sigma_z} \right)^2 \right] \quad (13)$$

where:

- X = water vapor density at a given downwind distance from the tower (gm/m<sup>3</sup>),
- Q = vapor release rate from a tower (gm/sec),
- $\sigma_y$  = horizontal diffusion coefficient (m),
- $\sigma_z$  = vertical diffusion coefficient (m),
- U = wind speed at top of tower (m/sec), and
- h = plume height above ground (m).

For this report, the vapor concentration for each of the 16 wind directions were calculated for twenty downwind points spaced at 500 meter intervals for each hour of meteorological data. As discussed previously, a comparison of hourly meteorological parameters for the base periods 1959-1969 indicated that 1960 meteorological input data to the model should result in maximum fogging frequencies during the base period. The computerized model used to perform these calculations tabulated the induced fogging occurrences on a seasonal and annual basis and also determined fog and cooling tower induced icing.

#### C. TOWER INDUCED ELEVATED PLUME MATHEMATICAL MODEL

The length of the elevated visible plumes emitted from the natural draft and round mechanical draft towers was calculated using Baker's Equation <sup>(5)</sup>.

$$X_p = 5.7 \left[ \frac{G}{102 \cdot V} \right]^{1/2} \left[ \frac{T_E - T_I}{T_P - T_I} - 1.0 \right]^{1/2} \quad (14)$$

where:

- $X_p$  = visible plume length (feet),
- G = total vapor rate from tower (m<sup>3</sup>/hr),

- $V$  = wind speed (feet/sec),  
 $T_E$  = temperature of plume at exit from tower ( $^{\circ}\text{C}$ ),  
 $T_I$  = ambient temperature ( $^{\circ}\text{C}$ ), and  
 $T_P$  = temperature at end of visible plume ( $^{\circ}\text{C}$ ).

The temperature at the end of the visible plume was calculated in the computerized program by the following iterative procedure:

1. The saturation mixing ratio ( $r_e$ ) at the end of the visible plume was calculated using the following relationship:

$$r_e = 0.622 \frac{e_s}{(P - e_s)} \quad (15)$$

where:

$e_s$  is the saturation vapor pressure ( $\text{lb}/\text{ft}^2$ ), and  
 $P$  is the atmospheric pressure ( $\text{lb}/\text{ft}^2$ ).

2. The saturation vapor pressure ( $e_s$ ) was obtained using Tetens (6) equation:

$$e_s = 0.08864 \times 10^B \quad (16)$$

where:

$$B = (715) \left[ 0.55 (T_E - 32)/237.3 + 0.55 (T_E - 32) \right] \quad (17)$$

and  $T_E$  is the temperature at end of visible plume.

3. The saturation mixing ratio at the end of the vapor plume was also calculated assuming that the plume follows a linear psychrometric mixing process. The process is expressed by the following:

$$r_e = r_I + \frac{r_P - r_I}{T_P - T_I} (T_E - T_I) \quad (18)$$

where:

$r_e$  is the mixing ratio at the end of visible plume,  
 $r_p$  is the tower exit mixing ratio,  
 $r_I$  is the ambient mixing ratio,  
 $T_I$  is the ambient temperature ( $^{\circ}\text{F}$ ),  
 $T_P$  is the plume exit temperature ( $^{\circ}\text{F}$ ), and  
 $T_E$  is the temperature at end of visible plume ( $^{\circ}\text{F}$ ).

4. Since there can only be one value for the mixing ratio at the end of the plume, successive values of  $T_E$  were substituted into Equations (15) - (18) until the temperature which gives the same value for  $r_e$  using both methods was found.

The exit plume temperature was calculated by a heat-and-mass balance method<sup>(7)</sup> based on the law of conservation of mass and energy. The mass of water evaporated in the cooling tower is absorbed by the air flowing through the tower, and the heat lost by the water must be gained by the air. It is assumed that the air becomes saturated during its passage through the tower. The evaporation rate is a function of ambient dry bulb and wet bulb temperatures.

One year (1960) of hourly meteorological data was used to compute seasonal frequencies of the elevated visible plumes from the ND, FAND, and RMD towers. The computerized plume frequency program calculated the length and areal distribution of the elevated visible plumes.

Elevated visible plumes will also result from the operation of the proposed Forked River Nuclear Generating Station natural draft tower. Since no areal distribution data for visible plumes from this tower were available, simple corrections were applied to the predicted Oyster Creek NGS cooling tower plume distribution to yield estimates for the Forked River NGS plumes. The corrections were based on tower differences (between OCNCS and FRNGS) in

heat load and resultant water vapor emissions. Visible plumes from the Forked River NGS tower were estimated to be 1.3 times longer than those from the Oyster Creek NGS tower.

After the Forked River NGS tower plume data were developed as described above, the analyses of plume merger were conducted, based on the geometric intersection of the plumes under the same meteorological conditions. It was found that (depending on wind direction) visible plumes must be 4,000 feet to 10,000 ft long before merger will occur. The visible tower plumes should remain separate during most of the year. Based on the given assumptions, plume merger is estimated to occur about 1.2 percent of the time, annually.

APPENDIX C

REFERENCES

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## VOLUME 3

### PREFACE

The Alternative Cooling Water System Study prepared by Ebasco Services, Incorporated consisted of three separately bound volumes.

Volume 1 contained an Executive Summary (Chapter I) of the Alternative Cooling Water System Study and is not reproduced as a part of this Appendix.

Volume 2 contains Chapter II (Description of the Existing Cooling Water System), Chapter III (Discussion of Alternative Cooling Water Systems), and Chapter IV (Discussion of Preferred Cooling Water Systems). This volume presents the approach, methodology, analysis and results of the study in detail.

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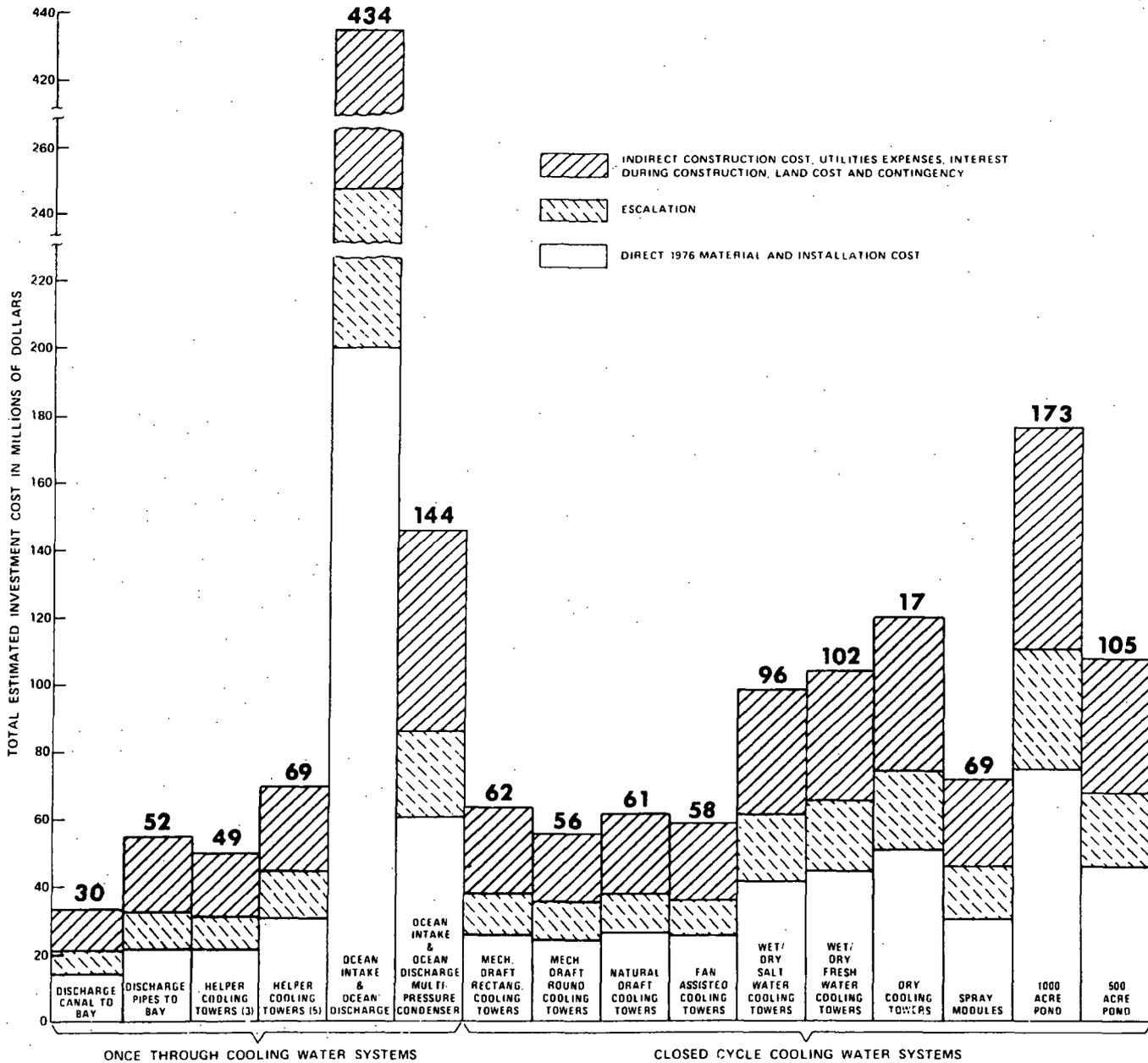
EXHIBIT 1

TOTAL COMPARABLE ANNUAL SYSTEM COSTS

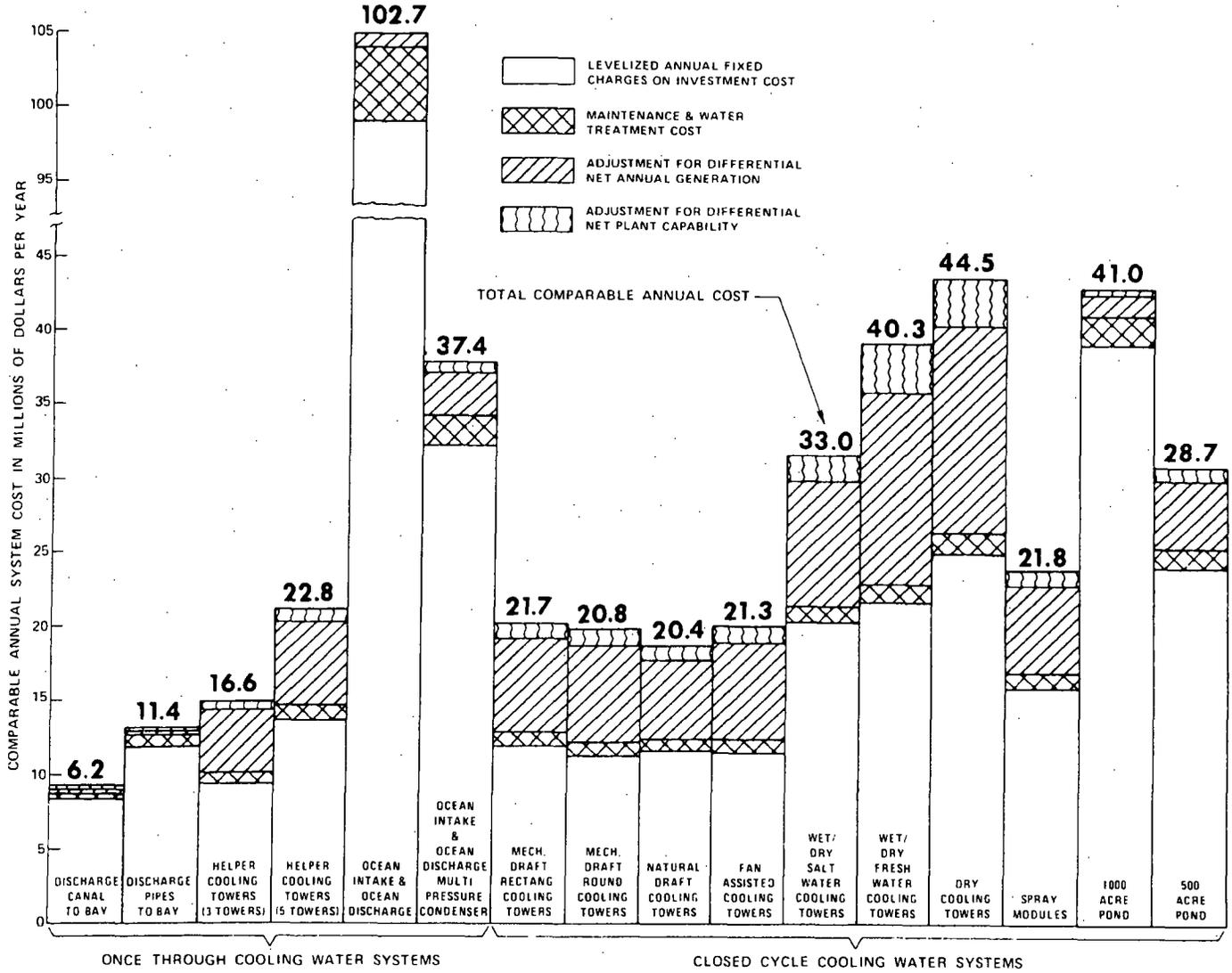
|  | Total<br>Comparable<br>Annual<br>Costs Including<br>Adjustments in<br>Million Dollars | Differential<br>Comparable<br>Annual Cost in<br>Million Dollars |
|--|---|---|
| Existing Cooling System  | 0.5   | Base  |
| Discharge Canal to the Bay   | 6.2   | 5.7   |
| Discharge Pipelines to the Bay   | 11.4  | 10.9  |
| Helper Cooling Tower with Minimum<br>Cold Water Temperature 50° F                    | 16.6  | 16.1  |
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**JERSEY CENTRAL POWER & LIGHT CO.  
OYSTER CREEK NUCLEAR GENERATING STATION  
ALTERNATIVE COOLING WATER SYSTEM STUDY  
TOTAL ESTIMATED INVESTMENT COST**

**EXHIBIT 2**



**JERSEY CENTRAL POWER & LIGHT CO.  
OYSTER CREEK NUCLEAR GENERATING STATION  
ALTERNATIVE COOLING WATER SYSTEM STUDY  
COMPARABLE ANNUAL SYSTEM COSTS**



**JERSEY CENTRAL POWER & LIGHT CO.  
OYSTER CREEK NUCLEAR GENERATING STATION  
ALTERNATIVE COOLING WATER SYSTEM STUDY  
PLANT OUTPUT AT AVERAGE SUMMER CONDITIONS**

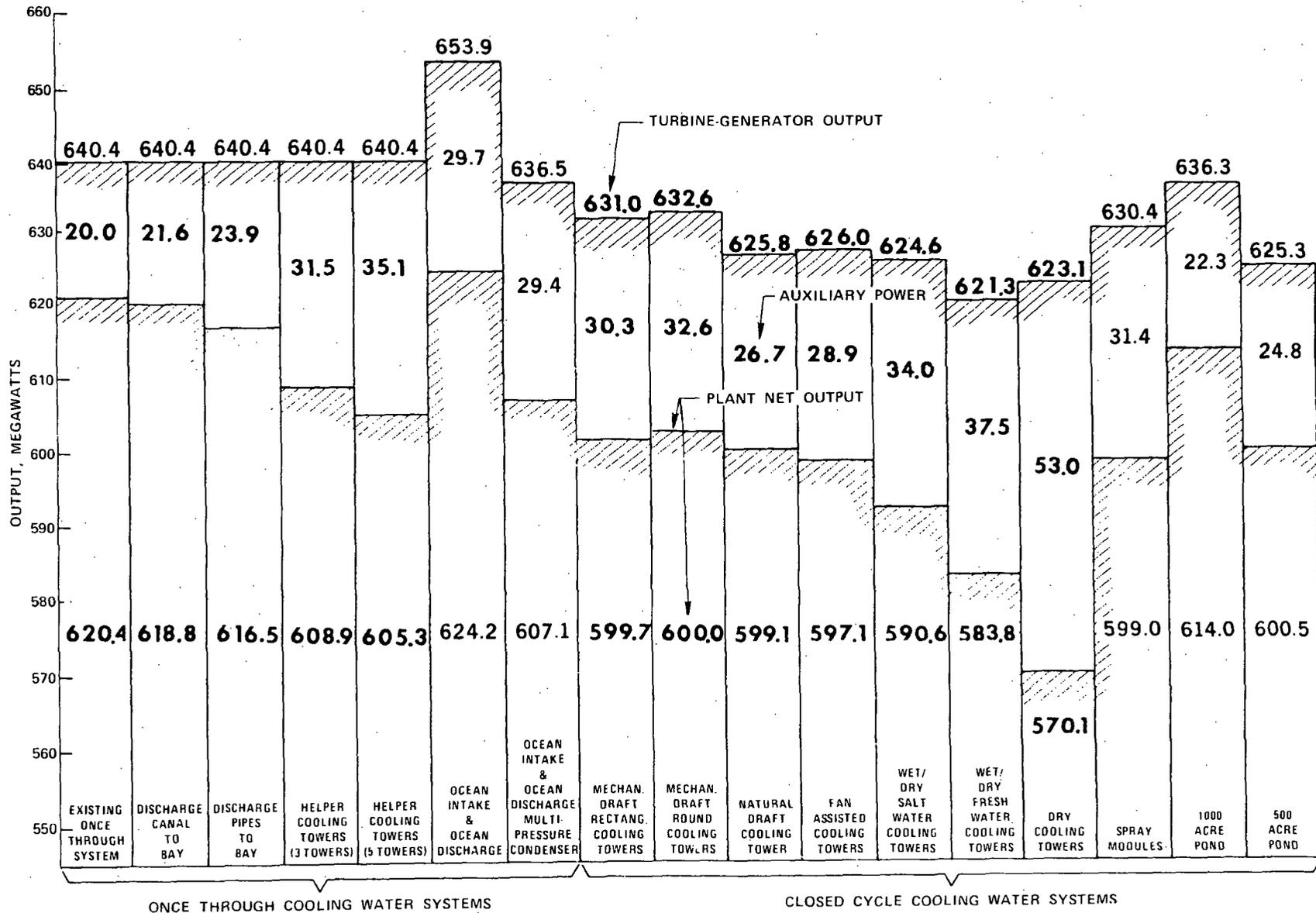


EXHIBIT 5

COMPARATIVE ANALYSIS OF ENVIRONMENTAL AND REGULATORY ASPECTS FOR PREFERRED COOLING SYSTEMS

| <u>Environmental Factors</u>                                      | <u>Units</u>                           | <u>Natural Draft Cooling Tower</u> | <u>Fan-Assisted Natural Draft Cooling Tower</u> | <u>Round Mechanical Cooling Tower</u> | <u>Canal-To-Bay System</u> | <u>Existing System</u> | <u>Existing System with Ristroph Bucket Screens</u> |
|---|--|------------------------------------|---|---------------------------------------|----------------------------|------------------------|---|
| <u>1. Atmospheric Effects</u>                                     |  |                                    |   |                                       |                            |                        |   |
| 1.1 Elevated Visible Plume  | Hrs/Summer (Max)                       | 3                                  | 22  | 3                                     | 0                          | 0                      | 0   |
| 1.2 Ground Level Fogging  | Hrs/yr (Max)                           | <1                                 | 9-12  | 2                                     | ND (3)                     | ND                     | ND  |
| 1.3 Salt Aerosol Concentration (max annual)                       | Ugm/M <sup>3</sup>                     | .06                                | 0.20  | 0.80                                  | 0                          | 0                      | 0   |
| 1.4 Salt Deposition (max annual)                                  | Kg/Km-month                            | 80                                 | 110   | 511                                   | 0                          | 0                      | 0   |
| <u>2. Air Quality</u>   |  |                                    |   |                                       |                            |                        |   |
| 2.1 Particulate Emission Rate                                     | % of Standard                          | 353                                | 336   | 336                                   | 0                          | 0                      | 0   |
| <u>3. Water Quality</u>   |  |                                    |   |                                       |                            |                        |   |
| 3.1 Construction Effects  | Qualitative                            | Low                                | Low   | Low                                   | Moderate                   | NA (4)                 | NA  |
| 3.2 Operation Effects   | % Change                               | +3                                 | +3  | +3                                    | Low                        | NA                     | Low   |
| <u>4. Thermal Discharge Characteristics</u>                       |  |                                    |   |                                       |                            |                        |   |
| 4.1 Heat Dissipation (Annual Ave)                                 | Btu/Hr x 10 <sup>6</sup>               | 202                                | 208   | 178                                   | 4460                       | 4460                   | 4460  |
| 4.2 Area of 1.5 <sup>o</sup> F (Summer Max)                       | Acres                                  | 0                                  | 0   | 0                                     | ~2300                      | ~2300                  | ~2300   |
| <u>5. Noise</u>   |  |                                    |   |                                       |                            |                        |   |
| 5.1 Noise Level at Property Line<br>(Without Mitigative Measures) | dB(A) above<br>NJ Criterion (50 dB(A)) | 4                                  | 11.5  | 10                                    | 13                         | ND                     | ND  |
| <u>6. Visual/Esthetic Effects</u>                                 |  |                                    |   |                                       |                            |                        |   |
| 6.1 Height of Structure   | Ft                                     | 540                                | 300   | 70                                    | 11                         | NA                     | NA  |
| 6.2 Elevated Visible Plume  | See Section 1.1                        |                                    |   |                                       |                            |                        |   |
| 6.3 Ground Level Fogging  | See Section 1.2                        |                                    |   |                                       |                            |                        |   |
| <u>7. Land Use</u>  |  |                                    |   |                                       |                            |                        |   |
| 7.1 Total Area Required   | Acres                                  | ~10                                | ~10   | ~10                                   | ~25                        | NA                     | 0   |
| <u>8. Terrestrial Ecology</u>                                     |  |                                    |   |                                       |                            |                        |   |
| 8.1 Sensitive Habitat Required                                    | Acres                                  | Low                                | Low   | Low                                   | 15                         | NA                     | 0   |
| 8.2 Potential for Salt Effects<br>on Vegetation                   | Qualitative                            | Low                                | Low   | Moderate                              | NA                         | NA                     | 0   |
| 8.3 Potential for Bird Collisions                                 | Qualitative                            | Moderate                           | Low   | Low                                   | NA                         | NA                     | 0   |

COMPARATIVE ANALYSIS OF ENVIRONMENTAL AND REGULATORY ASPECTS FOR PREFERRED COOLING SYSTEMS

| <u>Environmental Factors</u>                                  | <u>Units</u> | <u>Natural Draft<br/>Cooling Tower</u> | <u>Fan-Assisted<br/>Natural Draft<br/>Cooling Tower</u> | <u>Round<br/>Mechanical<br/>Cooling Tower</u> | <u>Canal-To-Bay<br/>System</u> | <u>Existing<br/>System</u> | <u>Existing System<br/>with Ristroph<br/>Bucket Screens</u> |
|---|--------------|--|---|---|--------------------------------|----------------------------|---|
| <b>9. Aquatic Ecology</b>                                     |              |  |   |   |                                |                            |   |
| 9.1 Impingement Mortalities (1)                               | % Base       | 5-50                                   | 5-50  | 5-50  | 100                            | Base                       | 26  |
| 9.2 Condenser Entrainment Rate                                | % Base       | 5                                      | 5   | 5   | NC                             | Base                       | NC  |
| 9.3 Dilution Entrainment Rate                                 | % Base       | NC                                     | NC  | NC  | 200                            | Base                       | NC  |
| 9.4 Wood Borer Population-Potential<br>Change in Oyster Creek | Qualitative  | Reduction (2)                          | Reduction   | Reduction                                     | Reduction                      | Base                       | NC (5)  |
| 9.6 Cold Shock Potential - Oyster Creek                       | Qualitative  | Reduction                              | Reduction   | Reduction                                     | Reduction                      | Base                       | NC  |
| <b>10. Radiological Effects</b>                               |              |  |   |   |                                |                            |   |
| 10.1 Dose to Highest Organ<br>(Liquid Pathway)                | Mrem/Yr      | 9.6                                    | 8.5   | 9.6   | 6.0                            | 6.0                        | 6.0   |

(1) Estimates Based on the Dominant Organism, Bay Anchovy

(2) The Term "Reduction" Means a Return to Near-Natural Conditions (Without OCNGS)

(3) ND: Not Determined

(4) NA: Not Applicable

(5) NC: No Change from Base

Note: Low - the impact is not a concern in the cooling system elimination process.

Moderate - the impact approaches a level of concern in the cooling system elimination process.

High - the impact is of sufficient magnitude to warrant serious consideration in the cooling system elimination process.

EXHIBIT 6

SUMMARY OF PREFERRED AND RECOMMENDED SYSTEM SELECTION PROCESS

|   | Differential<br>Comparable<br>Annual Cost<br>(million dollars) | Differential<br>Plant Net<br>Output <sup>(1)</sup><br>(MW) | Elimination<br>Rationale<br>Alternative<br>Systems <sup>(2)</sup> | Elimination<br>Rationale<br>for Preferred<br>Systems               |
|---|--|--|---|--|
| Discharge Canal to the Bay                                      | 7.2  | -1.6   | Preferred   | Insufficient Mitigation of Aquatic Impact                          |
| Discharge Pipelines to the Bay                                  | 12.6   | -3.9   | NCA   |  |
| Helper Cooling Towers with Minimum 50° F Cold Water Temperature | 16.5   | -11.5  | OEI-Fogging/<br>Icing, Salt<br>Deposition                         |  |
| Natural Draft Cooling Tower (CT)                                | 20.2   | -21.3  | Preferred   | Recommended  |
| Round Mechanical Draft CT                                       | 20.6   | -20.4  | Preferred   | Exceeding of<br>Noise Criteria                                     |
| Fan-Assisted Natural Draft CT                                   | 21.2   | -23.3  | Preferred   | Lack of Operating<br>Experience and<br>Noise Control<br>Experience |
| Rectangular Mechanical Draft CT                                 | 21.6   | -20.7  | OEI-Fogging/<br>Icing, Salt<br>Deposition                         |  |
| Helper CT with Minimum 43.8° F Cold Water Temperature           | 22.8   | -15.1  | OEI-Fogging/<br>Icing, Salt<br>Deposition                         |  |
| Spray Cooling Module Canal                                      | 22.8   | -21.4  | OEI-Fogging/<br>Icing, Salt<br>Deposition                         |  |
| 500 Acre Cooling Pond   | 30.3   | -19.9  | OEI-Fogging/<br>Icing, Terres-<br>trial and<br>Aquatic Ecology    |  |
| Wet/Dry Salt Water CT   | 33.0   | -29.8  | OEI-Salt Deposi-<br>tion  |  |
| Ocean Intake and Discharge with Multipressure Condenser         | 37.3   | -13.3  | NCA   |  |
| Wet/Dry Fresh Water CT  | 40.4   | -36.6  | SCR   |  |
| 1000 Acre Cooling Pond  | 42.5   | -6.4   | OEI-Fogging/<br>Icing, Terres-<br>trial and<br>Aquatic Ecology    |  |
| Dry Cooling Tower   | 44.7   | -50.3  | SCR   |  |
| Ocean Intake and Discharge with Existing Condenser              | 103.3  | +3.8   | NCA   |  |

(1) Computed as (Existing System Net Output - Alternative System Net Output) for Average Summer Conditions

(2) NCA: No Compensating Advantage Rationale  
 OEI: Overriding Environmental Impact Rationale  
 SCR: Significant Commercial Risk Rationale  
 See Section I-F for discussion

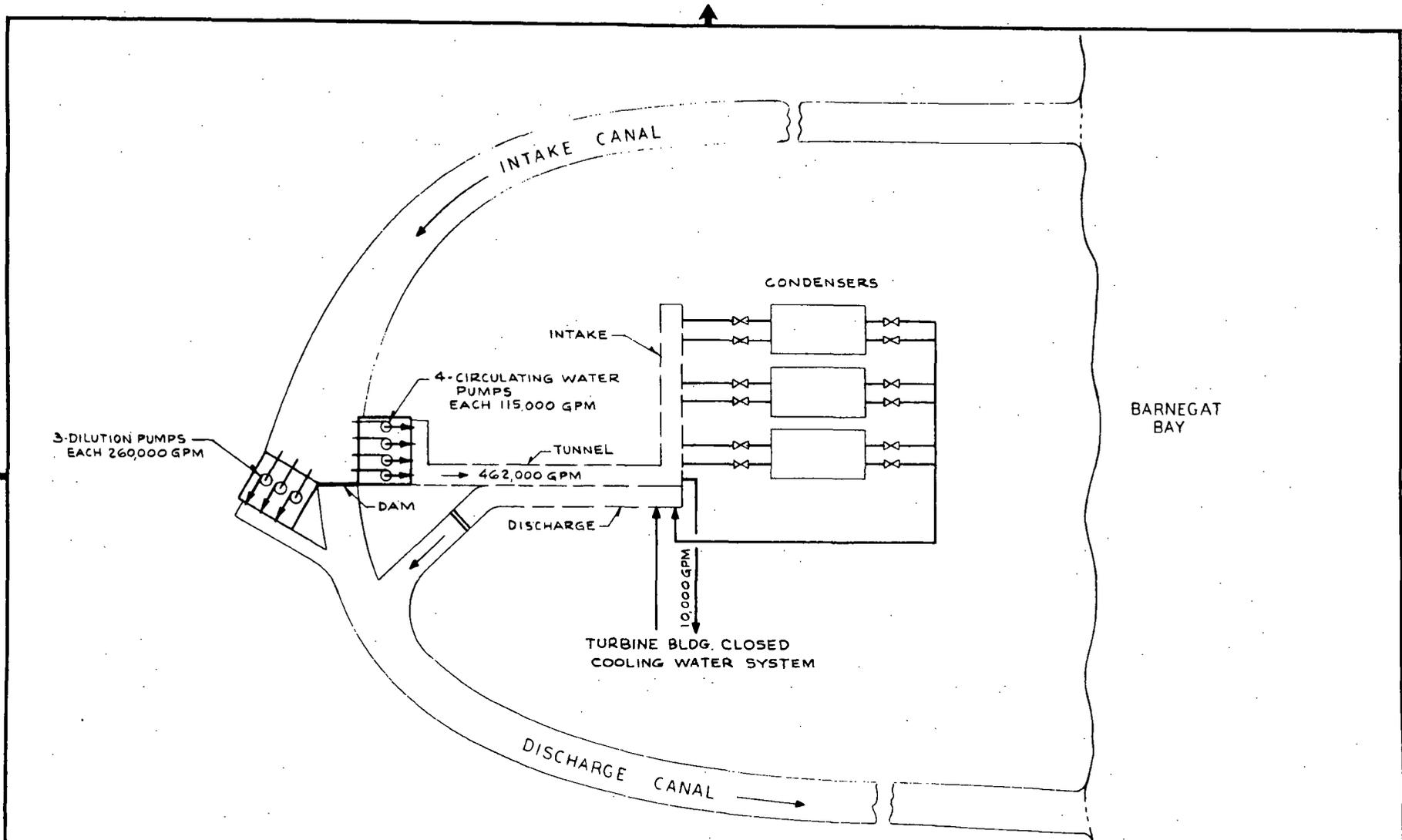


JERSEY CENTRAL  
POWER & LIGHT CO.

EBASCO SERVICES INCORPORATED  
New York

OYSTER CREEK NGS  
SITE & VICINITY

EXHIBIT  
7



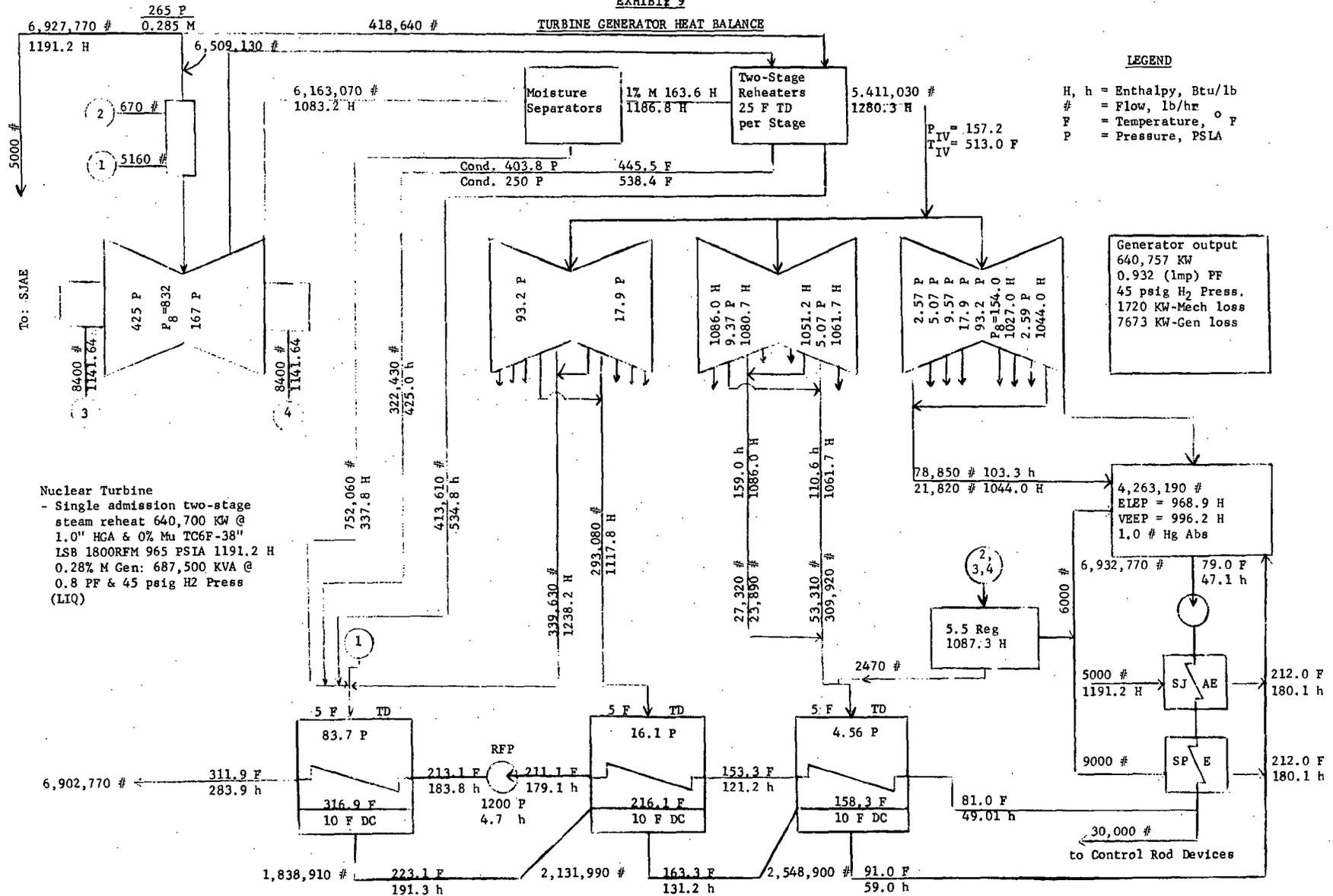
INCHES  
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INCHES  
CM.

|                              |          |   |           |
|------------------------------|----------|---|-----------|
| EBASCO SERVICES INCORPORATED |          | JERSEY CENTRAL POWER & LIGHT<br>OYSTER CREEK NUCLEAR GEN STATION<br>EXISTING COOLING WATER SYSTEM | EXHIBIT-8 |
| DIV. MECH DR. RMK            | APPROVED |   |           |
| CH                           |          |   |           |
| DATE MAR 31 1977             |          |   |           |

EXHIBIT 9

TURBINE GENERATOR HEAT BALANCE



**LEGEND**  
 H, h = Enthalpy, Btu/lb  
 # = Flow, lb/hr  
 F = Temperature, °F  
 P = Pressure, PSIA

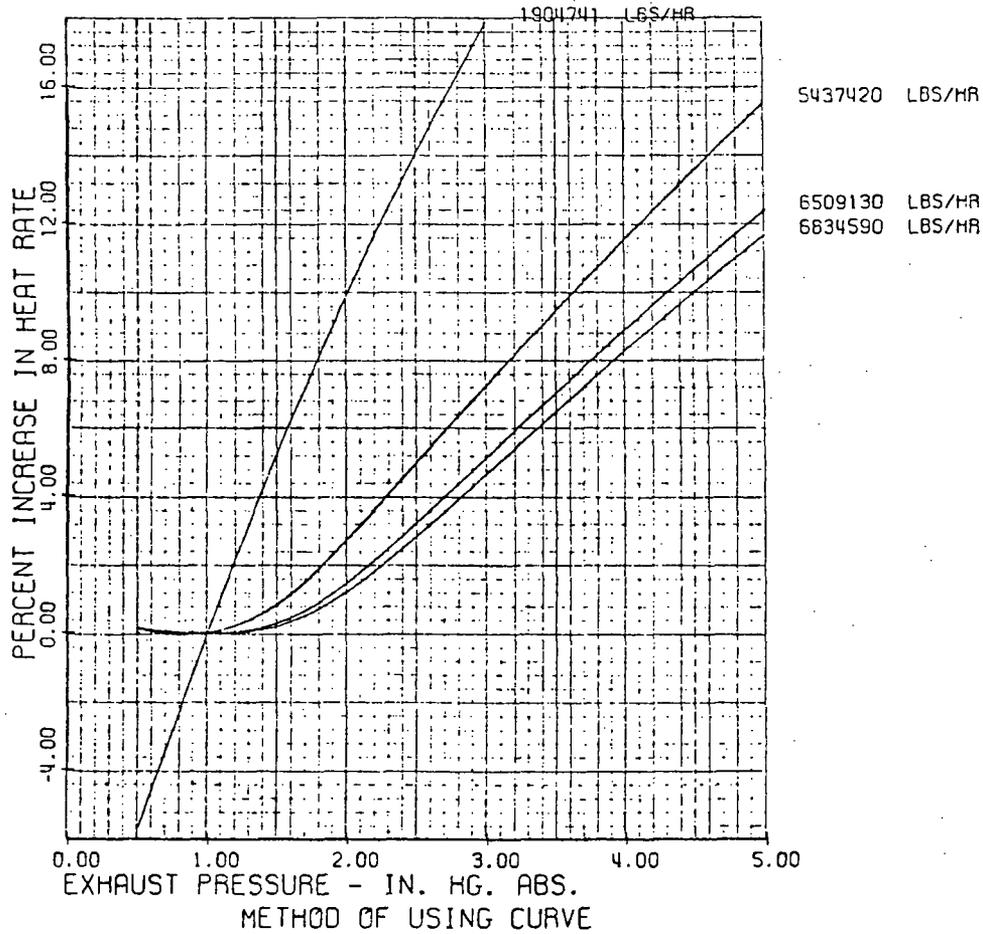
**Generator output**  
 640,757 KW  
 0.932 (imp) PF  
 45 psig H<sub>2</sub> Press.  
 1720 KW-Mech loss  
 7673 KW-Gen loss

**Nuclear Turbine**  
 - Single admission two-stage steam reheat 640,700 KW @ 1.0" HGA & 0% Mu TC6F-38" LSB 1800RFM 965 PSIA 1191.2 H 0.28% M Gen: 687,500 KVA @ 0.8 PF & 45 psig H<sub>2</sub> Press (LIQ)

Gross Heat Rate =  $6,927,770 \frac{(1191.2 - 283.9) + 30,000 (283.9 - 49.01)}{640,757}$

Source: General Electric Company

640.700 KW 1.0 IN. HG. ABS. 0 PCT MU  
 TC6F-38 IN. LSB 1800 RPM  
 950 PSIG 1191.2 H 0.28 M



FLows NEAR CURVES ARE THROTTLE FLOWS AT 950 PSIG 1191.2 H  
 THESE CORRECTION FACTORS ASSUME CONSTANT CONTROL VALVE OPENING  
 APPLY CORRECTIONS TO HEAT RATES AND KW LOADS  
 AT 1.0 IN. HG. ABS. AND 0 PCT MU

THE PERCENT CHANGE IN KW LOAD FOR VARIOUS EXHAUST PRESSURES IS EQUAL TO  
 (MINUS PCT INCREASE IN HEAT RATE)100/(100 + PCT INCREASE IN HEAT RATE)

THESE CORRECTION FACTORS ARE NOT GUARANTEED

GENERAL ELECTRIC COMPANY, SCHENECTADY, NEW YORK

|  |                    |         |
|--|--------------------|---------|
| JERSEY CENTRAL<br>POWER & LIGHT COMPANY  | EXHAUST PRESSURE   | EXHIBIT |
| EBASCO SERVICES INCORPORATED<br>New York | CORRECTION FACTORS | 10      |

PERIOD OF STUDY 60 TO 64 FOR MONTHS 1 TO 12

| WET BULB | WIND SPEED ALL MPH |    |    |    |    |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |    |    |    |    |   | TOTAL DRY BULB |     |
|----------|--------------------|----|----|----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|----|----|----|----|---|----------------|-----|
|          | 60                 | 61 | 62 | 63 | 64 | 65  | 66  | 67  | 68  | 69  | 70  | 71  | 72  | 73  | 74  | 75  | 76  | 77  | 78  | 79  |     |     |     |    |    |    |    |   |                |     |
| 58       | 31                 | 36 | 42 | 47 | 64 | 116 | 116 | 105 | 78  | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0  | 0  | 0  | 0  | 0 | 0              | 639 |
| 59       | 24                 | 25 | 33 | 43 | 55 | 73  | 67  | 39  | 127 | 47  | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0  | 0  | 0  | 0  | 0 | 0              | 591 |
| 60       | 36                 | 41 | 37 | 41 | 45 | 75  | 54  | 93  | 122 | 123 | 80  | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0  | 0  | 0  | 0  | 0 | 0              | 737 |
| 61       | 22                 | 17 | 26 | 40 | 34 | 36  | 46  | 62  | 74  | 77  | 116 | 61  | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0  | 0  | 0  | 0  | 0 | 0              | 628 |
| 62       | 32                 | 13 | 26 | 13 | 29 | 47  | 35  | 64  | 67  | 84  | 110 | 104 | 38  | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0  | 0  | 0  | 0  | 0 | 0              | 670 |
| 63       | 31                 | 32 | 29 | 35 | 31 | 52  | 48  | 50  | 53  | 53  | 95  | 119 | 115 | 40  | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0  | 0  | 0  | 0  | 0 | 0              | 753 |
| 64       | 24                 | 20 | 21 | 32 | 25 | 43  | 37  | 25  | 33  | 53  | 71  | 109 | 93  | 127 | 33  | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0  | 0  | 0  | 0  | 0 | 0              | 762 |
| 65       | 14                 | 15 | 23 | 24 | 24 | 42  | 32  | 22  | 36  | 51  | 72  | 63  | 113 | 99  | 129 | 43  | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0  | 0  | 0  | 0  | 0 | 0              | 820 |
| 66       | 6                  | 11 | 15 | 32 | 20 | 32  | 37  | 31  | 23  | 44  | 51  | 60  | 86  | 76  | 104 | 147 | 39  | 0   | 0   | 0   | 0   | 0   | 0   | 0  | 0  | 0  | 0  | 0 | 0              | 819 |
| 67       | 6                  | 7  | 10 | 23 | 23 | 27  | 19  | 29  | 31  | 39  | 49  | 47  | 56  | 72  | 64  | 124 | 114 | 46  | 0   | 0   | 0   | 0   | 0   | 0  | 0  | 0  | 0  | 0 | 0              | 783 |
| 68       | 4                  | 7  | 8  | 13 | 23 | 23  | 19  | 23  | 39  | 46  | 36  | 46  | 63  | 66  | 61  | 98  | 119 | 119 | 32  | 0   | 0   | 0   | 0   | 0  | 0  | 0  | 0  | 0 | 0              | 845 |
| 69       | 3                  | 5  | 5  | 14 | 23 | 25  | 16  | 16  | 32  | 33  | 42  | 33  | 45  | 57  | 60  | 64  | 75  | 115 | 106 | 25  | 0   | 0   | 0   | 0  | 0  | 0  | 0  | 0 | 0              | 791 |
| 70       | 4                  | 5  | 10 | 11 | 8  | 25  | 20  | 29  | 28  | 36  | 48  | 45  | 44  | 46  | 43  | 69  | 78  | 82  | 144 | 135 | 39  | 0   | 0   | 0  | 0  | 0  | 0  | 0 | 0              | 951 |
| 71       | 0                  | 6  | 5  | 5  | 7  | 16  | 12  | 15  | 20  | 21  | 29  | 35  | 32  | 33  | 35  | 36  | 47  | 52  | 73  | 99  | 115 | 19  | 0   | 0  | 0  | 0  | 0  | 0 | 0              | 713 |
| 72       | 0                  | 6  | 7  | 4  | 5  | 21  | 16  | 14  | 33  | 26  | 32  | 33  | 40  | 42  | 40  | 45  | 47  | 47  | 95  | 98  | 158 | 95  | 34  | 0  | 0  | 0  | 0  | 0 | 0              | 939 |
| 73       | 0                  | 1  | 4  | 2  | 7  | 15  | 16  | 15  | 23  | 22  | 31  | 38  | 36  | 39  | 35  | 52  | 42  | 31  | 52  | 62  | 109 | 106 | 80  | 18 | 0  | 0  | 0  | 0 | 0              | 836 |
| 74       | 0                  | 1  | 2  | 4  | 3  | 9   | 3   | 15  | 17  | 22  | 37  | 34  | 38  | 45  | 29  | 44  | 35  | 36  | 45  | 50  | 83  | 55  | 104 | 65 | 14 | 0  | 0  | 0 | 0              | 796 |
| 75       | 0                  | 0  | 0  | 3  | 2  | 9   | 6   | 14  | 19  | 19  | 24  | 28  | 40  | 45  | 46  | 40  | 37  | 38  | 63  | 47  | 82  | 48  | 113 | 93 | 63 | 16 | 0  | 0 | 0              | 895 |
| 76       | 0                  | 0  | 0  | 2  | 1  | 1   | 6   | 23  | 15  | 24  | 19  | 30  | 36  | 24  | 27  | 44  | 42  | 26  | 43  | 29  | 68  | 43  | 45  | 51 | 55 | 30 | 0  | 0 | 0              | 684 |
| 77       | 0                  | 0  | 0  | 0  | 4  | 6   | 5   | 10  | 11  | 16  | 17  | 22  | 25  | 27  | 31  | 30  | 35  | 20  | 43  | 40  | 58  | 32  | 39  | 37 | 42 | 25 | 5  | 0 | 0              | 585 |
| 78       | 0                  | 0  | 0  | 0  | 3  | 5   | 7   | 10  | 17  | 15  | 21  | 19  | 25  | 30  | 34  | 28  | 44  | 39  | 27  | 42  | 33  | 33  | 36  | 40 | 32 | 10 | 2  | 0 | 0              | 555 |
| 79       | 0                  | 0  | 0  | 0  | 0  | 3   | 1   | 6   | 2   | 15  | 11  | 15  | 28  | 15  | 25  | 15  | 20  | 27  | 31  | 39  | 40  | 35  | 36  | 33 | 23 | 31 | 13 | 2 | 0              | 468 |
| 80       | 0                  | 0  | 0  | 0  | 0  | 1   | 4   | 8   | 4   | 12  | 17  | 15  | 19  | 24  | 30  | 29  | 26  | 31  | 31  | 37  | 23  | 54  | 35  | 28 | 29 | 12 | 5  | 0 | 0              | 487 |
| 81       | 0                  | 0  | 0  | 0  | 0  | 2   | 2   | 5   | 3   | 11  | 8   | 16  | 16  | 12  | 16  | 15  | 18  | 24  | 19  | 33  | 36  | 32  | 23  | 32 | 34 | 23 | 4  | 0 | 0              | 384 |
| 82       | 0                  | 0  | 0  | 0  | 0  | 0   | 0   | 2   | 3   | 7   | 3   | 14  | 12  | 17  | 20  | 16  | 18  | 26  | 20  | 20  | 29  | 30  | 31  | 25 | 21 | 15 | 5  | 1 | 0              | 335 |
| 83       | 0                  | 0  | 0  | 0  | 0  | 0   | 0   | 1   | 3   | 6   | 8   | 5   | 11  | 13  | 16  | 12  | 21  | 15  | 10  | 31  | 25  | 26  | 33  | 41 | 30 | 14 | 3  | 1 | 0              | 325 |

Exhibit II  
Sheet 1 of 2







|     |          |          |          |          |          |          |          |          |          |          |          |          |          |          |
|-----|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| 87  | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 |
| 88  | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 |
| 89  | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 |
| 90  | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 |
| 91  | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 |
| 92  | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 |
| 93  | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 |
| 94  | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 |
| 95  | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 |
| 96  | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 |
| 97  | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 |
| 98  | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 |
| 99  | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 |
| 100 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 |
| 101 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 |
| 102 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 |
| 103 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 |
| 104 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 |
| 105 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 |

NUMBER HRT

|       |       |       |       |       |       |       |       |       |       |       |       |        |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
| 3700. | 3407. | 3720. | 3599. | 3718. | 3599. | 3719. | 3717. | 3598. | 3720. | 3598. | 3719. | 43836. |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|

AVG TEMP

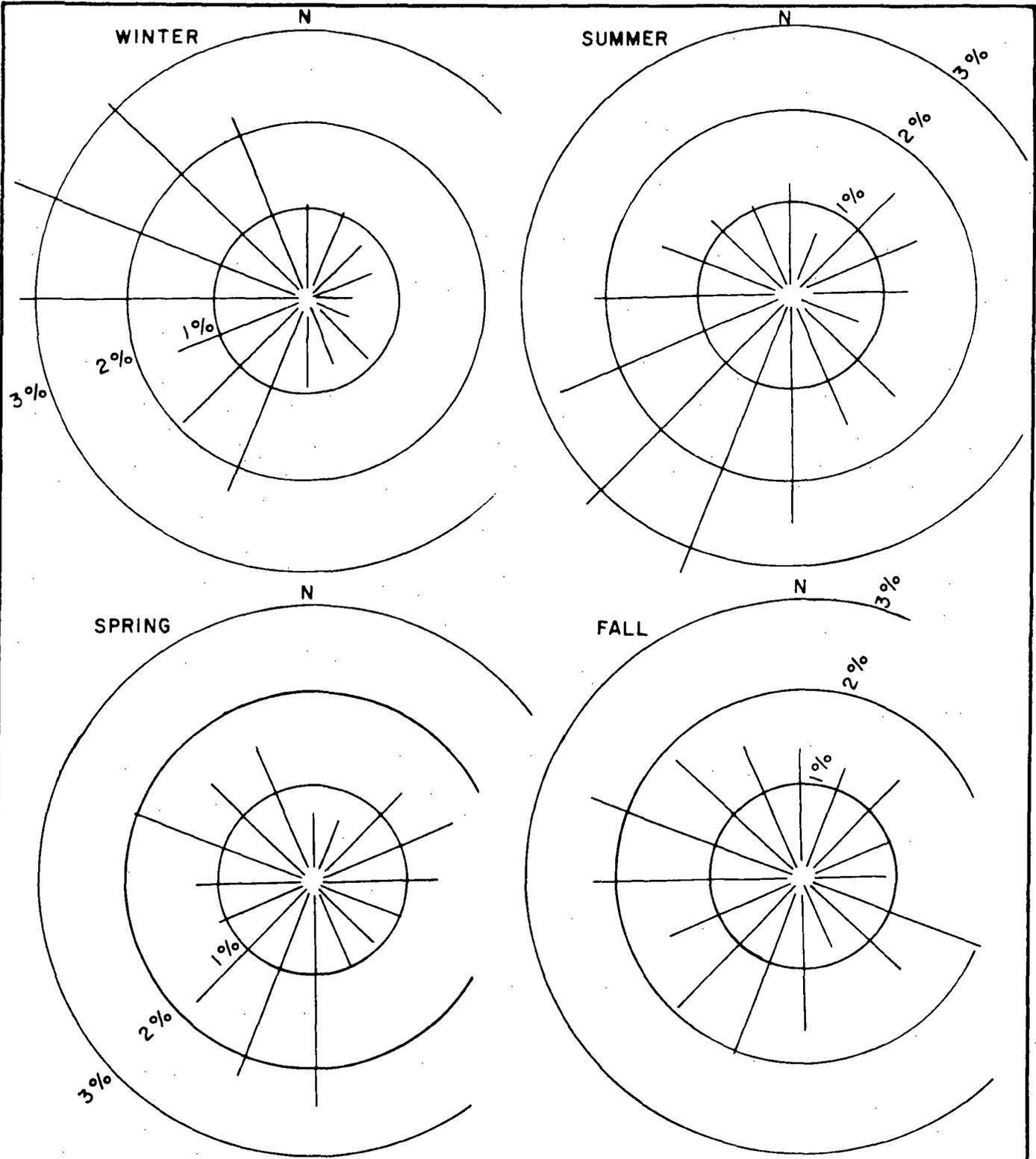
|        |        |        |        |        |        |        |        |        |        |        |        |        |
|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| 50.910 | 50.720 | 51.230 | 45.162 | 54.187 | 63.309 | 67.380 | 66.900 | 61.354 | 51.215 | 42.909 | 30.371 | 48.337 |
|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|



|     |          |          |          |          |         |         |          |          |          |          |          |          |          |
|-----|----------|----------|----------|----------|---------|---------|----------|----------|----------|----------|----------|----------|----------|
| 51  | 71.117   | 63.9402  | 49.5151  | 54.1339  | 17.0522 | 0.9169  | 0.0000   | 0.0269   | 4.2246   | 31.7204  | 62.6459  | 95.1062  | 45.1124  |
| 52  | 70.0000  | 70.0000  | 60.0000  | 57.7660  | 19.0342 | 1.2781  | 0.0000   | 0.1344   | 5.5864   | 34.8387  | 66.2034  | 95.9129  | 46.6842  |
| 53  | 70.7531  | 67.1529  | 60.4439  | 61.2392  | 22.0659 | 2.1395  | 0.0000   | 0.3227   | 7.1984   | 38.3065  | 69.3163  | 96.7464  | 48.3198  |
| 54  | 71.0000  | 67.0000  | 60.7312  | 64.9903  | 29.0624 | 2.6952  | 0.0000   | 0.5647   | 8.6437   | 41.9355  | 72.7071  | 97.4187  | 49.9373  |
| 55  | 71.0000  | 67.0000  | 60.0000  | 67.4355  | 29.5320 | 3.6955  | 0.1076   | 1.0467   | 10.5058  | 45.3226  | 76.1534  | 97.9833  | 51.5615  |
| 56  | 71.7173  | 67.0000  | 61.0000  | 70.7066  | 32.0671 | 4.7235  | 0.2958   | 1.7470   | 12.6181  | 48.9785  | 78.8772  | 98.3867  | 53.1288  |
| 57  | 72.2549  | 67.0000  | 62.0000  | 74.0262  | 36.5016 | 6.0074  | 0.6184   | 2.3662   | 15.2863  | 52.4462  | 81.9622  | 98.8976  | 54.9173  |
| 58  | 72.5000  | 67.0000  | 63.0000  | 77.4104  | 41.0436 | 8.6691  | 1.1293   | 3.3073   | 18.2601  | 56.2097  | 85.2140  | 99.3009  | 56.7583  |
| 59  | 72.5000  | 67.0000  | 64.0000  | 79.5099  | 44.7572 | 10.4190 | 1.3170   | 4.4307   | 20.6782  | 59.8656  | 88.4380  | 99.5698  | 58.3757  |
| 60  | 72.5000  | 67.0000  | 65.0000  | 81.0000  | 50.0269 | 13.0036 | 1.9490   | 5.6730   | 23.9578  | 64.4892  | 90.9116  | 99.8656  | 60.3353  |
| 61  | 72.7531  | 67.0000  | 66.0000  | 83.0000  | 53.2000 | 15.3933 | 3.0116   | 6.7700   | 26.8760  | 67.9032  | 92.9405  | 99.8924  | 61.9208  |
| 62  | 72.7531  | 67.0000  | 66.0000  | 85.1346  | 57.0466 | 18.8108 | 4.2485   | 8.2200   | 30.3224  | 71.2366  | 94.6359  | 99.9462  | 63.6113  |
| 63  | 100.0000 | 70.7531  | 67.0000  | 86.0000  | 61.2420 | 22.1728 | 5.9425   | 10.0505  | 34.6859  | 73.6022  | 96.4425  | 99.9731  | 65.4180  |
| 64  | 100.0000 | 70.7531  | 67.0000  | 87.7144  | 64.6853 | 25.1181 | 8.0936   | 12.3151  | 39.0555  | 76.6935  | 97.4430  | 99.9731  | 67.2294  |
| 65  | 100.0000 | 70.7531  | 67.0000  | 89.7414  | 68.1549 | 29.3693 | 11.0245  | 14.6545  | 44.2746  | 79.8118  | 98.1101  | 100.0000 | 69.1479  |
| 66  | 100.0000 | 70.7531  | 67.0000  | 90.0000  | 71.1673 | 35.0097 | 13.9265  | 17.5047  | 48.2490  | 82.3118  | 98.4436  | 100.0000 | 71.0437  |
| 67  | 100.0000 | 70.7531  | 67.0000  | 91.1364  | 73.0031 | 39.2053 | 17.4778  | 20.6507  | 52.3624  | 84.6505  | 98.6937  | 100.0000 | 72.8482  |
| 68  | 100.0000 | 70.7531  | 67.0000  | 91.0000  | 76.9769 | 44.1512 | 21.2960  | 24.6034  | 56.1423  | 86.9892  | 98.9161  | 100.0000 | 74.7827  |
| 69  | 100.0000 | 70.7531  | 67.0000  | 92.0000  | 78.9403 | 48.4579 | 25.1143  | 28.6367  | 60.2279  | 89.1129  | 99.0828  | 100.0000 | 76.5872  |
| 70  | 100.0000 | 70.7531  | 67.0000  | 93.0000  | 81.4954 | 53.5704 | 30.1963  | 34.0952  | 64.7860  | 90.9946  | 99.4441  | 100.0000 | 78.7613  |
| 71  | 100.0000 | 70.7531  | 67.0000  | 94.0000  | 83.0016 | 56.7380 | 34.9550  | 38.8545  | 67.6765  | 92.1505  | 99.5275  | 100.0000 | 80.3878  |
| 72  | 100.0000 | 70.7531  | 67.0000  | 95.0000  | 84.0037 | 61.9017 | 40.5485  | 43.1465  | 71.9288  | 93.3871  | 99.6665  | 100.0000 | 82.5299  |
| 73  | 100.0000 | 100.0000 | 70.7531  | 85.0000  | 87.0898 | 66.0461 | 46.6523  | 50.6319  | 74.9583  | 94.4892  | 99.8054  | 100.0000 | 84.4371  |
| 74  | 100.0000 | 100.0000 | 70.7531  | 86.1376  | 88.7036 | 69.4300 | 52.1914  | 56.5743  | 78.1545  | 95.6452  | 99.8332  | 100.0000 | 86.2530  |
| 75  | 100.0000 | 100.0000 | 70.7531  | 87.0000  | 90.2367 | 73.4926 | 57.9995  | 64.3721  | 81.7954  | 96.5591  | 99.9722  | 100.0000 | 88.2947  |
| 76  | 100.0000 | 100.0000 | 70.7531  | 88.0000  | 91.0000 | 76.3545 | 62.7657  | 69.4382  | 84.3246  | 97.3925  | 99.9722  | 100.0000 | 89.8551  |
| 77  | 100.0000 | 100.0000 | 70.7531  | 89.0000  | 92.0000 | 79.3270 | 67.2224  | 74.1860  | 86.2424  | 98.0645  | 100.0000 | 100.0000 | 91.1897  |
| 78  | 100.0000 | 100.0000 | 70.7531  | 90.0000  | 93.0000 | 82.6000 | 70.2200  | 78.2200  | 88.8441  | 100.0000 | 100.0000 | 100.0000 | 92.4558  |
| 79  | 100.0000 | 100.0000 | 70.7531  | 91.0000  | 94.0000 | 84.0000 | 74.9064  | 81.1771  | 90.4391  | 99.1129  | 100.0000 | 100.0000 | 93.5234  |
| 80  | 100.0000 | 100.0000 | 70.7531  | 92.0000  | 95.0000 | 86.0000 | 78.4351  | 84.7271  | 92.3013  | 99.5430  | 100.0000 | 100.0000 | 94.6344  |
| 81  | 100.0000 | 100.0000 | 100.0000 | 93.0000  | 96.0000 | 89.0000 | 81.7962  | 86.8752  | 93.9411  | 99.6774  | 100.0000 | 100.0000 | 95.5104  |
| 82  | 100.0000 | 100.0000 | 100.0000 | 94.0000  | 97.0000 | 91.0000 | 84.5920  | 89.1100  | 94.9972  | 99.8656  | 100.0000 | 100.0000 | 96.2747  |
| 83  | 100.0000 | 100.0000 | 100.0000 | 95.0000  | 97.0000 | 92.0000 | 87.4697  | 91.5031  | 95.8588  | 99.8656  | 100.0000 | 100.0000 | 97.0161  |
| 84  | 100.0000 | 100.0000 | 100.0000 | 96.0000  | 98.0000 | 93.0000 | 89.4050  | 93.5735  | 96.6370  | 99.9194  | 100.0000 | 100.0000 | 97.5567  |
| 85  | 100.0000 | 100.0000 | 100.0000 | 97.0000  | 98.0000 | 94.0000 | 91.9064  | 95.0225  | 97.2207  | 99.9731  | 100.0000 | 100.0000 | 98.0814  |
| 86  | 100.0000 | 100.0000 | 100.0000 | 98.0000  | 99.0000 | 95.0000 | 93.6932  | 96.3907  | 97.8321  | 100.0000 | 100.0000 | 100.0000 | 98.4852  |
| 87  | 100.0000 | 100.0000 | 100.0000 | 99.0000  | 99.0000 | 96.0000 | 95.7179  | 96.4157  | 97.2401  | 99.6330  | 100.0000 | 100.0000 | 98.8594  |
| 88  | 100.0000 | 100.0000 | 100.0000 | 99.0000  | 99.0000 | 97.0000 | 97.2200  | 96.9992  | 96.6120  | 99.4942  | 100.0000 | 100.0000 | 99.1628  |
| 89  | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 99.0000 | 97.0000 | 97.3276  | 97.4993  | 97.4993  | 99.1933  | 99.1166  | 100.0000 | 99.3841  |
| 90  | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 99.0000 | 97.0000 | 97.4621  | 96.0026  | 96.1447  | 99.4622  | 99.4997  | 100.0000 | 99.5529  |
| 91  | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 99.0000 | 97.0000 | 97.6172  | 96.4990  | 96.7631  | 99.7849  | 99.7449  | 100.0000 | 99.7057  |
| 92  | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 99.0000 | 97.0000 | 97.6117  | 96.9442  | 97.2740  | 99.8924  | 99.8332  | 100.0000 | 99.8129  |
| 93  | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 99.0000 | 97.0000 | 97.9193  | 97.3331  | 97.5967  | 99.9731  | 99.9166  | 100.0000 | 99.8951  |
| 94  | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 99.0000 | 97.0000 | 98.5276  | 97.7580  | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 99.9407  |
| 95  | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 99.0000 | 97.0000 | 99.8055  | 99.8650  | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 99.9726  |
| 96  | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 99.0000 | 97.0000 | 99.9444  | 99.9193  | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 99.9886  |
| 97  | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 99.0000 | 97.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 |
| 98  | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 99.0000 | 97.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 |
| 99  | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 99.0000 | 97.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 |
| 100 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 99.0000 | 97.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 |
| 101 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 99.0000 | 97.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 |
| 102 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 99.0000 | 97.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 |
| 103 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 99.0000 | 97.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 |
| 104 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 99.0000 | 97.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 |
| 105 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 99.0000 | 97.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 |
| 106 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 99.0000 | 97.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 |
| 107 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 99.0000 | 97.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 |
| 108 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 99.0000 | 97.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 |
| 109 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 99.0000 | 97.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 |
| 110 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 99.0000 | 97.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 | 100.0000 |

AVG TEMP

|        |        |        |        |        |        |        |        |        |        |        |        |        |
|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| 3719.  | 3407.  | 3720.  | 3599.  | 3718.  | 3599.  | 3719.  | 3719.  | 3598.  | 3720.  | 3598.  | 3719.  | 43835. |
| 66.007 | 64.324 | 64.747 | 61.364 | 61.364 | 70.340 | 74.540 | 73.121 | 67.996 | 56.634 | 47.311 | 33.144 | 53.593 |



NOTE: ALL PERCENTAGES ADD UP TO 100 %

JERSEY CENTRAL  
POWER & LIGHT COMPANY

---

EBASCO SERVICES INCORPORATED  
New York

PERCENT OCCURRENCE OF 16 DIRECTIONS  
SUMMED OVER ALL WIND SPEEDS  
AND STABILITIES FOR EACH SEASON  
OF YEAR (OYSTER CREEK 400 FT)

EXHIBIT  
13

PERCENT OCCURRENCE OF VARIOUS WIND SPEED RANGES  
SUMMED OVER ALL DIRECTIONS AND STABILITIES FOR  
EACH SEASON OF YEAR

(February 1966 - February 1967)

OYSTER CREEK SITE

400 Ft level (8016 hours)

| Speed Range<br>(mph) | Season |        |        |      |
|----------------------|--------|--------|--------|------|
|                      | Winter | Spring | Summer | Fall |
| 0-3 <sup>(a)</sup>   | 0.87   | 0.72   | 1.48   | 1.12 |
| 4-7                  | 1.88   | 2.48   | 4.08   | 3.21 |
| 8-12                 | 4.28   | 6.16   | 8.41   | 6.93 |
| 13-18                | 7.15   | 6.57   | 7.56   | 6.51 |
| 19-24                | 8.01   | 5.09   | 5.16   | 6.24 |
| Over 25              | 2.43   | 1.61   | 0.52   | 1.50 |

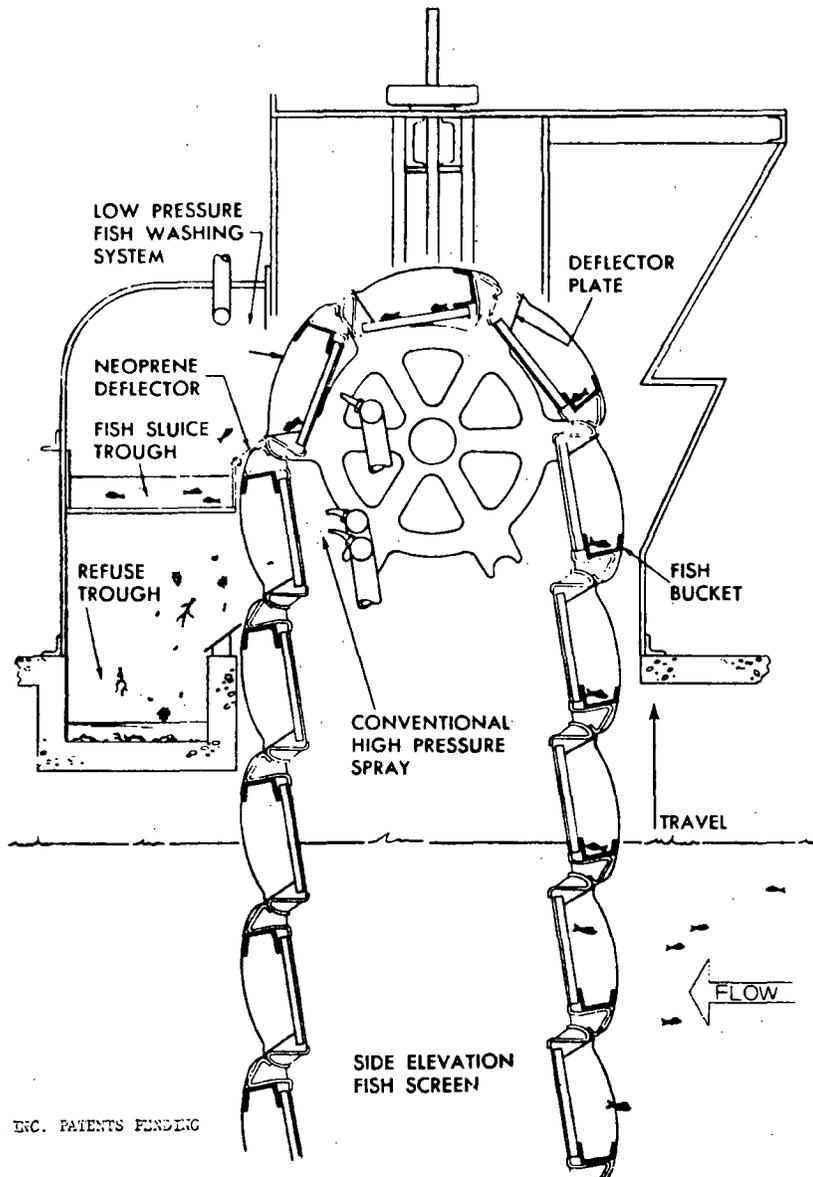
a. 88 hours of calm are included in total of 8016 hours.

Note: Total of all columns adds to about 100%.

BARNEGAT BAY AND ATLANTIC OCEAN WATER QUALITY

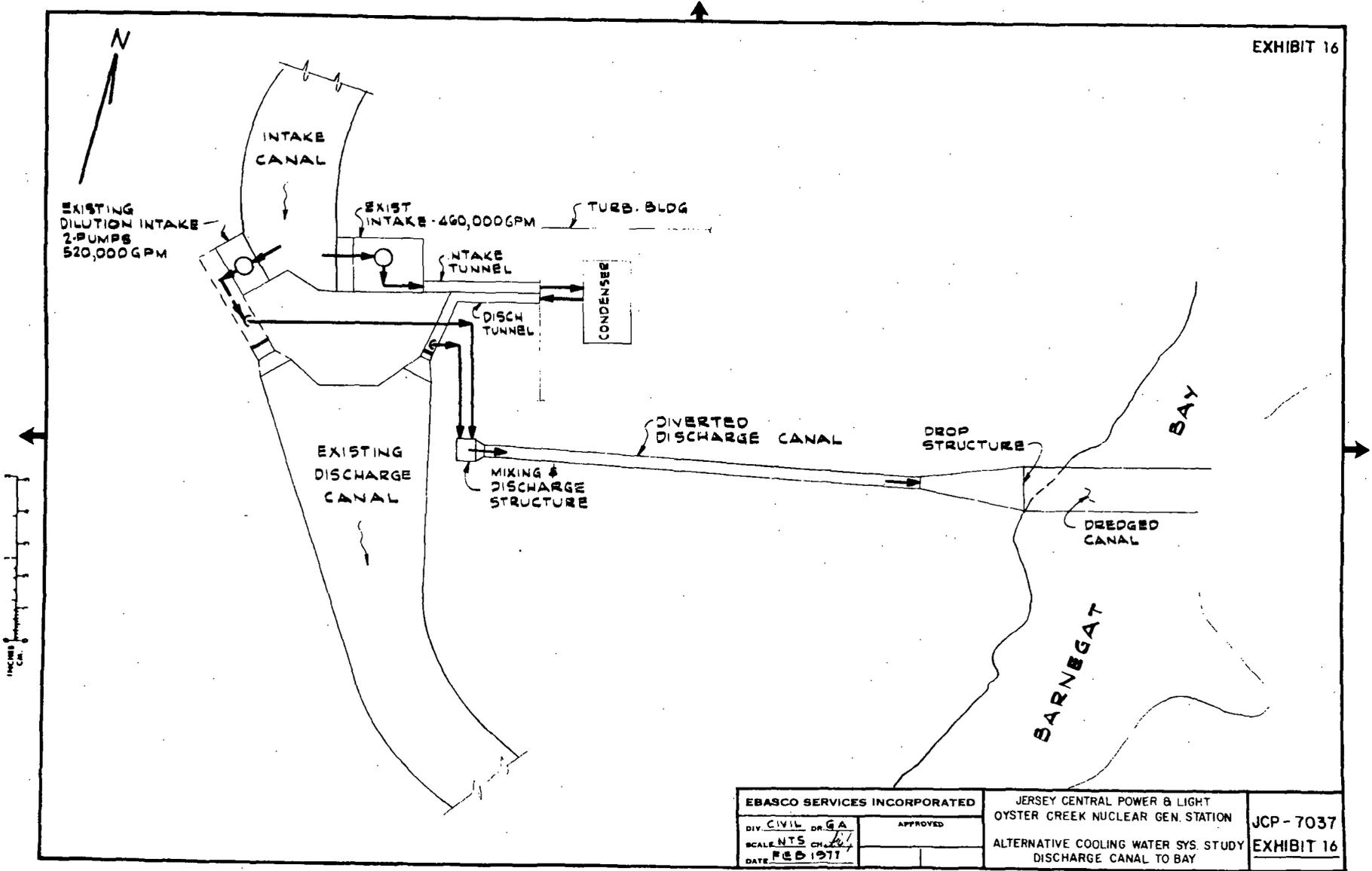
| Parameter                       | Barnegat Bay |         | Atlantic Ocean |
|---------------------------------|--------------|---------|----------------|
|                                 | Average      | Maximum | Average        |
| Calcium                         | 278          | 348     | 406            |
| Magnesium                       | 886          | 1,107   | 1,292          |
| Sodium                          | 7,347        | 9,183   | 10,714         |
| Potassium                       | 264          | 330     | 385            |
| Chloride                        | 13,200       | 16,500  | 19,250         |
| Sulfate                         | 1,843        | 2,304   | 2,688          |
| Nitrate                         | -            | -       | -              |
| Phosphate                       | 0.08         | 0.1     | 0.12           |
| Bicarbonate                     | 100          | 123     | 144            |
| Silica                          | 2.2          | 2.7     | 3.2            |
| Iron                            | 0.001        | 0.002   | 0.002          |
| Manganese                       | 0.003        | 0.004   | 0.005          |
| Zinc                            |              |         | 0.005          |
| Salinity                        | 24,000       | 30,000  | 25,000         |
| Alkalinity as CaCO <sub>3</sub> | 82           | 104     | 118            |
| pH                              | 7.7          | 8.3     | 8.3            |

Note: All units are in ppm, except pH which is in standard units.



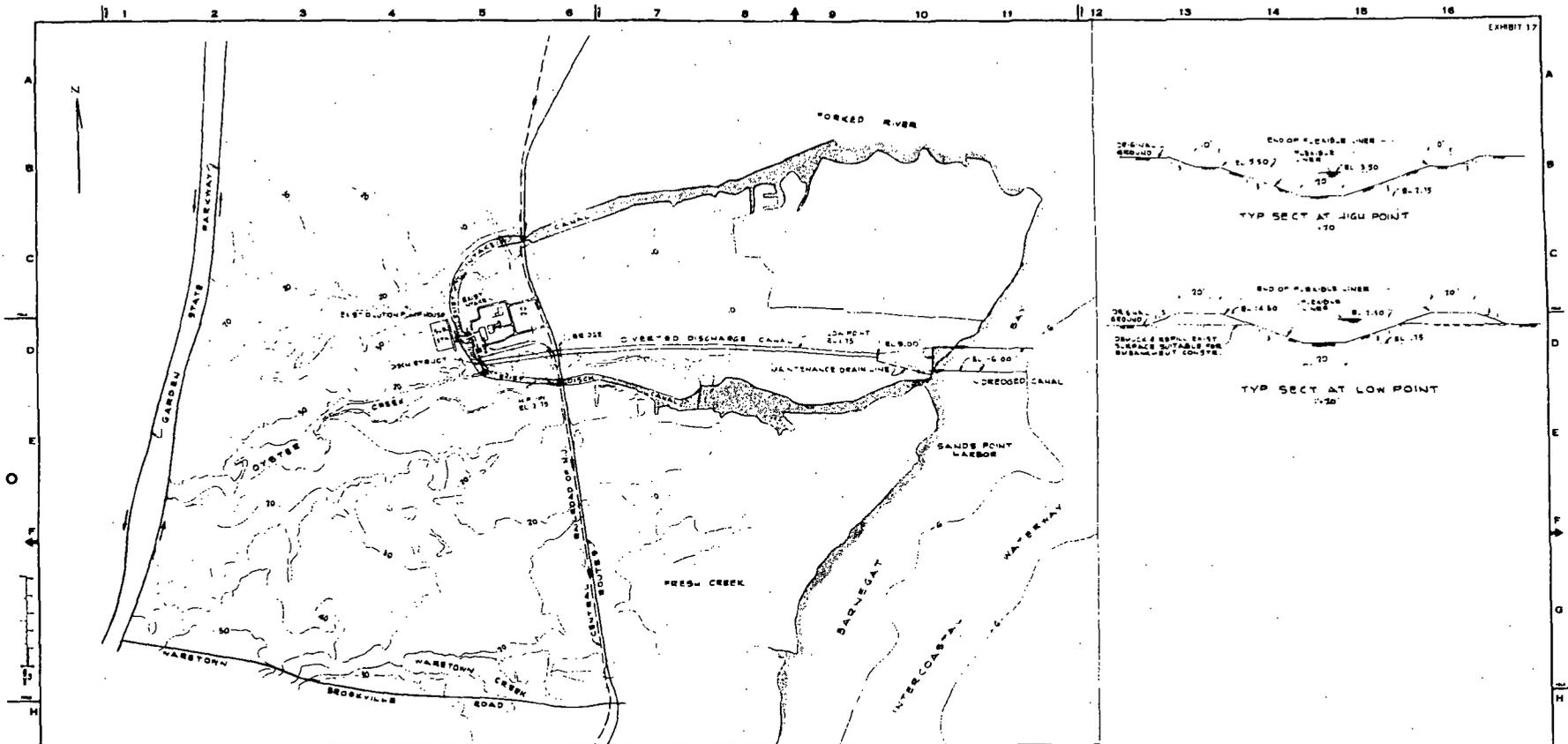
PERMISSION BY ERVIREX, INC. PATENTS PENDING

|   |   |                       |
|---|---|-----------------------|
| <p>JERSEY CENTRAL POWER &amp; LIGHT<br/>COMPANY</p> | <p>TRAVELING SCREEN WITH RISTROPH<br/>BUCKETS</p> | <p>EXHIBIT<br/>15</p> |
| <p>EBASCO SERVICES INCORPORATED<br/>New York</p>    |   |                       |

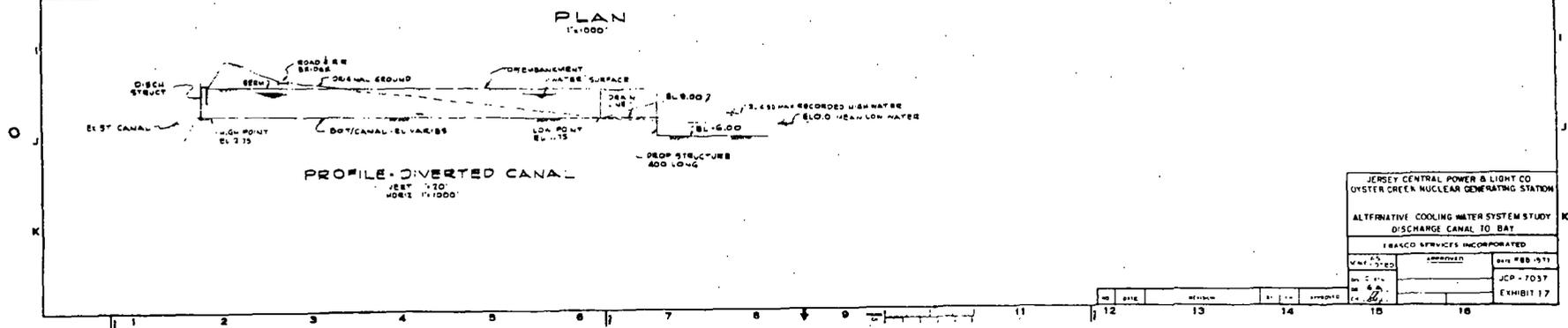
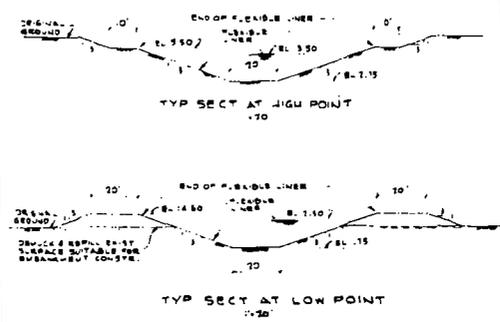


|                              |          |   |  |            |
|------------------------------|----------|---|--|------------|
| EBASCO SERVICES INCORPORATED |          | JERSEY CENTRAL POWER & LIGHT<br>OYSTER CREEK NUCLEAR GEN. STATION |  | JCP - 7037 |
| DIV. CIVIL DR. GA            | APPROVED |   |  | EXHIBIT 16 |
| SCALE: NTS CH. 2/27          |          | ALTERNATIVE COOLING WATER SYS. STUDY<br>DISCHARGE CANAL TO BAY    |  |            |
| DATE: FEB 1977               |          |   |  |            |

INCHES CA. 0 1 2 3 4 5 6 7 8 9 10



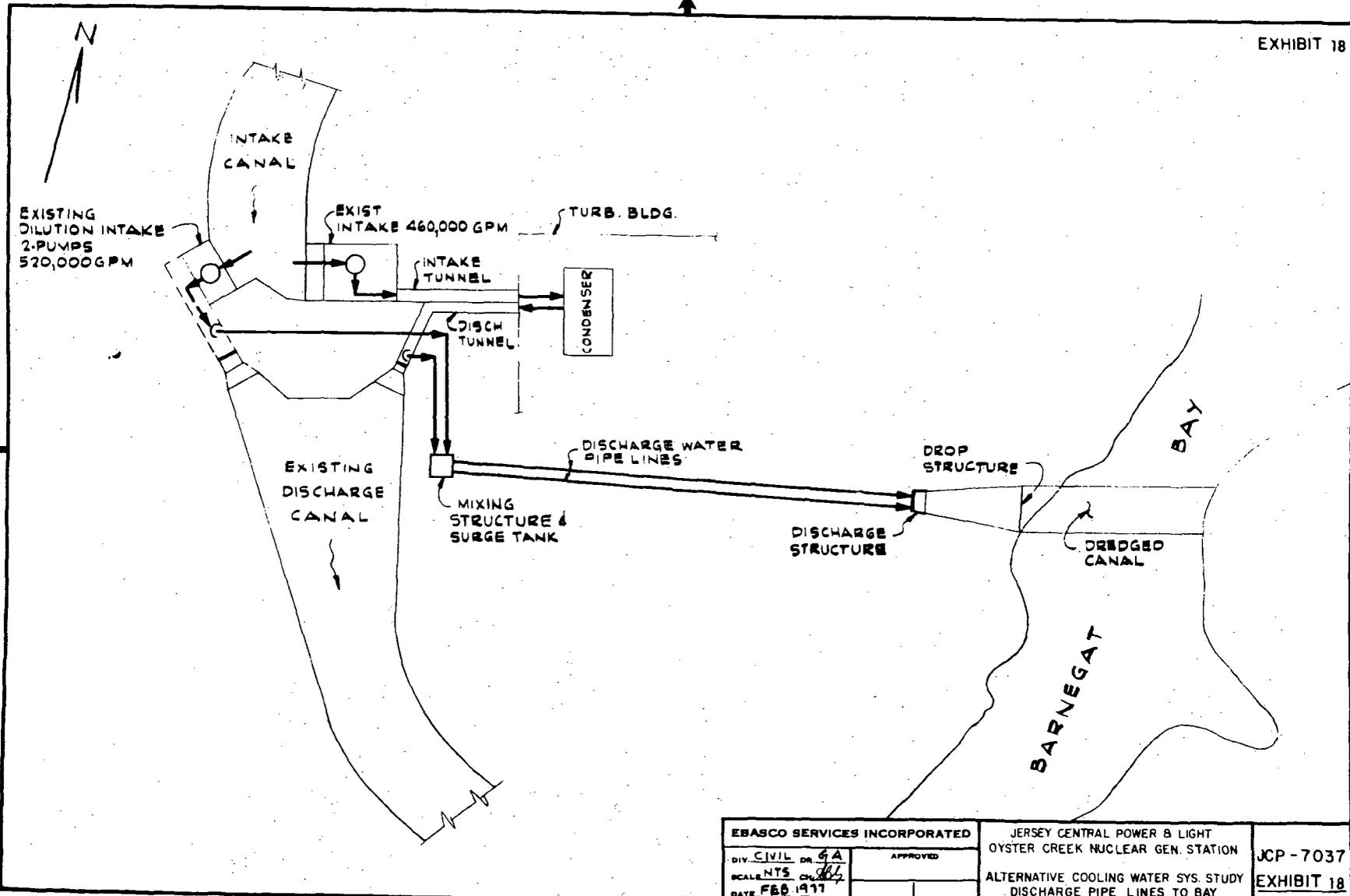
PLAN  
1"=100'



PROFILE - OVER-TOP DISCHARGE CANAL  
VERT. 1"=20'  
HORIZ. 1"=1000'

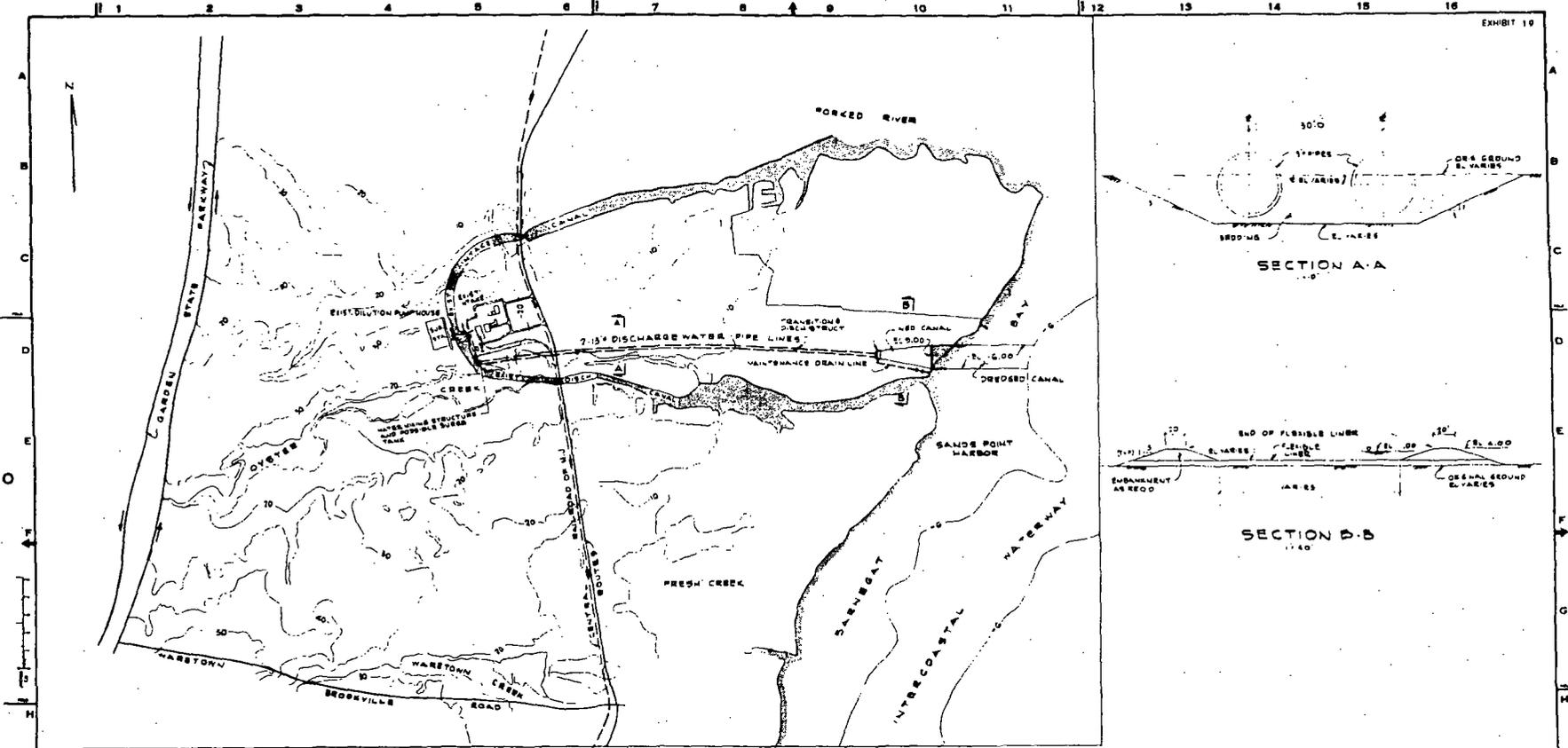
|  |          |      |            |
|--|----------|------|------------|
| JERSEY CENTRAL POWER & LIGHT CO<br>OYSTER CREEK NUCLEAR GENERATING STATION |          |      |            |
| ALTERNATIVE COOLING WATER SYSTEM STUDY<br>DISCHARGE CANAL TO BAT           |          |      |            |
| FRASCO SERVICES INCORPORATED   |          |      |            |
| DESIGNED BY  | APPROVED | DATE | NO. 88-971 |
| DR. C. H. ...  |          |      | JCP - 7037 |
| EX. 17   |          |      | EXHIBIT 17 |

|     |      |             |    |          |
|-----|------|-------------|----|----------|
| NO. | DATE | DESCRIPTION | BY | APPROVED |
| 12  |      |             |    |          |
| 13  |      |             |    |          |
| 14  |      |             |    |          |
| 15  |      |             |    |          |
| 16  |      |             |    |          |

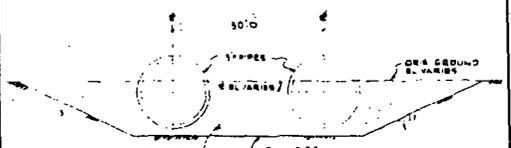


|                              |  |                                      |            |
|------------------------------|--|--------------------------------------|------------|
| EBASCO SERVICES INCORPORATED |  | JERSEY CENTRAL POWER & LIGHT         | JCP-7037   |
| DIV. CIVIL DR. GA            |  | OYSTER CREEK NUCLEAR GEN. STATION    |            |
| SCALE: NTS                   |  | APPROVED                             | EXHIBIT 18 |
| DATE: FEB 1977               |  | ALTERNATIVE COOLING WATER SYS. STUDY |            |
|                              |  | DISCHARGE PIPE LINES TO BAY          |            |

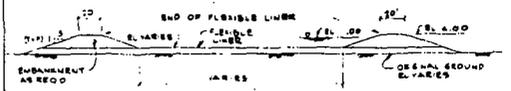
INCHES  
0 1 2



PLAN  
1:1000'



SECTION A-A  
1:100'



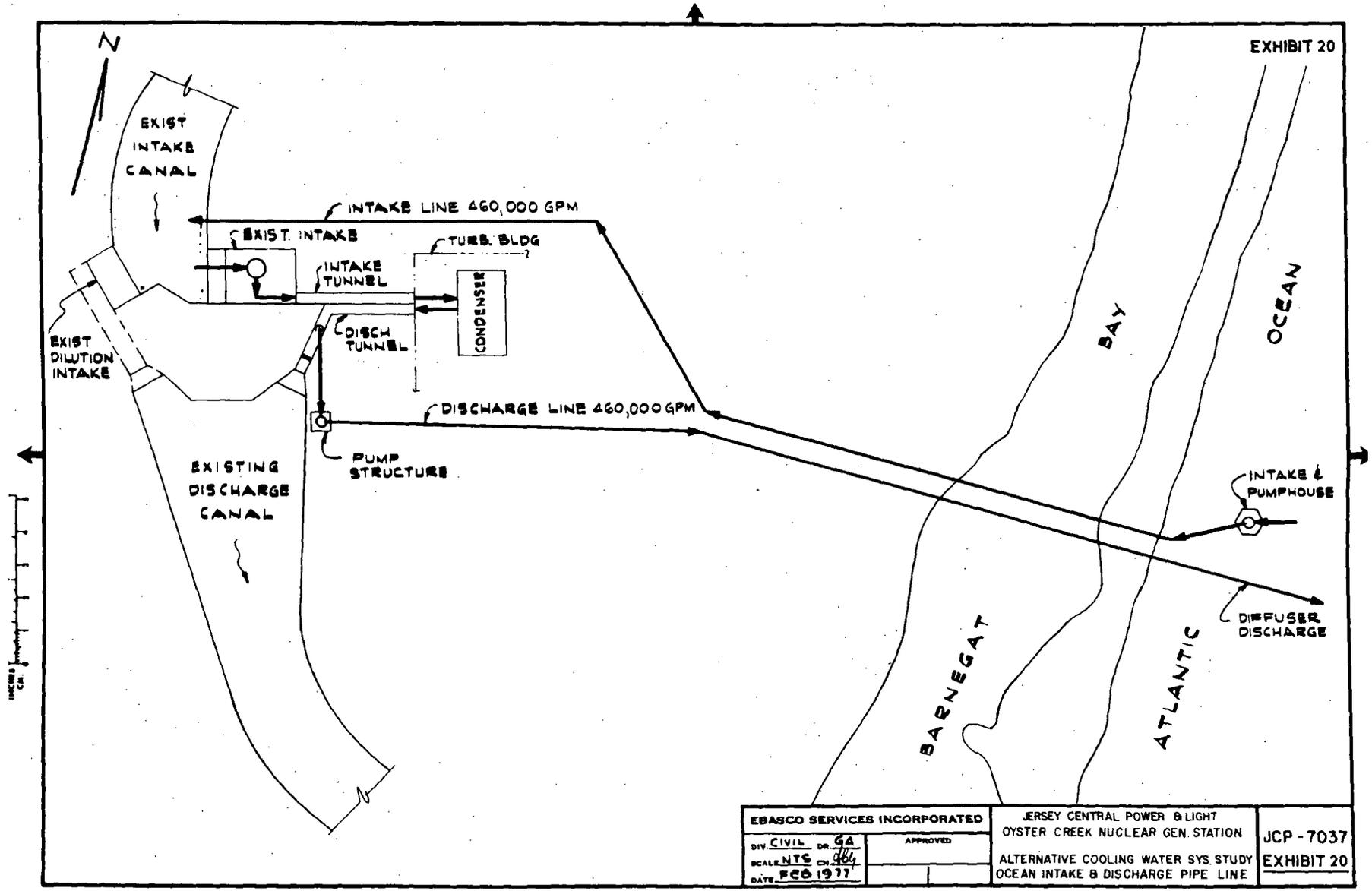
SECTION B-B  
1:100'



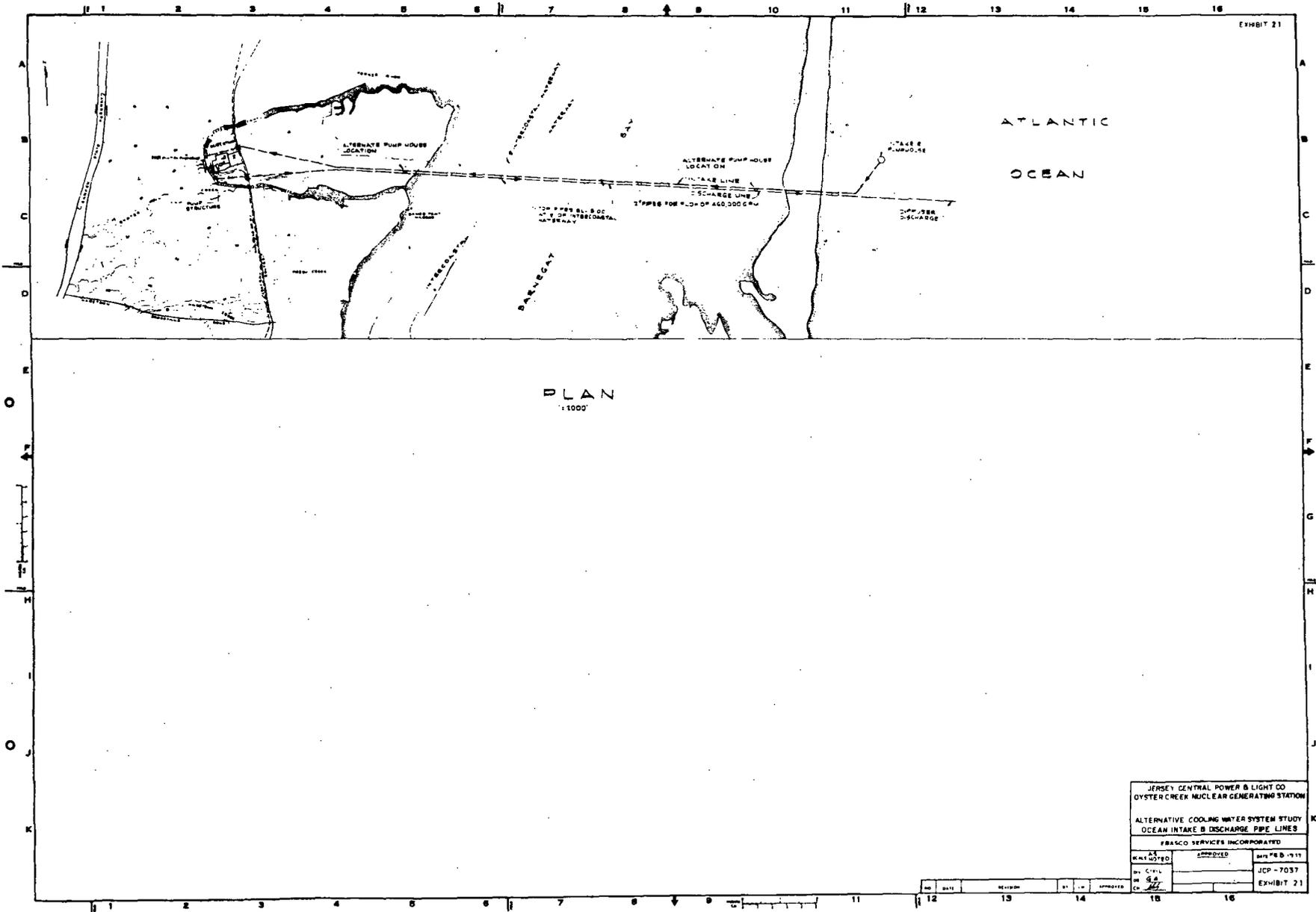
PROFILE ALONG PIPE LINES  
1:100'

|   |             |         |            |
|---|-------------|---------|------------|
| JERSEY CENTRAL POWER & LIGHT CO.<br>OYSTER CREEK NUCLEAR GENERATING STATION |             |         |            |
| ALTERNATIVE COOLING WATER SYSTEM STUDY<br>DISCHARGE PIPE LINES TO BAY       |             |         |            |
| EDASCO SERVICES INCORPORATED  |             |         |            |
| DATE  | APPROVED    | DATE    | NO. 1911   |
| 10/1/68   | [Signature] | 10/1/68 | JCP-7037   |
|   |             |         | EXHIBIT 10 |

|     |      |          |    |      |          |
|-----|------|----------|----|------|----------|
| NO. | DATE | REVISION | BY | CHK. | APPROVED |
| 1   |      |          |    |      |          |
| 2   |      |          |    |      |          |
| 3   |      |          |    |      |          |
| 4   |      |          |    |      |          |
| 5   |      |          |    |      |          |
| 6   |      |          |    |      |          |
| 7   |      |          |    |      |          |
| 8   |      |          |    |      |          |
| 9   |      |          |    |      |          |
| 10  |      |          |    |      |          |
| 11  |      |          |    |      |          |
| 12  |      |          |    |      |          |
| 13  |      |          |    |      |          |
| 14  |      |          |    |      |          |
| 15  |      |          |    |      |          |
| 16  |      |          |    |      |          |



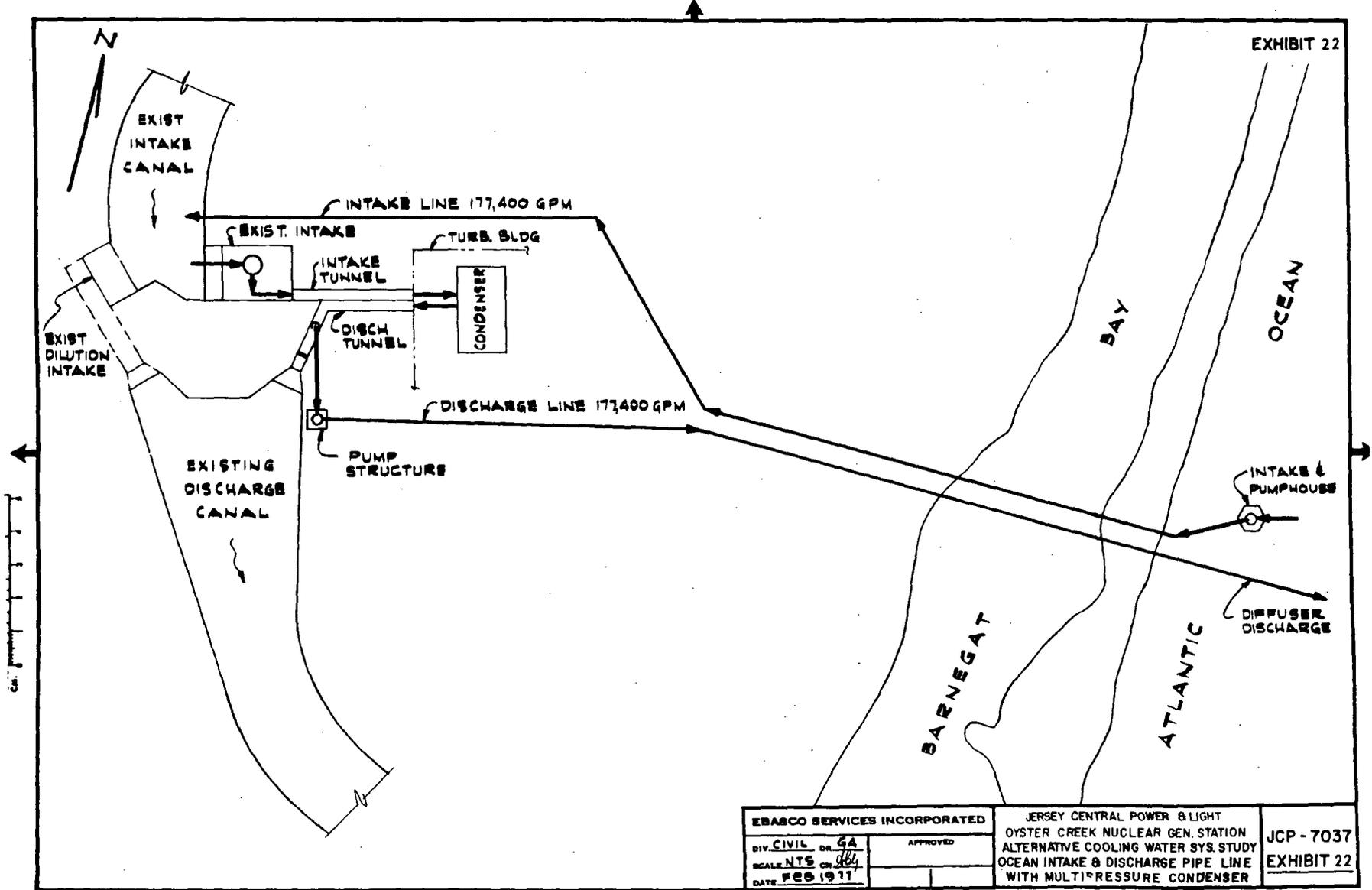
|                              |  |                                      |  |
|------------------------------|--|--------------------------------------|--|
| EBASCO SERVICES INCORPORATED |  | JERSEY CENTRAL POWER & LIGHT         |  |
| DIV. CIVIL DR. GA            |  | OYSTER CREEK NUCLEAR GEN. STATION    |  |
| SCALE: NTS CH. 364           |  | ALTERNATIVE COOLING WATER SYS. STUDY |  |
| DATE: FEB 1977               |  | OCEAN INTAKE & DISCHARGE PIPE LINE   |  |
| APPROVED                     |  | JCP - 7037                           |  |
|                              |  | EXHIBIT 20                           |  |



PLAN  
1:1000

|   |             |               |
|---|-------------|---------------|
| JERSEY CENTRAL POWER & LIGHT CO         |             |               |
| OYSTER CREEK NUCLEAR GENERATING STATION |             |               |
| ALTERNATIVE COOLING WATER SYSTEM STUDY  |             |               |
| OCEAN INTAKE & DISCHARGE PIPE LINES     |             |               |
| FRASCO SERVICES INCORPORATED            |             |               |
| DESIGNED BY                             | APPROVED BY | DATE FEB 1977 |
| BY C.F.L.                               | BY G.A.     | JCP-7037      |
| CH. J.C.                                |             | EXHIBIT 21    |

|     |      |          |    |          |
|-----|------|----------|----|----------|
| NO. | DATE | REVISION | BY | APPROVED |
| 12  |      |          |    |          |
| 13  |      |          |    |          |
| 14  |      |          |    |          |
| 15  |      |          |    |          |
| 16  |      |          |    |          |

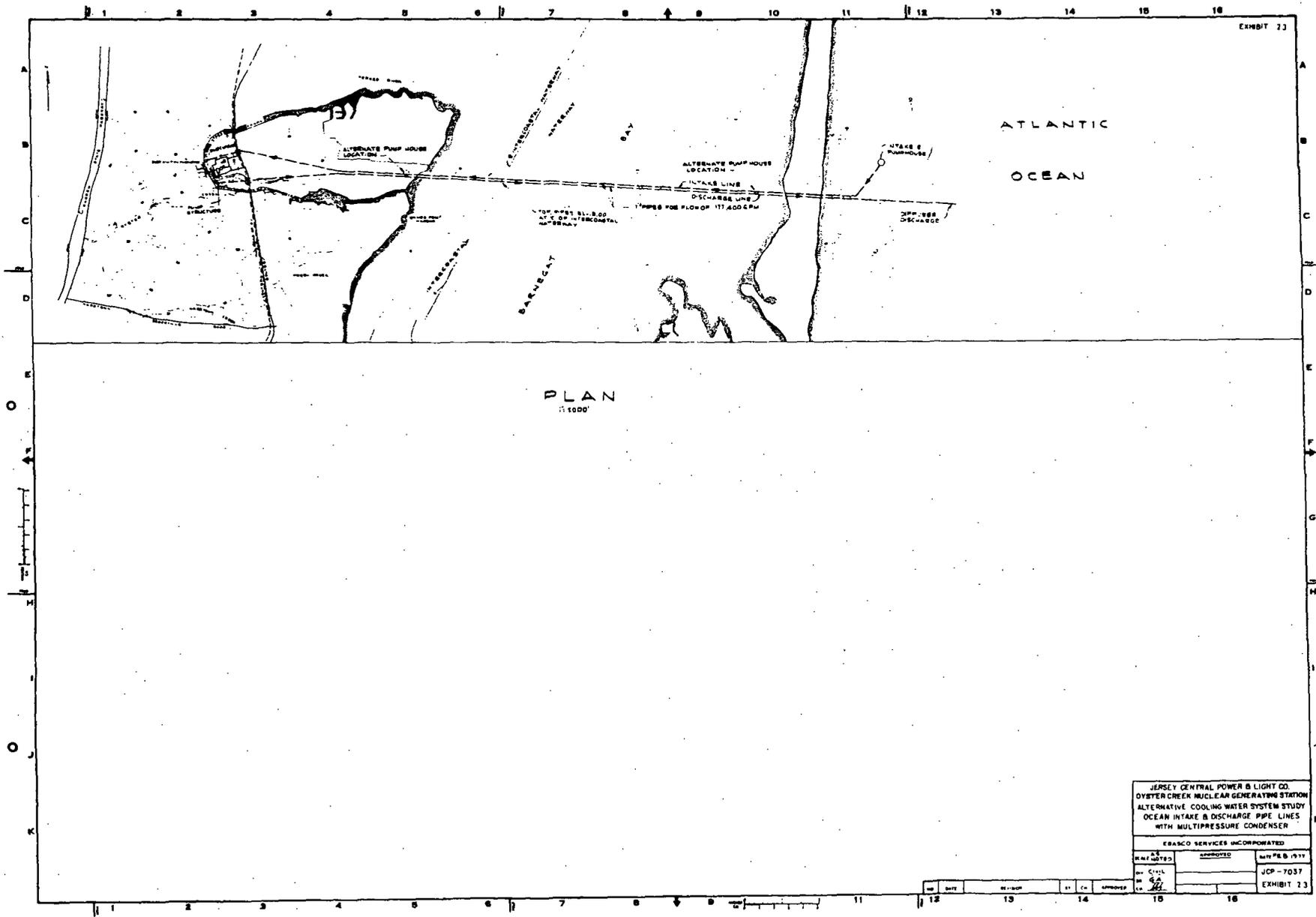


ERASCO SERVICES INCORPORATED  
 DIV. CIVIL DR. GA  
 SCALE NTS CH. 264  
 DATE FEB 1977

JERSEY CENTRAL POWER & LIGHT  
 OYSTER CREEK NUCLEAR GEN. STATION  
 ALTERNATIVE COOLING WATER SYS. STUDY  
 OCEAN INTAKE & DISCHARGE PIPE LINE  
 WITH MULTI-PRESSURE CONDENSER

JCP - 7037  
 EXHIBIT 22

INCHES  
 0 1 2 3 4 5 6 7 8 9 10

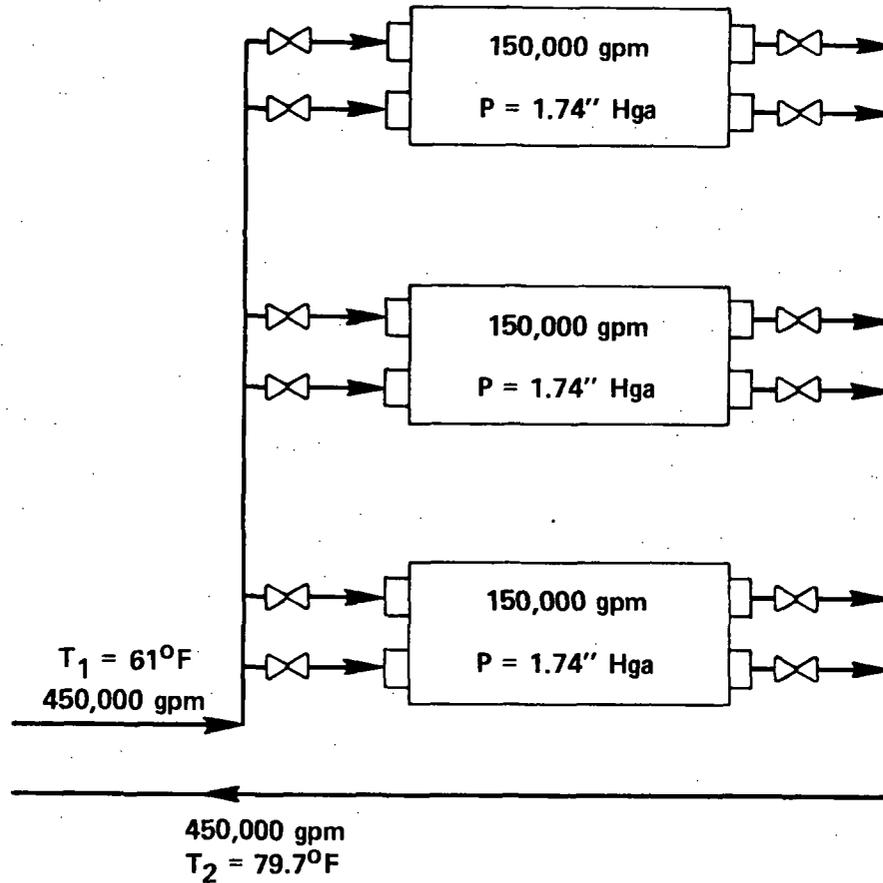


PLAN  
1:5000'

|  |                  |                |                          |
|--|------------------|----------------|--------------------------|
| JERSEY GENERAL POWER & LIGHT CO.<br>OYSTER CREEK NUCLEAR GENERATING STATION<br>ALTERNATIVE COOLING WATER SYSTEM STUDY<br>OCEAN INTAKE & DISCHARGE PIPE LINES<br>WITH MULTIPRESSURE CONDENSER |                  |                |                          |
| ERANCOS SERVICES INCORPORATED  |                  |                |                          |
| DRAWN BY<br>C.S.L.   | APPROVED<br>G.A. | DATE FEB. 1977 |                          |
| NO.  | DATE             | REVISION       | APPROVED                 |
|  |                  |                | JCP - 7037<br>EXHIBIT 23 |

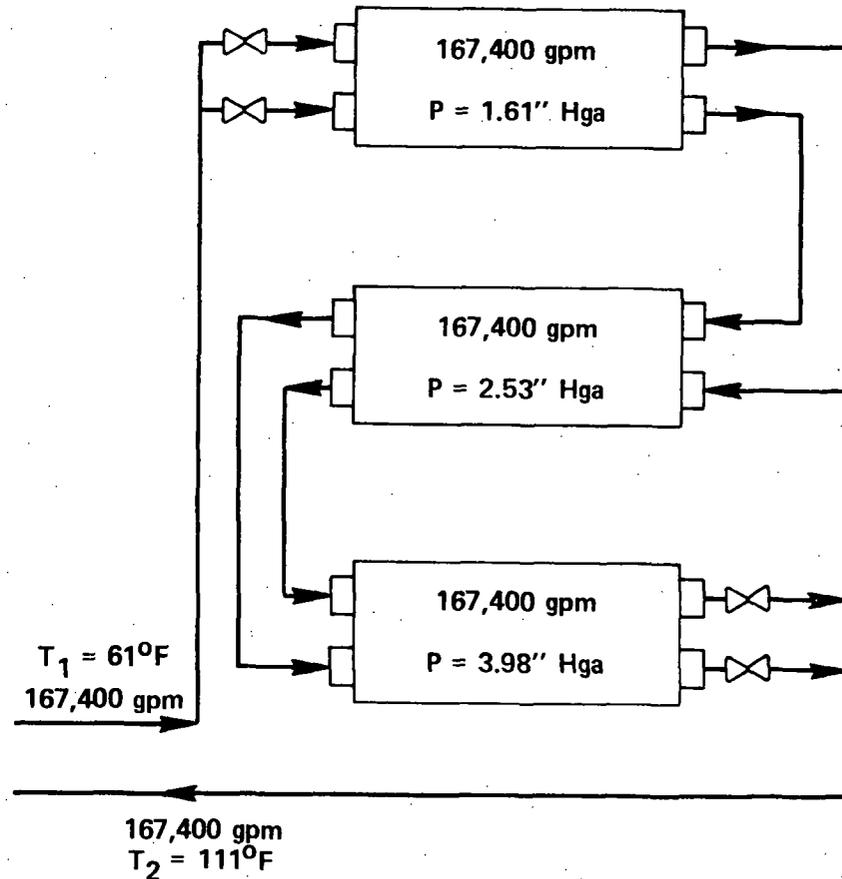
MULTIPRESSURE AND SINGLE PRESSURE  
CONDENSERS - WATER FLOW DIAGRAMS

**SINGLE PRESSURE  
CONDENSER**

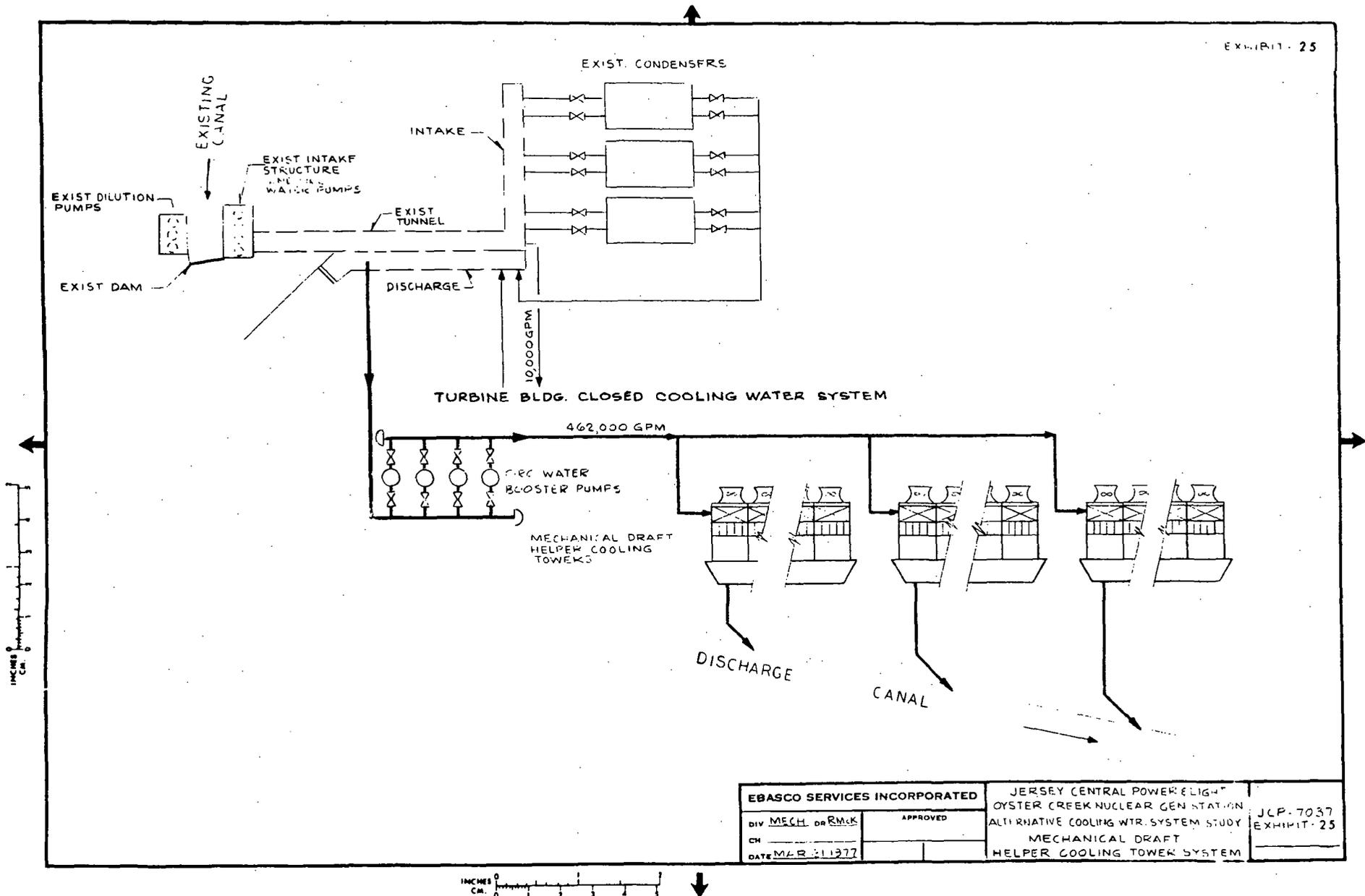


PLANT NET OUTPUT 624.2 MW  
CW PIPES 2 X 12' I.D.

**MULTIPRESSURE  
CONDENSER**

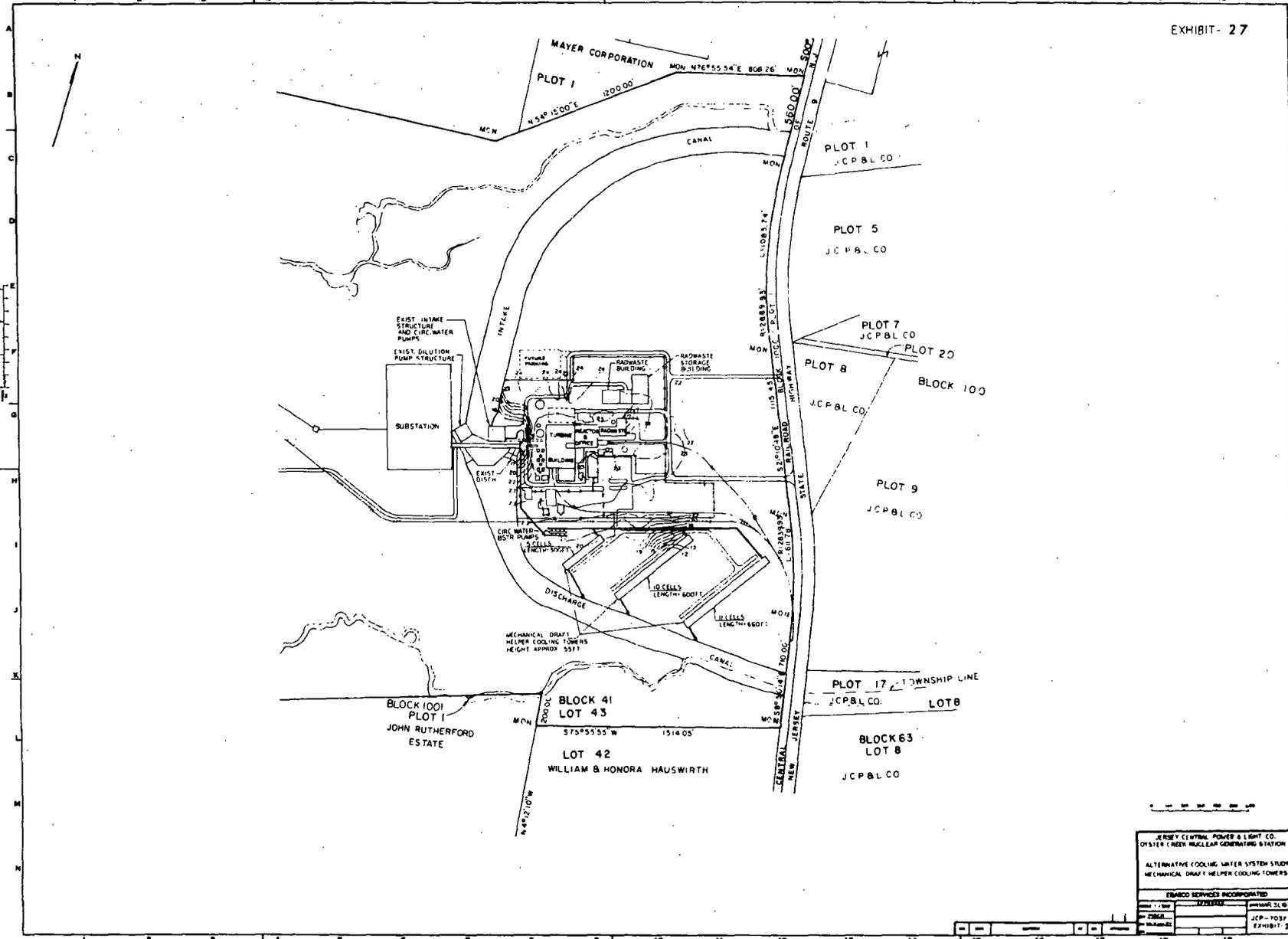


PLANT NET OUTPUT 607.1 MW  
CW PIPES 2 X 7' I.D.



|                                     |  |  |  |
|-------------------------------------|--|--|--|
| <b>EBASCO SERVICES INCORPORATED</b> |  | <b>JERSEY CENTRAL POWER &amp; LIGHT</b>      |  |
| DIV. <u>MECH. DR. RMCK</u>          |  | OYSTER CREEK NUCLEAR GEN. STATION            |  |
| CH. _____                           |  | ALTERNATIVE COOLING WTR. SYSTEM STUDY        |  |
| DATE <u>MAR 31 1977</u>             |  | MECHANICAL DRAFT HELPER COOLING TOWER SYSTEM |  |
| APPROVED _____                      |  | JCP-7037 EXHIBIT-25                          |  |

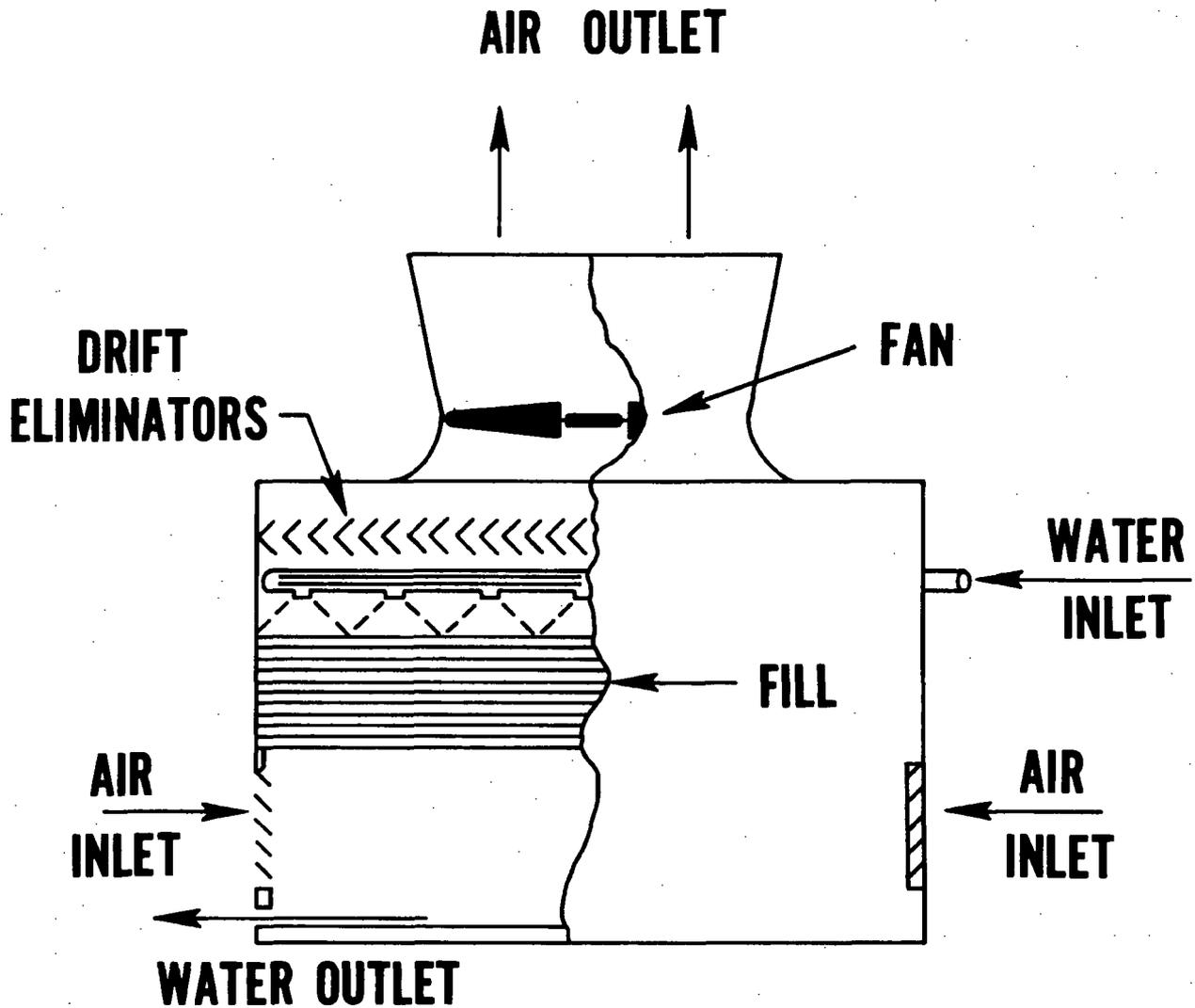


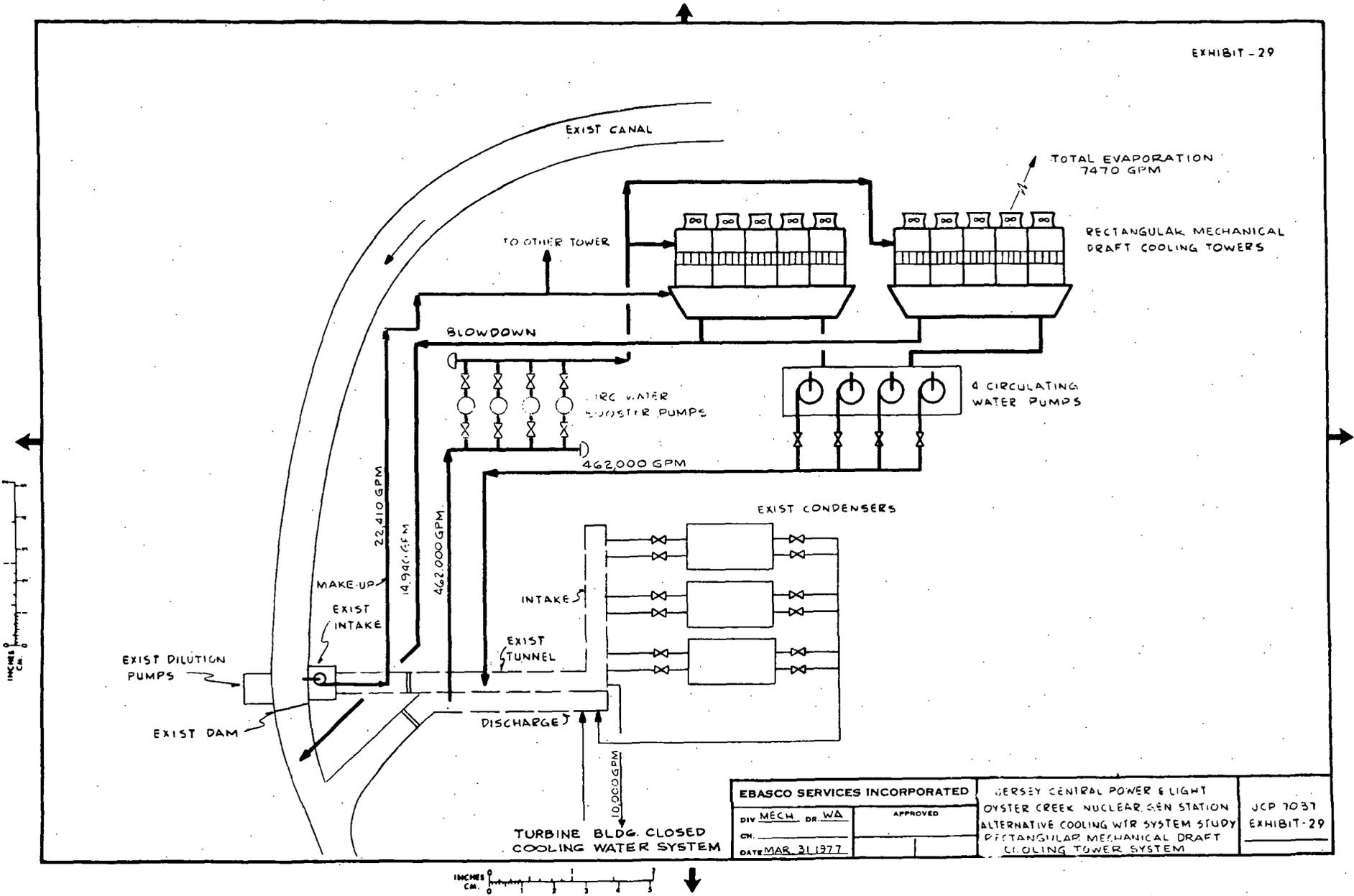


JERSEY CENTRAL POWER & LIGHT CO.  
 OYSTER CREEK NUCLEAR GENERATING STATION  
 ALTERNATIVE COOLING WATER SYSTEM STUDY  
 MECHANICAL DRAFT HELPER COOLING TOWERS  
 EMARCO SERVICES INCORPORATED  
 DATE: 11/87  
 DRAWN BY: JCP  
 CHECKED BY: JCP  
 APPROVED BY: JCP  
 DATE: 11/87  
 JCP-7037  
 EXHIBIT 27



# MECHANICAL DRAFT COUNTER-FLOW TOWER





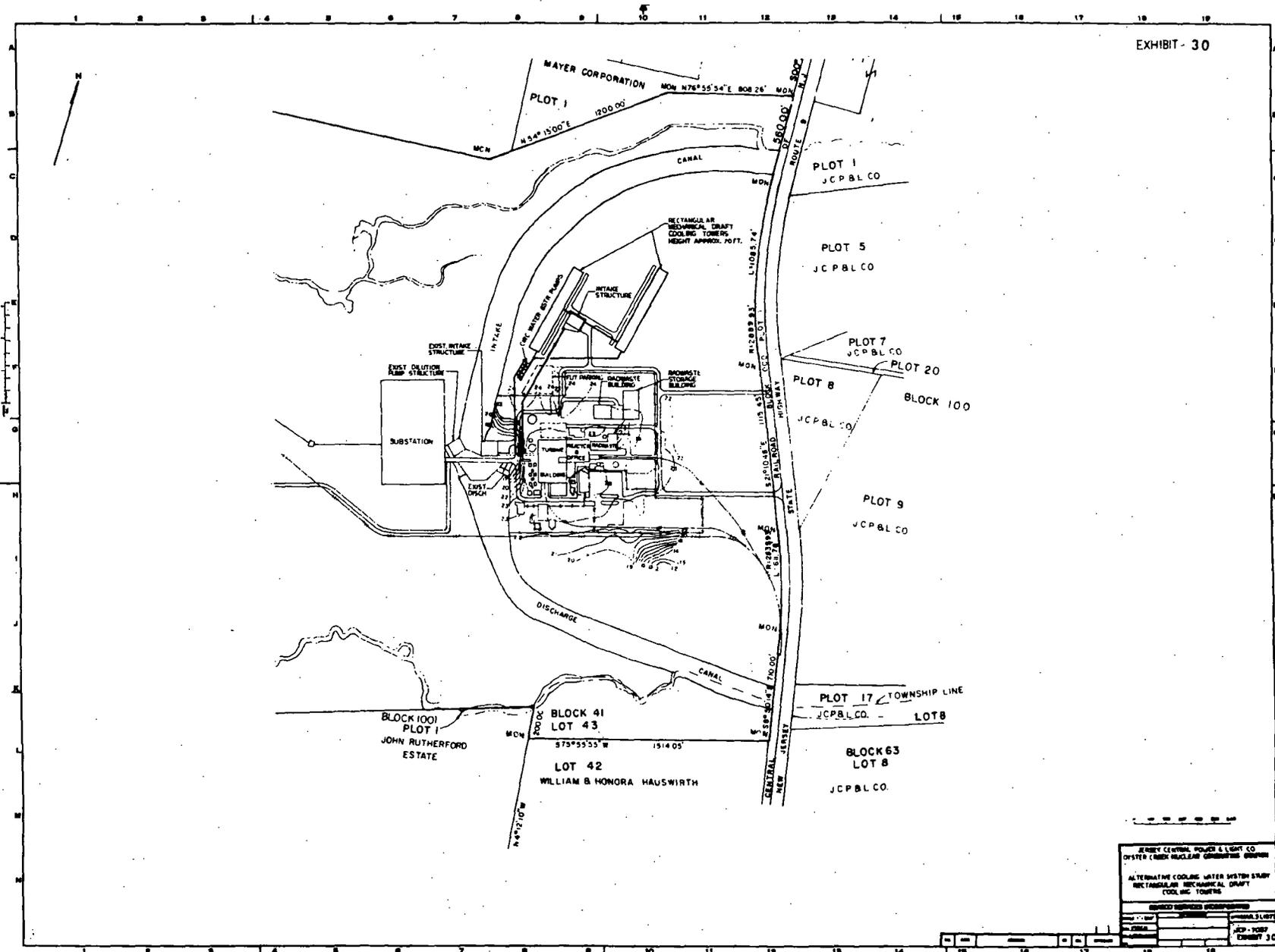
INCHES  
CM

INCHES  
CM

**EBASCO SERVICES INCORPORATED**  
 DIV. MECH. DR. WA  
 CH. \_\_\_\_\_  
 DATE: MAR. 31, 1977

APPROVED \_\_\_\_\_  
 JERSEY CENTRAL POWER & LIGHT  
 OYSTER CREEK NUCLEAR GEN. STATION  
 ALTERNATIVE COOLING WATER SYSTEM STUDY  
 RECTANGULAR MECHANICAL DRAFT  
 COOLING TOWER SYSTEM

JCP 7037  
 EXHIBIT-29



JERSEY CENTRAL POWER & LIGHT CO.  
 Oyster Creek Nuclear Generating Station  
 ALTERNATIVE COOLING WATER SYSTEM STUDY  
 RECTANGULAR AIR MECHANICAL DRAFT  
 COOLING TOWERS  
 ENGINEERING WORKSHEET  
 SHEET NO. 3107  
 JCP & L  
 EXHIBIT 30

SALT WATER COOLING TOWERS

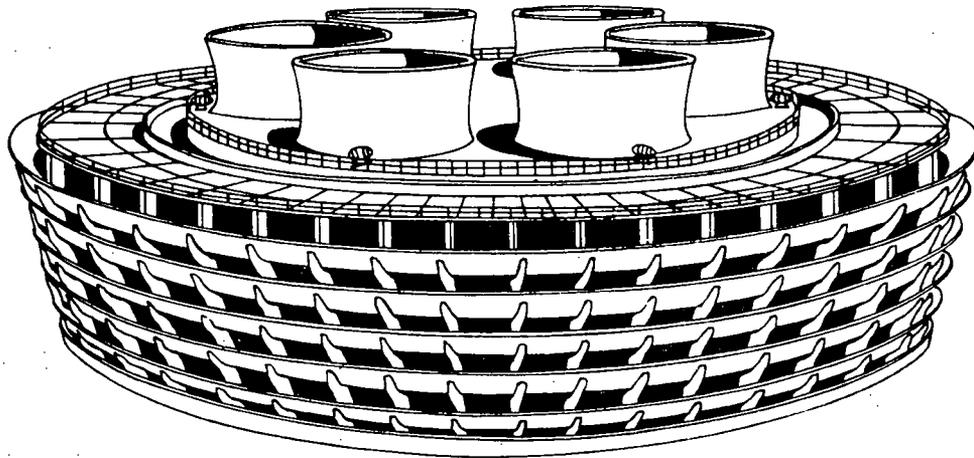
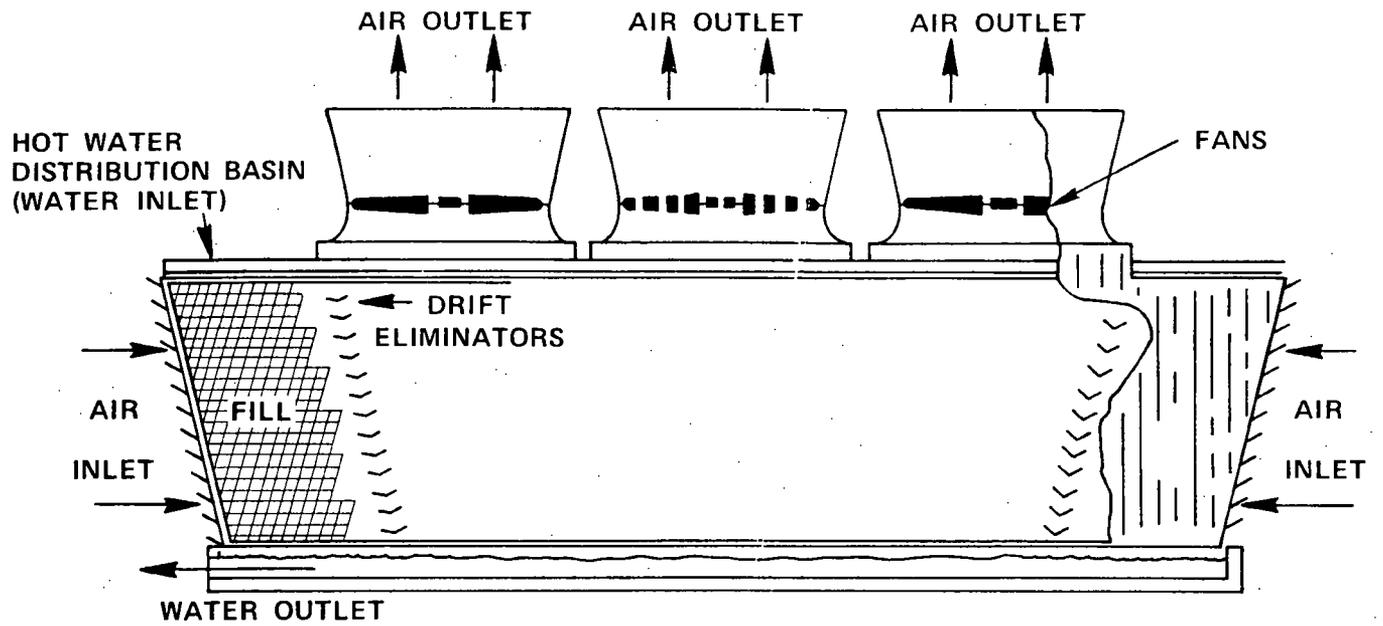
A. MECHANICAL DRAFT COOLING TOWERS

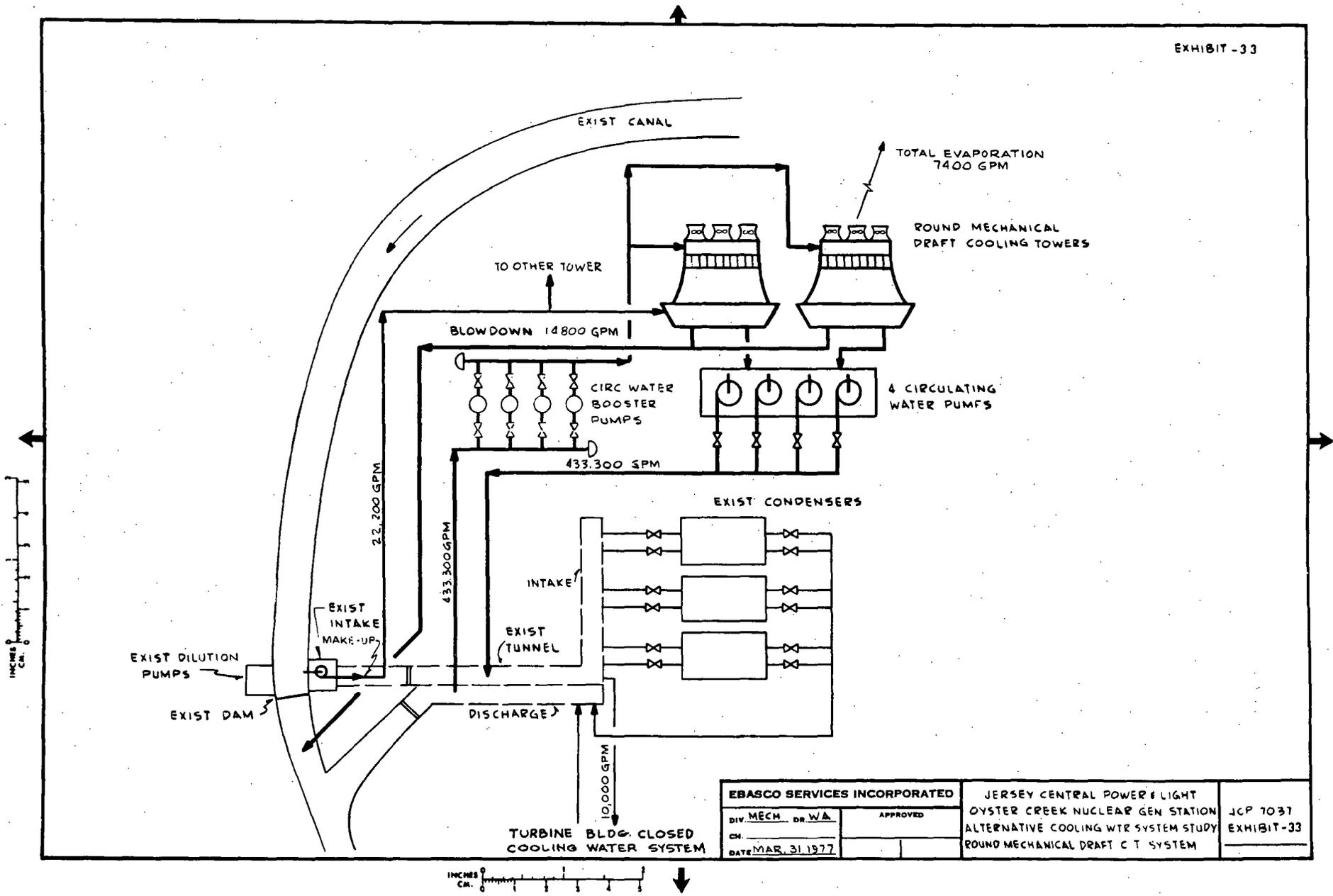
| <u>Plant &amp; Location</u>                  | <u>Cooling Tower Size<br/>And Manufacturer</u>   | <u>Water Quality<br/>In Closed Cycle</u>                      | <u>Experience</u>   | <u>In<br/>Operation</u> |
|--|--|---|---|-------------------------|
| Enjay Chemical Co<br>Bayway, N J             | 4 cells, wood structure<br>extended (40 ft) stacks<br>22 000 gpm, Marley Co  | Salinity, 20 000 -<br>30 000 ppm (makeup<br>from Arthur Kill) | Corrosion of galvini-<br>zed iron conduits,<br>silicon-bronze bolting,<br>biofouling.   | 1968                    |
| Chevron Oil Co,<br>Perth Amboy, N J          | 5 cells, wood structure<br>12 000 gpm, Gallagher<br>Mfg, 5 cells wood struc-<br>ture, 12 000 gpm, Fluor<br>Co & F&W Co | Same as for Item 1  | Deterioration of wood,<br>fan blades of monel<br>had to be replaced by<br>fiberglass blades.<br>No biofouling. Drift<br>effects are observed<br>in proximity of the<br>tower. | 1957                    |
| Mohave Plant,<br>Southern Calif<br>Edison Co | 60 cells, wood structure<br>540 000 gpm, Marley Co   | 16 000 ppm  | No corrosion problems<br>during first two years.  | 1970                    |
| Power Plant Bari,<br>Italy                   | 12 cells, reinforced<br>concrete with asbes-<br>tos cement fill,<br>133 000 gpm, Balcke<br>Co                          | 18 000 ppm  | To reduce drift loss<br>the drift eliminators<br>were covered with a<br>wire mesh   | 1960                    |
| Esso Chemicals<br>Stenungsund,<br>Sweden     | Fiberglass and wood,<br>20 000 gpm, 77 000<br>gpm, L T Mart Co   | 20 000 ppm  | Same corrosion pro-<br>blems with bolting   | 1969                    |

B. NATURAL DRAFT COOLING TOWERS

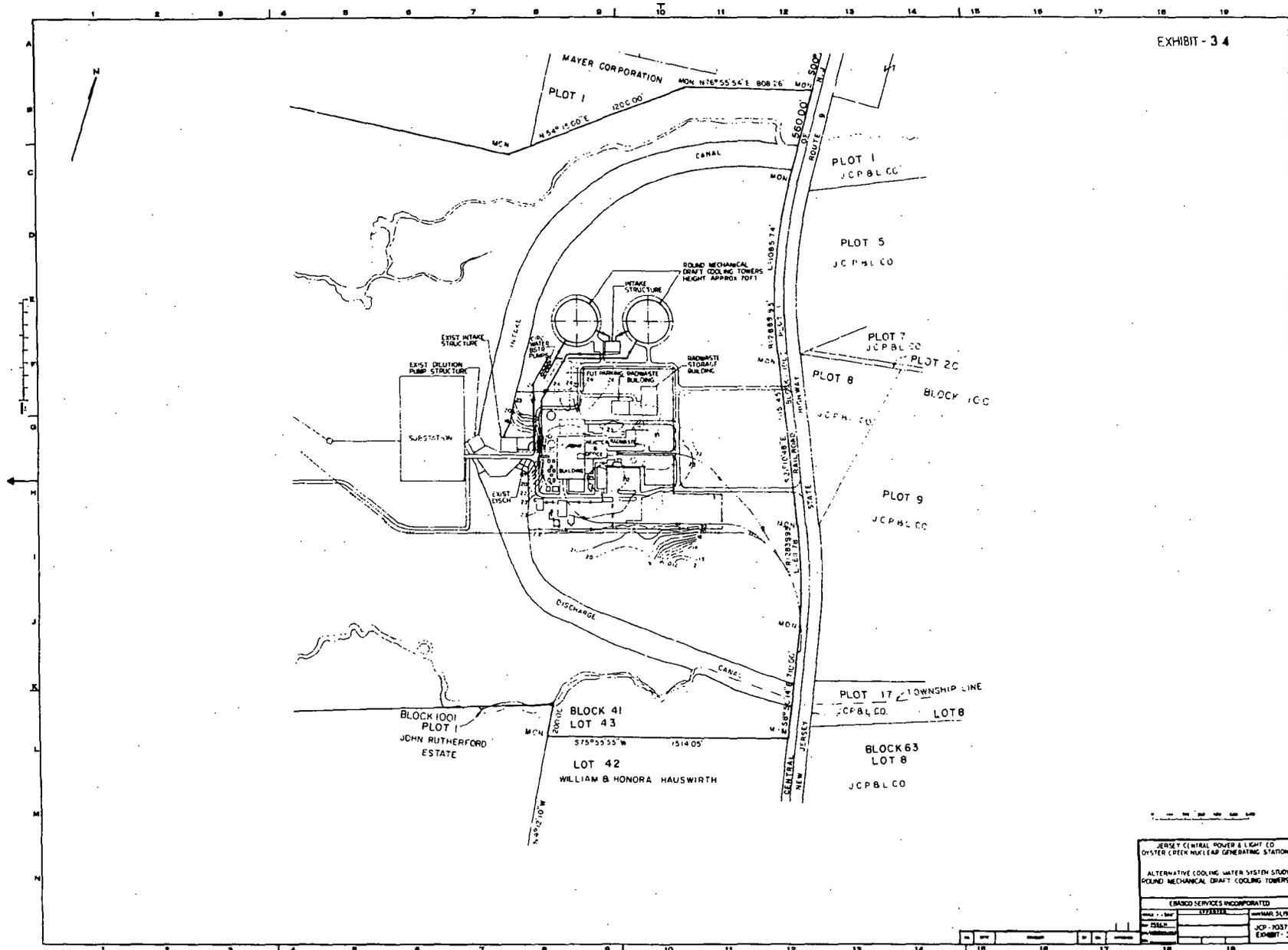
| <u>Plant &amp; Location</u> | <u>Cooling Tower Size<br/>And Manufacturer</u>  | <u>Water Quality<br/>In Closed Cycle</u> | <u>Experience</u>   | <u>In<br/>Operation</u> |
|-----------------------------|---|--|---|-------------------------|
| Fleetwood, CEGB,<br>England | 2 towers, diam. 216<br>ft, height 250 ft,<br>2 x 37 500 gpm,<br>shells of reinforced<br>concrete, fill of<br>treated wood | 40 000 ppm                               | Satisfactory operation,<br>even the redwood fill<br>is well preserved   | 1955                    |
| B L England Station,<br>N J | 1 tower, diam 180 ft,<br>height 208 ft,<br>63 500 gpm, shell of<br>reinforced concrete<br>fill of asbestos<br>cement      | 50 000 ppm                               | At high wind velocity<br>drift is blown through<br>the air inlet and causes<br>salt deposition in<br>vicinity | 1974                    |

# ROUND MECHANICAL DRAFT CROSS-FLOW TOWER





|                              |  |                                      |  |
|------------------------------|--|--------------------------------------|--|
| EBASCO SERVICES INCORPORATED |  | JERSEY CENTRAL POWER & LIGHT         |  |
| DIV. MECH. DR. W.A.          |  | OYSTER CREEK NUCLEAR GEN STATION     |  |
| CH.                          |  | ALTERNATIVE COOLING WTR SYSTEM STUDY |  |
| DATE MAR. 31. 1977           |  | ROUND MECHANICAL DRAFT C T SYSTEM    |  |
| APPROVED                     |  | JCP 7037                             |  |
|                              |  | EXHIBIT-33                           |  |



JERSEY CENTRAL POWER & LIGHT CO  
 OYSTER CREEK NUCLEAR GENERATING STATION  
 ALTERNATIVE COOLING WATER SYSTEM STUDY  
 ROUND MECHANICAL DRAFT COOLING TOWERS

BRAND SERVICES INCORPORATED

|             |          |               |
|-------------|----------|---------------|
| DATE        | REVISION | BY            |
| MAR 5, 1977 |          |               |
| JCP-1037    |          | EXHIBIT - 3 4 |

ROUND MECHANICAL DRAFT MULTI-FAN COOLING TOWERS

a) Crossflow Design

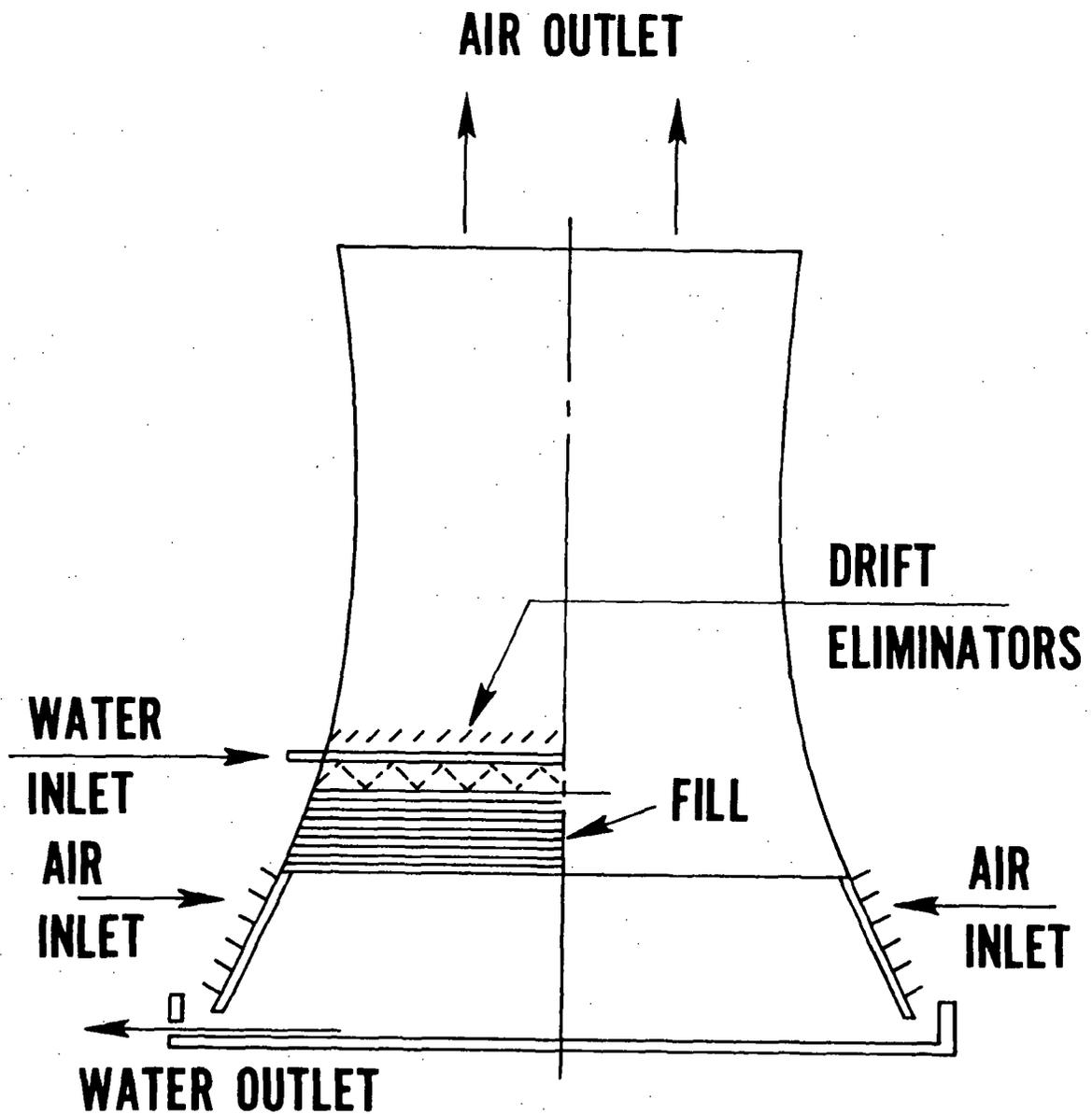
|   | <u>TWS<br/>F</u> | <u>Approach<br/>F</u> | <u>Range<br/>F</u> | <u>Unit Rating</u>                       | <u>CW Flow per<br/>Tower GPM</u> | <u>Number of Towers<br/>&amp; Size</u>   |
|---|------------------|-----------------------|--------------------|--|----------------------------------|--|
| Washington Public Power<br>Supply System<br>Hanford Unit 2<br>Wichland, Washington      | 60               | 16.3                  | 28                 | 1100 MW<br>(Nuclear)                     | 95 000                           | 6 @ 6 Fans                               |
| Mississippi Power Company<br>Jack Watson Unit 5<br>Gulfport, Mississippi                | 80               | 10                    | 30                 | 550 MW                                   | 172 000*                         | 1 @ 13 Fans                              |
| Gulf States Utilities<br>Sabine Unit 5<br>Bridge City, Texas                            | 81               | 10                    | 21                 | 480 MW                                   | 127 500                          | 2 @ 7 Fans                               |
| Duke Power Company<br>Catawba Unit 1 & 2<br>York, South Carolina                        | 76               | 12                    | 24                 | 2 @ 1180 MW<br>(Nuclear)                 | 221 300                          | 6 @ 13 Fans                              |
| Kansas Power and Light Co<br>Energy Center-Units 1 & 2<br>Belvue, Kansas                | 80               | 12.7                  | 21.3               | 2 @ 640 MW                               | 166 000                          | 4 @ 8 Fans<br>Wood Structure<br>and Fill |
| Gulf States Utilities<br>River Bend Station<br>Units 1 & 2<br>West Feliciana Parish, La | 81               | 12                    | 25.5               | 2 @ 934 MW<br>(Nuclear)<br>1 109 580 GPM | 138 700                          | 8 @ 7 Fans                               |
| Louisville Gas & Elec Co<br>Mill Creek - Unit No. 3<br>Louisville, Kentucky             | 78               | 17                    | 21.0               | 425 MW                                   | 205 000                          | 1 @ 8 Fans                               |
| Gulf State Utilities<br>Roy S Nelson<br>Unit No. 5<br>Lake Charles, La                  | 82               | 9                     | 26.2               | 550 MW                                   | 212 400                          | 1 @ 13 Fans                              |

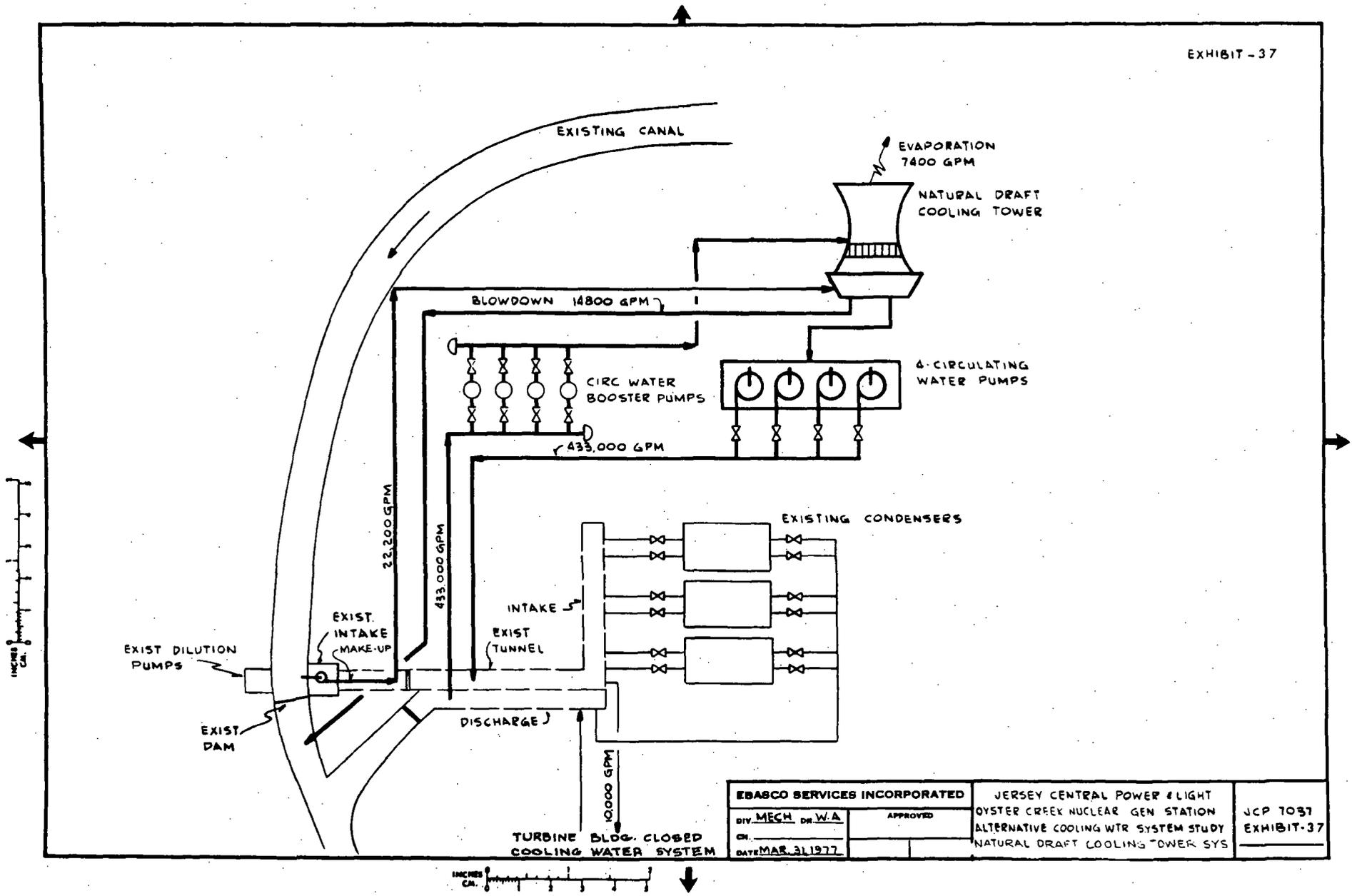
b) Counterflow Design

|   |      |    |    |                          |         |   |
|---|------|----|----|--------------------------|---------|---|
| Washington Public Power<br>Supply System<br>Hanford Units 1 & 4 | 66.4 | 16 | 26 | 2 @ 1100 MW<br>(Nuclear) | 219 500 | 6 |
|---|------|----|----|--------------------------|---------|---|

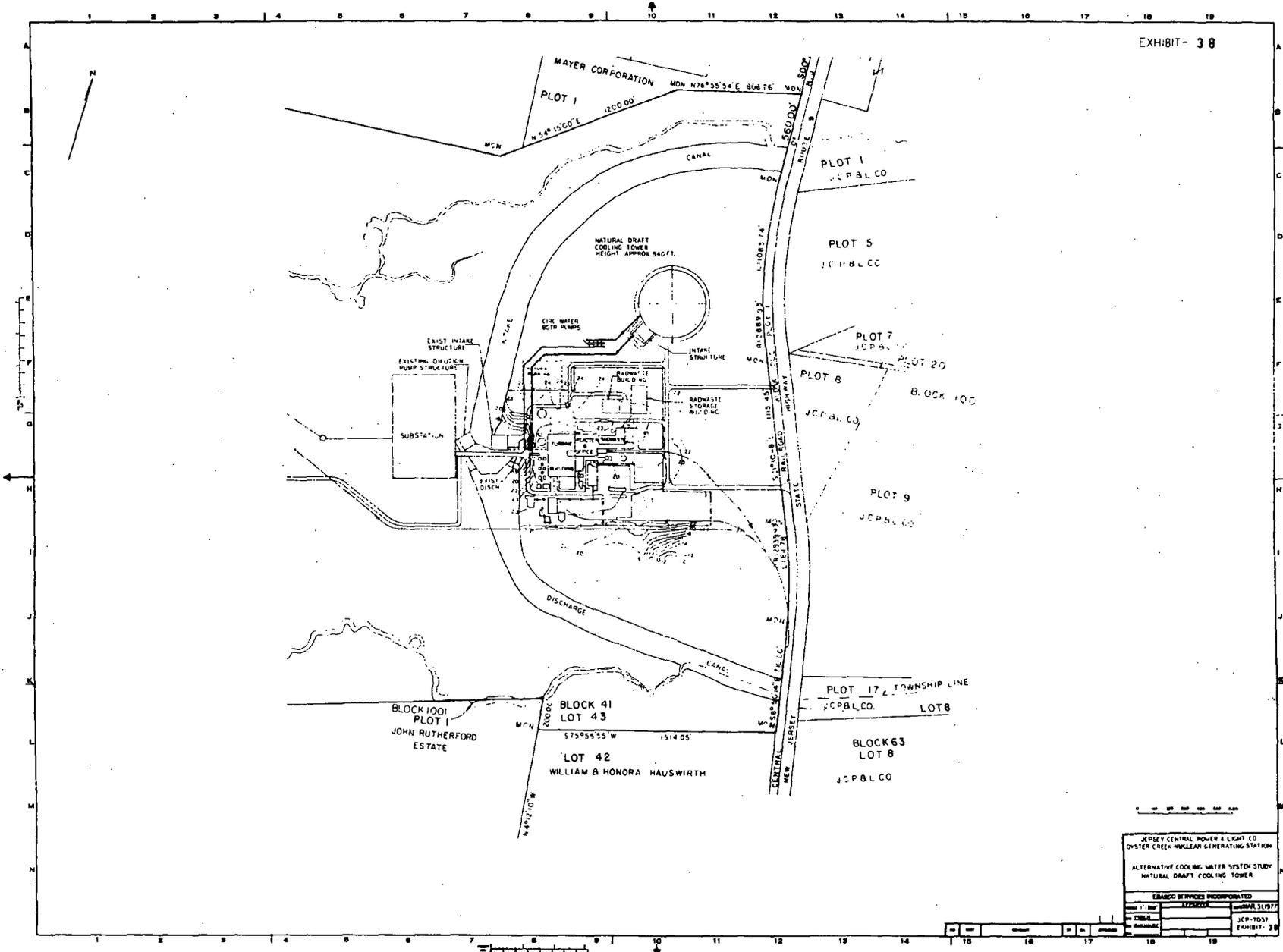
\* Brackish Water

# HYPERBOLIC NATURAL DRAFT COUNTER-FLOW TOWER





|   |  |   |                                      |
|---|--|---|--------------------------------------|
| <b>EBASCO SERVICES INCORPORATED</b><br>DIV. <u>MECH</u> DR. <u>W.A.</u><br>CH. _____<br>DATE <u>MAR 31 1977</u> |  | APPROVED _____<br><b>JERSEY CENTRAL POWER &amp; LIGHT</b><br><b>OYSTER CREEK NUCLEAR GEN STATION</b><br><b>ALTERNATIVE COOLING WTR SYSTEM STUDY</b><br><b>NATURAL DRAFT COOLING TOWER SYS</b> | <b>JCP 7037</b><br><b>EXHIBIT-37</b> |
|---|--|---|--------------------------------------|



|   |                     |
|---|---------------------|
| JERSEY CENTRAL POWER & LIGHT CO<br>OYSTER CREEK NUCLEAR GENERATING STATION<br>ALTERNATIVE COOLING WATER SYSTEM STUDY<br>NATURAL DRAFT COOLING TOWER |                     |
| ERANDI SERVICES INCORPORATED  |                     |
| DATE: 11/20/77  | DRAWN: JAMES SL/PTT |
| CHECKED:  | JCP-1033            |
| APPROVED:   | EXHIBIT- 38         |

## LARGEST NATURAL DRAFT COOLING TOWERS

Counterflow Design

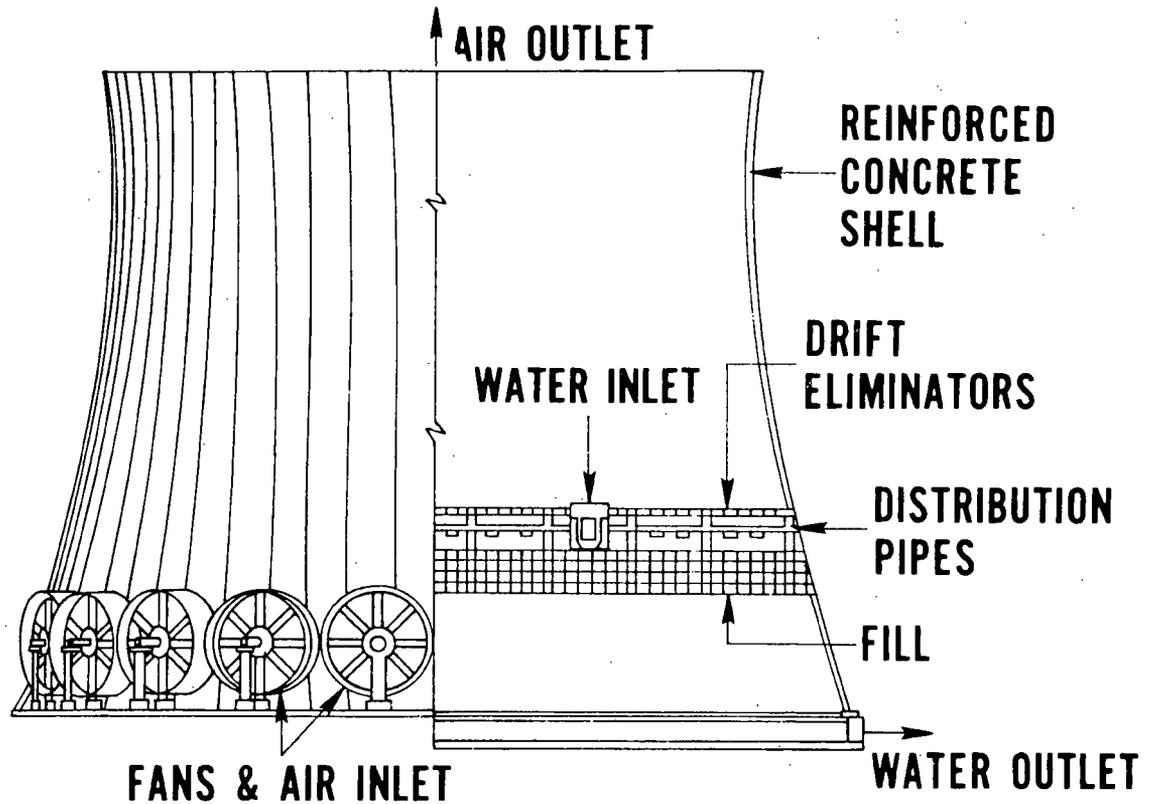
| <u>Owner</u>              | <u>Plant Name</u> | <u>Height, ft</u> | <u>Diam Ft</u> | <u>Flow, gpm</u> |
|---------------------------|-------------------|-------------------|----------------|------------------|
| Ohio Power Co             | Gavin             | 492               | 400            | 600 000          |
| Portland General Electric | Trojan NGS No. 1  | 492               | 385            | 425 000          |
| TVA                       | Watts Bar 1 & 2   | 506               | 405            | 410 000          |

Crossflow Design

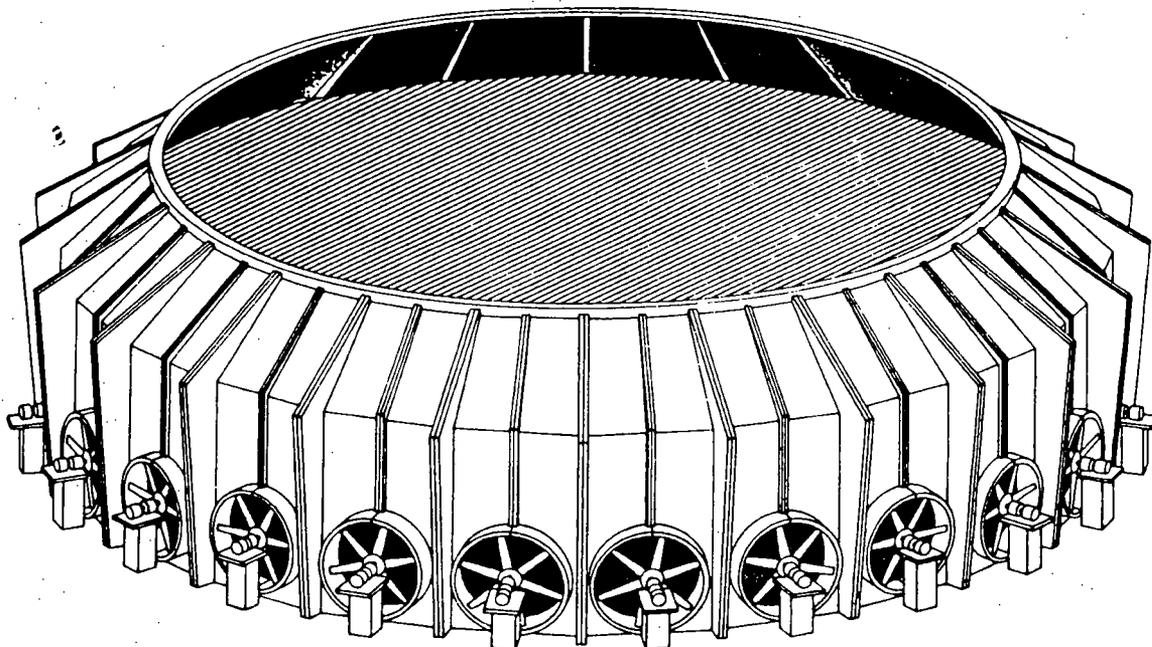
|  |                        |     |     |         |
|--|------------------------|-----|-----|---------|
| Duquesne Power & Light and<br>Ohio Edison Co | Beaver Valley<br>No. 1 | 500 | 475 | 507 000 |
| Appalachian Power AEP<br>System              | Project 1301           | 500 | 465 | 600 000 |

# MECHANICAL FORCED DRAFT COUNTERFLOW MULTI FAN COOLING TOWER

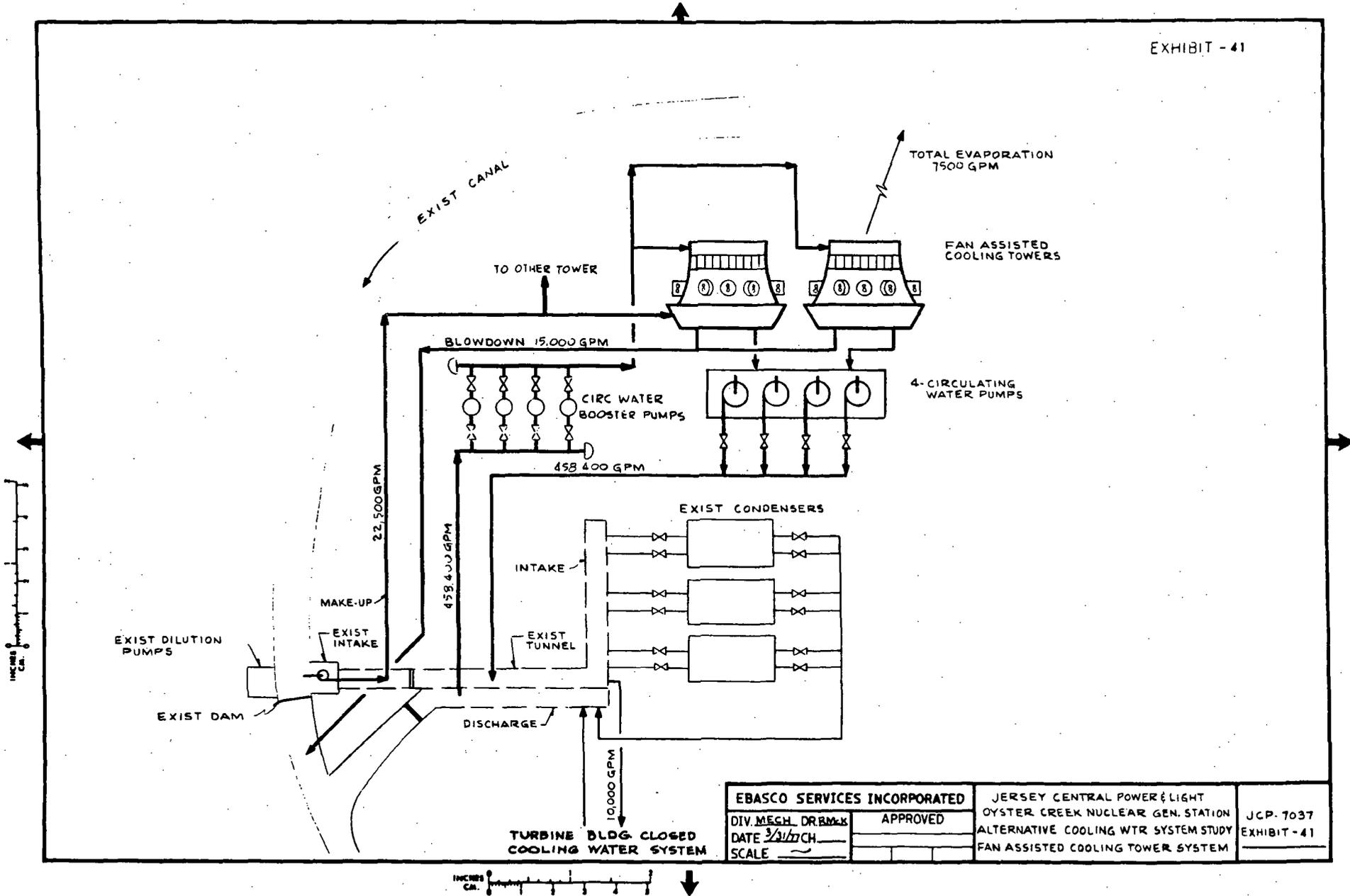
Exhibit 40



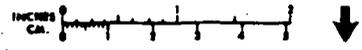
**A) ELEVATED DESIGN (FAN ASSISTED NATURAL DRAFT)**

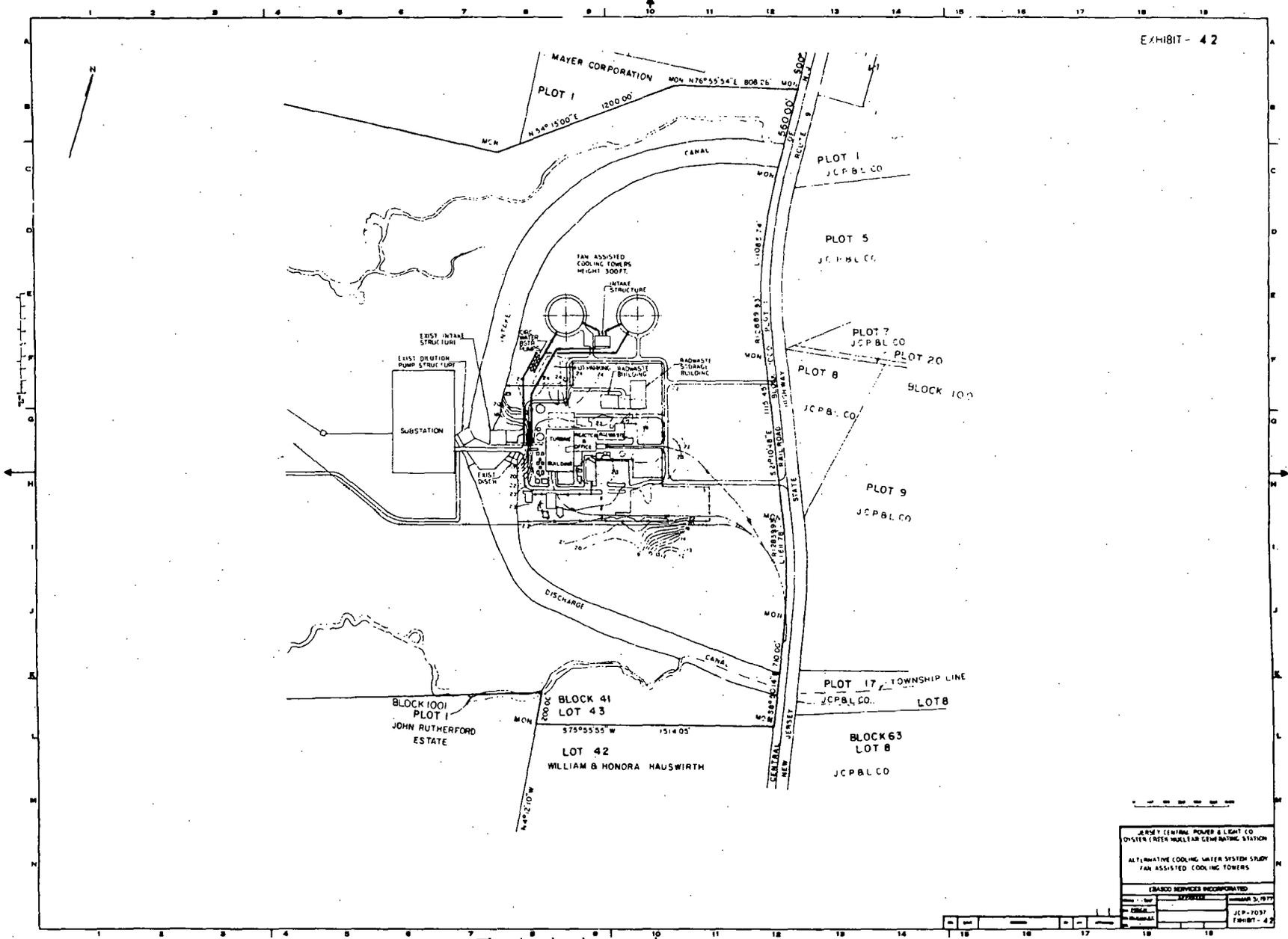


**B) LOW PROFILE DESIGN**



|                                     |  |                                      |  |
|-------------------------------------|--|--------------------------------------|--|
| <b>EBASCO SERVICES INCORPORATED</b> |  | JERSEY CENTRAL POWER & LIGHT         |  |
| DIV. MECH. DR. RM. K                |  | OYSTER CREEK NUCLEAR GEN. STATION    |  |
| DATE 3/21/77                        |  | ALTERNATIVE COOLING WTR SYSTEM STUDY |  |
| SCALE                               |  | FAN ASSISTED COOLING TOWER SYSTEM    |  |
| APPROVED                            |  | JCP-7037                             |  |
|                                     |  | EXHIBIT-41                           |  |





|  |  |
|--|--|
| JERSEY CENTRAL POWER & LIGHT CO          |  |
| OYSTER CREEK NUCLEAR GENERATING STATION  |  |
| ALTERNATIVE COOLING WATER SYSTEM STUDY   |  |
| FAN ASSISTED COOLING TOWERS              |  |
| ERAND SERVICES INCORPORATED              |  |
| Drawn by: <u>                    </u>    | Checked by: <u>                    </u>  |
| Designed by: <u>                    </u> | Reviewed by: <u>                    </u> |
| Date: <u>                    </u>        | Project No: <u>                    </u>  |
| Scale: <u>                    </u>       | Sheet No: <u>                    </u>    |
| JCP-7037                                 |  |
| EXHIBIT - 42                             |  |

FAN ASSISTED COOLING TOWERS

| <u>Country &amp; Owner</u> | <u>Plant Name</u> | <u>Diam<br/>ft</u> | <u>Height<br/>ft</u> | <u>No. of<br/>Towers</u> | <u>Water<br/>gpm</u> | <u>Wet<br/>Bulb<br/>F</u> | <u>RH<br/>%</u> | <u>Range<br/>F</u> | <u>Appr<br/>F</u> | <u>In<br/>Operation</u> |
|----------------------------|-------------------|--------------------|----------------------|--------------------------|----------------------|---------------------------|-----------------|--------------------|-------------------|-------------------------|
| Germany-UK                 | Wesseling         | 203                | 164                  | 1*                       | 101 000              | 64.4                      | 60              | 27                 | 9                 | Yes                     |
| Germany-                   |                   |                    |                      |                          |                      |                           |                 |                    |                   |                         |
| RWE                        | Biblis            | 223                | 262                  | 2*                       | 418 000              | 53.6                      | 60              | 19                 | 38***             | Yes                     |
| RWE                        | Biblis            |                    |                      |                          |                      |                           |                 |                    |                   |                         |
|                            | Kalkar            | 180                | 138                  | 1*                       | 181 000              | 71.6                      | 50              | 18                 | 19                | Ordered                 |
| Germany in<br>Lichterfeld- |                   |                    |                      |                          |                      |                           |                 |                    |                   |                         |
| Bewag                      | Berlin            |                    |                      | 2**                      |                      |                           |                 |                    |                   |                         |
| England-ICI                | Wilton            |                    |                      | 1                        |                      |                           |                 |                    |                   |                         |
| England-CEGB               | Ince "B"          | 307                | 375                  | 1****                    | 490 000              |                           |                 |                    |                   | Under Constr            |

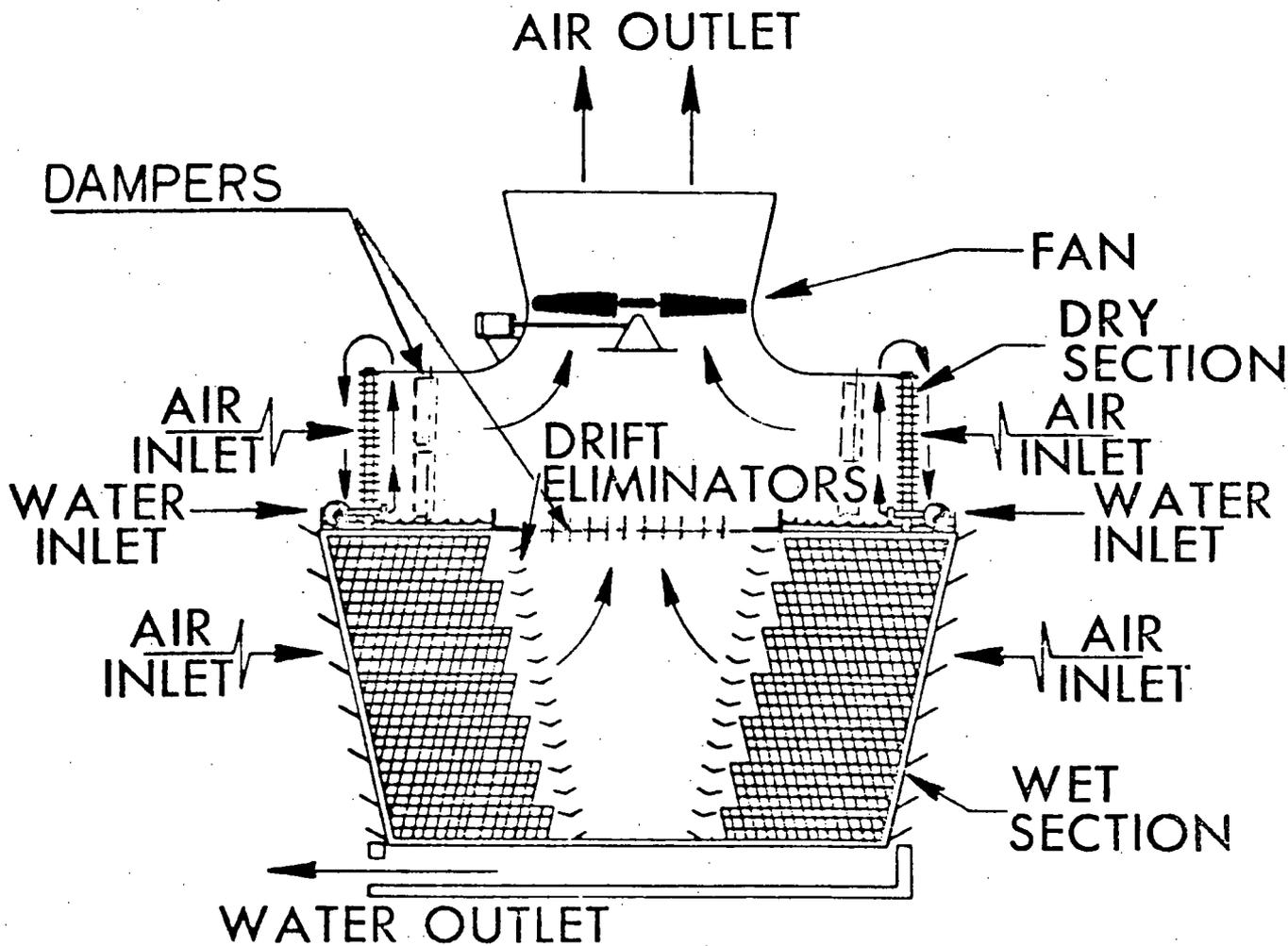
\*Manufactured by Hamon Sobelco

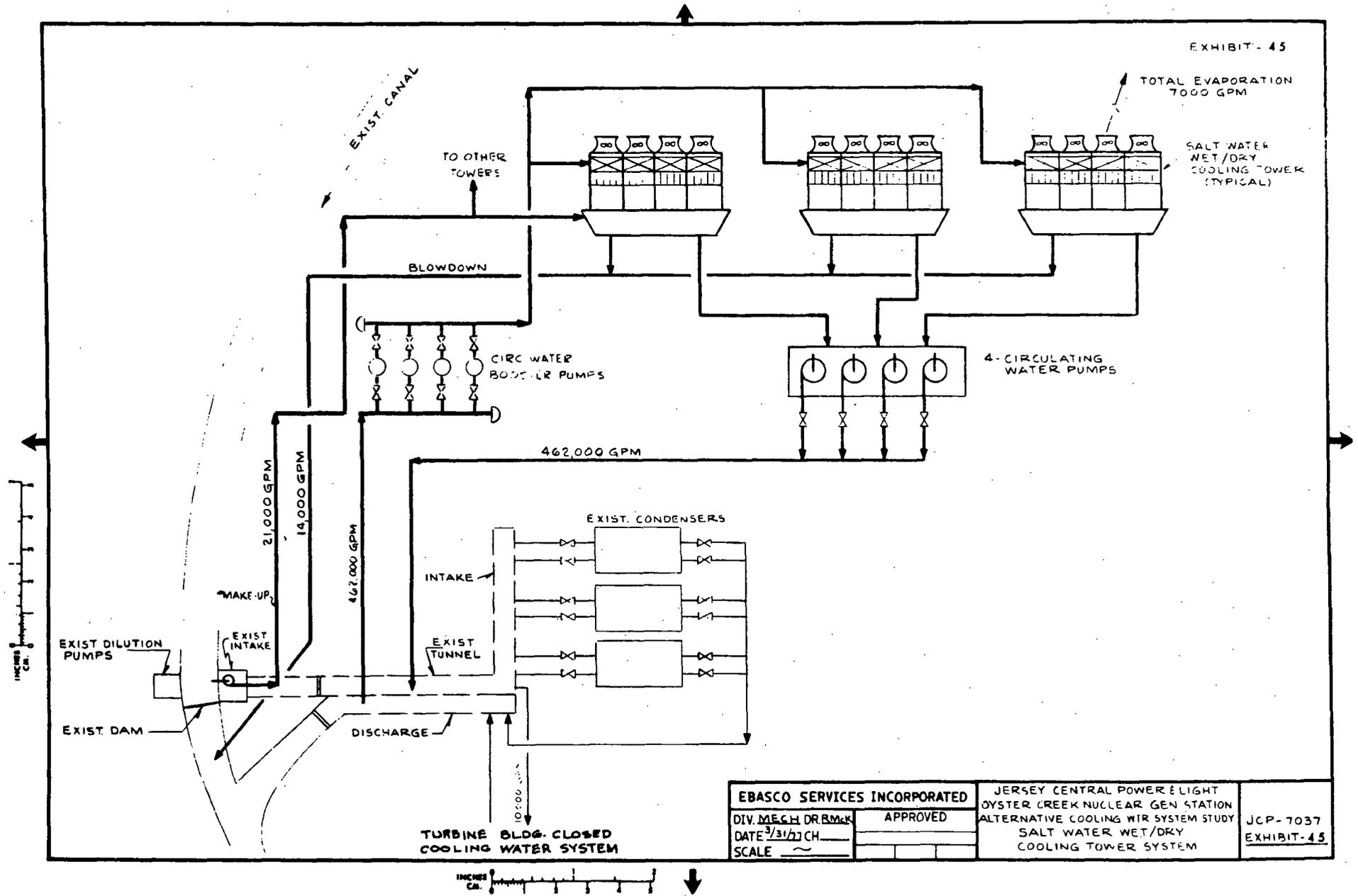
\*\*Manufactured by Balcke

\*\*\*Used as helper towers during summer months

\*\*\*\*Induced draft fans

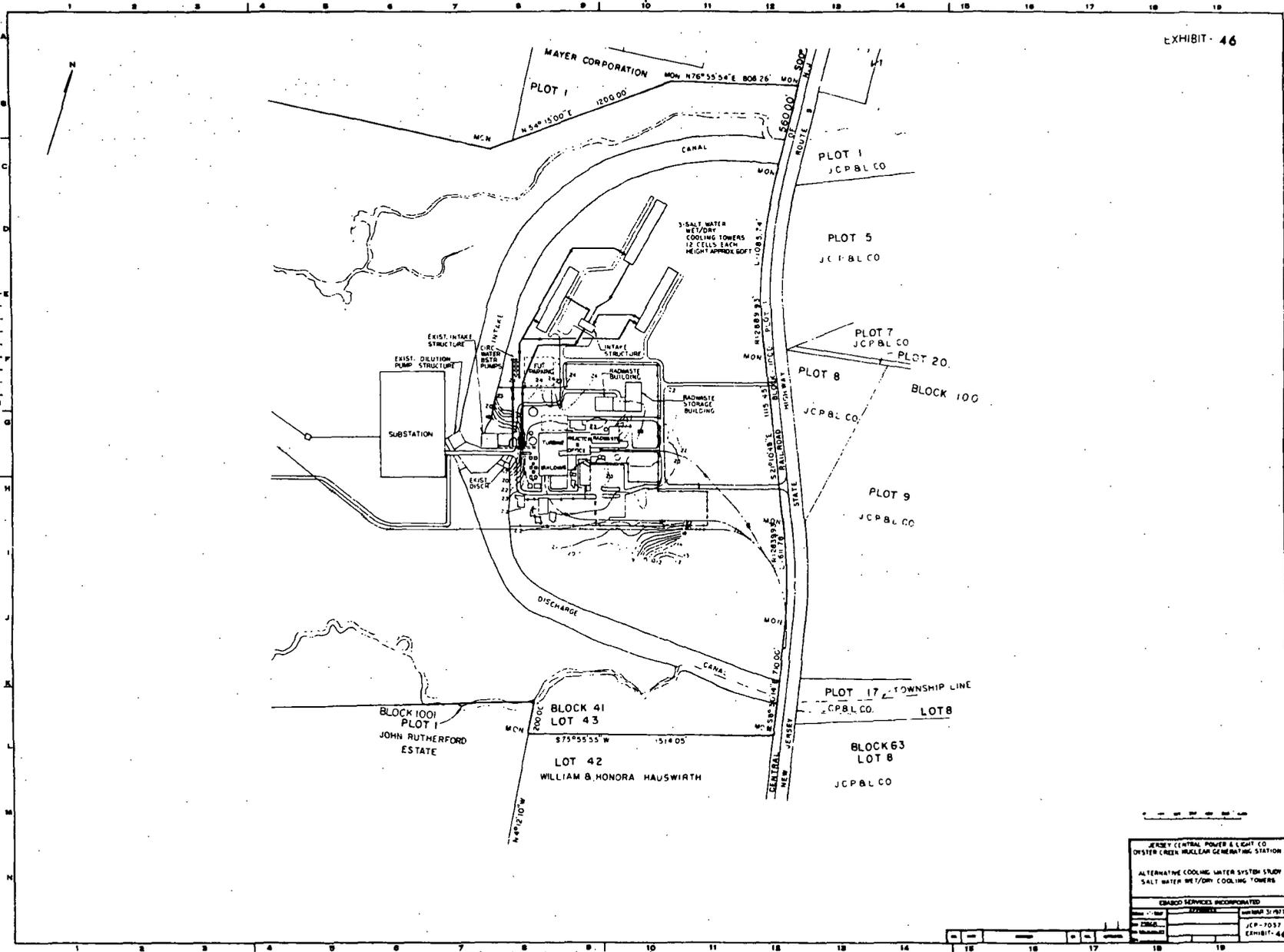
# PARALLEL PATH WET-DRY TOWER





|                                     |  |                                      |  |
|-------------------------------------|--|--------------------------------------|--|
| <b>EBASCO SERVICES INCORPORATED</b> |  | JERSEY CENTRAL POWER & LIGHT         |  |
| DIV. MECH DR. B.M.C.K.              |  | OYSTER CREEK NUCLEAR GEN STATION     |  |
| DATE 3/31/77 CH                     |  | ALTERNATIVE COOLING WTR SYSTEM STUDY |  |
| SCALE ~                             |  | SALT WATER WET/DRY                   |  |
|                                     |  | COOLING TOWER SYSTEM                 |  |
| APPROVED                            |  | JCP-7037                             |  |
|                                     |  | EXHIBIT-45                           |  |

TURBINE BLDG. CLOSED COOLING WATER SYSTEM



JERSEY CENTRAL POWER & LIGHT CO.  
 OYSTER CREEK NUCLEAR GENERATING STATION  
 ALTERNATIVE COOLING WATER SYSTEM STUDY  
 SALT WATER WET/DRY COOLING TOWERS

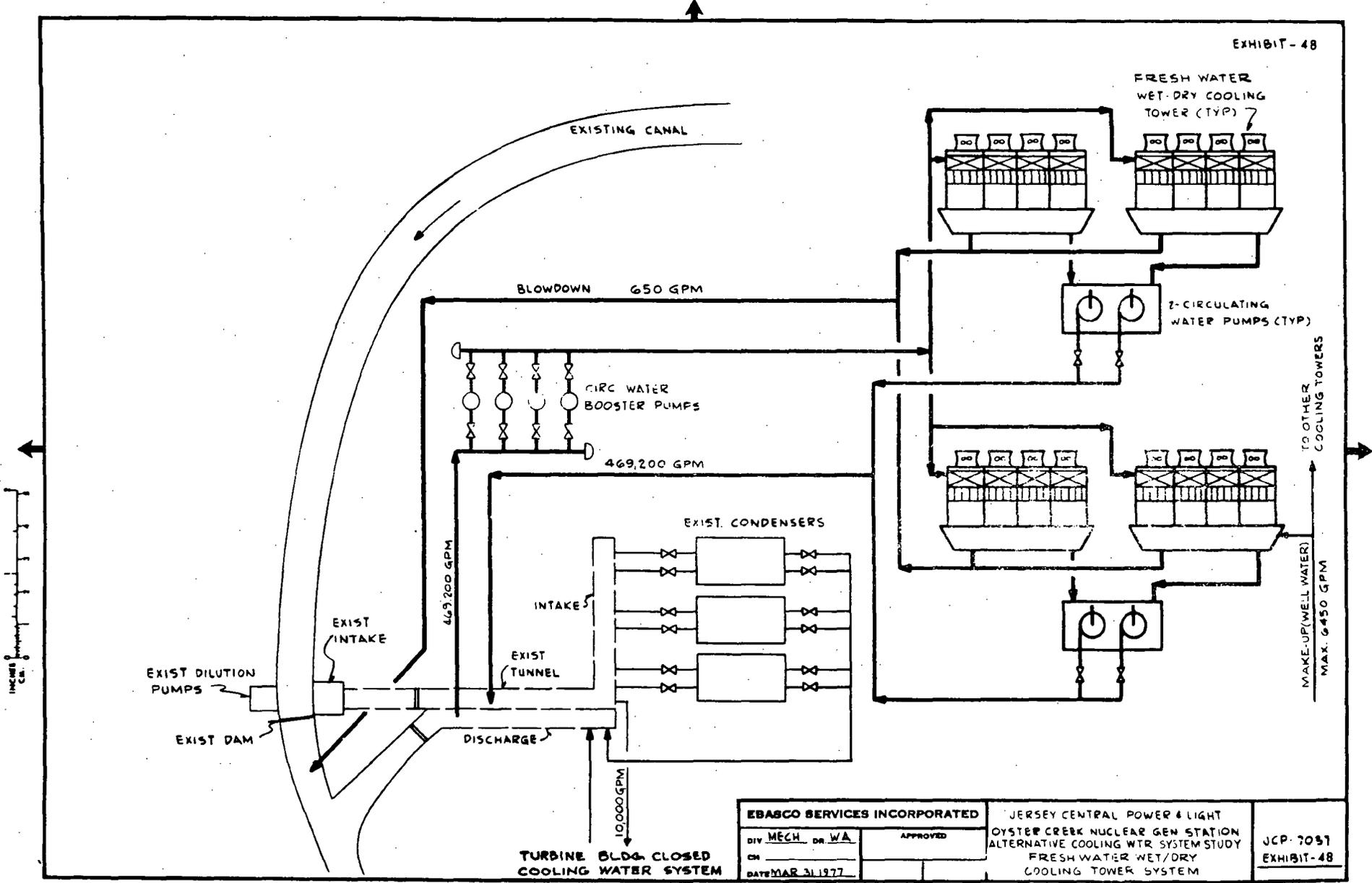
CS&SO SERVICES INCORPORATED

|      |          |      |
|------|----------|------|
| DATE | APPROVED | DATE |
| BY   | BY       | BY   |
| DATE | DATE     | DATE |

MAR 31 1977  
 JCP - 7037  
 EXHIBIT - 46

WET/DRY COOLING TOWERS

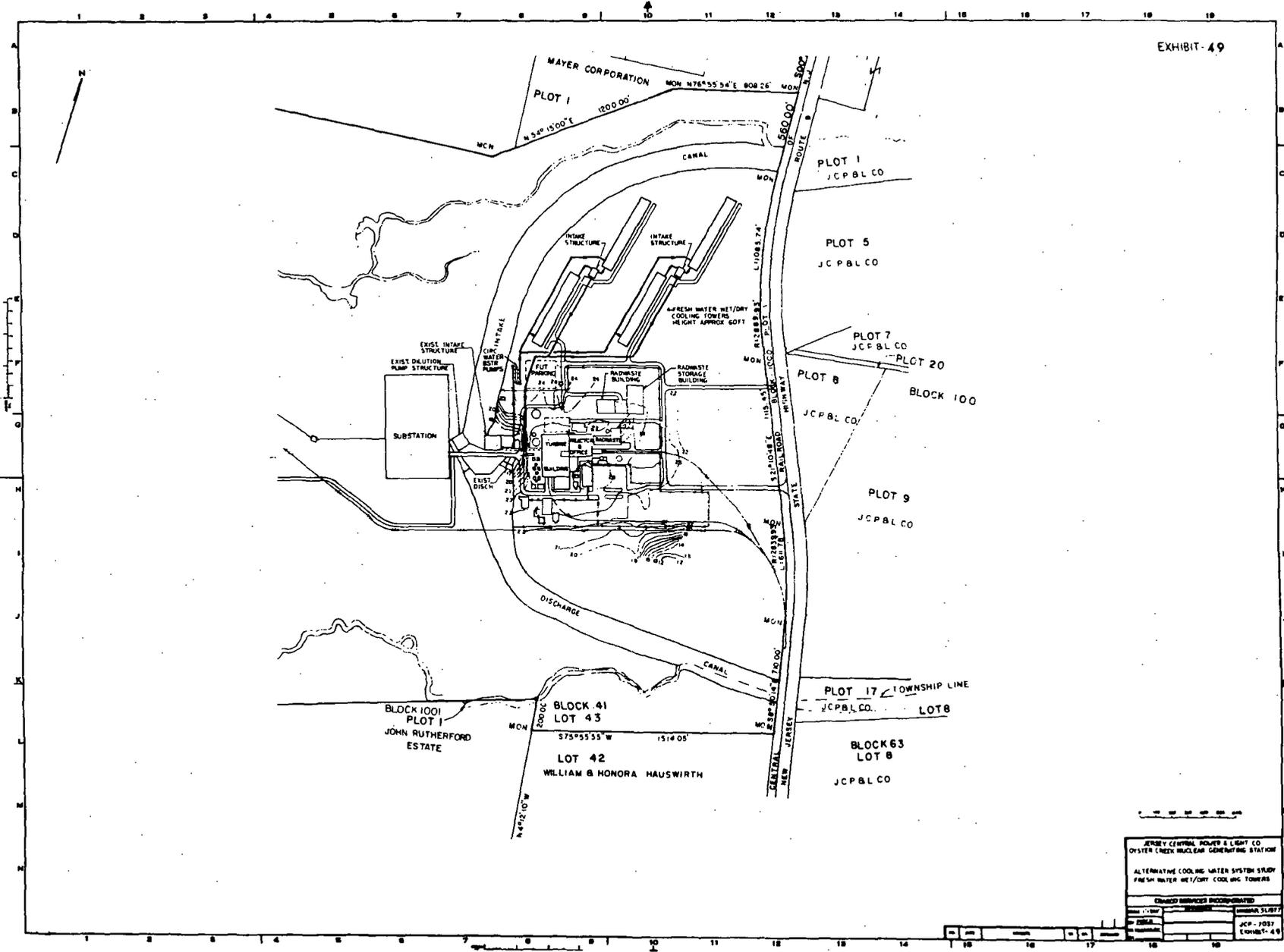
| <u>Owner</u>               | <u>Location &amp; Plant Name</u> | <u>No. of Towers</u> | <u>No. of Cells/Tower</u> | <u>Flow/Tower gpm</u> | <u>T<sub>1</sub>/T<sub>2</sub>/T<sub>wb</sub></u> | <u>Manufacturer</u> | <u>In Operation</u> |
|----------------------------|----------------------------------|----------------------|---------------------------|-----------------------|---|---------------------|---------------------|
| Sinclair Refinery          | Houston, Tex                     | 1                    |                           |                       |   | Marley              | 1972                |
| St Joseph Light & Power    | Missouri                         | 1                    |                           |                       |   | Marley              |                     |
| Northeast Utilities        | Middletown, Conn                 | 2                    | 7                         |                       |   | Marley              |                     |
| Consumer Power Co          | Marrysville, Mass                | 1                    | 3                         | 22 000                | 110/87/73   | Ecodyne             | 1973                |
| City of Hempstead          | Garbage Burner                   | 1                    | 4                         |                       |   | Ecodyne             | 1977                |
| Baltimore Gas & Electric   | Maryland Brandon Shores 1 & 2    | 4                    |                           | 236 000               | 111/87/70   | Ecodyne             | 1978-79             |
| Southern California Edison | California Mohavi                | 1                    | 1                         |                       |   | Ecodyne             | Ordered X-1976      |



EBASCO SERVICES INCORPORATED  
 DIV MECH. DR. WA  
 CH  
 DATE MAR 31 1977

JERSEY CENTRAL POWER & LIGHT  
 OYSTER CREEK NUCLEAR GEN STATION  
 ALTERNATIVE COOLING WTR SYSTEM STUDY  
 FRESH WATER WET/DRY  
 COOLING TOWER SYSTEM

JCP-7051  
 EXHIBIT-48

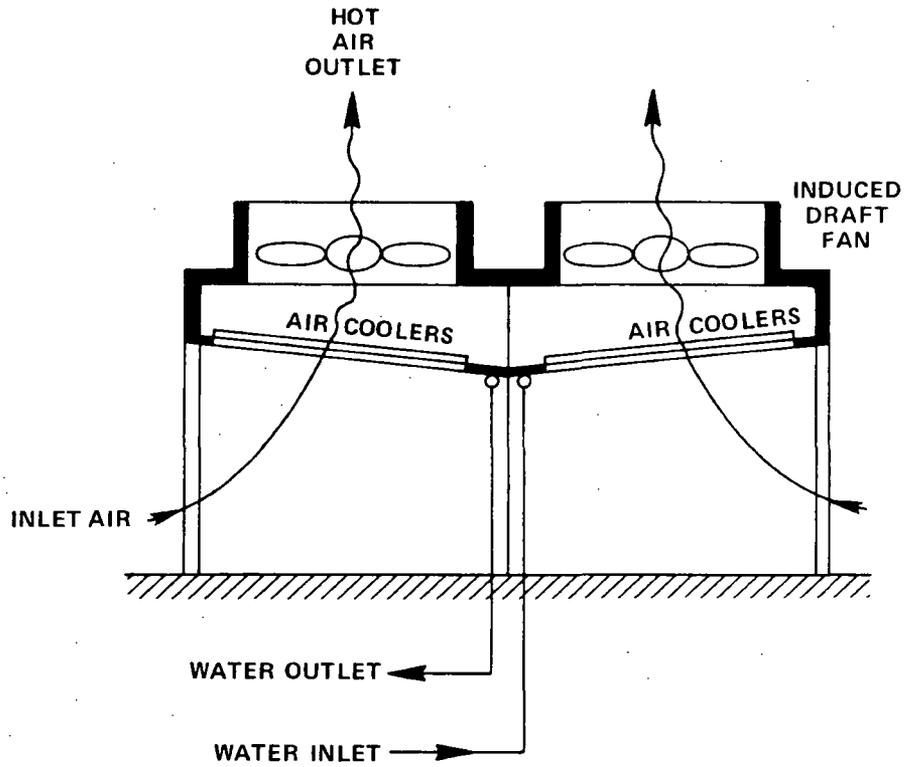


JERSEY CENTRAL POWER & LIGHT CO.  
 OYSTER CREEK NUCLEAR GENERATING STATION  
 ALTERNATIVE COOLING WATER SYSTEM STUDY  
 FRESH WATER WET/DRY COOLING TOWERS

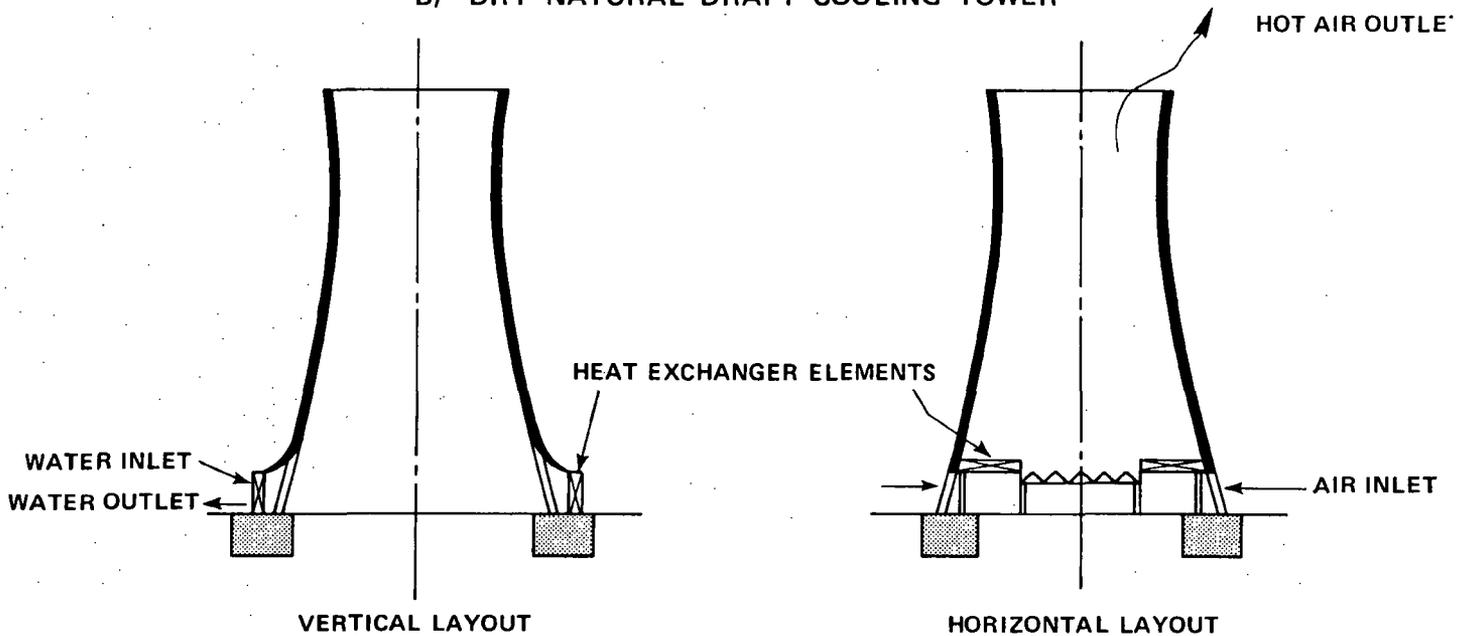
DESIGN SERVICES INCORPORATED

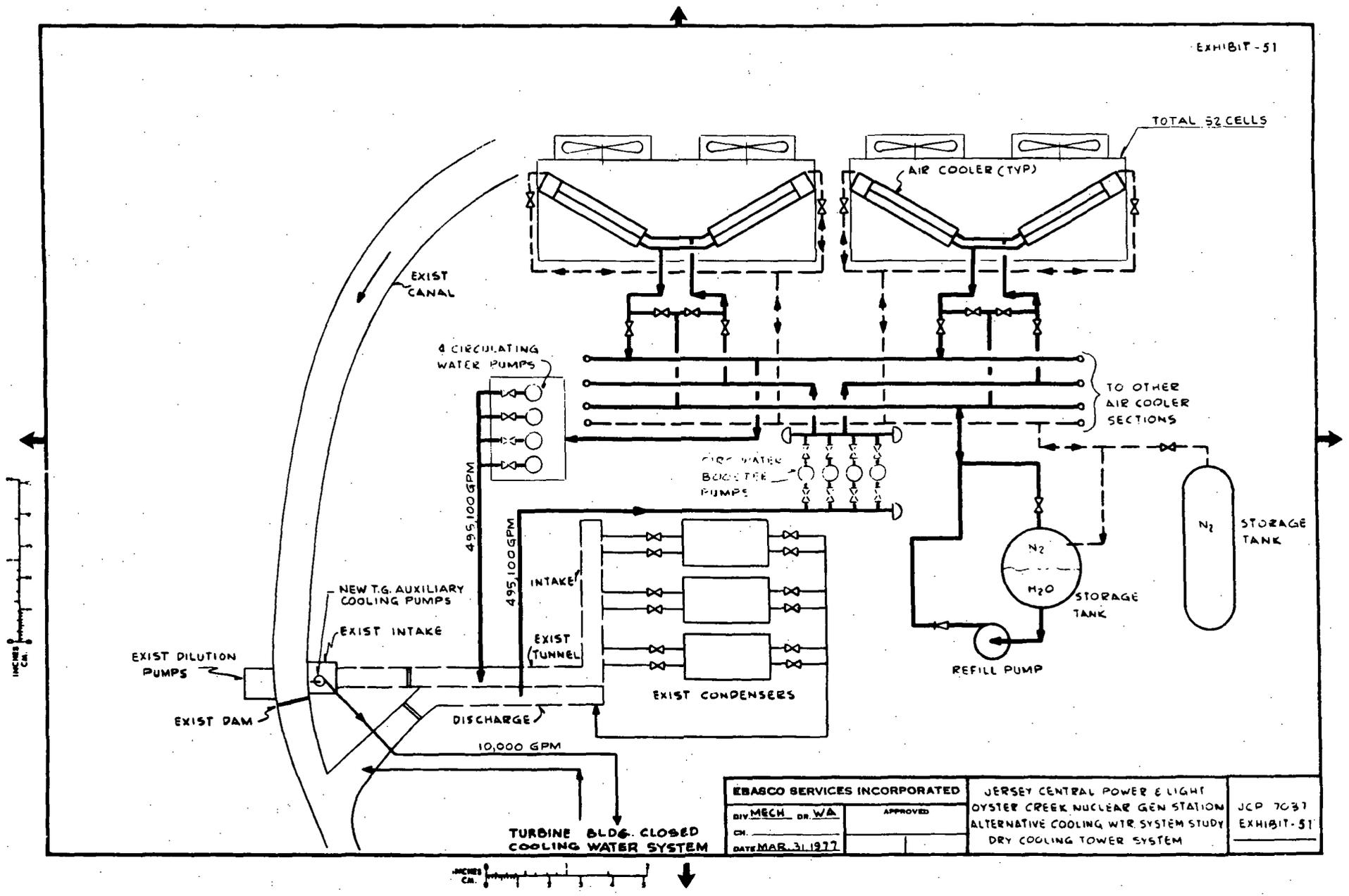
|       |            |
|-------|------------|
| DATE  | NOV 1977   |
| BY    | JCP-2027   |
| APP'D | EXHIBIT-49 |

A) DRY MECHANICAL DRAFT COOLING TOWER

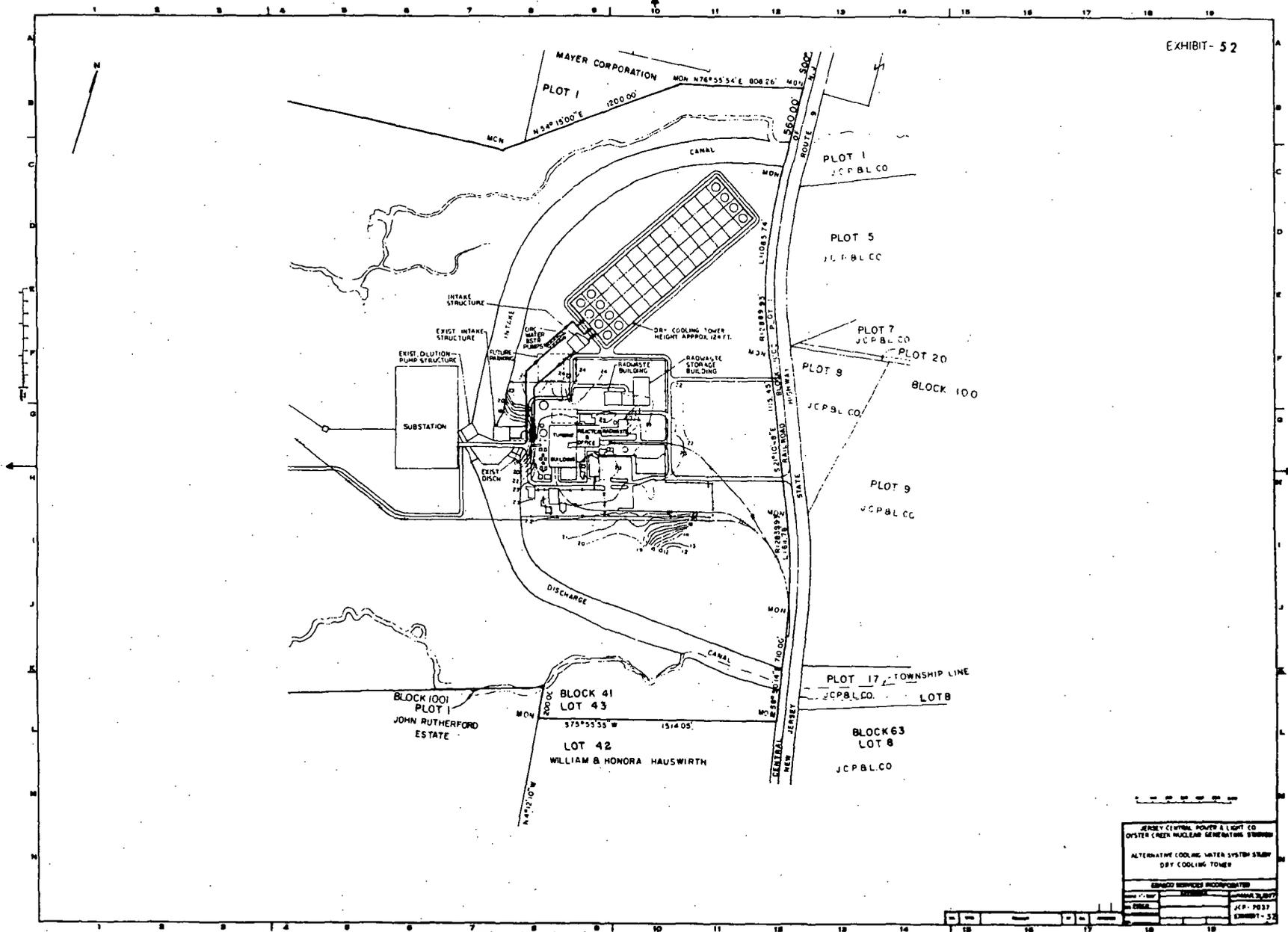


B) DRY NATURAL DRAFT COOLING TOWER





|   |  |                      |  |                        |
|---|--|----------------------|--|------------------------|
| <b>EBASCO SERVICES INCORPORATED</b><br>DIV. MECH. DR. WA<br>CH.<br>DATE MAR. 31. 1977 |  | APPROVED<br><br><br> | JERSEY CENTRAL POWER & LIGHT<br>OYSTER CREEK NUCLEAR GEN STATION<br>ALTERNATIVE COOLING WTR SYSTEM STUDY<br>DRY COOLING TOWER SYSTEM | JCP 7037<br>EXHIBIT-51 |
|---|--|----------------------|--|------------------------|

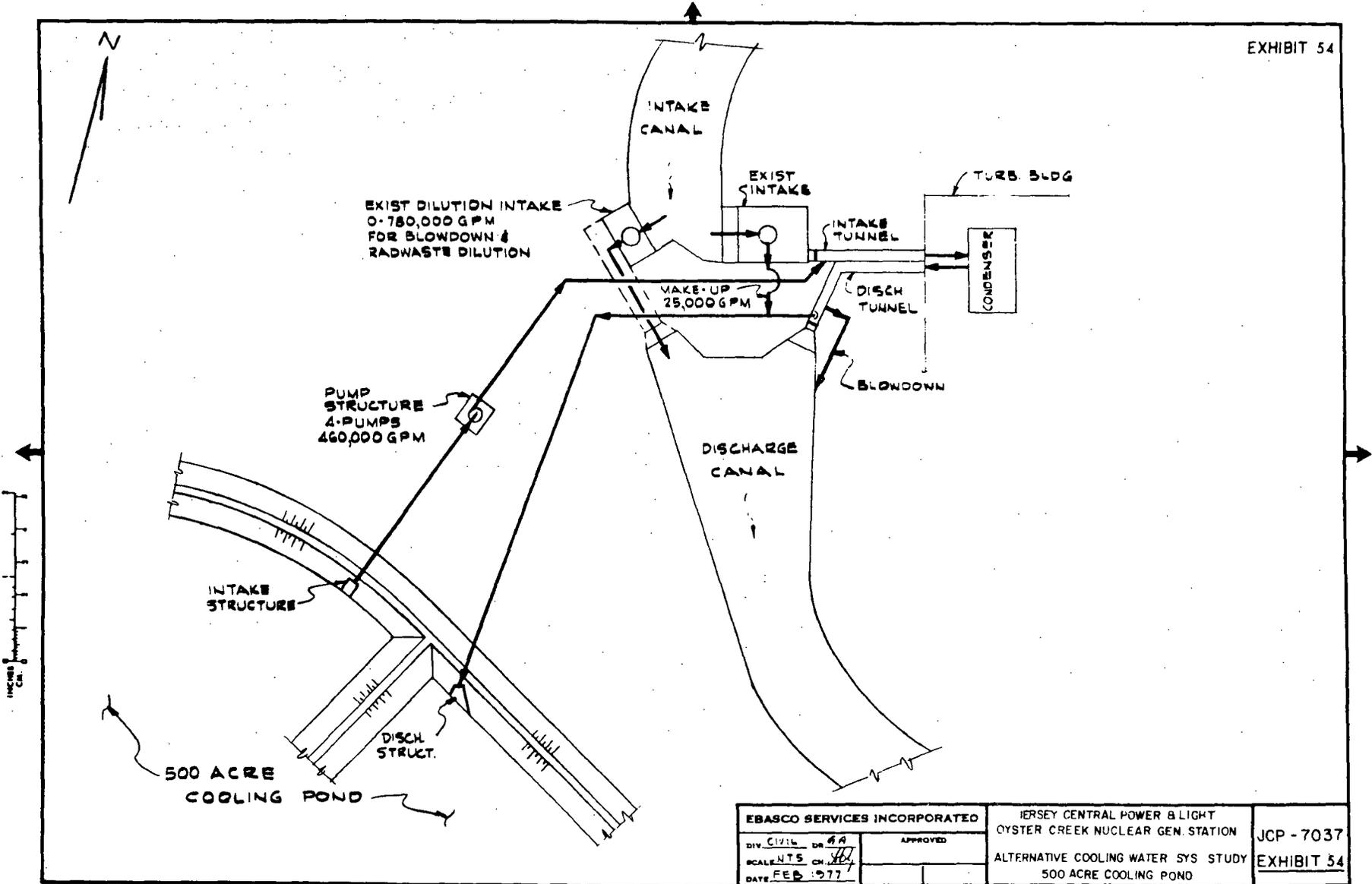


|   |                  |
|---|------------------|
| JERSEY CENTRAL POWER & LIGHT CO         |                  |
| OYSTER CREEK NUCLEAR GENERATING STATION |                  |
| ALTERNATIVE COOLING WATER SYSTEM STUDY  |                  |
| DRY COOLING TOWER                       |                  |
| SHEET NUMBER: 52                        |                  |
| DATE: 10/1/77                           | SCALE: AS SHOWN  |
| DRAWN BY: JCP                           | CHECKED BY: JCP  |
| DESIGNED BY: JCP                        | APPROVED BY: JCP |
| PROJECT NO: JCP-7033                    | EXHIBIT- 52      |

EXHIBIT 53

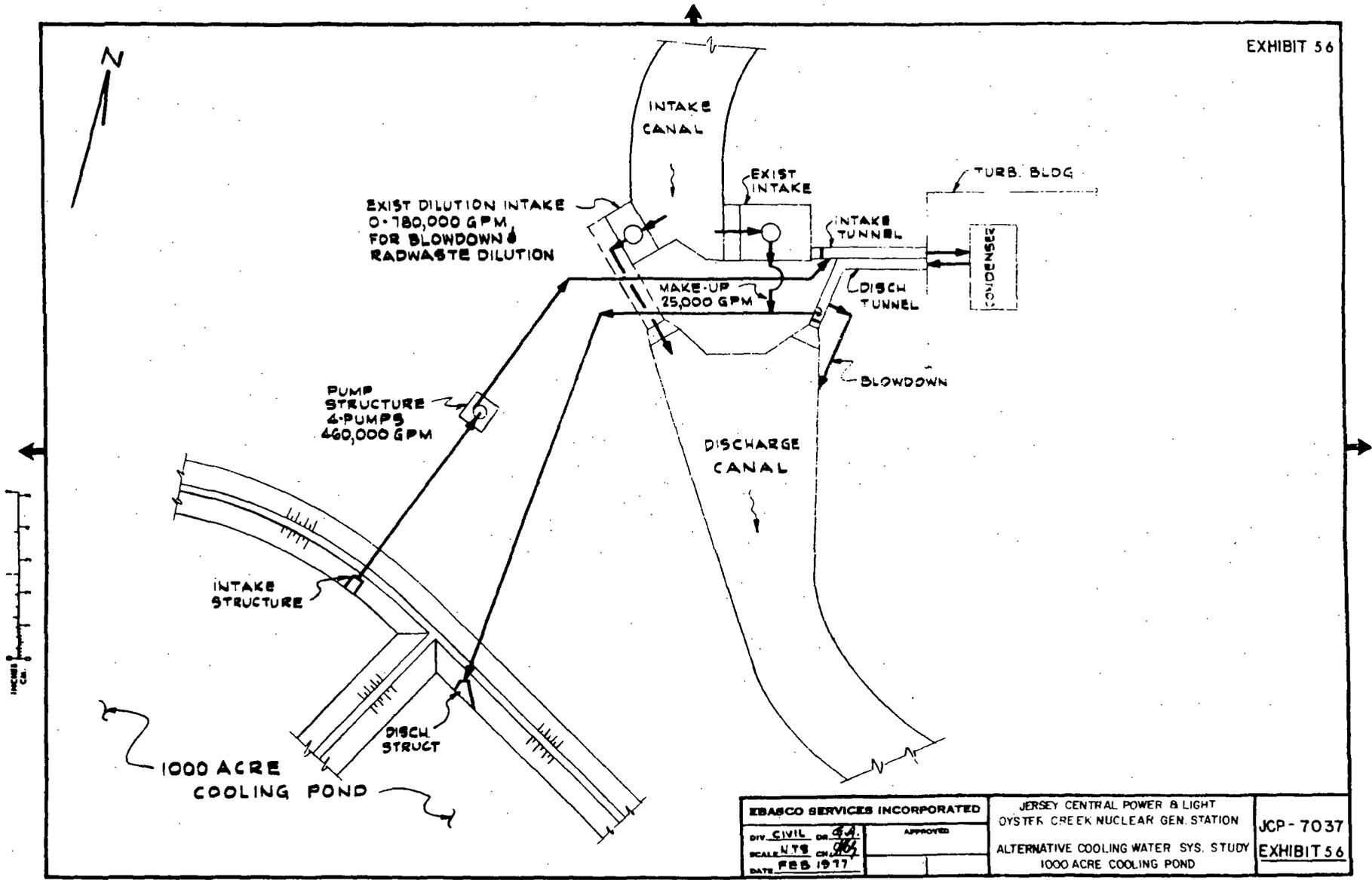
GENERATING PLANTS WITH DRY-TYPE COOLING TOWERS

| <u>Location</u>         | <u>Rating</u>        | <u>Type of<br/>Dry Tower</u>       | <u>Year<br/>Commissioned</u> |
|-------------------------|----------------------|------------------------------------|------------------------------|
| Rugeley, England        | 120 MW               | Heller                             | 1962                         |
| Ibbenburen, Germany     | 150 MW               | Heller                             | 1967                         |
| Wolfsburg, Germany      | 3-50 MW              | GEA Direct                         | 1961-1967                    |
| Grootvlei, South Africa | 200 MW               | MAN/Birwelco<br>(Indirect)         | 1971                         |
| Gyongyos, Hungary       | 2-100 MW<br>2-200 MW | Heller<br>Heller                   | 1969<br>Under Constr         |
| Razdan, USSR            | 3-220 MW             | Heller                             | 1970-1972                    |
| Razdan, USSR            | 1-220 MW             | Heller                             | 1975                         |
| Wyodak, Wyoming, USA    | 3 MW                 | Direct                             | 1962                         |
| Utrillas, Spain         | 160 MW               | GEA Direct                         | 1970                         |
| Quetta, West Pakistan   | 7.5 MW               | Baldwin-Lima-<br>Hamilton (Direct) | 1964                         |
| Bavaria                 | 40 MW                | GEA Direct                         | 1960                         |
| Windhok, South Africa   | 3-30 MW              | GEA Direct                         | 1971                         |
| Switzerland             | 4.3 MW               | GEA Direct                         | 1969                         |
| Luxemburg               | 13 MW                | GEA Direct                         | 1956                         |
| Rome, Italy             | 2-30 MW              | GEA Direct                         | 1957                         |
| Cologne, Germany        | 28 MW                | GEA Direct                         | 1958                         |
| Sindelfingen, Germany   | 11 & 15 MW           | GEA Direct                         | 1960-1961                    |
| Worms, Germany          | 5 MW                 | GEA Direct                         | 1962                         |
| Chile                   | 3.6 MW               | GEA Direct                         | 1963                         |
| Ludwigshafen, Germany   | 38 MW                | GEA Direct                         | 1966                         |
| Eilenburg, Germany      | 5.3 MW               | Heller                             | N A                          |
| Dunaujvarus, Hungary    | 16 MW                | Heller                             | 1961                         |
| Wyodak, Wyoming         | 22 MW                | GEA Direct                         | 1969                         |



|                              |  |                                     |  |            |
|------------------------------|--|-------------------------------------|--|------------|
| EBASCO SERVICES INCORPORATED |  | JERSEY CENTRAL POWER & LIGHT        |  | JCP - 7037 |
| DIV. CIVIL DR. 6A            |  | OYSTER CREEK NUCLEAR GEN. STATION   |  |            |
| SCALE: N.T.S. CH. 164        |  | APPROVED                            |  | EXHIBIT 54 |
| DATE: FEB. 1977              |  | ALTERNATIVE COOLING WATER SYS STUDY |  |            |
|                              |  | 500 ACRE COOLING POND               |  |            |





EBASCO SERVICES INCORPORATED

DIV. CIVIL DR. 34

SCALE N.T.S. CH. 205

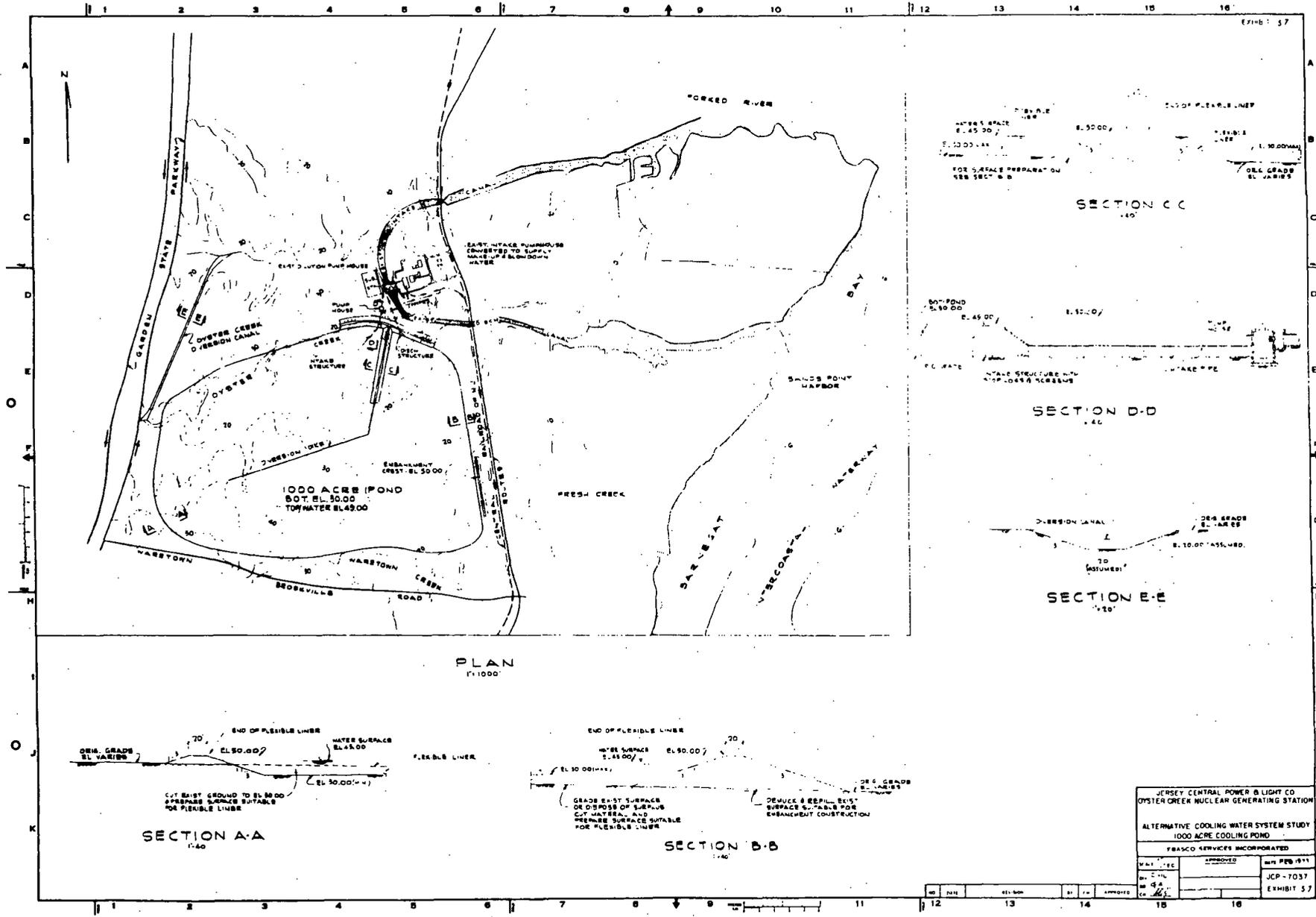
DATE FEB 1977

APPROVED

JERSEY CENTRAL POWER & LIGHT  
OYSTER CREEK NUCLEAR GEN. STATION

ALTERNATIVE COOLING WATER SYS. STUDY  
1000 ACRE COOLING POND

JCP-7037  
EXHIBIT 56



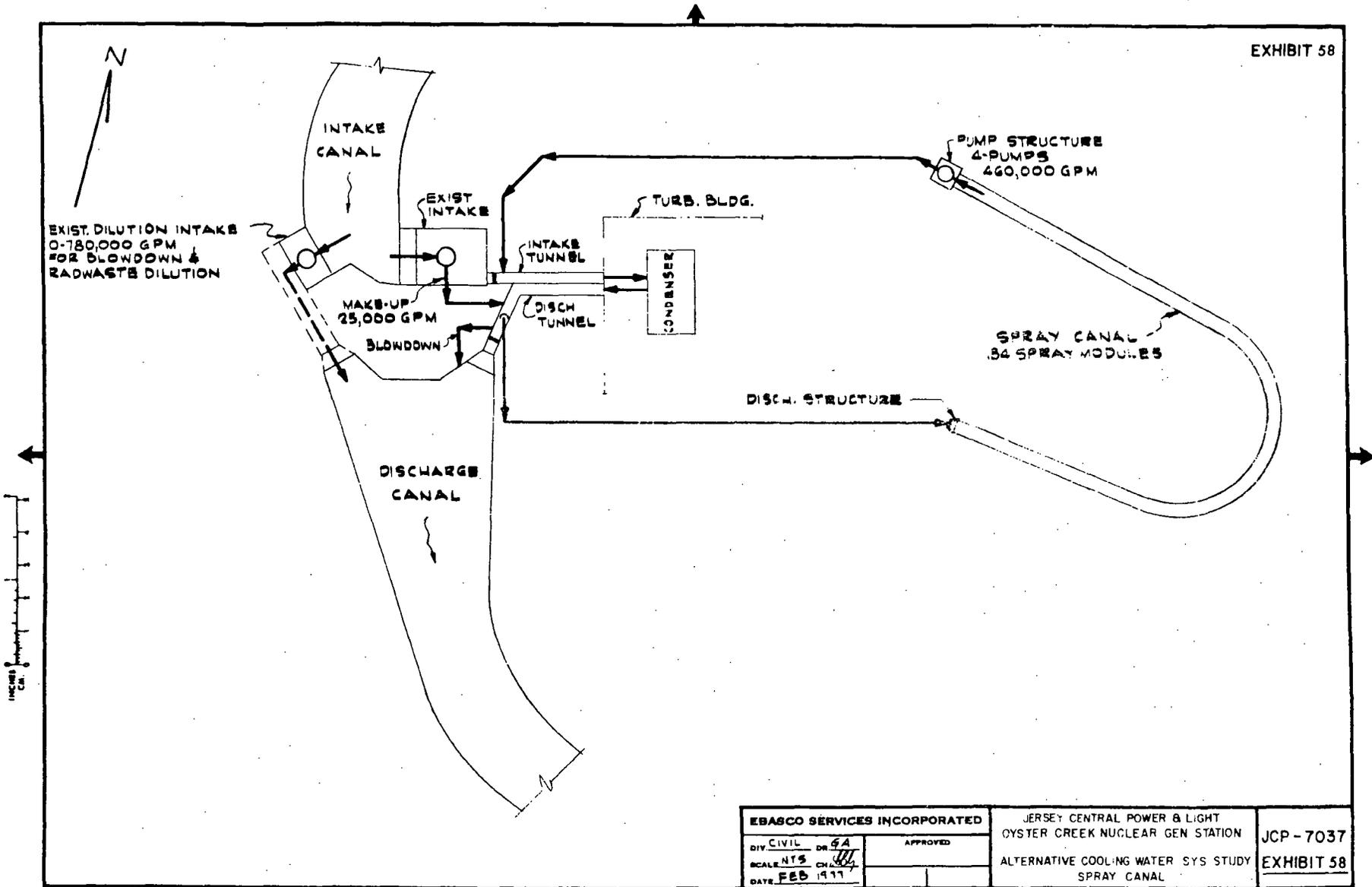
PLAN  
1"=1000'

SECTION A-A  
1"=40'

SECTION B-B  
1"=40'

SECTION C-C  
1"=40'

|   |    |            |          |
|---|----|------------|----------|
| JERSEY CENTRAL POWER & LIGHT CO.        |    |            |          |
| OYSTER CREEK NUCLEAR GENERATING STATION |    |            |          |
| ALTERNATIVE COOLING WATER SYSTEM STUDY  |    |            |          |
| 1000 ACRE COOLING POND                  |    |            |          |
| YRASCO SERVICES INCORPORATED            |    |            |          |
| DATE                                    | BY | APPROVED   | DATE     |
|   |    |            | 10/11/77 |
| DR. C. H. ...                           |    | JCP-7037   |          |
| BY G. A. ...                            |    | EXHIBIT 57 |          |
| BY ...                                  |    |            |          |



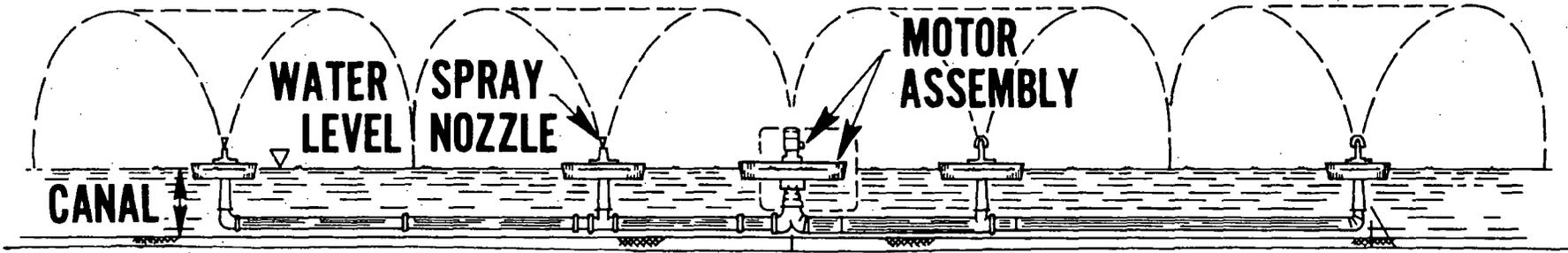
EBASCO SERVICES INCORPORATED  
 DIV. CIVIL DR. SA  
 SCALE: NTS CH. 304  
 DATE: FEB 1977

JERSEY CENTRAL POWER & LIGHT  
 OYSTER CREEK NUCLEAR GEN STATION  
 APPROVED  
 ALTERNATIVE COOLING WATER SYS STUDY  
 SPRAY CANAL

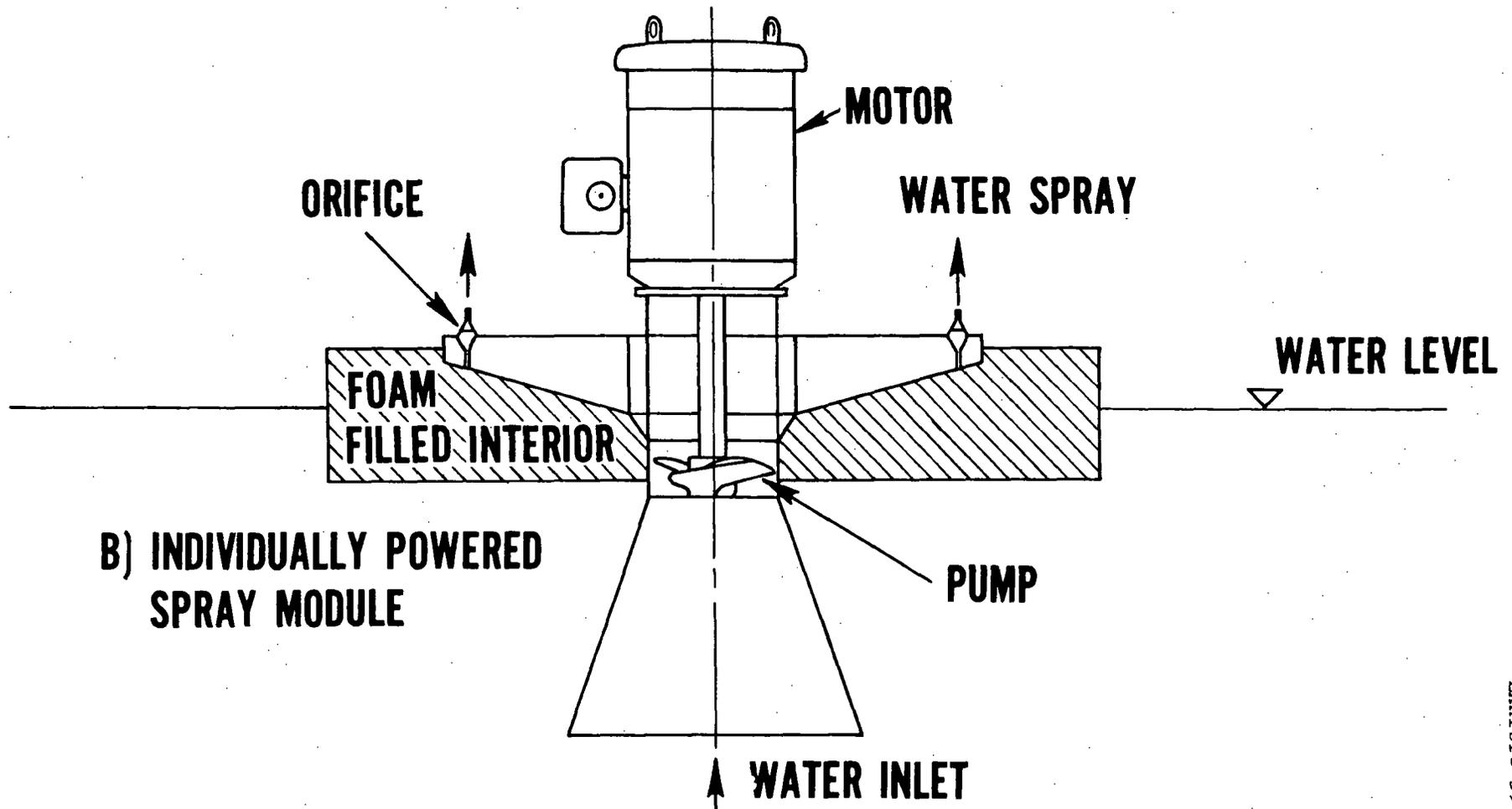
JCP-7037  
 EXHIBIT 58

INCHES  
 CM.

# POWERED SPRAY MODULES



**A) PUMP - GROUP SPRAY HEADS MODULE ASSEMBLY**



**B) INDIVIDUALLY POWERED  
SPRAY MODULE**



SPRAY COOLING MODULE SYSTEMS

| <u>Utility</u>                        | <u>Location</u>                     | <u>No. of<br/>Modules</u> | <u>Twb<br/>F</u> | <u>Approach<br/>F</u> | <u>Range<br/>F</u> | <u>Flow, gpm</u> | <u>Mode of Operation</u> |
|---------------------------------------|-------------------------------------|---------------------------|------------------|-----------------------|--------------------|------------------|--------------------------|
| Commonwealth Edison                   | Cordova, Ill<br>Quad Cities         | 152*                      |                  |                       |                    |                  | Closed Cycle             |
| Commonwealth Edison                   | Morris, Ill<br>Dresden NGS          | 98**                      | 71               | 29.1                  | 10.9               | 1 000 000        | Helper System            |
| E I DuPont                            | Victoria, Tex                       | 49*                       |                  |                       |                    |                  |                          |
| Pacific Gas & Electric                | Pittsburgh, CA                      | 135*                      |                  |                       |                    |                  |                          |
| Public Service Co of<br>New Hampshire | Merimack Sta,<br>Bow, N H           | 56**                      | 62               | 20.0                  | 18.0               | 200 000          | Helper System            |
| Virginia Electric &<br>Power Co       | Chesterfield<br>Sta, Chester,<br>Va | 40**                      | 77.1             | 26.2                  | 8.5                | 489 000          | Helper System            |
| Mississippi Power Co                  | Jack Watson Sta<br>Gulfport, Miss.  | 57**                      |                  |                       |                    |                  | Helper System            |
| Commonwealth Edison                   | Cordova, Ill<br>Quad Cities         | 176**                     | 75               | 18.0                  | 11.0               | 1 000 000        | Closed Cycle             |
| New England Power Co                  | Brayton Point #4                    | 54**                      | 75               | 25.0                  | 17.0               | 260 000          | Closed Cycle             |

\*Manufactured by Richard of Rockford, Inc

\*\*Manufactured by Ceramic Cooling Tower Co

JCP&L OYSTER CREEK NGS  
 ALTERNATIVE COOLING WATER SYSTEM STUDY  
 ONCE THROUGH, COOLING POND & SPRAY MODULE COOLING SYSTEMS

TECHNICAL SUMMARY

| <u>Cooling System Type</u>   | <u>Existing System</u> | <u>Ocean Intake &amp; Discharge</u> |                                | <u>Discharge Canal to Bay</u> | <u>Discharge Pipes to Bay</u> | <u>1000 Acre Pond</u> | <u>500 Acre Pond</u> | <u>Spray Modules</u> |
|--|------------------------|-------------------------------------|--------------------------------|-------------------------------|-------------------------------|-----------------------|----------------------|----------------------|
|  |                        | <u>Single Pressure Condenser</u>    | <u>Multipressure Condenser</u> |                               |                               |                       |                      |                      |
| Cooling Water (CW) Temp Entering Condenser at Design Conditions, F | 82                     | 64                                  | 64                             | 82                            | 82                            | 90                    | 100                  | 89                   |
| Cooling Range, F   | 19.4                   | 18.7                                | 50                             | 19.4                          | 19.4                          | 17.3                  | 17.5                 | 19.2                 |
| CW Flow, gpm   | 462 000                | 462 000                             | 177 400                        | 462 000                       | 462 000                       | 512 300               | 512 300              | 462 000              |
| CW System Auxiliary Power Input, MW                                | 2.5                    | 29.7                                | 29.4                           | 4.1                           | 4.1                           | 4.8                   | 5.0                  | 13.9                 |
| CW Pump TDH, ft  | 23                     | 111                                 | 280                            | 40                            | 40                            | 39                    | 41                   | 36                   |

\* Computer printout is listed as Exhibit 83.

JCP&L OYSTER CREEK NGS  
 ALTERNATIVE COOLING WATER SYSTEM STUDY  
 COOLING TOWER SYSTEM DESIGN PARAMETERS  
 TECHNICAL SUMMARY

|  | Natural<br>Draft Cooling<br>Tower | Fan<br>Assisted<br>Cooling<br>Tower | Mechanical Draft Cooling Towers |             |                |               |               |          |                         |
|--|-----------------------------------|-------------------------------------|---------------------------------|-------------|----------------|---------------|---------------|----------|-------------------------|
|  |                                   |                                     | Evaporative (Wet)               |             | Wet/Dry        |               | Helper Towers | Dry      |                         |
|  |                                   |                                     | Round                           | Rectangular | Fresh<br>Water | Salt<br>Water |               |          |                         |
| Approach to $T_{wb} = 74$ F,<br>F        | 14                                | 14                                  | 10                              | 12          | 18             | 16            | 10            | 8        | 16 (to $T_{db} = 89$ F) |
| Cooling Range, F                         | 21.2                              | 20                                  | 20.8                            | 19.2        | 19.0           | 19.8          | 12            | 15       | 17.7                    |
| Circ Water Flow, gpm                     | 433 300                           | 458,400                             | 426 200                         | 462 200     | 469 200        | 462 200       | 462 000       | 462 000  | 502 300                 |
| CW Temp Entering Cond, F                 | 88                                | 88                                  | 84                              | 86          | 92             | 90            | 84            | 82       | 105                     |
| CW System Aux Power Input,<br>MW         | 9.0                               | 10.7                                | 14.6                            | 12.6        | 19.6           | 16.0          | 14.2          | 17.9     | 35.2                    |
| No. of Cooling Towers                    | 1                                 | 2                                   | 2                               | 2           | 4              | 3             | 3             | 5        | 1                       |
| Cooling Tower Diameter, ft               | 430                               | 230                                 | 237                             | -           | -              | -             | -             | -        | -                       |
| Cooling Tower Width x Length,<br>ft x ft | -                                 | -                                   | -                               | 70 x 540    | 70 x 512       | 64 x 432      | 70 x 540      | 64 x 432 | 340 x 1300              |
| Cooling Tower Height, ft                 | 540                               | 300                                 | 69                              | 55          | 60             | 60            | 55            | 60       | 120                     |
| No. of Fans per Cooling<br>Tower         | -                                 | 20                                  | 19                              | 9           | 16             | 12            | 26 (Total)    | 12       | 52                      |
| Fan Diameter, ft                         | -                                 | 24                                  | 28                              | 40          | 28             | 30            | 40            | 30       | 60                      |
| Horsepower per Fan                       | -                                 | 68                                  | 206                             | 200         | 200            | 200           | 200           | 122      | 446                     |

## Incremental Capability Charge Calculation

| Year | Single<br>Payment<br>Present<br>Worth Factor<br>at R = 11.22% | Installed Capacity  |                            | Operating Capacity               |                        |
|------|---|---------------------|----------------------------|----------------------------------|------------------------|
|      |   | Charge<br>\$/MW-Day | Present Worth<br>\$/MW-Day | Charge<br>\$/MW-Period           | Charge<br>\$/MW-Period |
| 1984 | 0.8991  | 104.0               | 93.5                       | 23 x 1.07 <sup>8</sup><br>= 39.5 | 35.5                   |
| 5    | 0.8084  | 111.3               | 90.0                       | 42.3                             | 34.2                   |
| 6    | 0.7269  | 119.1               | 86.6                       | 45.2                             | 32.9                   |
| 7    | 0.6535  | 127.4               | 83.3                       | 48.4                             | 31.6                   |
| 8    | 0.5876  | 136.3               | 80.1                       | 51.8                             | 30.4                   |
| 9    | 0.5283  | 145.9               | 77.1                       | 55.4                             | 29.3                   |
| 1990 | 0.4750  | 156.1               | 74.1                       | 59.3                             | 28.2                   |
| 1    | 0.4271  | 167.0               | 71.3                       | 63.4                             | 27.1                   |
| 2    | 0.3840  | 178.7               | 68.6                       | 67.9                             | 26.1                   |
| 3    | 0.3453  | 191.2               | 66.0                       | 72.6                             | 25.1                   |
| 4    | 0.3104  | 204.6               | 63.5                       | 77.7                             | 24.1                   |
| 5    | 0.2791  | 218.9               | 61.1                       | 83.1                             | 23.2                   |
| 6    | 0.2509  | 234.2               | 58.8                       | 89.0                             | 22.3                   |
| 7    | 0.2256  | 250.6               | 56.5                       | 95.2                             | 21.5                   |
| 8    | 0.2029  | 268.2               | 54.4                       | 101.9                            | 20.7                   |
| 9    | 0.1824  | 286.9               | 52.3                       | 109.0                            | 19.9                   |
| 2000 | 0.1640  | 307.0               | 50.3                       | 116.6                            | 19.1                   |
| 1    | 0.1475  | 328.5               | 48.5                       | 124.8                            | 18.4                   |
| 2    | 0.1326  | 351.5               | 46.6                       | 133.5                            | 17.7                   |
| 3    | 0.1192  | 376.1               | 44.8                       | 142.9                            | 15.6                   |
| 2004 | <u>0.1072</u>   | 402.4               | <u>43.1</u>                | 152.9                            | <u>16.4</u>            |
|      | 7.9566  |                     | 1370.5                     |                                  | 519.3                  |

Levelized Cost

ICC = \$172.2/MW-Day

OCC = \$65.3/MW-Period

RELATIVE ATMOSPHERIC EFFECTS OF ALTERNATIVE COOLING WATER SYSTEMS FOR OYSTER CREEK NUCLEAR GENERATING STATION

| System                                       | Elevated Plumes |  | Ground Level Fogging |   | Salt Deposition-Drift   |   | Convective Instability,<br>Cloud Growth and<br>Precipitation Augmentation |
|--|-----------------|--|----------------------|---|-------------------------|---|---|
|  | Impact          | Comment  | Impact               | Comment   | Impact                  | Comment   | Impact  |
| <u>Cooling Towers</u>                        |                 |  |                      |   |                         |   |   |
| Natural Draft and Fan-Assisted Natural Draft | High            | Less than 825 hrs/year extending more than 1,000 yds | Low                  | -   | Low                     | Max annual deposition rates estimated less than 89 kg/km <sup>2</sup> per month | Moderate  |
| Rectangular                                  | Low             | -  | High                 | Probably less than several hundred hrs per year | High                    | Deposition generally about 7 times natural draft deposition rates               | Moderate  |
| Round  | High            | Frequency similar to natural draft tower             | Low                  | -   | Moderate                | -   | Moderate  |
| <u>Saltwater</u>                             |                 |  |                      |   |                         |   |   |
| Wet/dry                                      | Low             | -  | Low <sup>(1)</sup>   | -   | Moderate <sup>(3)</sup> | -   | Moderate  |
| Dry  | Low             | -  | Low                  | -   | Low                     | -   | High  |
| <u>Cooling Pond</u>                          | Low             | -  | Moderate             | Fogging may extend ½ mile                       | Low                     | -   | Low   |
| <u>Spray Canal</u>                           | -               | -  | Moderate             | Fogging may extend ½ mile                       | High                    | Drift may extend 2,000 ft or more from canal                                    | Low   |
| <u>Canal-to-bay</u>                          | Low             | -  | Low <sup>(2)</sup>   | -   | Low                     | -   | Low <sup>(2)</sup>  |
| <u>Once-through-ocean</u>                    | Low             | -  | Low                  | -   | Low                     | -   | Low   |
| <u>Helper Cooling Towers</u>                 |                 |  |                      |   |                         |   |   |
| Rectangular                                  | Low             | -  | High                 | Probably less than several hundred hrs per year | High                    | Deposition generally about 7 times natural draft deposition rates               | Moderate  |

(1) Low impact is based on assumption that tower is primarily on dry mode during periods of high tower-induced fogging potential.

(2) Pipe-to-Bay alternative would exhibit low atmospheric effects.

(3) Freshwater wet/dry tower would produce low impact due to salt deposition.

Note: Low - The impact is not a concern in the cooling system elimination system.

Moderate - The impact approaches a level of concern in the cooling system elimination process.

High - the impact if of sufficient magnitude to warrant serious consideration in the cooling system elimination system.

## Exhibit 65

SUMMARY OF CLOSED-CYCLE COOLING SYSTEM  
OPERATING CHARACTERISTICS

|  | Average<br>Summer | Average<br>Winter | Average<br>Spring |
|--|-------------------|-------------------|-------------------|
| <u>Round Mechanical Draft</u>  |                   |                   |                   |
| <u>Towers</u>  |                   |                   |                   |
| Makeup (gpm)   | 22,410            | 22,410            | 22,410            |
| Evaporation (gpm)  | 6,700             | 5,000             | 5,800             |
| Blowdown (gpm)   | 15,710            | 17,410            | 16,610            |
| Discharge Heat Load ( $10^6$ Btu/hr) *   | 135.6             | 659.8             | 342.8             |
| Temperature Differential ( $^{\circ}$ F)<br>between Blowdown Flow and<br>Receiving Water Temperature * | 7.0               | 30.8              | 16.7              |
| <u>Draft Towers</u>  |                   |                   |                   |
| Makeup (gpm)   | 22,410            | 22,410            | 22,410            |
| Evaporation (gpm)  | 6,700             | 5,000             | 5,800             |
| Blowdown (gpm)   | 15,710            | 17,410            | 16,610            |
| Discharge Heat Load ( $10^6$ Btu/hr) *   | 152.9             | 681.5             | 364.4             |
| Temperature Differential ( $^{\circ}$ F)<br>between Blowdown Flow and<br>Receiving Water Temperature * | 7.9               | 31.8              | 17.8              |
| <u>Natural Draft Tower</u>   |                   |                   |                   |
| Makeup (gpm)   | 22,200            | 22,200            | 22,200            |
| Evaporation (gpm)  | 6,700             | 5,000             | 5,800             |
| Blowdown (gpm)   | 15,500            | 17,200            | 16,400            |
| Discharge Heat Load ( $10^6$ Btu/hr) *   | 164.2             | 622.6             | 345.7             |
| Temperature Differential ( $^{\circ}$ F)<br>between Blowdown Flow and<br>Receiving Water Temperature * | 8.5               | 29.2              | 17.0              |
| <u>Floating Spray Modules</u>  |                   |                   |                   |
| Makeup (gpm)   | 23,403            | 23,403            | 23,403            |
| Evaporation (gpm)  | 7,018             | 5,005             | 5,790             |
| Blowdown (gpm)   | 16,385            | 18,398            | 17,613            |
| Discharge Heat Load ( $10^6$ Btu/hr) *   | 161.3             | 595.9             | 317.6             |
| Temperature Differential ( $^{\circ}$ F)<br>between Blowdown Flow and<br>Receiving Water Temperature * | 8.1               | 27.2              | 15.1              |

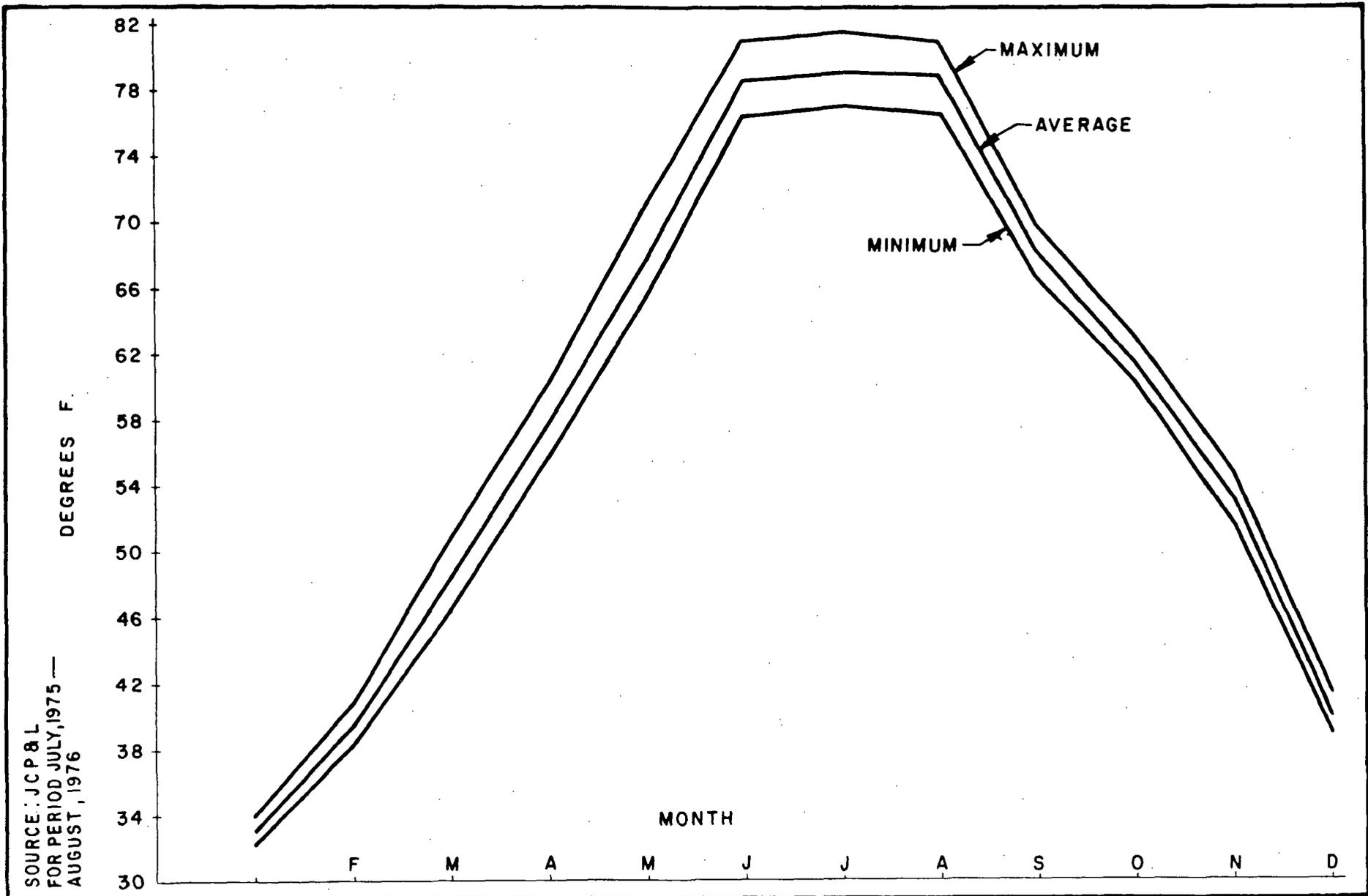
## Exhibit 65 (Cont'd)

SUMMARY OF CLOSED-CYCLE COOLING SYSTEMOPERATING CHARACTERISTICS

|  | Average<br>Summer | Average<br>Winter | Average<br>Spring |
|--|-------------------|-------------------|-------------------|
| <u>Salt Water Wet/Dry</u>  |                   |                   |                   |
| <u>Mechanical Draft Towers</u>   |                   |                   |                   |
| Makeup (gpm)   | 21,000            | 21,000            | 21,000            |
| Evaporation (gpm)  | 4,600             | 3,400             | 4,000             |
| Blowdown (gpm)   | 16,400            | 17,600            | 17,000            |
| Discharge Heat Load ( $10^6$ Btu/hr)*  | 172.8             | 684.3             | 402.7             |
| Temperature Differential ( $^{\circ}$ F)<br>between Blowdown Flow and<br>Receiving Water Temperature * | 8.7               | 31.8              | 19.5              |
| <u>500-Acre Cooling Pond</u>   |                   |                   |                   |
| Makeup (gpm)   | 23,268            | 23,268            | 23,268            |
| Evaporation (gpm)  | 7,008             | 3,760             | 5,534             |
| Blowdown (gpm)   | 16,260            | 19,508            | 17,734            |
| Discharge Heat Load ( $10^6$ Btu/hr)*  | 248.0             | 708.6             | 428.8             |
| Temperature Differential ( $^{\circ}$ F)<br>between Blowdown Flow and<br>Receiving Water Temperature * | 12.6              | 31.5              | 8.7               |
| <u>1,000-Acre Cooling Pond</u>   |                   |                   |                   |
| Makeup (gpm)   | 26,279            | 26,279            | 26,379            |
| Evaporation (gpm)  | 7,570             | 2,203             | 5,190             |
| Blowdown (gpm)   | 18,809            | 24,176            | 21,189            |
| Discharge Heat Load ( $10^6$ Btu/hr)*  | 147.1             | 549.3             | 311.2             |
| Temperature Differential ( $^{\circ}$ F)<br>between Blowdown Flow and<br>Receiving Water Temperature * | 7.0               | 22.2              | 13.7              |
| <u>Fresh Water Wet/Dry Mechanical</u>  |                   |                   |                   |
| <u>Draft Towers</u>  |                   |                   |                   |
| Makeup (gpm)   | 5,800             | 0                 | 5,800             |
| Evaporation (gpm)  | 4,800             | 0                 | 3,250             |
| Blowdown (gpm)   | 1,000             | 0                 | 2,550             |
| Discharge Heat Load ( $10^6$ Btu/hr)*  | 134.2             | 424.8             | 268.3             |
| Temperature Differential ( $^{\circ}$ F)<br>between Blowdown Flow and<br>Receiving Water Temperature * | 11.1              | 27.2              | 19.9              |

Note: Figures pertain to full load conditions.

\* Includes estimated Oyster Creek blowdown discharge plus Forked River Station blowdown discharge.



JERSEY CENTRAL POWER  
AND LIGHT COMPANY

EBASCO SERVICES INCORPORATED  
New York

OYSTER CREEK NUCLEAR GENERATING STATION  
INTAKE WATER TEMPERATURES  
MONTHLY AVERAGES OF DAILY READINGS

EXHIBIT 66

Exhibit 67

DISCHARGE FLOW RATES AND  
TEMPERATURE RISE ABOVE AMBIENT

CLOSED-CYCLE COOLING TOWER ALTERNATIVES

Rectangular Mechanical Draft Towers

| No. Dilution Pumps Operating                      | <u>1</u> | <u>2</u> |
|---|----------|----------|
| Average Summer Temperature Rise ( <sup>o</sup> F) | 1.02     | 0.55     |
| Average Summer Flow Rate (gpm)                    | 298,960. | 558,960. |
| Average Winter Temperature Rise ( <sup>o</sup> F) | 4.50     | 2.42     |
| Average Winter Flow Rate (gpm)                    | 302,860. | 562,860. |
| Average Spring Temperature Rise ( <sup>o</sup> F) | 2.42     | 1.30     |
| Average Spring Flow Rate (gpm)                    | 300,990. | 560,990. |

Round Mechanical Draft Towers

| No. Dilution Pumps Operating                      | <u>1</u> | <u>2</u> |
|---|----------|----------|
| Average Summer Temperature Rise ( <sup>o</sup> F) | 0.91     | 0.49     |
| Average Summer Flow Rate (gpm)                    | 298,960. | 558,960. |
| Average Winter Temperature Rise ( <sup>o</sup> F) | 4.36     | 2.35     |
| Average Winter Flow Rate (gpm)                    | 302,860. | 562,860. |
| Average Spring Temperature Rise ( <sup>o</sup> F) | 2.28     | 1.22     |
| Average Spring Flow Rate (gpm)                    | 300,990. | 560,990. |

\*Includes estimated Oyster Creek blowdown discharge plus Forked River Station blowdown discharge.

Exhibit 67 (Cont'd)

DISCHARGE FLOW RATES AND  
TEMPERATURE RISE ABOVE AMBIENT

CLOSED-CYCLE COOLING TOWER ALTERNATIVES

Natural Draft Towers

| No. Dilution Pumps Operating                      | <u>1</u> | <u>2</u> |
|---|----------|----------|
| Average Summer Temperature Rise ( <sup>o</sup> F) | 1.10     | 0.59     |
| Average Summer Flow Rate (gpm)                    | 298,750. | 558,750. |
| Average Winter Temperature Rise ( <sup>o</sup> F) | 4.12     | 2.21     |
| Average Winter Flow Rate (gpm)                    | 302,650. | 562,650. |
| Average Spring Temperature Rise ( <sup>o</sup> F) | 2.30     | 1.23     |
| Average Spring Flow Rate (gpm)                    | 300,780. | 560,780. |

\*Includes estimated Oyster Creek blowdown discharge plus Forked River Station blowdown discharge.

Exhibit 67 (Cont'd)

DISCHARGE FLOW RATES AND  
TEMPERATURE RISE ABOVE AMBIENT

CLOSED-CYCLE COOLING TOWER ALTERNATIVES

Fresh Water Wet/Dry Mechanical Draft Towers

| No. Dilution Pumps Operating          | <u>1</u> | <u>2</u> |
|---------------------------------------|----------|----------|
| Average Summer Temperature Rise (° F) | 0.94     | 0.49     |
| Average Summer Flow Rate (gpm)        | 284,250. | 544,250. |
| Average Winter Temperature Rise (° F) | 2.92     | 1.54     |
| Average Winter Flow Rate (gpm)        | 285,450. | 545,450. |
| Average Spring Temperature Rise (° F) | 1.87     | 0.98     |
| Average Spring Flow Rate (gpm)        | 286,930. | 546,930. |

Salt Water Wet/Dry Rectangular Mechanical Draft Towers

| No. Dilution Pumps Operating          | <u>1</u> | <u>2</u> |
|---------------------------------------|----------|----------|
| Average Summer Temperature Rise (° F) | 1.15     | 0.62     |
| Average Summer Flow Rate (gpm)        | 299,650. | 559,650. |
| Average Winter Temperature Rise (° F) | 4.52     | 2.43     |
| Average Winter Flow Rate (gpm)        | 303,050. | 563,050. |
| Average Spring Temperature Rise (° F) | 2.67     | 1.44     |
| Average Spring Flow Rate (gpm)        | 301,380. | 561,380. |

\* Includes estimated Oyster Creek blowdown discharge plus Forked River Station blowdown discharge.

Note: Flows are given in gallons per minute (gpm), temperatures in ° F.

Exhibit 68

DISCHARGE FLOW RATES AND  
TEMPERATURE RISE ABOVE AMBIENT

CLOSED-CYCLE COOLING POND ALTERNATIVES

500 Acre Pond - 20° Rise

| No. Dilution Pumps Operating          | 1        | 2        |
|---------------------------------------|----------|----------|
| Average Summer Temperature Rise (° F) | 1.66     | 0.89     |
| Average Summer Flow Rate (gpm)        | 299,510. | 599,510. |
| Average Winter Temperature Rise (° F) | 4.65     | 2.51     |
| Average Winter Flow Rate (gpm)        | 304,958. | 564,958. |
| Average Spring Temperature Rise (° F) | 2.84     | 1.53     |
| Average Spring Flow Rate (gpm)        | 302,114. | 562,114. |

1000 Acre Pond - 20° Rise

| No. Dilution Pumps Operating          | 1        | 2        |
|---------------------------------------|----------|----------|
| Average Summer Temperature Rise (° F) | .97      | .52      |
| Average Summer Flow Rate (gpm)        | 302,059. | 562,059. |
| Average Winter Temperature Rise (° F) | 3.55     | 1.93     |
| Average Winter Flow Rate (gpm)        | 309,626. | 569,626. |
| Average Spring Temperature Rise (° F) | 2.04     | 1.10     |
| Average Spring Flow Rate (gpm)        | 305,569. | 565,569. |

\* Includes estimated Oyster Creek blowdown discharge plus Forked River blowdown discharge.

Exhibit 69

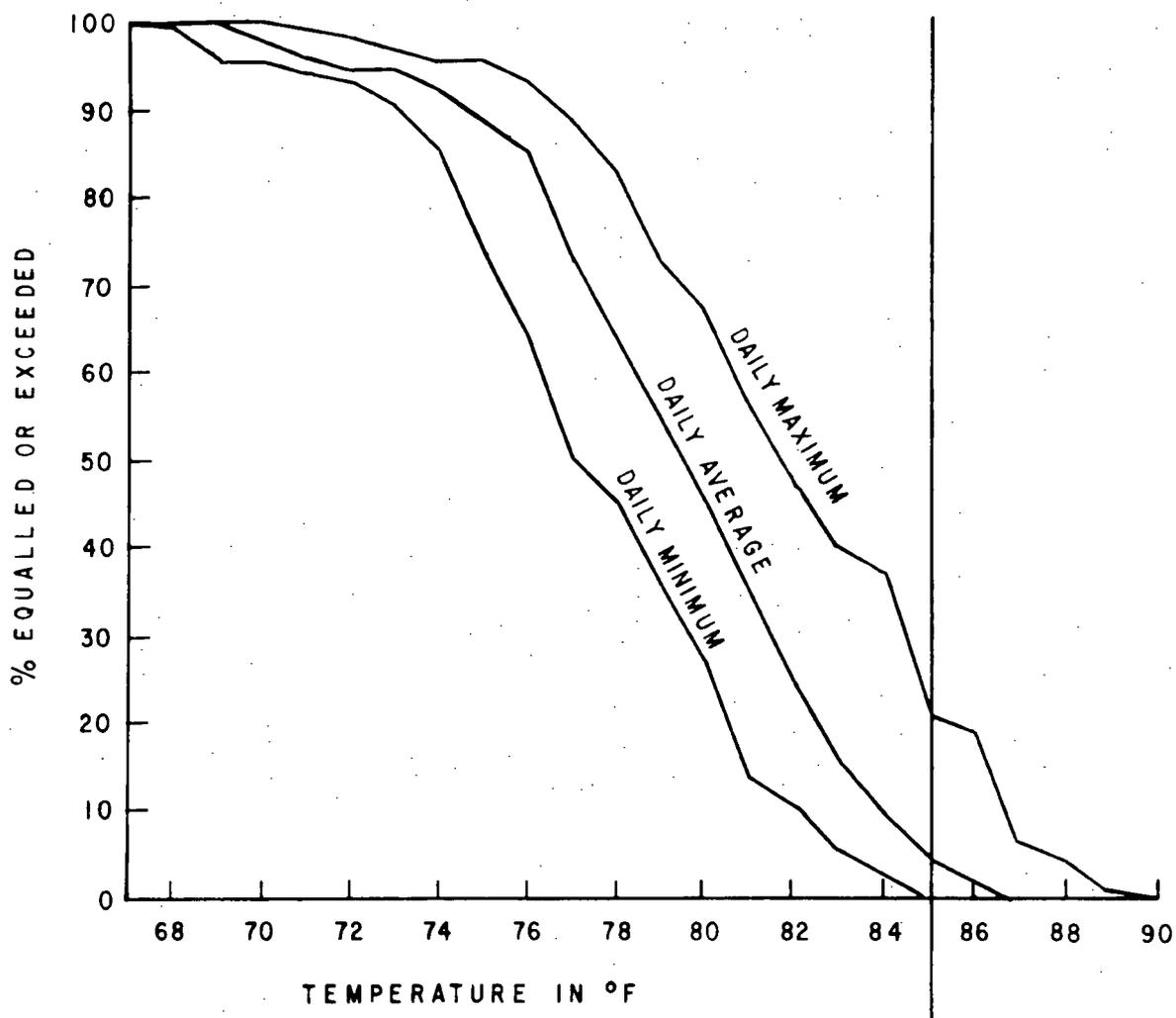
DISCHARGE FLOW RATES AND  
TEMPERATURE RISE ABOVE AMBIENT

CLOSED-CYCLE SPRAY CANAL ALTERNATIVE

184 Floating Spray Modules

| No. Dilution Pumps Operating                    | <u>1</u> | <u>2</u> |
|---|----------|----------|
| Average Summer Temperature Rise ( $^{\circ}$ F) | 1.08     | 0.58     |
| Average Summer Flow Rate (gpm)                  | 299,635. | 559,635. |
| Average Winter Temperature Rise ( $^{\circ}$ F) | 3.92     | 2.11     |
| Average Winter Flow Rate (gpm)                  | 303,848. | 563,848. |
| Average Spring Temperature Rise ( $^{\circ}$ F) | 2.10     | 1.13     |
| Average Spring Flow Rate (gpm)                  | 301,993. | 561,993. |

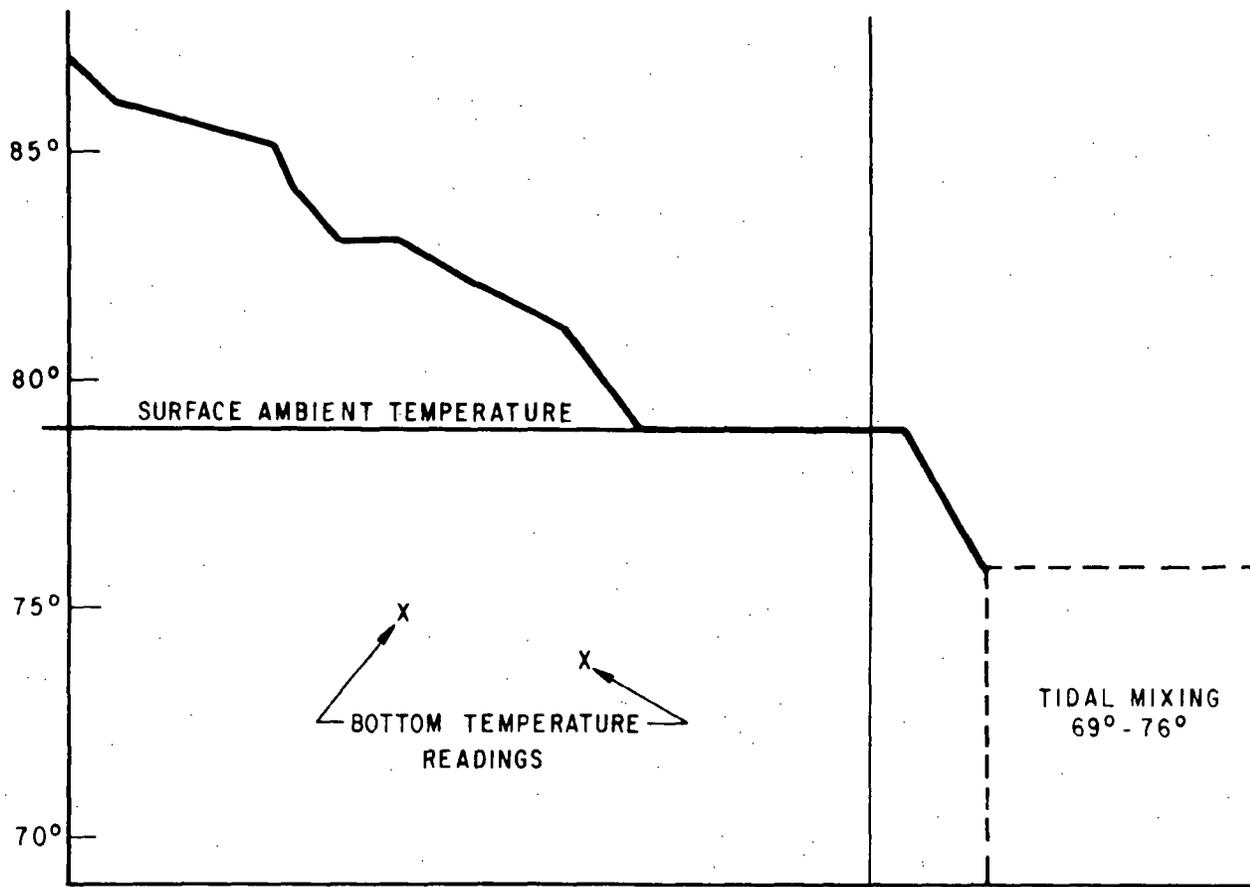
\* Includes estimated Oyster Creek blowdown discharge plus Forked River blowdown discharge.



85°

PERIOD OF RECORD:  
 JULY & AUGUST 1975  
 JUNE, JULY & AUGUST 1976  
 SOURCE: JCP & L

|   |                                  |            |
|---|----------------------------------|------------|
| JERSEY CENTRAL POWER<br>AND LIGHT COMPANY | OYSTER CREEK SUMMER INTAKE       | EXHIBIT 70 |
| EBASCO SERVICES INCORPORATED<br>New York  | WATER TEMPERATURE<br>FREQUENCIES |            |



MOUTH OF OYSTER CREEK

2/3 ACROSS SURFACE

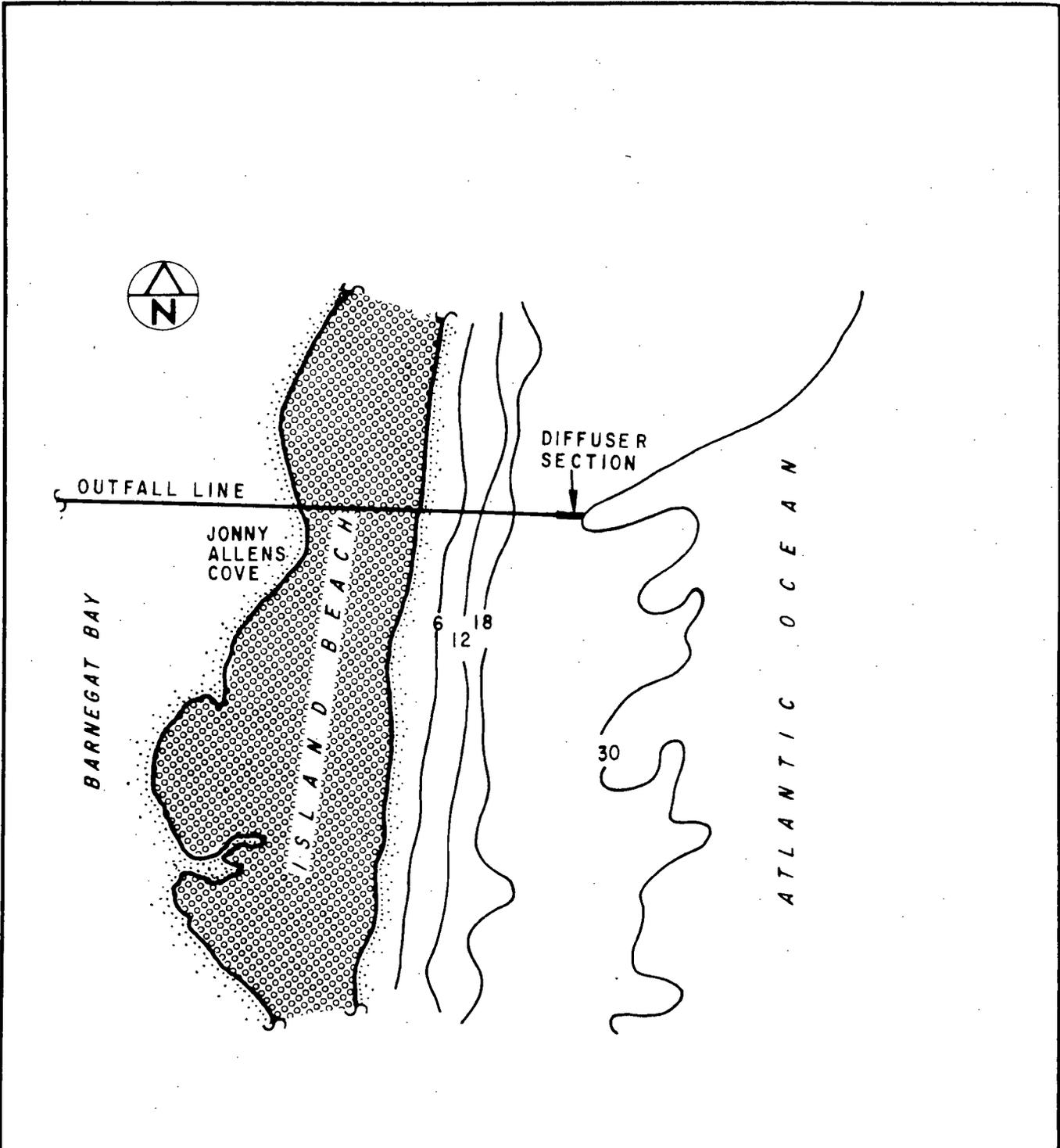
WESTERN EDGE  
ISLAND BEACH  
STATE PARK

1 MILE

JERSEY CENTRAL  
POWER & LIGHT COMPANY  
EBASCO SERVICES INCORPORATED  
New York

THERMAL PLUME PROFILE AUGUST 6, 1974  
FULL LOAD EBB TIDE

EXHIBIT  
71

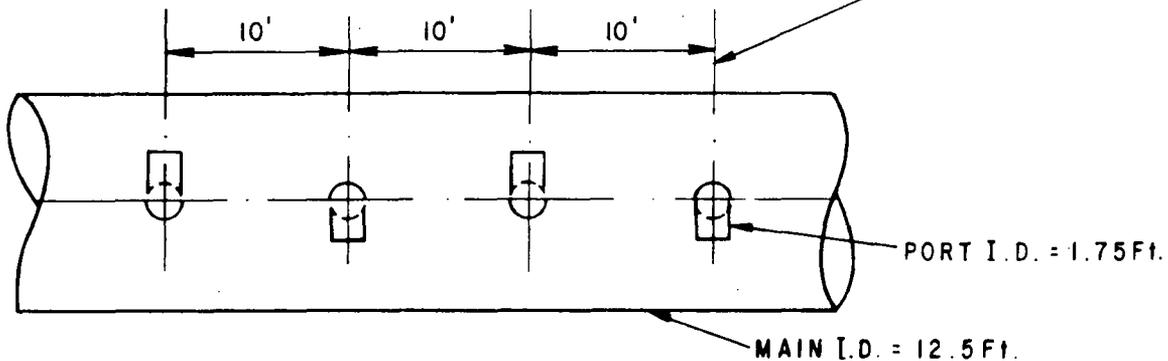


SCALE : 1" = 2000'

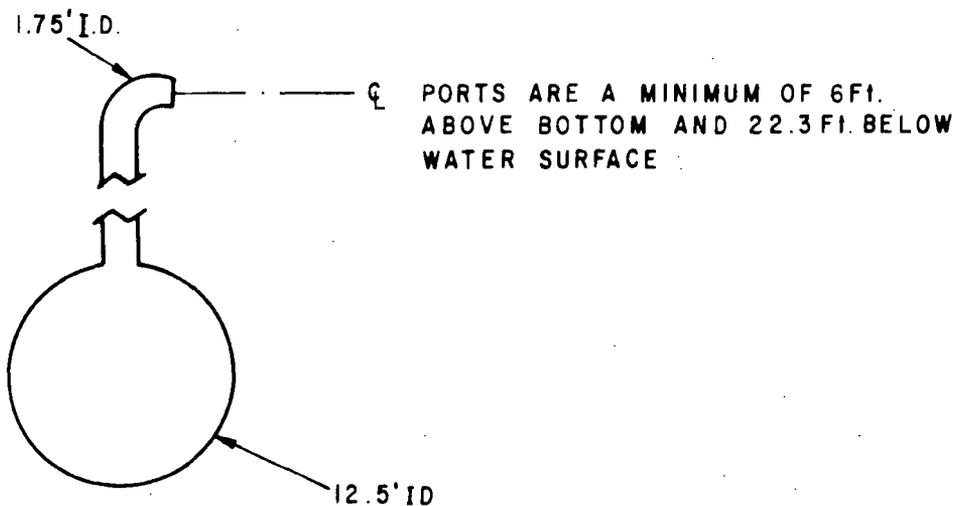
NOTE : DIFFUSER SECTION IS 350 FT. LONG  
 FROM CENTER LINE OF FIRST PORT  
 TO CENTER LINE OF LAST PORT

|   |   |                   |
|---|---|-------------------|
| <p>JERSEY CENTRAL POWER<br/>AND LIGHT COMPANY</p> | <p>LOCATION OF DIFFUSER<br/>FOR SINGLE PRESSURE<br/>CONDENSER</p> | <p>EXHIBIT 72</p> |
| <p>EBASCO SERVICES INCORPORATED<br/>New York</p>  |   |                   |

THERE ARE A TOTAL OF 36 PORTS  
ON 10FT. CENTERS FACING ALTERNATE  
DIRECTIONS



PLAN VIEW



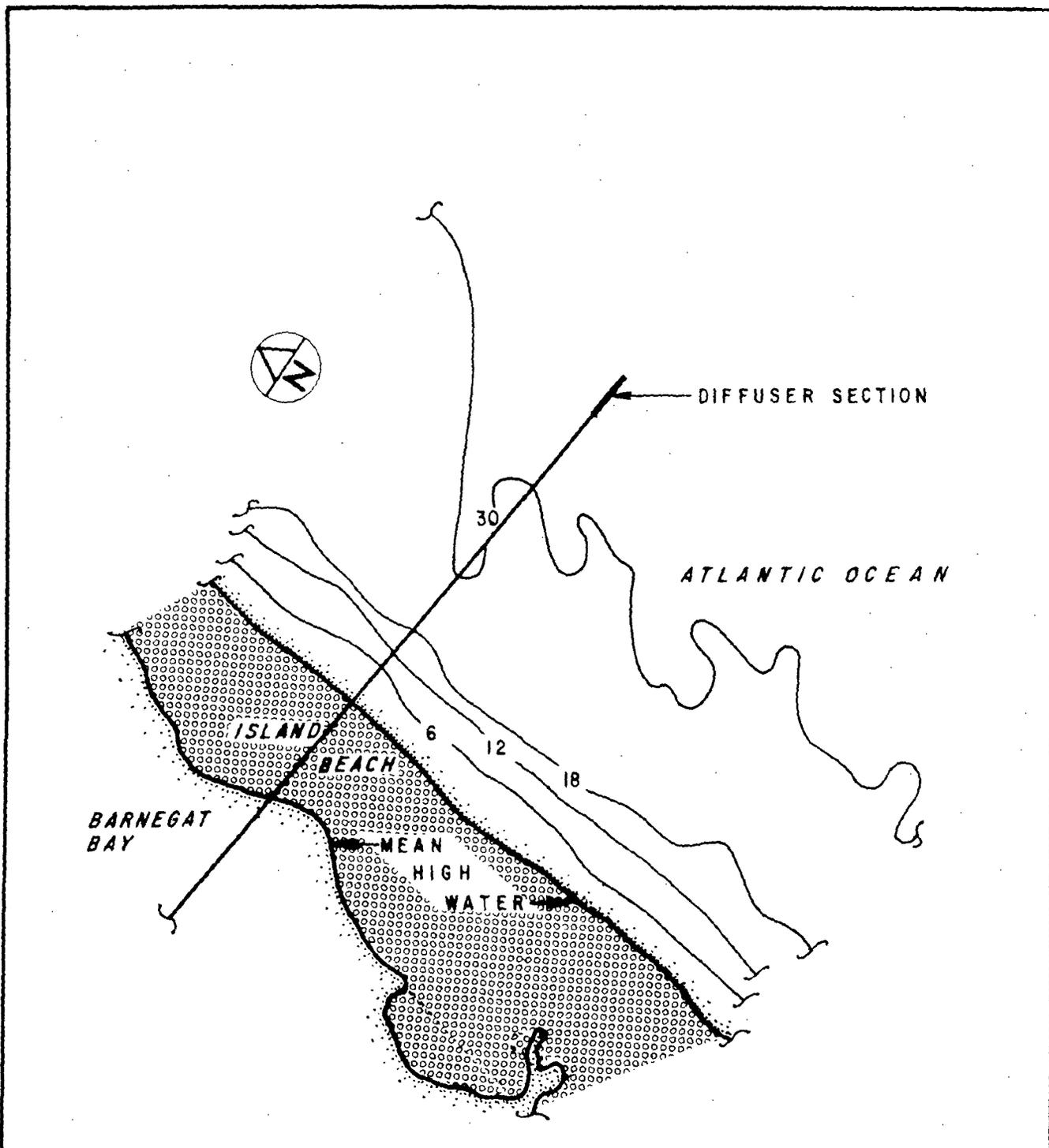
TYPICAL SECTION

JERSEY CENTRAL POWER  
AND LIGHT COMPANY

EBASCO SERVICES INCORPORATED  
New York

PLAN AND SECTION  
OF DIFFUSER FOR  
SINGLE PRESSURE CONDENSER

EXHIBIT 73

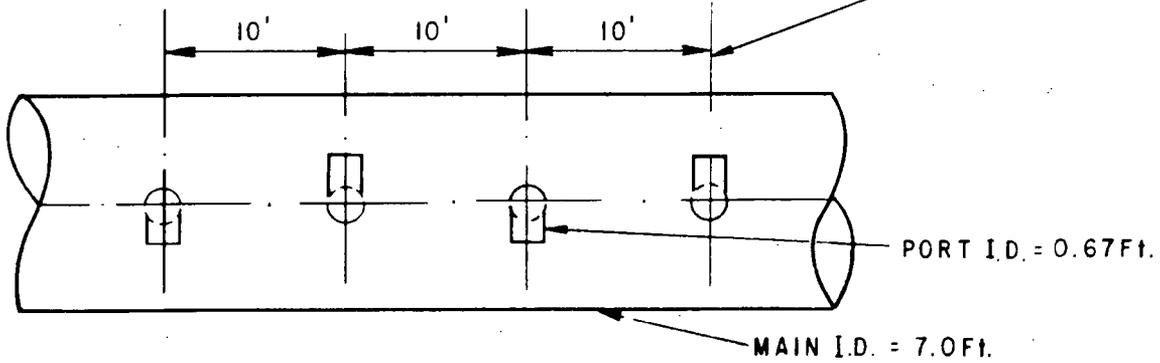


SCALE: 1" = 2000'

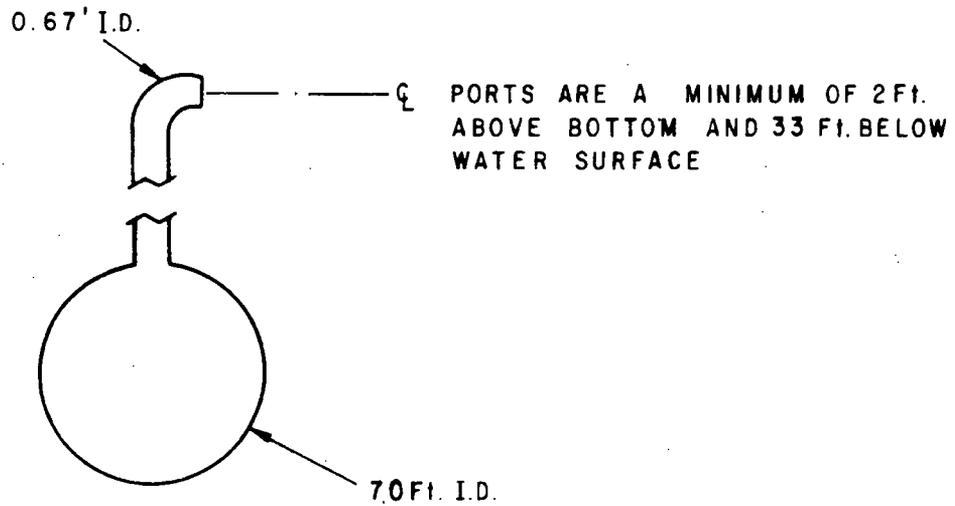
NOTE: DIFFUSER SECTION IS 660 FT. LONG  
FROM CENTER LINE OF FIRST PORT  
TO CENTER LINE OF LAST PORT

|   |   |            |
|---|---|------------|
| JERSEY CENTRAL POWER<br>AND LIGHT COMPANY | LOCATION OF DIFFUSER<br>FOR MULTI-PRESSURE<br>CONDENSER | EXHIBIT 74 |
| EBASCO SERVICES INCORPORATED<br>New York  |   |            |

THERE ARE A TOTAL OF 67 PORTS  
ON 10 FT. CENTERS FACING ALTERNATE  
DIRECTIONS



PLAN VIEW



TYPICAL SECTION

JERSEY CENTRAL POWER  
AND LIGHT COMPANY

EBASCO SERVICES INCORPORATED  
New York

PLAN AND SECTION  
OF DIFFUSER FOR  
MULTI-PRESSURE CONDENSER

EXHIBIT 75

Exhibit 76

LOW TEMPERATURE HELPER TOWER PERFORMANCE PREDICTIONS  
AVERAGE CONDITIONS

|                                  | Summer | Winter | Spring | Fall |
|----------------------------------|--------|--------|--------|------|
| Wet Bulb Temperature ( ° F)      | 66.7   | 32.3   | 45.5   | 52.5 |
| Intake Water Temperature ( ° F)  | 78.8   | 37.5   | 58.0   | 61.0 |
| Discharge Temperature            |        |        |        |      |
| Before Dilution ( ° F)           | 79.0   | 46.0   | 59.6   | 64.0 |
| Temperature Rise Above           |        |        |        |      |
| Ambient Before Dilution ( ° F)   | 0.2    | 8.5    | 1.6    | 3.0  |
| Temperature Rise After           |        |        |        |      |
| Dilution with Two Pumps ( ° F)   | 0.1    | 4.0    | 0.8    | 1.4  |
| Heat Load                        |        |        |        |      |
| (Million Btu/hour)               | 45     | 1,912  | 360    | 675  |
| Heat Load                        |        |        |        |      |
| (% of existing system heat load) | 1      | 42     | 8      | 15   |

NOTE: Results apply to Oyster Creek Station operating at full load.

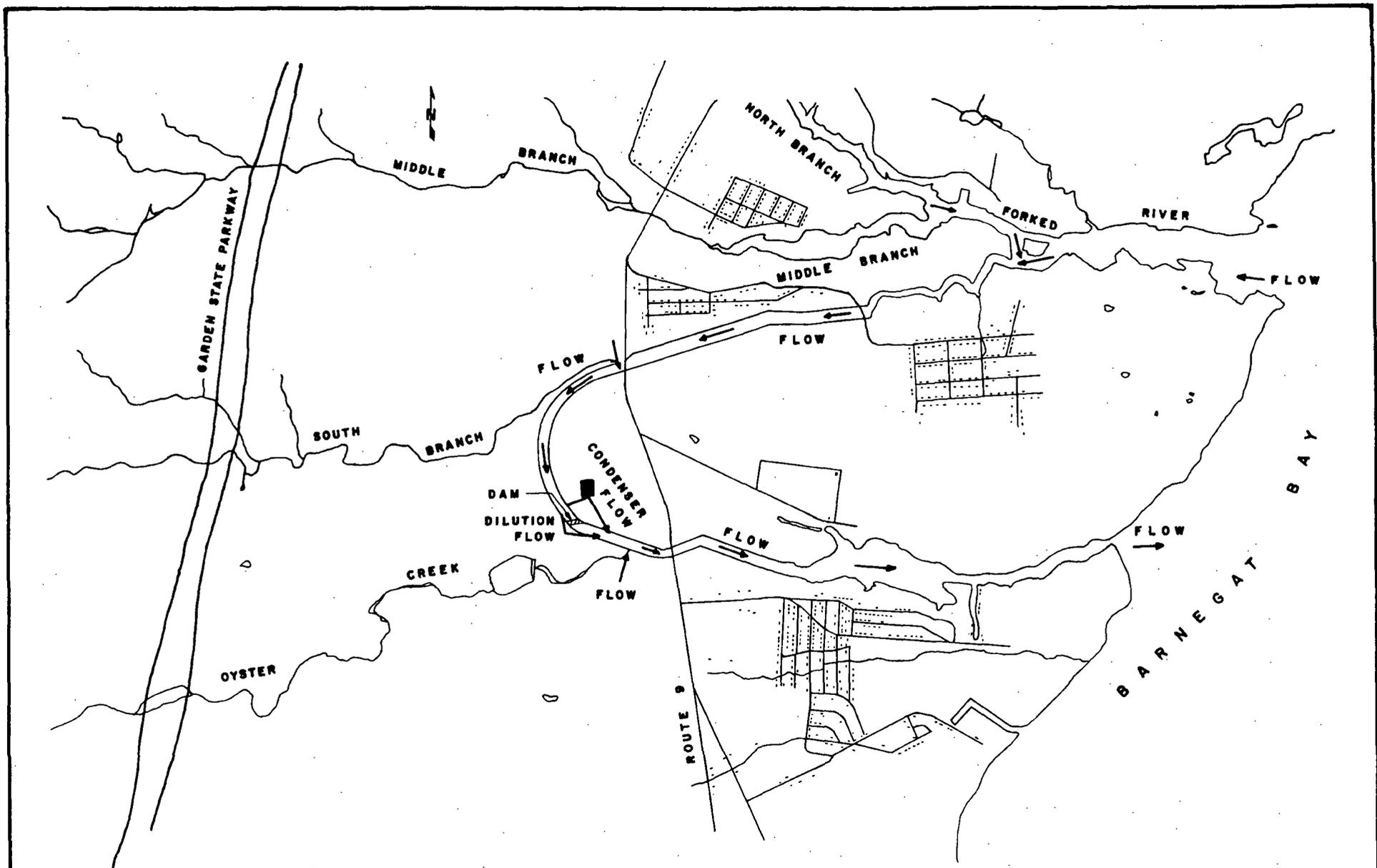
Exhibit 77

HIGH TEMPERATURE HELPER TOWER PERFORMANCE PREDICTIONS

AVERAGE CONDITIONS

|   | Summer | Winter | Spring | Fall |
|---|--------|--------|--------|------|
| Wet Bulb Temperature ( <sup>o</sup> F)                              | 66.7   | 32.3   | 45.5   | 52.5 |
| Intake Water Temperature ( <sup>o</sup> F)                          | 78.8   | 37.5   | 58.0   | 61.0 |
| Discharge Temperature<br>Before Dilution ( <sup>o</sup> F)          | 82.5   | 49.5   | 64.3   | 68.0 |
| Temperature Rise Above<br>Ambient Before Dilution ( <sup>o</sup> F) | 3.7    | 12.0   | 6.3    | 7.0  |
| Temperature Rise After<br>Dilution with Two Pumps ( <sup>o</sup> F) | 1.7    | 5.6    | 3.0    | 3.3  |
| Heat Load (Million Btu/Hour)  | 858    | 2784   | 1461   | 1624 |
| Heat Load (% of existing<br>system heat load)                       | 19     | 62     | 32     | 36   |

NOTE: Results apply to Oyster Creek Station operating at full load.



NOTE: REPRODUCED FROM REF. 3, FIG. 2.5-3

|   |   |                   |
|---|---|-------------------|
| JERSEY CENTRAL POWER<br>AND LIGHT COMPANY | <b>FLOW CHARACTERISTICS OF SURFACE<br/>WATER BODIES IN THE VICINITY<br/>OF THE OYSTER CREEK NGS</b> | <b>EXHIBIT 78</b> |
| EBASCO SERVICES INCORPORATED<br>New York  |   |                   |

## Exhibit 79

FLOW CHARACTERISTICS OF SURFACE WATER BODIES IN THE  
VICINITY OF THE OYSTER CREEK NUCLEAR GENERATING STATION

| <u>Surface Water Body</u>                        | <u>Average Flow<br/>(cfs)</u> | <u>Maximum Flow<br/>(cfs)</u> | <u>Minimum Flow<br/>(cfs)</u> | <u>Average Flow<br/>per Sq Mi of<br/>Drainage Area<br/>(cfs)</u> |
|--|-------------------------------|-------------------------------|-------------------------------|--|
| Oyster Creek <sup>(1)</sup><br>(near Brookville) | 28.3                          | 232                           | 12                            | 3.8  |
| Forked River <sup>(1)</sup>                      |                               |                               |                               |  |
| North Branch                                     | 13.7                          | 25.9                          | 5.4                           | 1.05   |
| Middle Branch                                    | 2.6 <sup>(2)</sup>            | -                             | -                             | 1.72   |
| South Branch                                     | 3.7                           | 5.4                           | 1.3                           | 2.8  |
| Tom's River <sup>(3)</sup>                       | 214                           | 855                           | 46                            | 1.72   |

(1) From USGS Surface Water Records, 1961-1974.

(2) Estimated using Tom's River flow to drainage area ratio.

(3) From USGS Surface Water Records, 1928-1974.

## Exhibit 80

TYPICAL WATER QUALITY ANALYSIS  
FOR SURFACE WATER BODIES IN THE VICINITY OF THE OYSTER CREEK NUCLEAR GENERATING STATION<sup>(1)</sup>

| Parameter                  | Units                  | Oyster<br>Creek | Forked River <sup>(2)</sup><br>North Branch | Forked River<br>South Branch | Tom's<br>River |
|----------------------------|------------------------|-----------------|---|------------------------------|----------------|
| Acidity, total             | mg/l-CaCO <sub>3</sub> | 5.0             | 5.0   | 5.0                          | 5.0            |
| Alkalinity, total          | mg/l-CaCO <sub>3</sub> | 2.8             | 2   | 2                            | 0              |
| Aluminum                   | mg/l                   | 0.2             | -   | 0.3                          | 0.4            |
| Bicarbonate                | mg/l-CaCO <sub>3</sub> | 2               | 2   | 2                            | 0              |
| Calcium                    | mg/l                   | 2.5             | 12  | 12                           | 2.8            |
| Carbon Dioxide             | mg/l                   | 8               | -   | -                            | -              |
| Carbonate                  | mg/l-CaCO <sub>3</sub> | 0               | -   | 0                            | 0              |
| Chloride                   | mg/l                   | 6.4             | 284   | 5.5                          | 7              |
| Color                      | units                  | 12              | 103   | 3                            | 8              |
| Conductivity               | umhos/cm               | 41              | 1680  | 70                           | 65             |
| Hardness                   |                        |                 |   |                              |                |
| Non-Carbonate total        | mg/l-CaCO <sub>3</sub> | 5               | -   | 4                            | 12             |
| Total                      | mg/l-CaCO <sub>3</sub> | 10              | 90  | 5                            | 12             |
| Iron                       | mg/l                   | 0.2             | 0.3   | 0.3                          | 0.7            |
| Magnesium                  | mg/l                   | 0.5             | 0.5   | 0.5                          | 0.5            |
| Manganese                  | mg/l                   | 0.05            | -   | 0.04                         | 0.04           |
| Nitrogen                   |                        |                 |   |                              |                |
| Ammonia                    | mg/l-N                 | 0.20            | 0.044                                       | 0.01                         | 0.4            |
| Nitrate                    | mg/l-N                 | 0.40            | 0.42  | 0.2                          | 0.5            |
| Phosphate, total           | mg/l-PO <sub>4</sub>   | 0.12            | 0.04  | 0.04                         | 0.18           |
| pH                         | units                  | 4.8             | 5.3   | 5.0                          | 4.5            |
| Residue, filterable        | mg/l                   | 25              | -   | -                            | -              |
| Residue, non-filterable    | mg/l                   | -               | 20  | -                            | 38             |
| Residue, total             | mg/l                   | 35              | 874   | 40                           | 45             |
| Silica (SiO <sub>2</sub> ) | mg/l                   | 3.5             | 5   | 5.2                          | 4.4            |
| Sodium                     | mg/l                   | 3.2             | -   | 4.8                          | 5.0            |
| Sulfate                    | mg/l-SO <sub>4</sub>   | 6.3             | -   | 5.5                          | 1.9            |
| Turbidity                  | JTU                    | 10              | -   | 15                           | -              |
| Zinc                       | mg/l                   | 0.02            | 0.05  | 0.05                         | 0.015          |

(1) Compiled from Storet, USGS and Oyster Creek NGS Environmental Report Data Sources.

(2) Statistical Data for a number of parameters reflect Tidal Effects from Barnegat Bay.

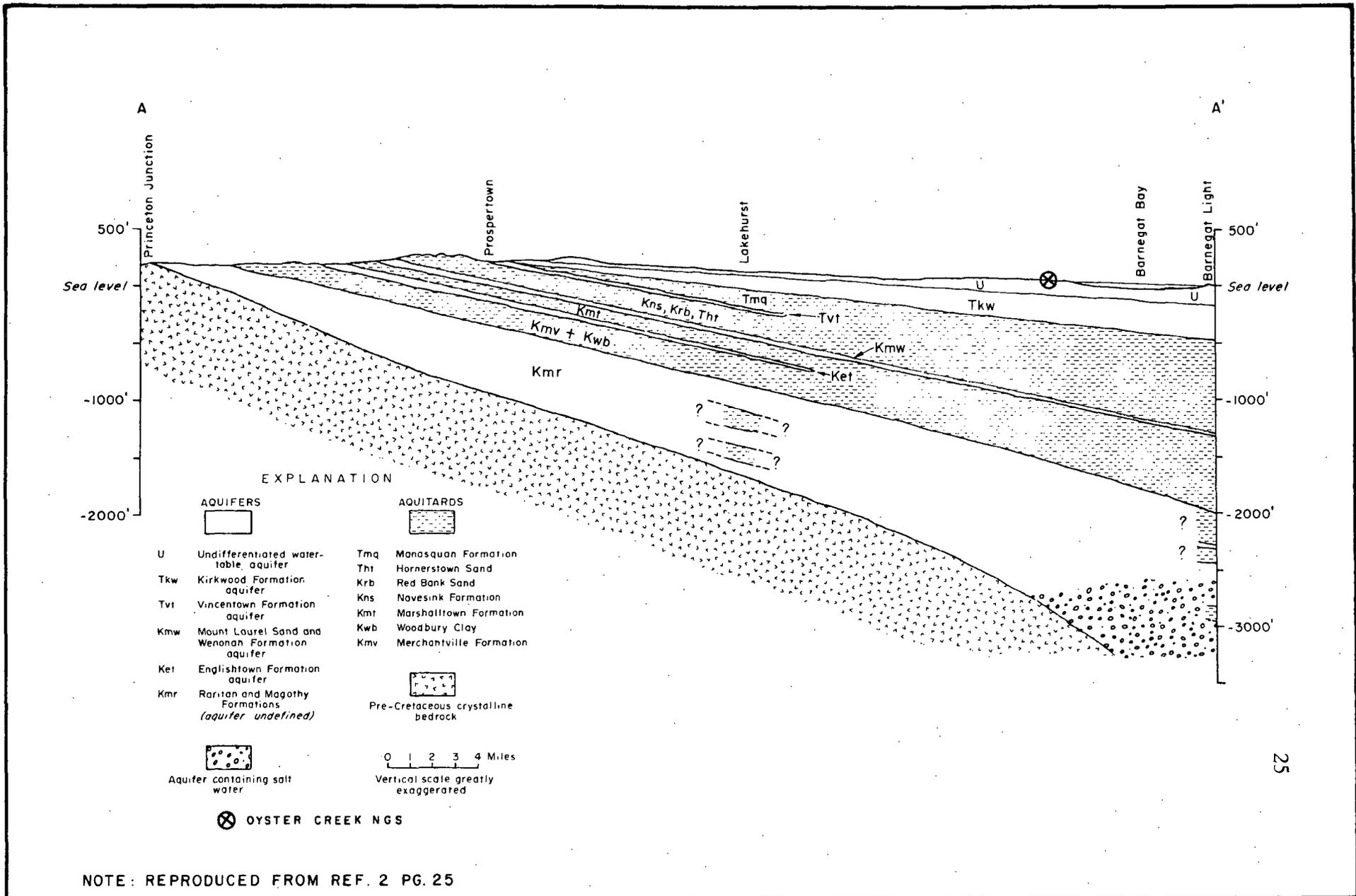
| System                 | Series  | Group     | Formation  | Lithology  | Thickness  | Water-bearing character   |
|------------------------|---|-----------|--|--|--|---|
| Quaternary             | Holocene  |           | Alluvium, beach sand and gravel  | Gravel, sand, and clay   | 0-50   | Unconfined water-table aquifer. Capable of yielding moderate to large quantities of water. Locally acidic, high in iron, and may have an odor. Contains saline water along the barrier bar and adjacent to Barnegat Bay. Utilized principally in Lakehurst and Toms River area where the average well yields are 320 gpm. Average specific capacity 12.8 gpm per foot. Confined water encountered beneath black clay layer along coast. |
|                        |   |           | Cape May Formation   |  | 0-20   |   |
|                        |   |           | Pemauken Formation   |  |  |   |
|                        | Pleistocene   |           | Bridgeton Formation  |  |  |   |
| Tertiary               | Miocene(?) and Pliocene(?)  |           | Beacon Hill Gravel   |  |  |   |
|                        | Miocene(?) and Pliocene(?)  |           | Coahancy Sand  | Sand, quartz, fine- to coarse-grained, locally clayey and clay.  | 0-200  |   |
|                        | Miocene   |           | Kirkwood Formation   | Sand, quartz, very fine to medium and coarse grained, micaceous, lignitic, silt, gray clay, and fine gravel lenses.  | 0-500  | Confined aquifer. Yields moderate quantities of water. Locally may be acidic and high in iron content. Average well yield 420 gpm. Average specific capacity 10.6. Utilized chiefly on Long Beach Island and along coast north to Point Pleasant.   |
|                        | Eocene  |           | Manasquan Formation  | Sand, Quartz-glaucouite medium to coarse-grained, clayey, fossiliferous.   | 18-392   | Aquitard - locally water bearing.   |
|                        | Paleocene   | Bancoas   | Vincentown Formation   | Upper - calcareous, fine to medium-grained, glauconitic, quartzitic, fossiliferous. Lower - sand, quartz, glauconitic, fine to coarse-grained, clayey. Downdip - clay, glauconitic, fossiliferous. | 25-328   | Near outcrop, aquifer yields small quantities of water to domestic wells. Average yield 50 gpm. Average specific capacity 1. Water high in calcium, bicarbonate, and hardness. Downdip unit is an aquitard.   |
|                        |   |           | Hornertown Sand  | Sand, glauconite, medium- to coarse-grained, clayey, fossiliferous.  | 30-50  | Aquitard containing shell beds that yield small quantities of water.  |
|                        | Upper Cretaceous  | Middmouth | Red Bank Sand  | Sand, quartz-glaucouite, fine- to coarse-grained, clayey, lignitic.  | 10-50  |   |
|                        |   |           | Navesink Formation   | Sand, glauconitic, fine- to coarse-grained, clayey, fossiliferous.   | 2-100  |   |
|                        |   |           | Mount Laurel Sand  | Sand, quartz, fine- to coarse-grained, glauconitic, fossiliferous.   | 40-128   | Confined aquifer. Yields small quantities of water. Average well yield 70 gpm. Non-water bearing in southern half of county.  |
|                        | Upper Cretaceous  | Matawan   | Winnah Formation   | Sand, quartz, fine-grained, micaceous, lignitic and silt, clayey.  |  | Aquitard.   |
| Marshalltown Formation |   |           | Sand, glauconite and quartz, fine- to medium-grained, clayey, fossiliferous. | 10-25  |  |   |
| Englishtown Formation  |   |           | Sand, quartz, fine- to medium-grained, micaceous, lignitic, clay seams.      | 0-75   | Confined aquifer. Absent in southern half of county. Yields moderate quantities of water. Average well yield 260 gpm. Average specific capacity 2.6 gpm per foot.  |   |
| Woodbury clay          |   |           | Clay and silt, glauconitic, fossiliferous.                                   | 100-212  | Aquitard.  |   |
| Merehanville Formation |   |           |  |  |  |   |
| Magohy Formation       |   |           | Sand, quartz, very fine- to medium-grained, glauconitic, micaceous, clay.    | 100-2,000  | Several confined aquifers. Yields large quantities of water high in iron content. Average well yield 600 gpm. Average specific capacity 20.0 gpm per foot. Ground-water temperature above 70°F. Saline water below 2,500-foot depth. |   |
| Farran Formation       | Sand, quartz, fine- to coarse-grained arkosic, sideritic, clay. Calcareous and kaolinitic downdip.                    |           |  |  |  |   |
| Pre-Cretaceous         | Precambrian and early Paleozoic rocks - schist, gneiss, pegmatite, and gabbro. Triassic sandstone, shale, and basalt. |           |  | Weathered gneiss   | 05   |   |
|                        |   |           |  | Biotite gneiss with pegmatite veins  | -----  |   |

NOTE: REPRODUCED FROM REF. 2, PG. 21

JERSEY CENTRAL POWER AND LIGHT COMPANY  
 EBASCO SERVICES INCORPORATED  
 New York

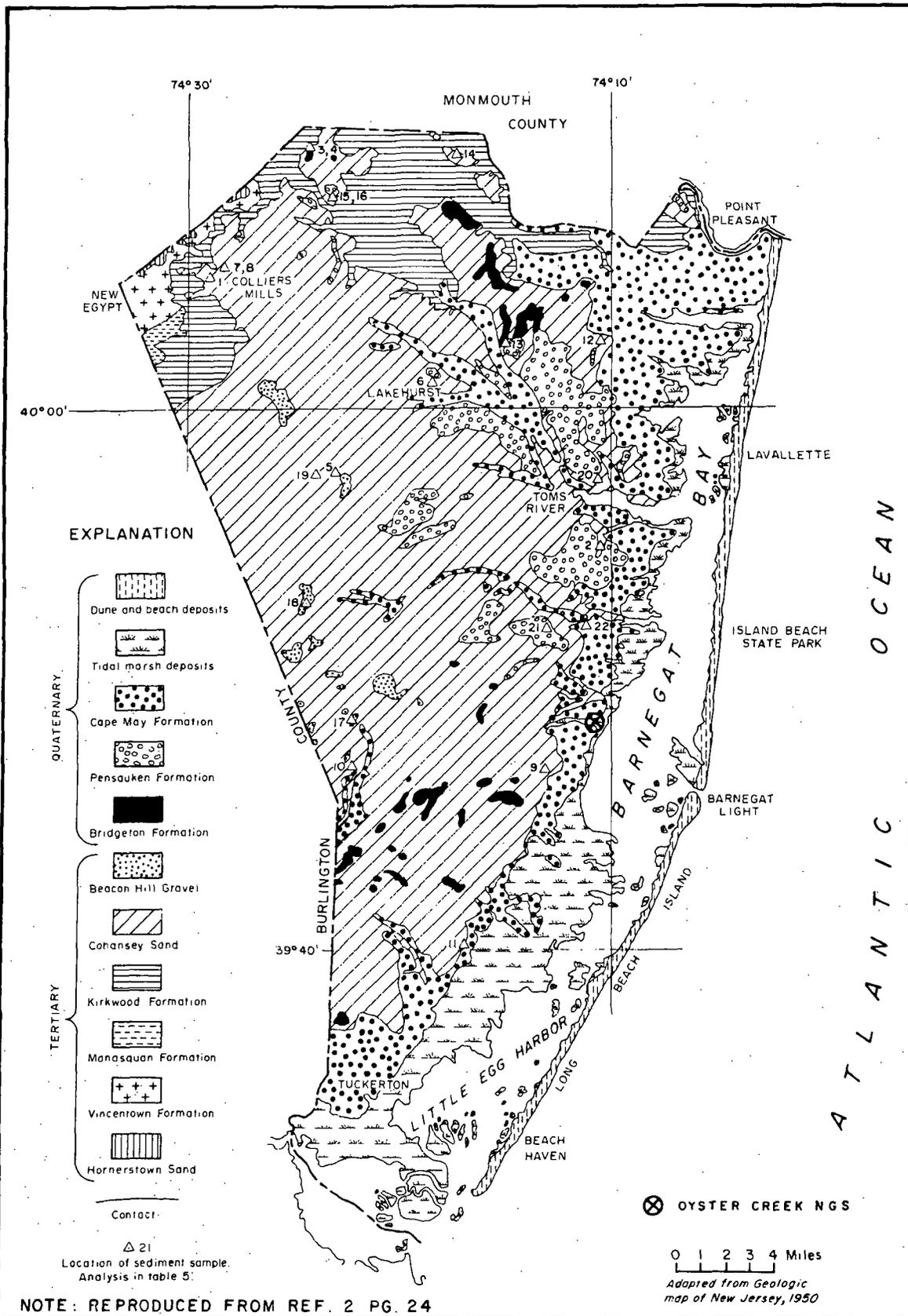
GEOLOGY AND HYDROLOGY OF THE GEOLOGIC FORMATIONS IN OCEAN COUNTY, N.J.

EXHIBIT 81



NOTE: REPRODUCED FROM REF. 2 PG. 25

|   |                                     |            |
|---|-------------------------------------|------------|
| JERSEY CENTRAL POWER<br>AND LIGHT COMPANY | GEOHYDROLOGIC SECTION, OCEAN COUNTY | EXHIBIT 82 |
| EBASCO SERVICES INCORPORATED<br>New York  |                                     |            |

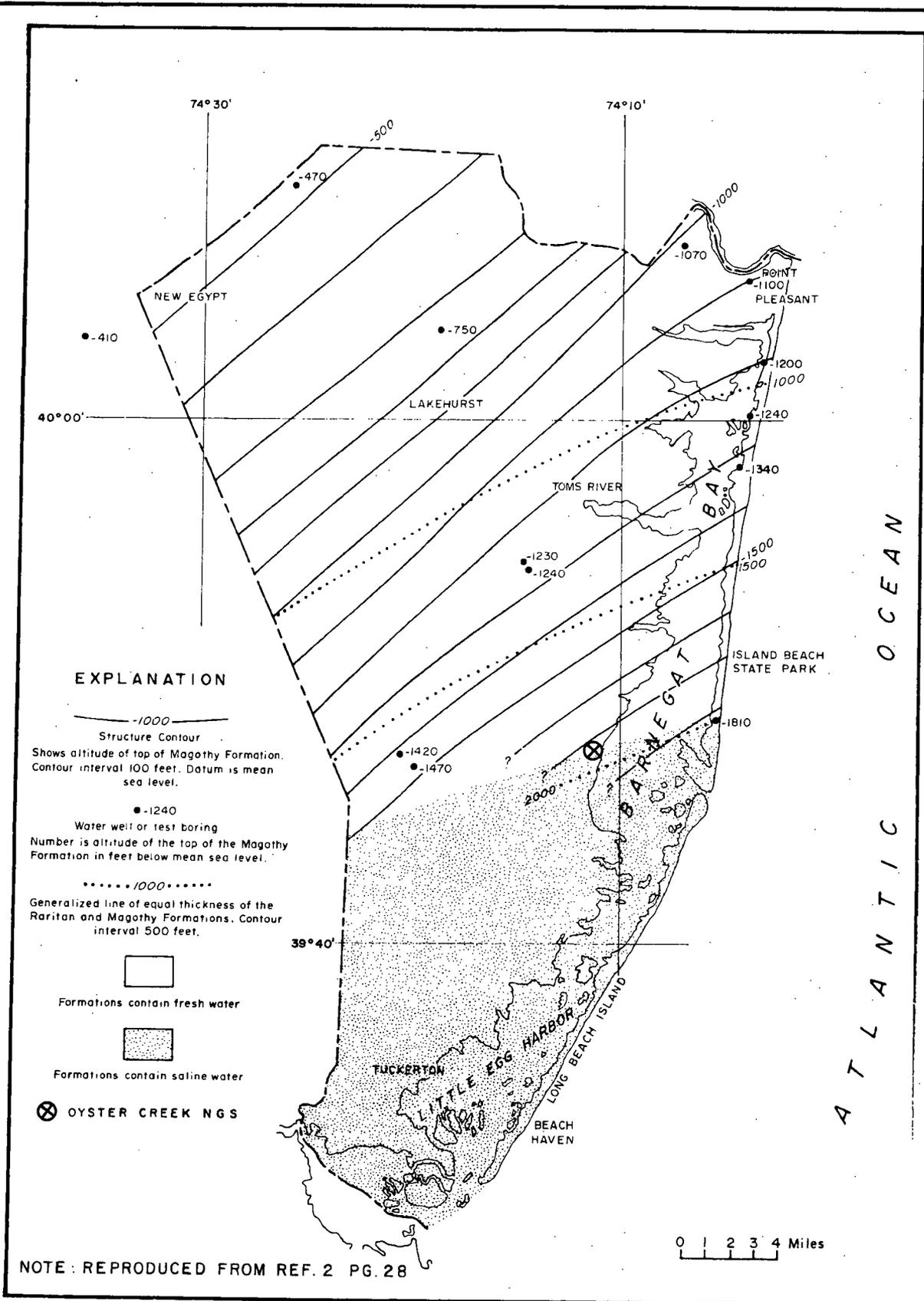


JERSEY CENTRAL POWER  
AND LIGHT COMPANY

EBASCO SERVICES INCORPORATED  
New York

GEOLOGIC MAP OF  
OCEAN COUNTY

EXHIBIT 83



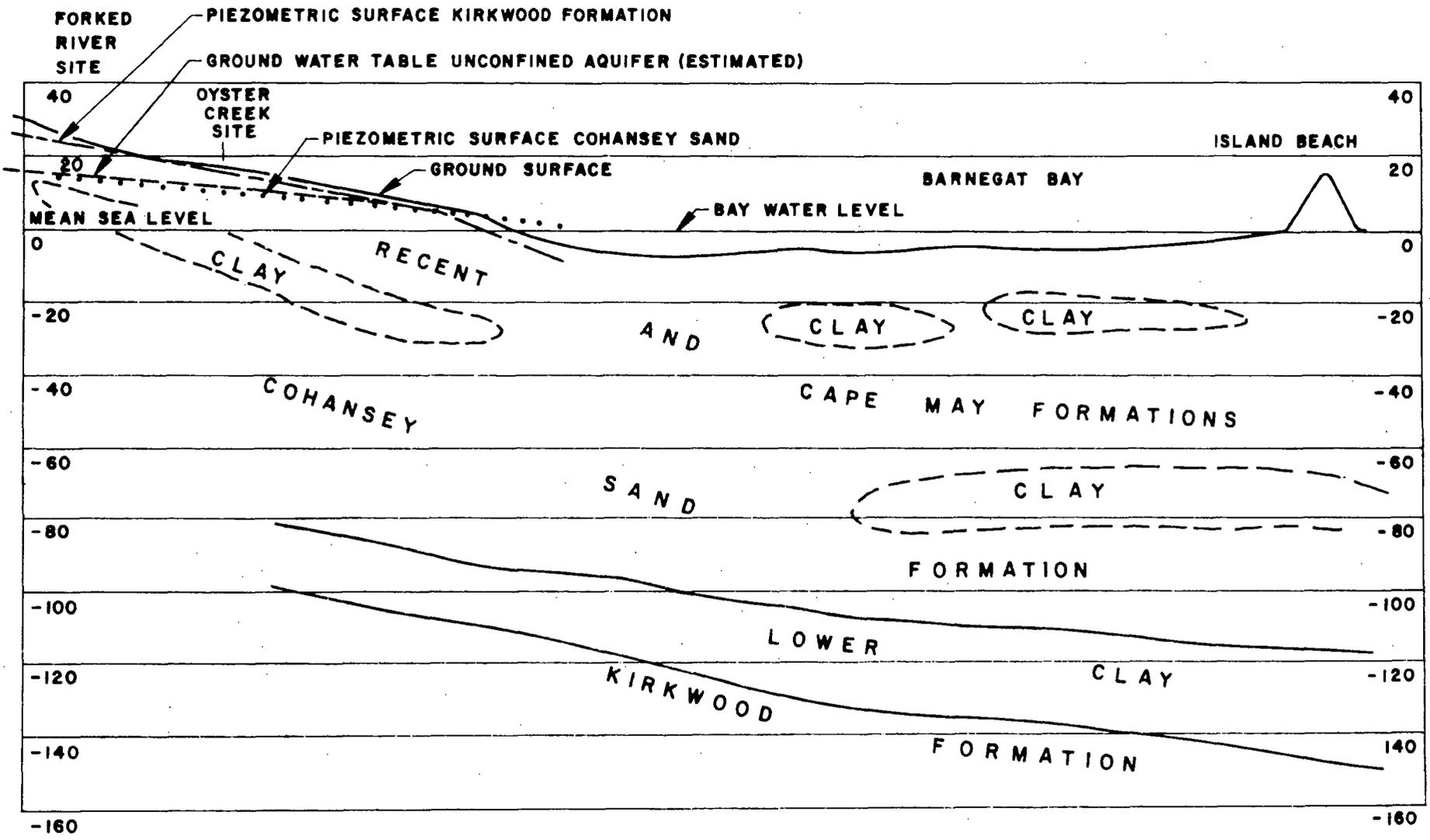
JERSEY CENTRAL POWER  
AND LIGHT COMPANY

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EBASCO SERVICES INCORPORATED  
New York

STRUCTURE CONTOUR AND  
THICKNESS MAP OF THE RARITAN  
AND MAGOTHY FORMATIONS

EXHIBIT 84



NOTE: REPRODUCED FROM REF. 3, FIG. 2.5-5

JERSEY CENTRAL POWER  
AND LIGHT COMPANY  
EBASCO SERVICES INCORPORATED  
New York

GEOHYDROLOGIC CROSS-SECTION  
AT OYSTER CREEK

EXHIBIT 85

## Exhibit 86

PHYSICAL PROPERTIES OF AQUIFERS NEAR OYSTER CREEK<sup>(1)</sup>

| <u>Aquifer</u>                                 | <u>Average Thickness</u><br>(feet) | <u>Yield of Wells</u><br>(gpm) | <u>Permeability</u><br>(gpd/ft <sup>2</sup> ) | <u>Transmissibility</u><br>(gpd/ft) | <u>Storage Coefficient</u> |
|--|------------------------------------|--------------------------------|---|-------------------------------------|----------------------------|
| Unconfined, Recent to Upper Cape May Formation | 50                                 | 10 to 1500                     | 10 to 2000                                    | 500 to 30000                        | 0.10 to 0.20               |
| Confined, Lower Cape May Formation             | 30                                 | 10 to 300                      | 100 to 1000                                   | 1000 to 15000                       | 1 X 10 <sup>-3</sup>       |
| Cohansey Sand                                  | 60                                 | 400 to 1200                    | 100 to 2000                                   | 20000 to 70000                      | 1 X 10 <sup>-3</sup>       |
| Kirkwood Formation<br>Upper Sand               | 50                                 | 300                            | 100 to 1000                                   | 10000 to 40000                      | 1 X 10 <sup>-4</sup>       |
| Kirkwood Formation<br>Lower Sand               | 90                                 | 500 to 1200                    | 200 to 1200                                   | 20000 to 70000                      | 1 X 10 <sup>-4</sup>       |

<sup>(1)</sup> From Oyster Creek NGS Environmental Report, pg 2.5-14.

Exhibit 87

ELEVATION OF PIEZOMETRIC SURFACE FOR GROUNDWATER FORMATIONS  
IN THE VICINITY OF THE OYSTER CREEK NUCLEAR GENERATING STATION (1)

| <u>Aquifer</u>     | <u>Approximate<br/>Depth Range</u> | <u>Elevation (MSL) of<br/>Piezometric Surface</u>  |
|--------------------|------------------------------------|--|
| Upper confined     | 10 to 30 ±                         | + 8 feet at Oyster Creek   |
| Cohansey Sand      | 10 to 90 ±                         | + 14 feet at Forked River Site<br>+ 10 feet at Oyster Creek Site<br>+ 4 feet at Barnegat Bay |
| Kirkwood Formation | 90 to 300 ±                        |  |

(1) From Oyster Creek NGS Environmental Report, pg 2.5-13

Exhibit 88

CHEMICAL COMPOSITION OF WATER IN THE MAJOR AQUIFERS IN THE OYSTER CREEK AREA<sup>(1)</sup>

| Aquifer   | Temperature<br>(°F) | Iron<br>(fe) | Calcium<br>(Ca)          | Magnesium<br>(Mg)        | Chloride<br>(Cl) | Silica<br>(SiO <sub>2</sub> ) | Total<br>Dissolved<br>Solids | pH         |
|---|---------------------|--------------|--------------------------|--------------------------|------------------|-------------------------------|------------------------------|------------|
| Unconfined, Re-<br>cent Cape May<br>Formation         | (3) 56 to 59        | .2 to 10     | 12 to 300 <sup>(2)</sup> | 12 to 300 <sup>(2)</sup> | 15 to 44         | -                             | -                            | 6.1 to 8.4 |
| Confined, Lower<br>Cape May<br>Formation              | (3) 58 to 62        | .5 to 1.4    | 9 to 26                  | 1 to 8                   | 11 to 17         | -                             | 80 to 170                    | 6.9 to 7.6 |
| Cohansey Sand   | (3) 57 to 62        | .1 to 4.0    | 6 to 98                  | 2 to 56                  | 11 to 64         | -                             | 100 to 400                   | 6.9 to 8.2 |
| Kirkwood Forma-<br>tion (Upper<br>and Lower<br>Zones) | (4) 54 to 62        | 0.04 to 25   | 1.2 to 73                | 0.7 to 21                | 3 to 264         | 4.9 to 32                     | 40 to 688 <sup>(5)</sup>     | 4.0 to 8.3 |

(1) With the exception of temperature and pH, all values for constituents are given in parts per million.

(2) Values given are for combined total of calcium and magnesium.

(3) From Oyster Creek NGS Environmental Report, Pg 2.5-17.

(4) From Special Report #29 (Reference 1), Table 6, Pg 77-79.

(5) Maximum value experienced at one station only; average of other wells is 90 mg/l.

Exhibit 89

OYSTER CREEK WELL WATER ANALYSIS<sup>(1)</sup>  
(Kirkwood Formation)

| <u>Constituent</u>                                 | <u>Parts per Million</u> |
|--|--------------------------|
| Calcium  | 5.82                     |
| Magnesium  | 1.30                     |
| Sodium and Potassium (by difference)               | 16.56                    |
| Chloride   | 19.00                    |
| Sulfate  | 7.50                     |
| Nitrate  | 0.25                     |
| Phosphate  | 1.95                     |
| Bicarbonate  | 0.00 <sup>(2)</sup>      |
| Silica   | 10.80                    |
| Iron (total)                                       | 3.75                     |
| Manganese  | 0.01                     |
| Total Residue                                      | 96.0                     |
| Suspended Matter                                   | 0.0                      |
| Volatile Residue                                   | 36.0                     |
| Hardness as Calcium Carbonate (CaCO <sub>3</sub> ) | 26.6 (Ca, Mg & Fe)       |
| Phenol Phthalein Alkalinity (CaCO <sub>3</sub> )   | 0.0                      |
| Methyl Orange Alkalinity (CaCO <sub>3</sub> )      | 18.0                     |
| pH, units  | 6.35                     |
| Biochemical Oxygen Demand                          | 0.0                      |

(1) From Oyster Creek NGS Environmental Report, Pg 2.5-18

(2) Value in doubt based on pH and alkalinity measurements

Exhibit 90

ESTIMATED BARNEGAT BAY AND ATLANTIC OCEAN WATER QUALITY

| Parameter                       | Barnegat Bay      |                   | Atlantic Ocean <sup>(1)</sup> |
|---------------------------------|-------------------|-------------------|-------------------------------|
|                                 | Average<br>(mg/l) | Maximum<br>(mg/l) | Average<br>(mg/l)             |
| Calcium                         | 278               | 348               | 406                           |
| Magnesium                       | 886               | 1107              | 1292                          |
| Sodium                          | 7347              | 9183              | 10,714                        |
| Potassium                       | 264               | 330               | 385                           |
| Chloride                        | 13,200            | 16,500            | 19,250                        |
| Sulfate                         | 1843              | 2304              | 2688                          |
| Nitrate                         | -                 | -                 | -                             |
| Phosphate                       | 0.08              | 0.1               | 0.12                          |
| Bicarbonate                     | 100               | 123               | 144                           |
| Silica                          | 2.2               | 2.7               | 3.2                           |
| Iron                            | 0.001             | 0.002             | 0.002                         |
| Manganese                       | 0.003             | 0.004             | 0.005                         |
| Zinc                            |                   |                   | 0.005                         |
| Salinity                        | 24,000            | 30,000            | 35,000                        |
| Alkalinity as CaCO <sub>3</sub> | 82                | 104               | 118                           |
| pH, units                       | 7.7               | 8.3               | 8.3                           |

(1) Based on information presented in References 8 and 9.

Exhibit 91

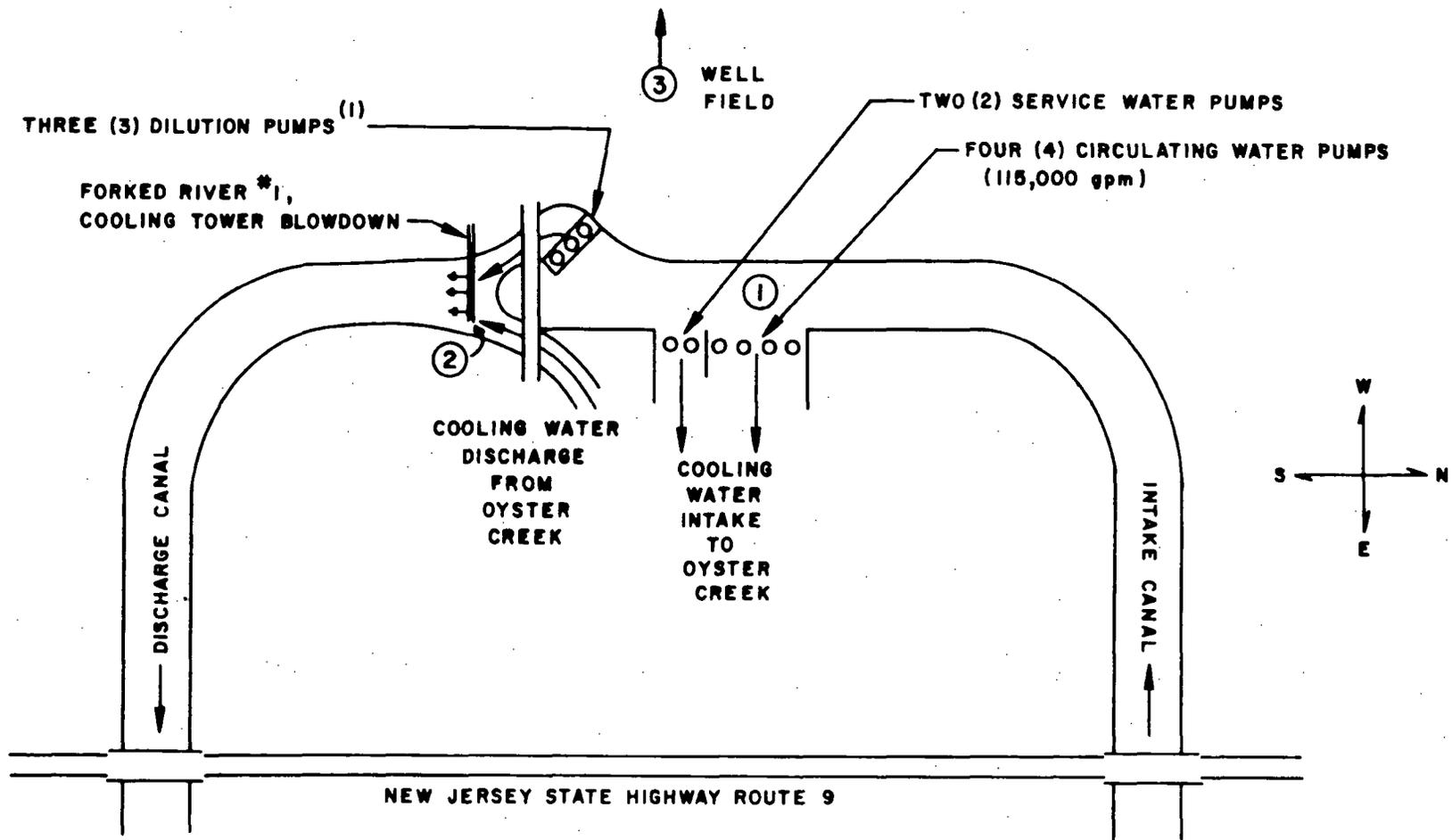
OYSTER CREEK NUCLEAR GENERATING STATION INTAKE WATER ANALYSIS

| Constituents (1)                 | Average (2) | Maximum (3) |
|----------------------------------|-------------|-------------|
| Calcium                          | 289         | 364         |
| Magnesium                        | 881         | 1,111       |
| Sodium                           | 6,878       | 8,672       |
| Potassium                        | 256         | 323         |
| Chloride                         | 12,680      | 15,989      |
| Sulphate                         | 1,816       | 2,290       |
| Nitrate                          | 0.00        | 0.20        |
| Phosphate                        | 0.70        | 0.90        |
| Bicarbonate                      | 100         | 126         |
| Silica                           | 18.00       | 23          |
| Iron                             | 0.60        | 0.76        |
| Manganese                        | 0.01        | 0.013       |
| Zinc                             | 0.01        | 0.013       |
| Salinity                         | 23,000      | 29,000      |
| Alkalinity, as CaCO <sub>3</sub> | 82          | 104         |
| pH                               | 6.95        | 7.8         |

(1) All values reported in mg/l except pH which is in units

(2) From Oyster Creek NGS Environmental Report, pg. 3.4-2

(3) Estimated from Maximum Reported Canal Salinity and the percent of Salinity encountered for All Average Parameter Concentrations.



NOTE: ① LOCATIONS REFERED TO IN EXHIBIT II-36

JERSEY CENTRAL POWER  
AND LIGHT COMPANY  
EBASCO SERVICES INCORPORATED  
New York

SCHÉMATIC DIAGRAM OF OYSTER CREEK AND FORKED  
RIVER NGS INTAKE AND DISCHARGE CANAL

EXHIBIT 92

(1)

SUMMARY OF CONDENSER COOLING WATER SYSTEM OPERATIONAL PARAMETERS

| System                                      | Makeup<br>Flow<br>(gpm) | Blowdown<br>Flow<br>(gpm) | Evaporation<br>Rate<br>(gpm) | Cycle of<br>Concentration | Makeup (2)<br>Location | Discharge (2)<br>Location |
|---|-------------------------|---------------------------|------------------------------|---------------------------|------------------------|---------------------------|
| Mechanical<br>Draft Cool-<br>ing Tower      | 22,410                  | 14,940                    | 7,470                        | 1.5                       | 1                      | 2                         |
| Natural<br>Draft Cool-<br>ing Tower         | 22,200                  | 14,800                    | 7,400                        | 1.5                       | 1                      | 2                         |
| Cooling<br>Pond<br>500 Acres                | 23,268                  | 15,512                    | 7,756                        | 1.5                       | 1                      | 2                         |
| Cooling<br>Pond<br>1000Acres                | 26,379                  | 17,586                    | 8,793                        | 1.5                       | 1                      | 2                         |
| Spray<br>Canal                              | 23,403                  | 15,602                    | 7,801                        | 1.5                       | 1                      | 2                         |
| Salt Water<br>Wet/Dry<br>Cooling System     | 21,000                  | 14,000                    | 7,000                        | 1.5                       | 1                      | 2                         |
| Fresh Water<br>Wet/Dry<br>Cooling<br>System | 8,700                   | 2,900                     | 5,800                        | 3                         | 3                      | 2                         |
| Helper<br>Tower<br>System                   | 462,000                 | 455,300                   | 6,700                        | Once-Through              | 1                      | 2                         |
| Ocean<br>Once-Through<br>System             | 462,000                 | 462,000                   | --                           | Once-Through              | 4                      | 4                         |

(1) ALL FLOWS REPRESENT DESIGN CONDITIONS

(2) LOCATIONS DEPICTED IN FIGURE II-35

Exhibit 94

CONDENSER COOLING WATER SYSTEM BLOWDOWN QUALITY

| Parameter (1)                     | Recirculating Cooling Water Systems (2) |         | Freshwater (3)                  |
|-----------------------------------|---|---------|---------------------------------|
|                                   | Average                                 | Maximum | Wet/Dry Tower System<br>Average |
| Calcium                           | 433.5                                   | 546     | 17.46                           |
| Magnesium                         | 1321                                    | 1666    | 3.9                             |
| Sodium                            | 10,317                                  | 13,008  | 49.68                           |
| Potassium                         | 384                                     | 484     | -                               |
| Chloride                          | 19,020                                  | 23,983  | 57.0                            |
| Sulfate                           | 2724                                    | 3435    | 22.5                            |
| Nitrate                           | 0.0                                     | 0.3     | 0.75                            |
| Phosphate                         | 1.05                                    | 1.35    | 5.85                            |
| Bicarbonate                       | 150                                     | 189     | 45.9                            |
| Silica                            | 27                                      | 34      | 32.4                            |
| Iron                              | 0.9                                     | 1.14    | 11.25                           |
| Manganese                         | 0.015                                   | 0.02    | 0.03                            |
| Zinc                              | 0.015                                   | 0.02    | -                               |
| Salinity (Total Dissolved Solids) | 34,500                                  | 43,500  | 288                             |
| Alkalinity as CaCO <sub>3</sub>   | 123                                     |         | 54                              |
| pH                                | 7.5                                     | 8.3     | 7.5                             |

(1) All water quality parameters expressed in mg/l except pH which is in units

(2) Includes Mechanical and Natural Draft Tower Systems and Cooling Pond and Spray Canal Alternates and Salt Water Wet/Dry System; all at 1.5 cycles of concentration

(3) Utilizes groundwater only and operates at 3 cycles of concentration

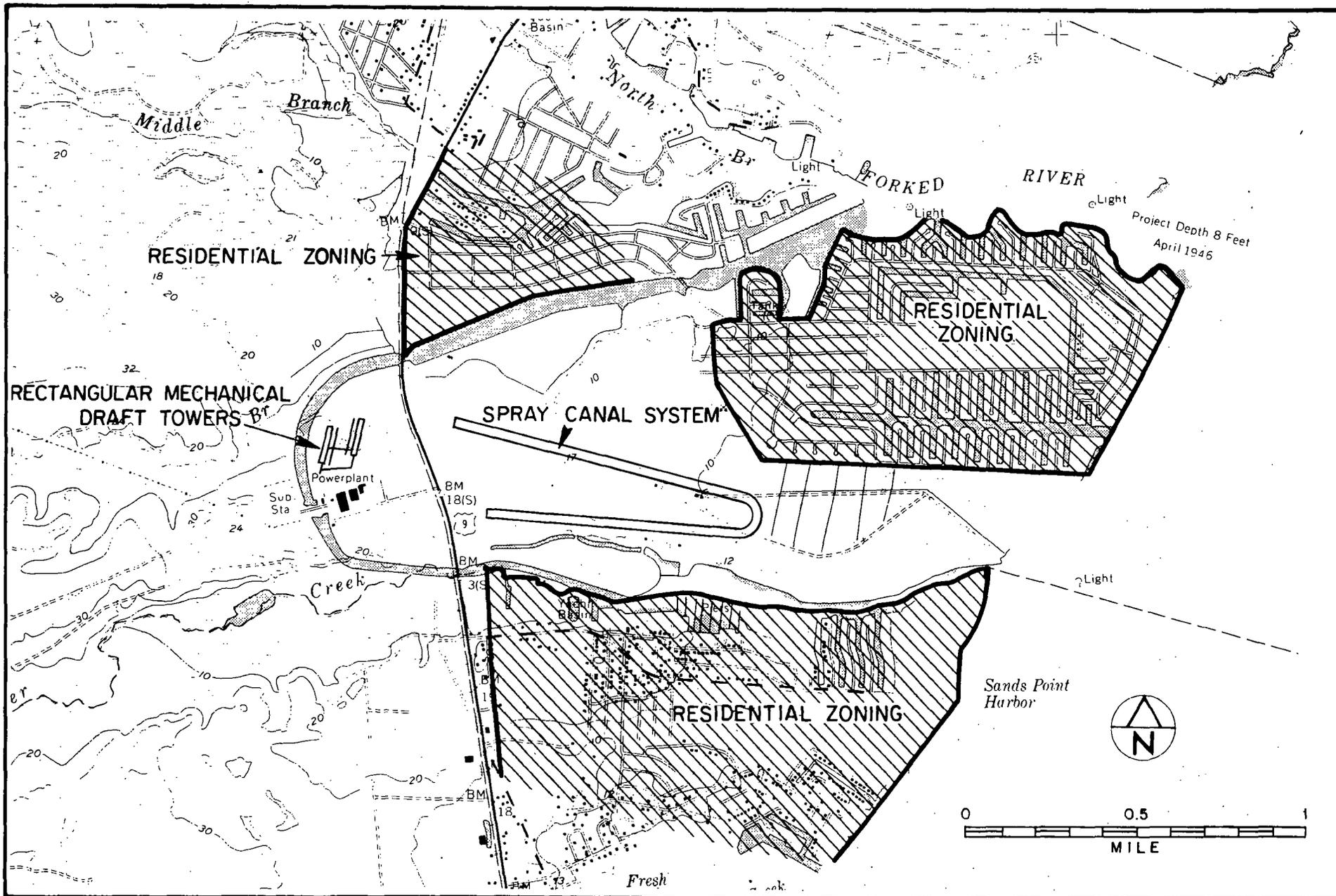
## SUMMARY OF RESULTANT WATER QUALITY CONCENTRATIONS IN RECEIVING WATER BODY AFTER MIXING

| Parameter (2)                    | Natural & Mechanical Draft Towers |         | Cooling Pond 500 Acres |         | Cooling Pond 1000 Acres |         | Salt Water Wet/Dry Tower System |         | Spray Canal |         | Freshwater Wet/Dry Tower System |         | Helper Tower System |         | Ocean Once-Through |
|----------------------------------|-----------------------------------|---------|------------------------|---------|-------------------------|---------|---------------------------------|---------|-------------|---------|---------------------------------|---------|---------------------|---------|--------------------|
|                                  | Average                           | Maximum | Average                | Maximum | Average                 | Maximum | Average                         | Maximum | Average     | Maximum | Average                         | Maximum | Average             | Maximum | Average            |
| Calcium                          | 299                               | 377     | 299                    | 377     | 300                     | 378     | 299                             | 376     | 299         | 377     | 294                             | 370     | 294                 | 370     | 406                |
| Magnesium                        | 912                               | 1150    | 912                    | 1150    | 914                     | 1152    | 911                             | 1149    | 912         | 1150    | 896                             | 1130    | 897                 | 1131    | 1292               |
| Sodium                           | 7119                              | 8976    | 7119                   | 8976    | 7132                    | 9086    | 7112                            | 8967    | 7119        | 8976    | 6993                            | 8817    | 7002                | 8828    | 10,714             |
| Potassium                        | 265                               | 334     | 265                    | 334     | 265                     | 335     | 265                             | 334     | 265         | 334     | -                               | -       | 261                 | 329     | 385                |
| Chloride                         | 13,124                            | 16,549  | 13,124                 | 16,549  | 13,149                  | 16,581  | 13,111                          | 16,533  | 13,124      | 16,549  | 12,891                          | 16,255  | 12,908              | 16,277  | 19,250             |
| Sulphate                         | 1,946                             | 2,370   | 1,946                  | 2,370   | 1,950                   | 2,375   | 1,878                           | 2,368   | 1,946       | 2,370   | 1,846                           | 2,328   | 1,849               | 2,331   | 2,688              |
| Nitrate                          | 0.0                               | 0.21    | 0.0                    | 0.21    | 0.0                     | 0.21    | 0.0                             | 0.21    | 0.0         | 0.21    | 0.004                           | 0.21    | 0.0                 | 0.20    | -                  |
| Phosphate                        | 0.72                              | 0.93    | 0.72                   | 0.93    | 0.73                    | 0.93    | 0.72                            | 0.93    | 0.72        | 0.93    | 0.74                            | 0.95    | 0.71                | 0.92    | 0.12               |
| Bicarbonate                      | 103                               | 130     | 103                    | 130     | 104                     | 131     | 103                             | 130     | 103         | 130     | 102                             | 128     | 102                 | 128     | 144                |
| Silica                           | 18.6                              | 24      | 18.6                   | 24      | 18.7                    | 24      | 18.6                            | 24      | 18.6        | 24      | 18.5                            | 23.6    | 18.3                | 23      | 3.2                |
| Iron                             | 0.62                              | 0.79    | 0.62                   | 0.79    | 0.62                    | 0.79    | 0.62                            | 0.79    | 0.62        | 0.79    | 0.67                            | 0.83    | 0.61                | 0.77    | 0.002              |
| Manganese                        | 0.01                              | 0.013   | 0.01                   | 0.013   | 0.01                    | 0.013   | 0.01                            | 0.013   | 0.01        | 0.013   | 0.01                            | 0.013   | 0.01                | 0.013   | 0.005              |
| Zinc                             | 0.01                              | 0.013   | 0.01                   | 0.013   | 0.01                    | 0.013   | 0.01                            | 0.013   | 0.01        | 0.013   | -                               | -       | 0.01                | 0.013   | 0.005              |
| Salinity                         | 23,805                            | 30,015  | 23,805                 | 30,015  | 23,851                  | 30,073  | 23,782                          | 29,986  | 23,805      | 30,015  | 23,384                          | 29,484  | 23,414              | 29,522  | 35,000             |
| Alkalinity, as CaCO <sub>3</sub> | 85                                | 108     | 85                     | 108     | 85                      | 108     | 85                              | 108     | 85          | 108     | 84                              | 106     | 84                  | 106     | 118                |
| pH                               | 7.5                               | 8.3     | 7.5                    | 8.3     | 7.5                     | 8.3     | 7.5                             | 8.3     | 7.5         | 8.3     | 7.5                             | 8.3     | 7.5                 | 8.3     | 8.3                |
| Percent Increase above Ambient   | 3.5                               |         | 3.5                    |         | 3.7                     |         | 3.4                             |         | 3.5         |         | 1.7(3)                          |         | 1.8                 |         | 0                  |

(1) Mixing of Oyster Creek NGS Cooling System Blowdown with the Flow from Forked River NGS and Two Dilution Pumps.

(2) All water quality concentrations are expressed in mg/l except pH which is in units.

(3) Percent increase for most parameters; nutrients (5%) and iron (11%) exhibit more substantial increases.



JERSEY CENTRAL POWER  
AND LIGHT COMPANY

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EBASCO SERVICES INCORPORATED  
New York

RESIDENTIALLY ZONED PROPERTIES  
IN THE SITE VICINITY

EXHIBIT 96

SUMMARY OF VISUAL/ESTHETIC IMPACTS

| <u>Cooling System</u>         | <u>Permanent<br/>Loss of<br/>Vegetative<br/>Cover</u> | <u>Profile<br/>Impact</u> | <u>Visible<br/>Plume</u> | <u>Ground<br/>Fog</u> |
|-------------------------------|---|---------------------------|--------------------------|-----------------------|
| Rectangular Mechanical Towers | None  | High                      | Low                      | High                  |
| Helper Towers                 | None  | High                      | Low                      | High                  |
| Natural Draft Towers          | None  | High                      | Moderate                 | None                  |
| Round Mechanical Towers       | None  | High                      | Moderate                 | None                  |
| Wet/Dry Mechanical Towers     | None  | High                      | Low                      | Low                   |
| Dry Towers                    | None  | High                      | None                     | None                  |
| Spray Canal System            | Low   | Low                       | Low                      | Moderate              |
| Cooling Ponds                 | High  | Low                       | None                     | Moderate              |
| Canal-to-Bay Discharge        | Low   | Low                       | None                     | Low                   |
| Ocean Intake-Discharge        | None  | Low                       | None                     | None                  |

Note: Low - the impact is not a concern in the cooling system elimination system.

Moderate - the impact approaches a level of concern in the cooling system elimination process.

High - the impact is of sufficient magnitude to warrant serious consideration in the cooling system elimination process.

Exhibit 98

Commercial fish landings for Atlantic County, New Jersey in 1974 (From Ichthyological Associates AGS 1975).

|                     | Pounds    | Rank in<br>Atlantic<br>County | Rank in<br>New Jersey |                     | Dollars | Rank in<br>Atlantic<br>County |
|---------------------|-----------|-------------------------------|-----------------------|---------------------|---------|-------------------------------|
| Summer flounder     | 670,413   | 1                             | 3                     | Summer flounder     | 258,963 | 1                             |
| Scup                | 340,842   | 2                             | 2                     | Scup                | 59,173  | 2                             |
| Silver hake         | 187,253   | 3                             | 1                     | Striped bass        | 43,911  | 3                             |
| Striped bass        | 182,141   | 4                             | 13                    | Atlantic mackerel   | 41,707  | 4                             |
| Weakfish            | 174,577   | 5                             | 5                     | Weakfish            | 21,264  | 5                             |
| Atlantic mackerel   | 162,908   | 6                             | 12                    | Black sea bass      | 19,601  | 6                             |
| Bluefish            | 116,441   | 7                             | 6                     | Silver hake         | 17,662  | 7                             |
| Black sea bass      | 56,124    | 8                             | 11                    | Swordfish           | 12,196  | 8                             |
| White perch         | 33,895    | 9                             | 20                    | Bluefish            | 9,934   | 9                             |
| Winter flounder     | 28,710    | 10                            | 18                    | White perch         | 7,732   | 10                            |
| Butterfish          | 28,311    | 11                            | 7                     | Butterfish          | 6,056   | 11                            |
| Red hake            | 22,727    | 12                            | 8                     | Atlantic cod        | 5,363   | 12                            |
| Yellowtail flounder | 21,923    | 13                            | 16                    | Tilefish            | 5,153   | 13                            |
| Tilefish            | 19,760    | 14                            | 10                    | American eel        | 4,424   | 14                            |
| Atlantic cod        | 18,553    | 15                            | 15                    | Yellowtail flounder | 3,724   | 15                            |
| Black drum          | 17,359    | 16                            | 25                    | Winter flounder     | 3,409   | 16                            |
| American eel        | 13,805    | 17                            | 17                    | Black drum          | 1,736   | 17                            |
| Swordfish           | 7,132     | 18                            | 30                    | American shad       | 1,230   | 18                            |
| American shad       | 7,017     | 19                            | 19                    | Red hake            | 987     | 19                            |
| Alewife             | 6,800     | 20                            | 28                    | Alewife             | 272     | 20                            |
| White hake          | 4,318     | 21                            | 21                    | Witch flounder      | 261     | 21                            |
| Atlantic herring    | 1,962     | 22                            | 14                    | Haddock             | 125     | 22                            |
| Witch flounder      | 1,301     | 23                            | 24                    | Tuna                | 92      | 23                            |
| Tuna                | 1,141     | 24                            | 9                     | Atlantic sturgeon   | 87      | 24                            |
| Atlantic menhaden   | 709       | 25                            | 4                     | Atlantic herring    | 72      | 25                            |
| Conger eel          | 610       | 26                            | 32                    | Conger eel          | 67      | 26                            |
| Spot                | 537       | 27                            | 27                    | Spanish mackerel    | 63      | 27                            |
| Tautog              | 516       | 28                            | 26                    | Atlantic croaker    | 49      | 28                            |
| Atlantic sturgeon   | 390       | 29                            | 29                    | Spot                | 43      | 29                            |
| Haddock             | 366       | 30                            | -                     | Tautog              | 34      | 30                            |
| Atlantic croaker    | 303       | 31                            | 23                    | Atlantic menhaden   | 31      | 31                            |
| Northern kingfish   | 227       | 32                            | 41                    | King mackerel       | 10      | 32                            |
| Spanish mackerel    | 179       | 33                            | 36                    |                     |         |                               |
| King mackerel       | 34        | 34                            | -                     |                     | 525,621 |                               |
|                     | 2,129,284 |                               |                       |                     |         |                               |

Exhibit 99

Some major New Jersey Commercial fish landings for 12 months ending December 1971, 1972, 1973<sup>a</sup> (From Ichthyological Associates AGS 1974)

| Species                      | 1971       |           |                             | 1972        |           |                             | 1973        |           |                             |
|------------------------------|------------|-----------|-----------------------------|-------------|-----------|-----------------------------|-------------|-----------|-----------------------------|
|                              | lbs.       | Dollars   | Rank<br>in N. J.<br>by lbs. | lbs.        | Dollars   | Rank<br>in N. J.<br>by lbs. | lbs.        | Dollars   | Rank<br>in N. J.<br>by lbs. |
| Atlantic menhaden            | 59,836,182 | 1,023,017 | 1                           | 137,475,910 | 2,262,142 | 1                           | 154,483,250 | 3,939,309 | 1                           |
| Silver hake (whiting)        | 3,948,096  | 374,689   | 2                           | 5,439,740   | 452,744   | 2                           | 6,449,617   | 868,235   | 2                           |
| Summer flounder (fluke)      | 1,851,049  | 670,662   | 6                           | 1,851,796   | 738,312   | 6                           | 3,091,541   | 1,103,242 | 3                           |
| Scup (porgy)                 | 2,020,537  | 442,128   | 5                           | 3,646,889   | 678,881   | 3                           | 2,970,040   | 772,910   | 4                           |
| Weakfish (grey sea trout)    | 3,080,730  | 254,474   | 3                           | 3,178,790   | 332,842   | 4                           | 2,562,545   | 338,772   | 5                           |
| Bluefin tuna                 | 2,022,740  | 404,706   | 4                           | 2,151,926   | 430,394   | 5                           | 1,251,757   | 267,166   | 5                           |
| Atlantic mackerel            | 978,005    | 48,390    | 10                          | 1,511,659   | 104,818   | 7                           | 1,154,801   | 93,647    | 7                           |
| Red hake                     | 711,499    | 34,935    | 11                          | 758,914     | 43,925    | 10                          | 1,116,404   | 87,900    | 8                           |
| Yellowtail flounder          | 1,297,064  | 97,110    | 7                           | 867,103     | 89,640    | 8                           | 1,052,966   | 122,512   | 9                           |
| Butterfish                   | 1,245,480  | 193,465   | 8                           | 492,327     | 92,735    | 11                          | 1,029,938   | 157,592   | 10                          |
| Bluefish                     | 978,926    | 125,573   | 9                           | 811,636     | 123,795   | 9                           | 887,256     | 132,755   | 11                          |
| Striped bass                 | 283,174    | 83,130    | 13                          | 372,131     | 111,325   | 13                          | 776,163     | 210,277   | 12                          |
| Tilefish                     | 32,622     | 5,351     | 18                          | 244,034     | 78,416    | 14                          | 711,125     | 233,960   | 13                          |
| Black sea bass               | 296,202    | 104,883   | 12                          | 422,977     | 152,936   | 12                          | 693,925     | 263,863   | 14                          |
| American eel                 | 103,601    | 28,065    | 15                          | 262,214     | 57,763    | 15                          | 230,878     | 54,760    | 15                          |
| Winter flounder (black back) | 63,010     | 6,755     | 17                          | 94,084      | 8,976     | 18                          | 159,493     | 15,923    | 16                          |
| American shad                | 100,705    | 15,824    | 16                          | 263,121     | 33,833    | 16                          | 142,783     | 27,377    | 17                          |
| Atlantic cod                 | 137,446    | 30,594    | 14                          | 42,611      | 12,424    | 17                          | 85,004      | 26,501    | 18                          |

<sup>a</sup> Data from U. S. Dept. of Commerce, 1973; 1973-1974.

Exhibit 100

Commercial Fisheries Landing of selected species for the Mid-Atlantic Bight, New Jersey and Atlantic County, New Jersey. Weights are in thousand of pounds<sup>a</sup>.

| Fishes                                     |                   | 1974    | 1973    | 1972    | 1971   | 1970   | 1969   |
|--|-------------------|---------|---------|---------|--------|--------|--------|
| Pomatomus saltatrix<br>(blue fish)         | Atlantic County   | -       | 140     |         |        |        |        |
|  | New Jersey*       |         | 887     | 812     | 979    | 1 063  | 680    |
|  | Mid-Atlantic†     | 2 074   | 2 303   | 1 816   | 2 190  | 2 666  | 1 801  |
| Yellow tail flounder                       | Atlantic County   |         | 168     |         |        |        |        |
|  | New Jersey        | -       | 1 053   | 8 671   | 1 297  | 1 067  | 390    |
|  | Mid-Atlantic      | 2 048   | 6 087   | 8 056   | 8 540  | 5 778  | 5 089  |
| Paralichthys dentatus<br>(summer flounder) | Atlantic County   |         | 432     |         |        |        |        |
|  | New Jersey        | -       | 3 092   | 1 852   | 1 851  | 1 952  | 1 275  |
|  | Mid-Atlantic      | 5 986   | 4 917   | 2 953   | 2 940  | 2 858  | 1 850  |
| Urophycis chuss<br>(red hake)              | Atlantic County   |         | 59      |         |        |        |        |
|  | New Jersey        | -       | 1 116   | 759     | 711    | -      | 385    |
|  | Mid-Atlantic      | 1 113   | 1 454   | 1 161   | 997    | 893    | 644    |
| Alosa spp<br>(shad)                        | Atlantic County** |         | 1       |         |        |        |        |
|  | New Jersey        | -       | 143     | 263     | 101    | -      | -      |
|  | Mid-Atlantic      | -       | 308     | 375     | 222    | 314    | 342    |
| Brevoortia turannus<br>(menhaden)          | Atlantic County   | -       |         |         |        |        |        |
|  | New Jersey        |         | 154 483 | 137 476 | 59 836 | 2 282  | 1 869  |
|  | Mid-Atlantic      | 107 908 | 156 250 | 140 380 | 61 562 | 31 470 | 43 755 |
| Stenotomus chrysops<br>(porgy)             | Atlantic County   |         | 163     |         |        |        |        |
|  | New Jersey        | -       | 2 970   | 3 647   | 2 021  | 3 047  | 3 618  |
|  | Mid-Atlantic      | 9 674   | 5 873   | 4 968   | 3 389  | 4 331  | 5 255  |

a data from Gusey 1976 and Ichthyological Associates 1974, 1975

†

\*

\*\* A sapidissima landings

Exhibit 100 (Cont'd)

Commercial Fisheries Landing of selected species for the Mid-Atlantic Bight, New Jersey and Atlantic County, New Jersey. Weights are in Thousand of pounds<sup>a</sup>.

| Fishes                                    |                 | 1974   | 1973   | 1972   | 1971   | 1970   | 1969     |
|---|-----------------|--------|--------|--------|--------|--------|----------|
| Cynoscion regalis<br>(weakfish)           | Atlantic County |        | 238    |        |        |        |          |
|   | New Jersey      |        | 2 563  | 3 179  | 3 081  | 1 957  | 1 869    |
|   | Mid-Atlantic    | 4 300  | 4 200  | 5 400  | 4 600  | 2 000  | 2 000    |
| Morone saxatilis<br>(striped bass)        | Atlantic County |        | 159    |        |        |        |          |
|   | New Jersey      | -      | 776    | 372    | 283    | -      | -        |
|   | Mid-Atlantic    | 2 233  | 3 093  | 1 457  | 1 513  | 1 615  | 1 888    |
| <u>Invertebrates</u>                      |                 |        |        |        |        |        |          |
| Callinectes sapidus<br>(blue crab)        | Atlantic County |        | 127    | 114    |        |        |          |
|   | New Jersey      | -      | 2 594  | 1 452  | 1 167  | 509    | 617      |
|   | Mid-Atlantic    | 4 568  | 4 945  | 3 014  | 2 149  | 1 394  | 1 144    |
| Spisula solidissima<br>(surf clam)        | Atlantic County |        | 4 743  | 1 403  |        |        |          |
|   | New Jersey      | -      | 21 588 | 21 332 | 28 721 | 39 291 | 36 029   |
|   | Mid-Atlantic    | 32 425 | 31 537 | 32 596 | 40 103 | 53 585 | 42 227   |
| Crassostrea virginica<br>(oyster)         | Atlantic County |        | 7      | 10     |        |        |          |
|   | New Jersey      |        | 1 397  | 1 714  | 848*** | 653*** | 1 045*** |
|   | Mid-Atlantic    | 2 764  | 3 181  | 3 335  | 1 965  | 1 413  | 1 322    |
| Placopecten magellanicus<br>(sea scallop) | Atlantic County |        | 56     | 72     |        |        |          |
|   | New Jersey      |        | 416    | 247    | 112    | 96     | 307      |
|   | Mid-Atlantic    | 534    | 569    | 468    | 514    | 635    | 912      |
| Aequipecten irradians<br>(bay scallop)    | Mid-Atlantic    | 694    | 230    | 93     | 144    | 365    | 249      |

<sup>a</sup> data from Gusey 1976 and Ichthyological Associates 1974, 1975.

\*\*\* (Excluding Delaware Bay)

Exhibit 101

Total number of fishes taken by hook and line on two charter boats (docked at Oyster Creek, Atlantic County) from March through November, 1974. (From Ichthyological Associates AGS 1975).

|                               | March | April | May   | June | July | August | September | October | November | Total  |
|-------------------------------|-------|-------|-------|------|------|--------|-----------|---------|----------|--------|
| No. of boats in ocean         | -     | 12    | 19    | 5    | 24   | 23     | 25        | 37      | 15       | 170    |
| No. of boats in bay           | 10    | 2     | 11    | 34   | 11   | 10     | -         | -       | 1        | 79     |
| No. of boats in bay and ocean | -     | -     | 9     | -    | 7    | 10     | 3         | -       | -        | 29     |
| Total boats                   | 10    | 14    | 39    | 39   | 42   | 43     | 28        | 37      | 26       | 273    |
| Total No. angler hours        | 247   | 568   | 1776  | 1802 | 2038 | 2072   | 1228      | 1572    | 1152     | 12455  |
| Total No. of fishermen        | 47    | 76    | 229   | 231  | 257  | 263    | 162       | 213     | 165      | 1643   |
| Atlantic cod                  | -     | -     | -     | -    | -    | -      | -         | -       | 14       | 14     |
| Red hake                      | -     | -     | 31+   | 1    | -    | -      | -         | -       | -        | 32+    |
| Striped bass                  | -     | 6     | 11    | -    | 1    | -      | -         | 86      | 262      | 366    |
| Black sea bass                | -     | -     | 1130+ | -    | 11   | 54     | -         | 10      | 275      | 430    |
| Breafish                      | -     | -     | 5     | 131  | 310  | 1037   | 150       | 702     | 176      | 2561   |
| Amber jack                    | -     | -     | -     | -    | -    | 1      | -         | -       | -        | 1      |
| Dolphin                       | -     | -     | -     | -    | -    | 1      | -         | -       | -        | 1      |
| Seap                          | -     | -     | 51    | 101  | -    | 3      | -         | -       | 13       | 168    |
| Weakfish                      | -     | -     | 4     | 1    | -    | 516    | 1766      | 723     | 240      | 3250   |
| Northern kingfish             | -     | -     | -     | -    | -    | -      | 1         | -       | -        | 1      |
| Atlantic croaker              | -     | -     | -     | -    | -    | 1      | -         | -       | -        | 1      |
| Tautog                        | -     | -     | 251   | -    | -    | -      | -         | -       | 105      | 356    |
| Gunner                        | -     | -     | 30    | -    | -    | -      | -         | -       | -        | 30     |
| Atlantic bonito               | -     | -     | -     | -    | 52   | 7      | 4         | -       | -        | 63     |
| Atlantic mackerel             | -     | 5253+ | 515+  | -    | -    | -      | -         | -       | -        | 5768+  |
| Tuna                          | -     | -     | -     | 3    | 113  | 13     | -         | -       | -        | 129    |
| Little Tunny                  | -     | -     | -     | -    | 8    | 13     | 35        | -       | -        | 56     |
| Summer flounder               | -     | -     | 430   | 2230 | 2255 | 748    | 122       | 10      | 6        | 5801   |
| Winter flounder               | 420   | -     | 33    | -    | -    | -      | -         | -       | -        | 453    |
| Northern puffer               | -     | -     | -     | -    | 1    | -      | -         | -       | -        | 1      |
| Total                         | 420   | 5259  | 2491  | 2467 | 2751 | 2443   | 2079      | 1531    | 1031     | 20472+ |

Exhibit 102

Monthly and total fishing effort statistics of fishes caught by anglers on two ocean charter boats in the vicinity of Little Egg Inlet during 1974 (From Ichthyological Associates AGS 1975).

|                                   | March | April | May  | June | July | August | September | October | November | Total |
|-----------------------------------|-------|-------|------|------|------|--------|-----------|---------|----------|-------|
| Black sea bass                    | -     | -     | 1130 | -    | 11   | 54     | -         | 10      | 275      | 1480  |
| % of total catch                  | -     | -     | 45.4 | -    | 0.4  | 2.2    | -         | 0.7     | 26.7     | 7.2   |
| Fish per fisherman per trip (n/t) | -     | -     | 4.9  | -    | +    | 0.2    | -         | +       | 1.7      | 0.9   |
| Fish per angler hour (n/h)        | -     | -     | 0.6  | -    | +    | +      | -         | +       | 0.2      | 0.1   |
| Fish per boat (n/b)               | -     | -     | 29.0 | -    | 0.3  | 1.3    | -         | 0.3     | 10.6     | 5.3   |
| Bluefish                          | -     | -     | 5    | 131  | 310  | 1087   | 150       | 702     | 176      | 2561  |
| % of total catch                  | -     | -     | 0.2  | 5.3  | 11.3 | 44.5   | 7.2       | 45.9    | 0.2      | 12.5  |
| Fish per fisherman per trip (n/t) | -     | -     | +    | 0.6  | 1.2  | 4.1    | 0.9       | 3.3     | 1.1      | 1.6   |
| Fish per angler hour (n/h)        | -     | -     | +    | 0.1  | 0.2  | 0.5    | 0.1       | 0.4     | 0.2      | 0.2   |
| Fish per boat (n/b)               | -     | -     | 0.1  | 3.4  | 7.4  | 25.3   | 5.4       | 19.0    | 6.8      | 9.2   |
| Weakfish                          | -     | -     | 4    | 1    | -    | 516    | 1766      | 723     | 240      | 3250  |
| % of total catch                  | -     | -     | 0.2  | +    | -    | 21.1   | 84.9      | 47.2    | 23.3     | 15.9  |
| Fish per fisherman per trip (n/t) | -     | -     | +    | +    | -    | 2.0    | 10.9      | 3.4     | 1.5      | 2.0   |
| Fish per angler hour (n/h)        | -     | -     | +    | +    | -    | 0.2    | 1.4       | 0.5     | 0.2      | 0.3   |
| Fish per boat (n/b)               | -     | -     | 0.1  | +    | -    | 12     | 63.1      | 19.5    | 9.2      | 11.7  |
| Summer flounder                   | -     | -     | 430  | 2230 | 2255 | 748    | 122       | 10      | 6        | 5801  |
| % of total catch                  | -     | -     | 17.3 | 90.4 | 82.0 | 30.6   | 5.9       | 0.7     | 0.6      | 28.3  |
| Fish per fisherman per trip (n/t) | -     | -     | 1.9  | 9.7  | 8.8  | 2.8    | 0.8       | +       | +        | 3.5   |
| Fish per angler hour (n/h)        | -     | -     | 0.2  | 1.2  | 1.1  | 0.4    | 0.1       | +       | +        | 0.5   |
| Fish per boat (n/b)               | -     | -     | 11.0 | 57.2 | 53.7 | 17.4   | 4.4       | 0.3     | 0.2      | 20.9  |
| Other sport fishes combined       | 420   | 5259  | 922  | 105  | 175  | 38     | 41        | 86      | 334      | 7380  |
| % of total catch                  | 100   | 100   | 37.0 | 4.3  | 6.4  | 1.6    | 2.0       | 5.6     | 32.4     | 36.0  |
| Fish per fisherman per trip (n/t) | 8.9   | 69.2  | 4.0  | 0.5  | 0.7  | 0.1    | 0.3       | 0.4     | 2.0      | 4.5   |
| Fish per angler hour (n/h)        | 1.7   | 9.3   | 0.5  | 0.1  | 0.1  | +      | +         | 0.1     | 0.3      | 0.6   |
| Fish per boat (n/b)               | 42    | 375.6 | 23.6 | 2.7  | 4.2  | 0.9    | 1.5       | 2.3     | 12.8     | 26.5  |

+ Indicates less than 0.1.

## EXHIBIT 103

(sheet 1 of 2)

SPORT FISHERIES CATCHES IN WESTERN BARNEGAT BAY FORKED RIVER AND  
OYSTER CREEK FROM SEPTEMBER 1975 THROUGH APRIL 1976  
(FROM ICHTHYOLOGICAL ASSOCIATES OCNGS 1975, 1976)

|                                | Cedar<br>Creek to<br>& Including<br>Forked River | Waretown<br>Creek to<br>& Including<br>Oyster Creek | Northern<br>Approach<br>Barnegat<br>Inlet |
|--------------------------------|--|---|---|
| Temperature Range (C), Surface | 7.0-19.5   | 7.0-18.8  | 11.0-18.0                                 |
| Salinity Range (ppt), Surface  | 16.0-21.0  | 19.5-22.5   | 21.5-29.1                                 |
| <u>September - December</u>    |  |   |   |
| Boats Fishing                  | 8  | 22  | 24  |
| Boats Sampled                  | 8  | 20  | 21  |
| Hours Fished                   | 11.0   | 49.5  | 45.5                                      |
| Rods Used                      | 11   | 40  | 25  |
| Traps Used                     | 10   | 42  | 49  |
| Catch                          | 12   | 286   | 313                                       |
| Individuals Fishing            | 15   | 48  | 42  |
| Catch/Boat                     | 1.5  | 14.3  | 14.9                                      |
| Catch/Individual               | 0.8  | 5.9   | 7.5                                       |
| <u>Species Taken</u>           |  |   |   |
| Black seabass                  | -  | 16  | -   |
| Bluefish                       | -  | 20  | 7   |
| Northern kingfish              | -  | 3   | -   |
| Winter flounder                | -  | 1   | -   |
| Blue crab                      | 12   | 246   | 306                                       |
| Total                          | 12   | 286   | 313                                       |

SPORT FISHERIES CATCHES IN WESTERN BARNEGAT BAY FORKED RIVER AND  
OYSTER CREEK FROM SEPTEMBER 1975 THROUGH APRIL 1976  
(FROM ICHTHYOLOGICAL ASSOCIATES OCNGS 1975, 1976)

|                                       | <u>Cedar<br/>Creek to<br/>&amp; Including<br/>Forked River</u> | <u>Waretown<br/>Creek to<br/>&amp; Including<br/>Oyster Creek</u> | <u>Northern<br/>Approach<br/>Barnegat<br/>Inlet</u> | <u>Forked<br/>River</u> | <u>Oyster<br/>Creek</u> |
|---------------------------------------|--|---|---|-------------------------|-------------------------|
| <u>Temperature Range (C), Surface</u> | 8.5-20.0   | 8.1-21.0  | 6.2-20.2  | 4.5-21.5                | 4.5-26.0                |
| <u>Salinity Range (ppt), Surface</u>  | 18.5-20.0  | 22.0-23.0   | 21.0-30.0   | 14.0-22.0               | 12.0-22.0               |
| <u>January - April</u>                |  |   |   |                         |                         |
| Boats Fishing                         | 0  | 3   | 3   | -                       | -                       |
| Boats Sampled                         | 0  | 3   | 3   | -                       | -                       |
| Hours Fished                          | -  | 24  | 11  | 39                      | 9.5                     |
| Rods Used                             | -  | 11  | 9   | 26                      | 8                       |
| Traps Used <sup>a</sup>               | -  | -   | -   | -                       | -                       |
| Catch                                 | -  | 24  | 12  | 5                       | -                       |
| Individuals Fishing                   | -  | 10  | 8   | 19                      | 10                      |
| Catch/Boat                            | -  | 8.0   | 4.0   | -                       | -                       |
| Catch/Individual                      | -  | 2.4   | 1.5   | 0.3                     | 0                       |
| <u>Species Taken</u>                  |  |   |   |                         |                         |
| American eel                          | -  | 1   | 1   | -                       | -                       |
| Winter flounder                       | -  | 23  | 11  | 5                       | -                       |
| <b>Total</b>                          | 0  | 24  | 12  | 5                       | 0                       |

<sup>a</sup>No traps were observed during the period.

EXHIBIT 104

COMMERCIAL FISHERIES LANDINGS REPORTED FOR THE WATERS BETWEEN  
TOMS RIVER AND THE MANAHAWKIN BRIDGE FROM SEPTEMBER 1975 THROUGH APRIL 1976  
(FROM ICHTHYOLOGICAL ASSOCIATES OCNGS 1975, 1976)

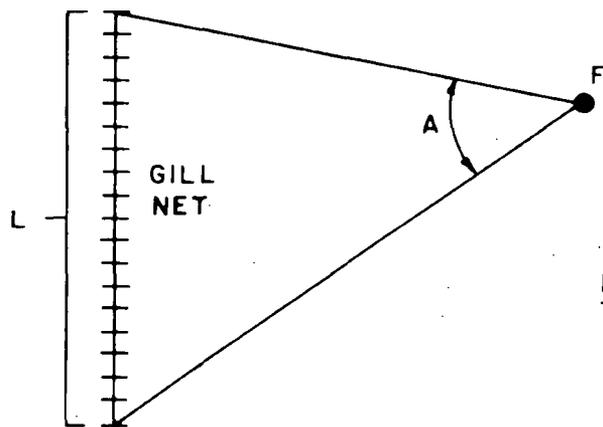
| Species         | September 1975 |               |       | October 1975  |               |      | November 1975 |               |      | December 1975 |               |      |
|-----------------|----------------|---------------|-------|---------------|---------------|------|---------------|---------------|------|---------------|---------------|------|
|                 | lbs            | Value<br>(\$) | Gear* | lbs           | Value<br>(\$) | Gear | lbs           | Value<br>(\$) | Gear | lbs           | Value<br>(\$) | Gear |
| Blue crab       | 14,640         | 3,294         | 330   | 24,000        | 6,000         | 330  | -             | -             | -    | 31,200        | 9,300         | 805  |
| American eel    | 1,285          | 386           | 340   | 1,100         | 330           | 340  | -             | -             | -    | -             | -             | -    |
| Northern quahog | 3,020          | 3,174         | 845   | 3,030         | 3,105         | 845  | 3,530         | 3,702         | 845  | 3,400         | 3,569         | 845  |
| Northern quahog | 12,090         | 12,696        | 855   | 19,690        | 20,183        | 855  | 18,800        | 19,742        | 855  | 13,600        | 14,277        | 855  |
| Northern quahog | 15,120         | 15,871        | 955   | 7,570         | 7,762         | 955  | 1,170         | 1,234         | 955  | -             | -             | -    |
| Winter flounder | -              | -             | -     | 1,300         | 156           | 310  | -             | -             | -    | 5,200         | 780           | 310  |
| White perch     | -              | -             | -     | -             | -             | -    | -             | -             | -    | 3,000         | 750           | 310  |
| Species         | January 1976   |               |       | February 1976 |               |      | March 1976    |               |      | April 1976    |               |      |
|                 | lbs            | Value<br>(\$) | Gear  | lbs           | Value<br>(\$) | Gear | lbs           | Value<br>(\$) | Gear | lbs           | Value<br>(\$) | Gear |
| Blue crab       | 8,800          | 2,220         | 805   | 15,280        | 3,820         | 805  | 8,000         | 2,000         | 805  | -             | -             | -    |
| American eel    | -              | -             | -     | -             | -             | -    | -             | -             | -    | 4,800         | 1,680         | 340  |
| Northern quahog | 2,140          | 2,354         | 845   | 2,040         | 2,296         | 845  | 3,380         | 3,806         | 845  | 2,790         | 3,143         | 845  |
| Northern quahog | 8,560          | 9,416         | 855   | 11,570        | 13,013        | 855  | 13,540        | 15,226        | 855  | 11,180        | 12,574        | 855  |
| Northern quahog | -              | -             | -     | -             | -             | -    | -             | -             | -    | 4,660         | 5,239         | 955  |
| Winter flounder | 6,300          | 945           | 310   | 8,900         | 1,602         | 310  | 12,000        | 2,400         | 310  | 6,300         | 945           | 310  |
| White perch     | 5,500          | 1,375         | 310   | 10,310        | 2,570         | 310  | 8,850         | 2,213         | 310  | 7,120         | 1,780         | 310  |
| Total           | 31,300         | 16,310        |       | 48,100        | 23,309        |      | 45,770        | 25,645        |      | 36,850        | 25,361        |      |

\* Gear = 310 - fyke net  
330 - crab pots  
340 - eel pots  
805 - crab dredge  
845 - clam tongs  
855 - clam rake  
955 - clam by hand

Exhibit 105

AQUATIC ECOLOGY DIFFERENTIATING FACTORS

1. Change in Temperature -  $\Delta T$ 
  - a. At Different Dilutions
  - b. By Season
2. Change in Salinity -  $\Delta S$ 
  - a. At Different Dilutions
  - b. By Season
3. Nekton Entrapment/Impingement
  - a. At Different Dilutions
  - b. By Season\*
  - c. With and Without Rex-Fit
  - d. Assumed Mortalities - 75% Traveling Screens  
46% Dilution Pumps  
15% Rex Bucket Screens
4. Ichthyoplankton Entrapment
  - a. At Different Dilutions
  - b. By Season\*
  - c. Assumed Mortalities - 100% Through the Condenser  
50% Through the Dilution Pumps



TOP VIEW

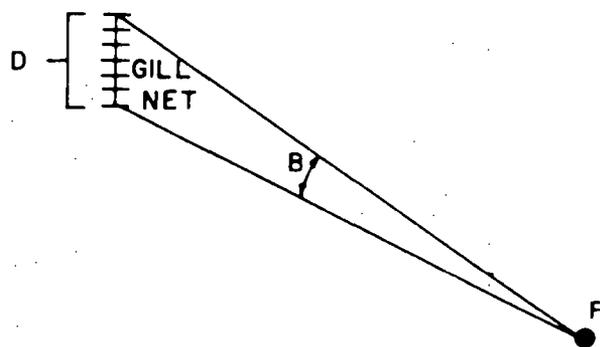
NOTES

POINT F : LOCATION OF FISH

ANGLES A, B : ANGLES  
SUBTENDED BY NET IN  
RESPECT TO POINT F

LENGTH L : HORIZONTAL EXTENT  
OF NET

DEPTH D : VERTICAL EXTENT  
OF NET



SIDE VIEW

JERSEY CENTRAL  
POWER & LIGHT COMPANY

EBASCO SERVICES INCORPORATED  
New York

ILLUSTRATION FOR ESTIMATING  
PELAGIC FISH DENSITY

EXHIBIT  
106

|   | Canal(Pipe)-to-Bay System or Existing System |     |     |     | Canal(Pipe)-to-Bay System or Existing System with Bucket Screens |     |     |     | "Low Temperature" Helper Towers with Bucket Screens |     |     |     | Salt Water Cooling Tower Systems |     |     |     | Fresh Water Wet/Dry and Dry Cooling Tower Systems |     |     |     | 500 Acre Cooling Pond |     |     |     | 1,000 Acre Cooling Pond or Spray Canal |     |     |     |   |   |   |   |
|---|--|-----|-----|-----|--|-----|-----|-----|---|-----|-----|-----|----------------------------------|-----|-----|-----|---|-----|-----|-----|-----------------------|-----|-----|-----|--|-----|-----|-----|---|---|---|---|
|   | 0  | 1   | 2   | 3   | 0  | 1   | 2   | 3   | 0   | 1   | 2   | 3   | 0                                | 1   | 2   | 3   | 0   | 1   | 2   | 3   | 0                     | 1   | 2   | 3   | 0                                      | 1   | 2   | 3   |   |   |   |   |
| Dilution Pumps                              | 0  | 1   | 2   | 3   | 0  | 1   | 2   | 3   | 0   | 1   | 2   | 3   | 0                                | 1   | 2   | 3   | 0   | 1   | 2   | 3   | 0                     | 1   | 2   | 3   | 0                                      | 1   | 2   | 3   | 0 | 1 | 2 | 3 |
| $\Delta T (F)^1$                            | 20   | 13  | 9   | 7   | 20   | 13  | 9   | 7   | 0.7   | 0.5 | 0.4 | 0.3 | 8                                | 1   | 0.6 | 0.4 | 11  | 0.9 | 0.5 | 0.3 | 13                    | 2   | 0.9 | 0.6 | 7                                      | 1   | 0.5 | 0.4 |   |   |   |   |
| $\Delta S (0/00)$                           | 0.8  | 0.5 | 0.3 | 0.3 | 0.8  | 0.5 | 0.3 | 0.3 | 1.0   | 0.5 | 0.5 | 0.3 | 12.5                             | 1.8 | 0.8 | 0.5 | 9   | 1.5 | 0.8 | 0.5 | 12.5                  | 1.8 | 1.0 | 0.5 | 12.0                                   | 1.8 | 1.0 | 0.5 |   |   |   |   |
| Impingement $\times 10^2 /wk$               | 105  | 115 | 125 | 135 | 20   | 30  | 40  | 50  | 20  | 30  | 40  | 50  | 5                                | 15  | 25  | 35  | 0   | 10  | 20  | 30  | 5                     | 15  | 25  | 35  | 5                                      | 15  | 25  | 35  |   |   |   |   |
| Entrainment $\times 10^1 /Min$ <sup>2</sup> | 14   | 16  | 18  | 20  | 14   | 16  | 18  | 20  | 14  | 16  | 18  | 20  | 1                                | 3   | 5   | 7   | 0   | 2   | 4   | 6   | 1                     | 3   | 5   | 7   | 1                                      | 3   | 5   | 7   |   |   |   |   |

<sup>1</sup>Estimates based on combined Oyster Creek and Forked River flows.

<sup>2</sup>Equivalent Adults

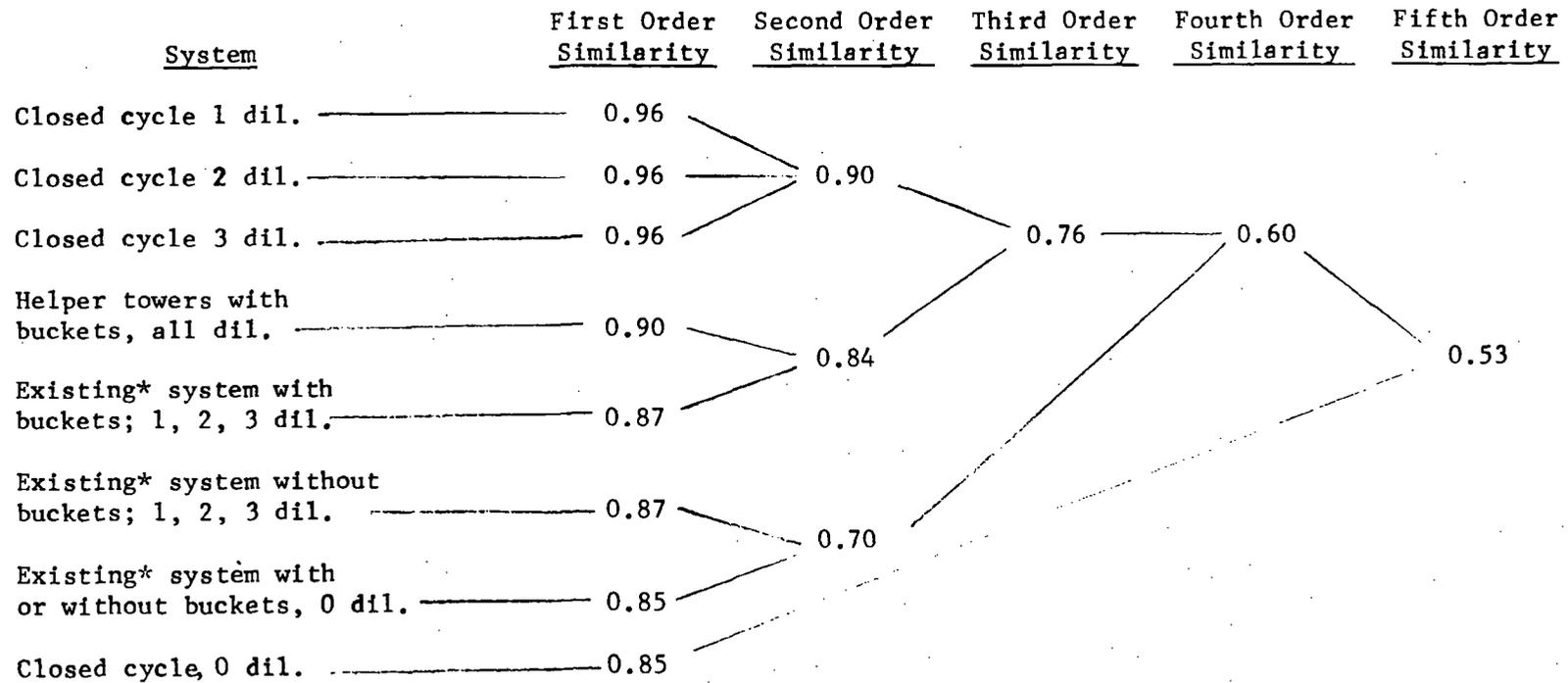
|   | Canal(Pipe)-to-Bay System or Existing System |      |      |      | Canal(Pipe)-to-Bay System or Existing System with Bucket Screens |     |     |     | "Low Temperature" Helper Towers with Bucket Screens |     |     |     | Salt Water Cooling Tower Systems |     |     |     | Fresh Water Wet/Dry and Dry Cooling Tower Systems |     |     |     | 500 Acre Cooling Pond |     |     |     | 1,000 Acre Cooling Pond or Spray Canal |     |     |     |
|---|--|------|------|------|--|-----|-----|-----|---|-----|-----|-----|----------------------------------|-----|-----|-----|---|-----|-----|-----|-----------------------|-----|-----|-----|--|-----|-----|-----|
|   | 0  | 1    | 2    | 3    | 0  | 1   | 2   | 3   | 0   | 1   | 2   | 3   | 0                                | 1   | 2   | 3   | 0   | 1   | 2   | 3   | 0                     | 1   | 2   | 3   | 0                                      | 1   | 2   | 3   |
| Dilution Pumps                              |  |      |      |      |  |     |     |     |   |     |     |     |                                  |     |     |     |   |     |     |     |                       |     |     |     |  |     |     |     |
| $\Delta T (F)^1$                            | 21   | 13   | 10   | 8    | 21   | 13  | 10  | 8   | 10  | 6   | 5   | 4   | 30                               | 4   | 2   | 2   | 27  | 3   | 2   | 1   | 32                    | 5   | 3   | 2   | 22                                     | 4   | 2   | 1   |
| $\Delta S (O/00)$                           | 0.4  | 0.2  | 0.2  | 0.2  | 0.4  | 0.2 | 0.2 | 0.2 | 0.6   | 0.4 | 0.2 | 0.2 | 7.2                              | 1.0 | 0.6 | 0.4 | 10  | 0.8 | 0.4 | 0.2 | 6.4                   | 1.0 | 0.6 | 0.4 | 5.2                                    | 0.8 | 0.9 | 0.4 |
| Impingement $\times 10^2$ /Wk               | 1900   | 1910 | 1920 | 1930 | 375  | 385 | 395 | 405 | 375   | 385 | 395 | 405 | 90                               | 100 | 110 | 120 | 0   | 10  | 20  | 30  | 90                    | 100 | 110 | 120 | 90                                     | 100 | 110 | 120 |
| Entrainment <sup>2</sup> $\times 10^1$ /Min | 42   | 52   | 62   | 72   | 42   | 52  | 62  | 72  | 42  | 52  | 62  | 72  | 2                                | 12  | 22  | 32  | 0   | 10  | 20  | 30  | 2                     | 12  | 22  | 32  | 2                                      | 12  | 22  | 32  |

<sup>1</sup>Estimates based on combined Oyster Creek and Forked River flows.

<sup>2</sup>Equivalent Adults

Exhibit 109

RESULTS OF CLUSTER ANALYSIS FOR DATA GIVEN IN EXHIBITS 107 AND 108



\*Or Canal

Exhibit 110

KNOWN FISH KILLS AT THE OYSTER CREEK NUCLEAR GENERATING  
STATION SINCE THE INITIATION OF PLANT OPERATION

| <u>Date</u>         | <u>Species</u>    | <u>Number</u> <sup>1</sup> | <u>Size Range</u> | <u>Probable Cause</u> | <u>Intake Temperature</u> °F  |
|---------------------|-------------------|----------------------------|-------------------|-----------------------|---|
| January 29, 1972    | Atlantic Menhaden | 100,000-1,000,000          | ---               | Thermal Shock         | 35.0 (12:30 p.m.)   |
| January 5-8, 1973   | Atlantic Menhaden | 18,000-1,200,000           | 102-356 mm        | Thermal Shock         | 42 ( 8:00 p.m., Jan 5)  |
|                     | Bay Anchovy       | 20                         | ---               | Thermal Shock         |   |
| February 16-21      | Atlantic Menhaden | 2                          | ---               | Thermal Shock         | 40 (12:30 a.m.)   |
| August 9, 1973      | Atlantic Menhaden | 2,000-4,000                | ---               | Thermal Shock         | 84 ( 8:30 p.m.)   |
| January 11-15, 1974 | Atlantic Menhaden | 9,900-180,000              | 102-356 mm        | Thermal Shock         | 35 ( 8:30 p.m.)   |
|                     | Bluefish          | 100-3,600                  | 228-356 mm        | Thermal Shock         |   |
|                     | Spot              | ---                        | ---               | Thermal Shock         | Winter dilution pump<br>operation and new shutdown<br>procedures instituted |
| February 4, 1975    | Atlantic Menhaden | 100                        | ---               | Thermal Shock         |   |
|                     | Bluefish          | 50-100                     | ---               | Thermal Shock         |   |
| November 24, 1975   | Cravelle Jacks    | 7-100                      | ---               | Thermal Shock         | 48  |
| December 19, 1975   | Atlantic Menhaden | 15-100                     | 100-250           | Thermal Shock         | 37 ( 7:40 p.m.)   |
|                     | Bluefish          | 3-200                      | 90-170            |                       |   |

<sup>1</sup>Source: Reintjes (1973 b, c,; 1974a)<sup>34,35,36</sup>; JCP&L (1973 a, 1973 b)<sup>37,38</sup>; AEC (1973)<sup>39</sup>; Younger (1974)<sup>40</sup>.

<sup>2</sup>Several thousand, but no estimate.

|                   |                   |     |            |    |                   |
|-------------------|-------------------|-----|------------|----|-------------------|
| December 27, 1975 | Atlantic Menhaden | 350 | 120-150 mm | pH | 36.0 (10:00 p.m.) |
|-------------------|-------------------|-----|------------|----|-------------------|

Exhibit 111

SUMMARY OF AQUATIC ECOLOGICAL ANALYSIS  
IN TERMS OF OVERRIDING IMPACT

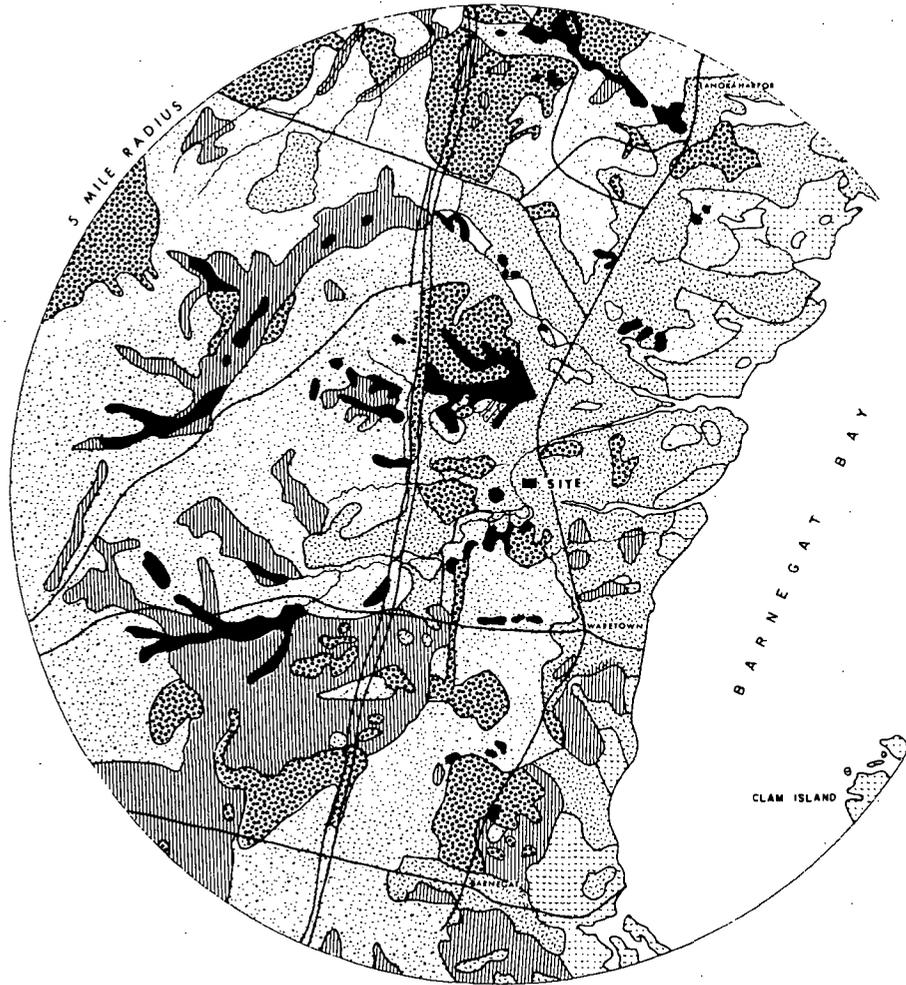
| <u>System</u>                         | <u>No. Dilution Pumps</u>   |          |          |                       |
|---------------------------------------|---|----------|----------|-----------------------|
|                                       | <u>0</u>  | <u>1</u> | <u>2</u> | <u>3<sup>1/</sup></u> |
| Existing                              | No  | No       | No       | Yes                   |
| Existing with Ristroph Bucket Screens | No  | No       | No       | Yes                   |
| Canal-To-Bay                          | No  | No       | No       | Yes                   |
| Saltwater Cooling Towers              | Yes <sup>2</sup>  | No       | No       | Yes                   |
| Freshwater Cooling Towers             | Yes <sup>2</sup>  | No       | No       | Yes                   |
| Helper Cooling Towers <sup>4</sup>    | Yes   | Yes      | Yes      | Yes                   |
| Cooling Ponds <sup>3</sup>            | Yes <sup>2</sup>  | Yes      | Yes      | Yes                   |
| Ocean Intake/Discharge System         | No; however, this system has potentially high aquatic impacts relating to construction (i.e. dredging), entrainment, impingement and fouling. |          |          |                       |

<sup>1</sup> Unnecessary entrainment/impingement increase per level of temperature reduction achieved.

<sup>2</sup> Significant increase in Oyster Creek salinity.

<sup>3</sup> High watershed losses.

<sup>4</sup> Helper towers offer no advantages over the other cooling tower systems and exhibit much greater impingement and entrainment losses.



LEGEND

-  HARDWOOD
-  WHITE CEDAR
-  MIXED HARDWOOD PINE
-  PINE
-  SALTWATER MARSH
-  BAY
-  NON - FORESTED

JERSEY CENTRAL POWER  
AND LIGHT COMPANY

EBASCO SERVICES INCORPORATED  
New York

KEY TO VEGETATION IN A 5 MILE RADIUS

EXHIBIT

112

## CHARACTERISTICS OF ALTERNATIVE COOLING SYSTEMS AFFECTING TERRESTRIAL ECOSYSTEMS

| Alternative Cooling System                              | Land Requirements |   | Fogging/Icing              | Salt Deposition   |  | Height of Structure (feet) |
|---|-------------------|---|----------------------------|---|--|----------------------------|
|   | Acreage           | Sensitive Areas Disturbed                             |                            | Rate  | Aereal Extent                                      |                            |
| Closed Cycle Systems                                    |                   |   |                            |   |  |                            |
| Cooling Towers  |                   |   |                            |   |  |                            |
| 1. Dry  | <10               |   |                            |   |  | 120                        |
| 2. Wet  |                   |   |                            |   |  |                            |
| a. Natural Draft (NDCT)<br>(includes fan-assisted)      | <10               |   |                            | Less than 89 kg/<br>km <sup>2</sup> /mo (maximum<br>annual) | Max ESE near<br>tower                              | 550                        |
| b. Mechanical Draft                                     |                   |   |                            |   |  |                            |
| i. Rectangular  | <10               |   |                            | 7 times NDCT  | Max deposition<br>near tower                       | 55                         |
| ii. Round   | <10               |   |                            | 7 times NDCT  | Max deposition<br>near tower                       | 70                         |
| iii. Wet-dry<br>(salt and fresh water)                  | <10               |   |                            | 7 times NDCT<br>(salt water<br>tower)                       | Max deposition<br>near tower (salt<br>water tower) | 60                         |
| Cooling Ponds   |                   |   |                            |   |  |                            |
| 1. 500 acre   | 500               | Forested<br>acreage                                   |                            |   |  | 0                          |
| 2. 1,000 acre   | 1,000             | Forested<br>acreage lost;<br>including<br>white cedar |                            |   |  | 0                          |
| Spray Canal   | <25               |   | Icing within<br>2,000 feet | 7 times NDCT  | 2,000 feet of<br>canal                             | 0                          |
| Open Cycle Systems                                      |                   |   |                            |   |  |                            |
| Canal (pipe)-to-Bay                                     | <25               | Portion of<br>salt marsh<br>lost                      |                            |   |  | 0                          |
| Once-through Ocean System                               | <25               | Barrier beach<br>habitat lost                         |                            |   |  | 0                          |
| Helper Cooling Towers<br>(Rectangular Mechanical Draft) | <10               |   |                            | 7 times NDCT  | Max deposition<br>near tower                       | 55                         |

EXHIBIT 114

IMPACT ASSESSMENT OF ALTERNATIVE COOLING SYSTEMS - TERRESTRIAL ECOLOGY

| <u>Alternative Cooling System</u>                          | <u>Land Requirements</u>                                | <u>Fogging/Icing</u>                   | <u>Salt Deposition</u>  | <u>Height of Structure</u>                |
|--|---|--|---|---|
|  | <u>Impact</u>   | <u>Impact</u>                          | <u>Impact</u>   | <u>Impact</u>                             |
| <b>Closed Cycle Systems</b>                                |   |  |   |   |
| <b>Cooling Towers</b>                                      |   |  |   |   |
| 1. Dry   | Minimal habitat lost                                    | N/A*                                   | N/A   | N/A                                       |
| 2. Wet   |   |  |   |   |
| a. Natural Draft (NDCT)<br>(includes fan-assisted)         | Minimal habitat lost                                    | N/A                                    | Potential effects on<br>vegetation growth and<br>distribution | Potential bird migra-<br>tion obstruction |
| b. Mechanical Draft  |   |  |   |   |
| i. Rectangular   | Minimal habitat lost                                    | N/A                                    | Vegetation damage<br>near tower                               | N/A                                       |
| ii. Round  | Minimal habitat lost                                    | N/A                                    | Vegetation damage<br>near tower                               | N/A                                       |
| iii. Wet-Dry<br>(Salt and Fresh-<br>water)                 | Minimal habitat lost                                    | N/A                                    | Vegetation damage<br>near tower<br>(salt water)               | N/A                                       |
| <b>Cooling Ponds</b>                                       |   |  |   |   |
| 1. 500 acre  | Extensive habitat lost                                  | N/A                                    | N/A   | N/A                                       |
| 2. 1000 acre   | Extensive habitat lost,<br>including sensitive<br>areas | N/A                                    | N/A   | N/A                                       |
| Spray Canal  | Minimal habitat lost                                    | Vegetation damage<br>within 2,000 feet | Vegetation damage<br>near spray canal                         |   |
| <b>Open-Cycle Systems</b>                                  |   |  |   |   |
| Canal (Pipe)-to-Bay  | Sensitive habitat lost                                  | N/A                                    | N/A   | N/A                                       |
| Once-Through Ocean System                                  | Sensitive and rare<br>habitat disrupted                 | N/A                                    | N/A   | N/A                                       |
| Helper Cooling Towers<br>(Rectangular Mechanical<br>Draft) | Minimal habitat lost                                    | N/A                                    | Vegetation damage<br>near tower                               | N/A                                       |

\*N/A - Not Applicable

Exhibit 115  
 JERSEY CENTRAL POWER & LIGHT COMPANY  
 OYSTER CREEK NUCLEAR GENERATING STATION  
 ALTERNATIVE COOLING WATER SYSTEM STUDY  
 PLANT NET OUTPUT

|   | Plant Net Capability at Design Conditions* |                  | Plant Net Average Seasonal Capability, MW** |             |        |
|---|--|------------------|---|-------------|--------|
|   | MW   | Differential, MW | Summer                                      | Spring/Fall | Winter |
| Existing Cooling System                                 | 608.8***                                   | Base             | 620.4                                       | 635.3       | 637.2  |
| Ocean Intake & Discharge                                | 622.6                                      | -13.8            | 624.2                                       | 627.0       | 627.5  |
| Discharge Canal to the Bay                              | 608.6                                      | 1.4              | 618.8                                       | 633.8       | 635.7  |
| Discharge Pipelines to the Bay                          | 608.6                                      | 1.4              | 616.5                                       | 633.8       | 635.7  |
| Ocean Intake & Discharge with a Multipressure Condenser | 603.1                                      | 5.7              | 607.1                                       | 619.4       | 623.6  |
| Helper Cooling Towers (CT) with T <sub>min</sub> = 50 F | 597.6                                      | 11.2             | 608.9                                       | 623.8       | 625.9  |
| 1000 Acre Cooling Pond                                  | 597.1                                      | 11.7             | 614.0                                       | 631.6       | 634.8  |
| Helper CT with T <sub>min</sub> = 43 F                  | 593.9                                      | 14.9             | 605.3                                       | 620.1       | 622.2  |
| Mechanical Draft Rectangular CT                         | 589.4                                      | 19.4             | 599.7                                       | 616.5       | 621.3  |
| Fan Assisted CT   | 587.6                                      | 21.2             | 597.1                                       | 615.2       | 622.3  |
| Mechanical Draft Round CT                               | 588.8                                      | 20.0             | 600.0                                       | 615.3       | 620.1  |
| Natural Draft CT  | 587.0                                      | 21.8             | 599.1                                       | 621.4       | 628.5  |
| Spray Modules   | 585.4                                      | 23.4             | 599.0                                       | 619.3       | 624.5  |
| Wet/Dry Salt Water CT                                   | 579.2                                      | 29.6             | 590.6                                       | 605.3       | 615.7  |
| 500 Acre Cooling Pond                                   | 576.0                                      | 32.8             | 600.5                                       | 622.4       | 630.7  |
| Wet/Dry Fresh Water CT                                  | 574.1                                      | 34.7             | 583.8                                       | 604.8       | 569.3  |
| Dry Cooling Tower                                       | 534.1                                      | 74.7             | 570.1                                       | 598.4       | 603.9  |

\*At design Ambient Conditions (T<sub>wb</sub> = 74 F, T<sub>db</sub> = 89 F, wind speed 5 mph) and Reactor Thermal Output 1900 MWt.

\*\*At Reactor Thermal Output 1900 MWt.

\*\*\*For Intake Cooling Water Temperature of 82 F.

## EXHIBIT 116

## SUMMARY OF ENVIRONMENTAL EFFECTS - ALTERNATIVE COOLING WATER SYSTEMS

| Environmental Factors                              | Units                    | Natural Draft Cooling Tower | Fan-Assisted Natural Draft Tower | Round Mechanical Draft Towers | Dry Cooling Towers | Ocean Intake-Discharge Systems | Canal (Pipe)-to Bay System | Freshwater Wet/Dry Towers | Saltwater Wet/Dry Towers | Helper Cooling Tower System (1) | Rectangular Mechanical Draft Towers | Spray Canal System | Cooling Ponds 1000 & 500 acres  | Existing System | Existing System With Bucket Screens |
|--|--------------------------|-----------------------------|----------------------------------|-------------------------------|--------------------|--------------------------------|----------------------------|---------------------------|--------------------------|---------------------------------|-------------------------------------|--------------------|---------------------------------|-----------------|-------------------------------------|
| <b>1. Atmospheric Effects</b>                      |                          |                             |                                  |                               |                    |                                |                            |                           |                          |                                 |                                     |                    |                                 |                 |                                     |
| 1.1 Elevated Visible Plumes                        | Qualitative              | High                        | High                             | High                          | Low                | Low                            | Low                        | Low                       | Low                      | Low                             | Low                                 | Low                | Low                             | Low             | Low                                 |
| 1.2 Ground Level Fogging                           | Qualitative              | Low                         | Low                              | Low                           | Low                | Low                            | Low                        | Low                       | Low                      | High                            | High                                | Moderate           | Moderate                        | Low             | Low                                 |
| 1.3 Salt Deposition                                | Qualitative              | Low                         | Low                              | Moderate                      | Low                | Low                            | Low                        | Low                       | Moderate                 | Moderate                        | High                                | High               | Low                             | Low             | Low                                 |
| 1.4 Convective Instability                         | Qualitative              | Moderate                    | Moderate                         | Moderate                      | High               | Low                            | Low                        | Moderate                  | Moderate                 | Moderate                        | Moderate                            | Moderate           | Low                             | Low             | Low                                 |
| <b>2. Air Quality</b>                              |                          |                             |                                  |                               |                    |                                |                            |                           |                          |                                 |                                     |                    |                                 |                 |                                     |
| 2.1 Particulate Emission Rate                      | % of Standard            | 353                         | 336                              | 336                           | -                  | -                              | -                          | <50                       | 336                      | 336                             | 336                                 | -                  | -                               | -               | -                                   |
| <b>3. Water Quality</b>                            |                          |                             |                                  |                               |                    |                                |                            |                           |                          |                                 |                                     |                    |                                 |                 |                                     |
| 3.1 Construction Effects                           | Qualitative              | Low                         | Low                              | Low                           | Low                | High                           | Moderate                   | Low                       | Low                      | Low                             | Low                                 | Low                | High                            | -               | -                                   |
| 3.2 Water Quality Concentrations                   | % Change                 | +3.5                        | +3.5                             | +3.5                          | 0                  | 0                              | 0                          | +1.7                      | +3.4                     | +1.8                            | +3.5                                | +3.5               | +3.6                            | 0               | 0                                   |
| <b>4. Thermal Discharge Characteristics</b>        |                          |                             |                                  |                               |                    |                                |                            |                           |                          |                                 |                                     |                    |                                 |                 |                                     |
| 4.1 Heat Dissipation in Receiving Water (S/Winter) | Btu/hr X 10 <sup>6</sup> | 164/622                     | 164/622                          | 135/660                       | -                  | 4500                           | 4500                       | 134/425                   | 172/684                  | 858/2784                        | 153/681                             | 161/596            | 500: 163/568<br>1000: 147/549   | 4500            | -                                   |
| 4.2 Heat Dissipation Rate (Summer/Winter)          | % of Existing System     | 3.6/13.8                    | 3.6/13.8                         | 3.0/14.7                      | -                  | 100                            | 100                        | 3.0/9.4                   | 3.8/15.0                 | 19/62                           | 3.4/15.1                            | 3.6/13.2           | 500: 5.5/15.7<br>1000: 3.3/12.2 | 100             | -                                   |
| 4.3 Area Affected by 1.5° F (Summer Max)           | Acres                    | 0                           | 0                                | 0                             | -                  | 0                              | ~2300                      | 0                         | 0                        | 437                             | 0                                   | 0                  | 0                               | ~2300           | Same as Existing System             |
| <b>5. Noise</b>                                    |                          |                             |                                  |                               |                    |                                |                            |                           |                          |                                 |                                     |                    |                                 |                 |                                     |
| 5.1 Noise Level                                    |                          | **                          | **                               | **                            | **                 | Low                            | 63                         | **                        | **                       | **                              | **                                  | 60-62              | Low                             | Unavailable     | -                                   |
| <b>6. Visual/Esthetic Effects</b>                  |                          |                             |                                  |                               |                    |                                |                            |                           |                          |                                 |                                     |                    |                                 |                 |                                     |
| 6.1 Loss of Vegetative Cover                       | Qualitative              | None                        | None                             | None                          | None               | None                           | Low                        | None                      | None                     | None                            | None                                | Low                | High                            | -               | -                                   |
| 6.2 Profile Impact                                 | Qualitative              | High                        | High                             | High                          | High               | Low                            | Low                        | High                      | High                     | High                            | High                                | Low                | Low                             | Moderate        | -                                   |
| 6.3 Elevated Visible Plumes                        | Qualitative              | High                        | High                             | Moderate                      | None               | None                           | None                       | None                      | None                     | Low                             | Low                                 | Low                | None                            | None            | -                                   |
| 6.4 Ground Fog                                     | Qualitative              | None                        | None                             | Low                           | None               | None                           | Low                        | Low                       | Low                      | High                            | High                                | Moderate           | Moderate                        | Low             | -                                   |

## EXHIBIT 116

## SUMMARY OF ENVIRONMENTAL EFFECTS - ALTERNATIVE COOLING WATER SYSTEMS

| Environmental Factors  | Units       | Natural Draft Cooling Tower | Fan-Assisted Natural Draft Tower | Round Mechanical Draft Towers | Dry Cooling Towers | Ocean Intake-Discharge Systems | Canal (Pipe) to Bay System | Freshwater Wet/Dry Towers | Saltwater Wet/Dry Towers | Helper Cooling Tower System | Rectangular Mechanical Draft Towers | Spray Canal System | Cooling Ponds 1000 & 500 acres | Existing System | Existing System with Bucket Screens |
|--|-------------|-----------------------------|----------------------------------|-------------------------------|--------------------|--------------------------------|----------------------------|---------------------------|--------------------------|-----------------------------|-------------------------------------|--------------------|--------------------------------|-----------------|-------------------------------------|
| <b>7. Land Use</b>   |             |                             |                                  |                               |                    |                                |                            |                           |                          |                             |                                     |                    |                                |                 |                                     |
| 7.1 Area Required  | Acres       | ~10                         | ~10                              | ~10                           | ~10                | ~ 25                           | ~ 25                       | ~10                       | ~10                      | ~10                         | ~10                                 | ~25                | 1000/500                       | -               | Same as Existing System             |
| <b>8. Terrestrial Ecology</b>  |             |                             |                                  |                               |                    |                                |                            |                           |                          |                             |                                     |                    |                                |                 |                                     |
| 8.1 Sensitive Land Requirements                                      | Qualitative | Low                         | Low                              | Low                           | Low                | Moderate                       | Moderate                   | Low                       | Low                      | Low                         | Low                                 | Low                | High                           | -               | Same as Existing System             |
| 8.2 Fogging/Icing Effects on Vegetation                              | Qualitative | None                        | None                             | None                          | None               | None                           | None                       | None                      | None                     | None                        | None                                | Moderate           | None                           | None            |                                     |
| 8.3 Salt Deposition Effects on Vegetation                            | Qualitative | Low                         | Low                              | Moderate                      | None               | None                           | None                       | None                      | Moderate                 | Moderate                    | Moderate                            | High               | None                           | None            |                                     |
| 8.4 Bird Collision Effects   | Qualitative | Moderate                    | Moderate                         | Low                           | None               | None                           | None                       | None                      | None                     | None                        | None                                | None               | None                           | None            |                                     |
| <b>9. Aquatic Ecology</b>  |             |                             |                                  |                               |                    |                                |                            |                           |                          |                             |                                     |                    |                                |                 |                                     |
| 9.1 Impingement (Summer)   | Qualitative | Low                         | Low                              | Low                           |                    | Potentially High               | Moderate                   | Low                       | Low                      | Moderate                    | Low                                 | Low                | Low                            | Moderate        | Low                                 |
| 9.2 Impingement (Winter)   | Qualitative | Moderate                    | Moderate                         | Moderate                      |                    | Potentially High               | High                       | Low                       | Moderate                 | High                        | Moderate                            | Moderate           | Moderate                       | High            | Moderate                            |
| 9.3 Entrainment (Summer)   | Qualitative | Low                         | Low                              | Low                           |                    | Potentially High               | Moderate                   | Low                       | Low                      | Moderate                    | Low                                 | Low                | Low                            | Moderate        | Moderate                            |
| 9.4 Entrainment (Winter)   | Qualitative | Moderate                    | Moderate                         | Moderate                      |                    | Potentially High               | High                       | Moderate                  | Moderate                 | High                        | Moderate                            | Moderate           | Moderate                       | High            | High                                |
| 9.5 Wood Borers* Potential in Bay relative to Existing System (Base) | Qualitative | Lower                       | Lower                            | Lower                         |                    | Lower                          | Lower                      | Lower                     | Lower                    | Lower                       | Lower                               | Lower              | Lower                          | Base            | -                                   |
| 9.6 Cold Shock Potential in Bay relative to Existing System          | Qualitative | Lower                       | Lower                            | Lower                         |                    |                                | Lower                      | Lower                     | Lower                    | Lower                       | Lower                               | Lower              | Lower                          | Base            | -                                   |

\*On the basis of temperature and salinity only, assuming 2 dilution pump operation.

\*\* Insufficient data available to show differentiating noise levels. However, all cooling tower systems would be expected to exceed noise criteria without noise reducing modifications.

Note: Low - the impact is not a concern in the cooling system elimination system.

Moderate - the impact approaches a level of concern in the cooling system elimination system.

High - the impact is of sufficient magnitude to warrant serious considerations in the cooling elimination process.

Exhibit 117

COOLING TOWER CHARACTERISTICS  
USED IN SALT DRIFT ANALYSIS  
OYSTER CREEK STATION  
OYSTER CREEK NUCLEAR GENERATING STATION

|  | Natural<br>Draft   | Fan-Assisted<br>Natural<br>Draft | Round<br>Mechanical<br>Draft |
|--|--------------------|----------------------------------|------------------------------|
| <u>Tower Geometry</u>                    |                    |                                  |                              |
| Height (meters)                          | 164.6              | 91.4                             | 21.0                         |
| Top Exit Diameter (meters)               | 70.1               | 52.0                             | 9.6(1)                       |
| Number of Towers                         | 1                  | 2                                | 2                            |
| Number of Cells (2)                      | -                  | -                                | 19                           |
| Number of Fans (2)                       | -                  | 24                               | 19                           |
| <u>Design Conditions</u>                 |                    |                                  |                              |
| Circulating Water Flow Rate<br>(gpm) (3) | 433,300            | 458,500                          | 433,300                      |
| Heat Load (BTU/hr) (3)                   | $4.59 \times 10^9$ | $4.58 \times 10^9$               | $4.57 \times 10^9$           |
| Wet Bulb Temperature (F)                 | 74                 | 74                               | 74                           |
| Relative Humidity (%)                    | 50                 | 50                               | 50                           |
| Approach Temperature (F)                 | 14                 | 14                               | 10                           |
| Range Temperature (F)                    | 21                 | 20                               | 21.1                         |
| Drift Rate (%)                           | .001               | .001                             | .001                         |
| Plant Factor and Power (%)               | 100                | 100                              | 100                          |
| Exit Velocity (meters per sec)           | 3.7                | 3.6                              | 6.9                          |
| Basin Water Salinity (ppm)               | 45,000             | 45,000                           | 45,000                       |
| Salt Mass Drift Rate (kg/hr)             | 44.2               | 46.8                             | 44.2                         |

(1) Value per cell

(2) Value per tower

(3) Value per tower system (i.e., per 2 - fan-assisted or round towers)

Source: Pickard, Lowe and Garrick, Inc.,  
 October 1977.

Exhibit 118

DROP SIZE DISTRIBUTIONS  
USED IN SALT DRIFT ANALYSIS  
OYSTER CREEK NUCLEAR GENERATING STATION

| Group | Nominal Drop Diameter (um) | Range of Diameter (um) | Fraction of Total Mass in Group |   |                                       |
|-------|----------------------------|------------------------|---------------------------------|---|---------------------------------------|
|       |                            |                        | Natural Draft                   | Fan-Assisted Natural Draft <sup>(1)</sup> | Round Mechanical Draft <sup>(1)</sup> |
| 1     | 50                         | 10 - 75                | .22                             | .22                                       | .50                                   |
| 2     | 100                        | 75 - 125               | .42                             | .42                                       | .05                                   |
| 3     | 150                        | 125 - 175              | .21                             | .21                                       | .08                                   |
| 4     | 200                        | 175 - 270              | .13                             | .13                                       | .32                                   |
| 5     | 280                        | 270 - 325              | .012                            | .012                                      | .04                                   |
| 6     | 450                        | >325                   | .008                            | .008                                      | .01                                   |

(1) Calculations described herein were done for each nominal drop diameter with its associated mass fraction except that the 50 and 100 u diameter groups were combined and treated all as 100 u diameter droplets.

Exhibit 119

STRATIFICATION OF HOURLY  
METEOROLOGICAL DATA  
OYSTER CREEK NUCLEAR GENERATING STATION

| <u>Atmospheric<br/>Condition</u> | <u>No. of<br/>Groups</u> | <u>Group Classification</u>   |
|----------------------------------|--------------------------|---|
| Wind Direction                   | 16 Sectors               | N, NNE, NE, ENE, E, ESE, SE, SSE,<br>S, SSW, SW, WSW, W, WNW, NW, NNW   |
| Wind Speed                       | 8                        | 0 - 3.0 mph<br>3.0 - 6.0 mph<br>6.0 - 9.0 mph<br>9.0 - 12.0 mph<br>12.0 - 18.0 mph<br>18.0 - 25.0 mph<br>25.0 - 32.0 mph<br>> 32.0 mph<br>Wake Conditions for Winds 26 mph <sup>(1)</sup> |
| Stability Class                  | 3                        | Pasquill Category C<br>Pasquill Category D<br>Pasquill Category E   |
| Relative Humidity                | 2                        | > 75%<br>≤ 75%  |

(1) Aerodynamic wake conditions assumed to exist when wind speeds greater than 25 mph.

Exhibit 120

REPRESENTATIVE VALUES OF STRATIFIED  
METEOROLOGICAL DATA OYSTER CREEK NUCLEAR GENERATING STATION

| Wind Speed (mph) | Representative Wind (m/sec) | Stability Class (2) | Relative Humidity (%) | Representative Relative Humidity (%) |
|------------------|-----------------------------|---------------------|-----------------------|--------------------------------------|
| 0-3 (1)          | 1.0                         | C, D, E             | > 75<br>≤ 75          | 90<br>65                             |
| 4-6              | 2.3                         | C, D, E             | > 75<br>≤ 75          | 90<br>65                             |
| 7-9              | 3.5                         | C, D, E             | > 75<br>≤ 75          | 90<br>65                             |
| 10-12            | 5.0                         | C, D, E             | > 75<br>≤ 75          | 90<br>65                             |
| 13-18            | 7.0                         | D                   | > 75<br>≤ 75          | 90<br>65                             |
| 19-25            | 10.0                        | D                   | > 75<br>≤ 75          | 90<br>65                             |
| 26-32            | 13.0                        | D                   | > 75<br>≤ 75          | 90<br>65                             |
| ≥ 33             | 16.0                        | D                   | > 75<br>≤ 75          | 90<br>65                             |

(1) Calms represented as 0.5 mph with a wind direction of the first subsequent non-calm hour.

(2) Definition of Pasquill Category used:

$$C = \text{Unstable, } \frac{\Delta T (F)}{100 \text{ ft}} \leq -0.8$$

$$D = \text{Neutral } -0.8 < \frac{\Delta T (F)}{100 \text{ ft}} \leq -0.3$$

$$E = \text{Stable } \frac{\Delta T (F)}{100 \text{ ft}} > -0.3$$

Exhibit 121

COLLECTION EFFICIENCY OF CYLINDRICAL AND RIBBON TYPE OBJECTS  
OF VARIOUS DIMENSIONS FOR DRIFT DROPS AS A FUNCTION OF  
DRIFT DROP DIAMETER AND WIND SPEED

|                                |                             | Collection Efficiency for Drop Diameter (um) |      |      |      |      |      |
|--------------------------------|-----------------------------|--|------|------|------|------|------|
| Wind Speed Group (mph)         | Obstacle Dimension (inches) | 10   | 100  | 150  | 200  | 300  | 500  |
| Type of Structure: Cylindrical |                             |  |      |      |      |      |      |
| 0 - 12                         | ½                           | 0.07   | 0.98 | 0.99 | 1.00 | 1.00 | 1.00 |
|                                | 2                           | -  | 0.76 | 0.86 | 0.96 | 0.99 | 1.00 |
|                                | 120                         | -  | -    | 0.60 | 0.12 | 0.32 | 0.58 |
| 12 - 25                        | ½                           | 0.21   | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
|                                | 2                           | -  | 0.89 | 0.94 | 0.99 | 1.00 | 1.00 |
|                                | 120                         | -  | -    | 0.16 | 0.32 | 0.54 | 0.74 |
| 25 - 32                        | ½                           | 0.36   | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
|                                | 2                           | 0.02   | 0.85 | 0.92 | 0.99 | 1.00 | 1.00 |
|                                | 120                         | -  | -    | 0.22 | 0.44 | 0.60 | 0.84 |
| > 32                           | ½                           | 0.44   | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
|                                | 2                           | 0.04   | 0.90 | 0.95 | 1.00 | 1.00 | 1.00 |
|                                | 120                         | -  | 0.13 | 0.33 | 0.52 | 0.64 | 0.86 |
| Type of Structure: Ribbon      |                             |  |      |      |      |      |      |
| 0 - 12                         | 120                         | -  | -    | -    | -    | 0.60 | 0.81 |
|                                | 400                         | -  | -    | -    | -    | -    | 0.51 |
|                                | 1,200                       | -  | -    | -    | -    | -    | -    |
| 12 - 25                        | 120                         | -  | -    | 0.31 | 0.62 | 0.82 | 0.90 |
|                                | 400                         | -  | -    | -    | -    | 0.40 | 0.73 |
|                                | 1,200                       | -  | -    | -    | -    | -    | 0.38 |
| 25 - 32                        | 120                         | -  | -    | 0.35 | 0.70 | 0.84 | 0.95 |
|                                | 400                         | -  | -    | -    | -    | 0.59 | 0.84 |
|                                | 1,200                       | -  | -    | -    | -    | -    | 0.51 |
| > 32                           | 120                         | -  | -    | 0.38 | 0.76 | 0.88 | 0.96 |
|                                | 400                         | -  | -    | -    | -    | 0.64 | 0.85 |
|                                | 1,200                       | -  | -    | -    | -    | -    | 0.62 |

Data Source: Calculated from Ranz and Wong curves as presented by Mason, Physics of Clouds, 1971.

Source: Pickard, Lowe and Garrick, Inc., October 1977.

## Exhibit 122

AVERAGE DAILY INTAKE WATER TEMPERATURES

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| <u>Month</u> | <u>Period of Record</u> | <u>Maximum Temperature</u><br>(° F) | <u>Average Temperature</u><br>(° F) | <u>Minimum Temperature</u><br>(° F) |
|--------------|-------------------------|-------------------------------------|-------------------------------------|-------------------------------------|
| January      | 1976-1977               | 33.6                                | 32.6                                | 31.5                                |
| February     | 1976-1977               | 39.6                                | 38.3                                | 36.0                                |
| March        | 1976-1977               | 50.8                                | 46.7                                | 45.2                                |
| April        | 1976                    | 60.2                                | 57.8                                | 55.7                                |
| May          | 1976                    | 71.3                                | 67.9                                | 65.5                                |
| June         | 1975-1976               | 78.5                                | 75.9                                | 74.1                                |
| July         | 1975-1976               | 81.6                                | 79.2                                | 77.2                                |
| August       | 1975-1976               | 80.8                                | 78.6                                | 76.8                                |
| September    | 1975-1976               | 73.0                                | 71.0                                | 69.3                                |
| October      | 1975-1976               | 63.5                                | 60.2                                | 58.6                                |
| November     | 1975-1976               | 50.5                                | 48.8                                | 47.2                                |
| December     | 1975-1976               | 40.4                                | 38.2                                | 36.4                                |

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Source: JCP&amp;L

Exhibit 123

EXTREME AND AVERAGE WET BULB AND WATER TEMPERATURES

DEGREES F

| <u>Month</u> | <u>Extreme Case</u> |                     | <u>Average Case</u> |                     |
|--------------|---------------------|---------------------|---------------------|---------------------|
|              | <u>Wet Bulb*</u>    | <u>Intake Water</u> | <u>Wet Bulb*</u>    | <u>Intake Water</u> |
| January      | 58                  | 31.5                | 29.4                | 32.6                |
| February     | 61                  | 36.0                | 30.7                | 38.3                |
| March        | 62                  | 45.2                | 36.2                | 46.7                |
| April        | 67                  | 55.7                | 45.1                | 57.8                |
| May          | 73                  | 65.5                | 54.2                | 67.9                |
| June         | 79                  | 74.1                | 63.3                | 75.9                |
| July         | 79                  | 77.2                | 67.4                | 79.2                |
| August       | 79                  | 76.8                | 67.0                | 78.6                |
| September    | 78                  | 69.3                | 61.4                | 71.0                |
| October      | 70                  | 58.6                | 51.2                | 60.2                |
| November     | 67                  | 47.2                | 42.9                | 48.8                |
| December     | 59                  | 36.4                | 30.4                | 38.2                |

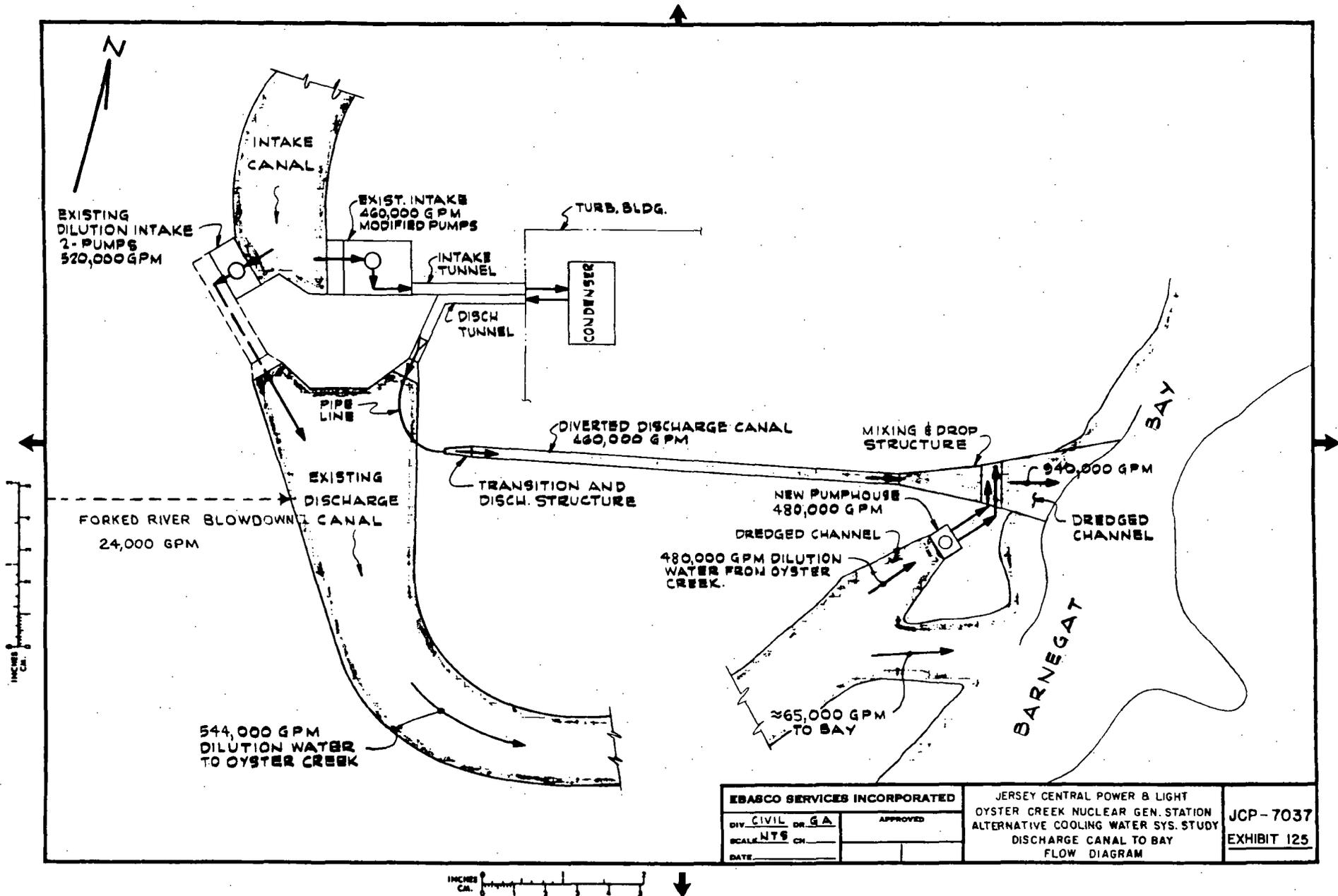
\* Source: Atlantic City

Exhibit 124

COOLING TOWER PERFORMANCE DATA

| <u>Wet Bulb</u> | <u>Basin Water Temperature - ° F</u> |                                |                                |                                       |
|-----------------|--------------------------------------|--------------------------------|--------------------------------|---------------------------------------|
|                 | <u>Round Mech<br/>Draft Towers</u>   | <u>Natural<br/>Draft Tower</u> | <u>Fan Assisted<br/>Towers</u> | <u>Forked River<br/>Station Tower</u> |
| 30              | 60                                   | 55                             | 64                             | 70                                    |
| 46              | 67                                   | 67                             | 72                             | 78                                    |
| 65              | 78                                   | 81                             | 83                             | 89                                    |
| 74              | 84                                   | 88                             | 88                             | 95                                    |
| 78              | 87                                   | 91                             | 91                             | 98                                    |

| <u>Evaporation Rate - GPM</u> |       |       |       |        |
|-------------------------------|-------|-------|-------|--------|
| 30                            | 4,800 | 5,000 | 5,000 | 9,800  |
| 46                            | 5,700 | 5,700 | 5,800 | 11,100 |
| 65                            | 6,550 | 6,550 | 6,600 | 12,000 |
| 74                            | 7,000 | 7,000 | 7,100 | 13,000 |
| 78                            | 7,400 | 7,400 | 7,500 | 13,500 |



EBASCO SERVICES INCORPORATED

DIV. CIVIL DR. G.A.

SCALE: NTS CH.

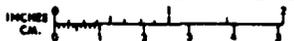
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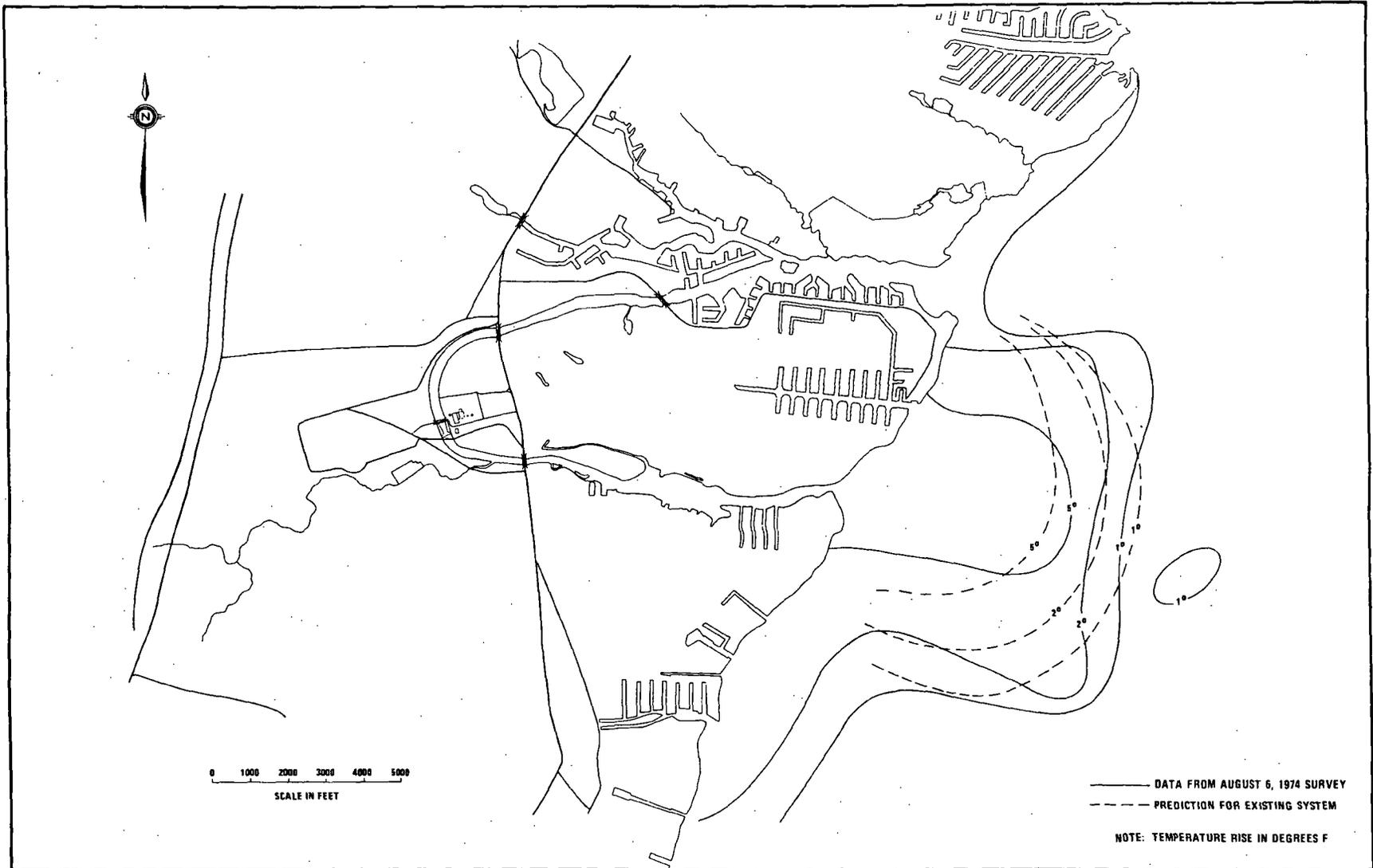
APPROVED

JERSEY CENTRAL POWER & LIGHT  
 OYSTER CREEK NUCLEAR GEN. STATION  
 ALTERNATIVE COOLING WATER SYS. STUDY  
 DISCHARGE CANAL TO BAY  
 FLOW DIAGRAM

JCP-7037

EXHIBIT 125





JERSEY CENTRAL POWER  
AND LIGHT COMPANY

EBASCO SERVICES INCORPORATED  
New York

EXISTING OYSTER CREEK NGS COOLING SYSTEM  
MEASURED AND PREDICTED SURFACE TEMPERATURE DISTRIBUTIONS

EXHIBIT  
126

Exhibit 127

ESTIMATED CHEMICAL RELEASES TO THE CIRCULATING WATER DISCHARGE CANAL

| Source                                | Compound            | Average <sup>(e)</sup><br>Addition<br>lb/day | Ionic<br>Species     | Normal<br>Concentration<br>in Cooling<br>Water Inlet <sup>(e)</sup><br>mg/liter | Concentration<br>Increase<br>in Cooling Water <sup>(a)</sup><br>mg/liter |                            |
|---------------------------------------|---------------------|--|----------------------|---|--|----------------------------|
|                                       |                     |  |                      |   | Average<br>Release<br>Rate   | Maximum<br>Release<br>Rate |
| Cooling Water<br>Biocide              | Chlorine            | 1,000  | Chloride             | 12,680  | 0.18   | 0.36 <sup>(b)</sup>        |
|                                       |                     |  | Chlorine<br>Residual | 0   | 0.2  | 0.2 <sup>(b)</sup>         |
|                                       |                     |  | Chloride<br>Residual | 12,680  |  |                            |
| Sewage Treat-<br>ment                 | Chlorine            | -  | Chloride             | 12,680  |  |                            |
|                                       |                     |  | Chlorine<br>Residual | 0   |  |                            |
|                                       |                     |  | Sulfate              | 1,820   | 0.012  | 0.82 <sup>(c)</sup>        |
| Demineralizer<br>Regenerant           | Sulfuric Acid       | 68   | Sulfate              | 1,820   | 0.012  | 0.82 <sup>(d)</sup>        |
|                                       |                     |  | Sodium Hydroxide     | 32  | 0.0034   | 0.21 <sup>(c)</sup>        |
|                                       |                     |  | pH                   | 6.95  | 6.95   | 6.88 <sup>(c)</sup>        |
| Boiler<br>Blowdown                    | Trisodium Phosphate | 0.22   | Sodium               | 7,130   | -  | 7.04 <sup>(d)</sup>        |
|                                       |                     |  | Sulfite              | -   | -  | 0.02 <sup>(f)</sup>        |
|                                       |                     |  | Phosphate            | 0.7   | -  | 0.01 <sup>(f)</sup>        |
| Condenser Tube<br>Corrosion<br>Copper | Sodium Sulfite      | 0.25   | Phosphate            | 0.7   | -  | 0.01 <sup>(f)</sup>        |
|                                       |                     |  | Copper               | 0.02 - 0.10 <sup>(e)</sup>  |  | Inconclusive               |

(a) Assuming 460,000 gpm circulating water flow and neglecting all freshwater flows

(b) 178 lb of sulfuric acid rinsed from cation exchanger in 1 hour

(c) 84 lb of sodium hydroxide rinsed from anion exchanger in 1 hour

(d) Jersey Central Power and Light Company, Oyster Creek Nuclear Generating Station Environmental Report, March 6, 1972, to the "Application for Construction Permit and Operating License," Docket No. 50-219, March 26, 1964, Table 3.4-1.

(e) Ibid, Appendix C, Response B4

(f) 10-minute blowdown, every 3 days

Exhibit 128

MANUFACTURERS NOISE DATA FOR PREFERRED COOLING TOWER SYSTEMS

NATURAL DRAFT COOLING TOWER

| <u>Distance From Tower, Feet</u> | <u>Unattenuated Sound Level, dB(A)</u> |
|----------------------------------|--|
| 50                               | 81.5                                   |
| 1,400                            | 55.5                                   |

Unattenuated sound level at 1,800 feet from the tower:

| Octave Band Center Frequency (Hz) | 31.5 | 63 | 125 | 250 | 500  | 1K   | 2K   | 4K   | 8K   | A Scale |
|-----------------------------------|------|----|-----|-----|------|------|------|------|------|---------|
| Sound Pressure Level (dB)         |      |    |     |     |      |      |      |      |      |         |
| Re-0.0002 Microbars               | 49   | 49 | 47  | 44  | 48.5 | 49.5 | 46.5 | 38.5 | 11.3 | 53      |

FAN-ASSISTED COOLING TOWERS

| <u>Distance From Tower, Feet</u> | <u>Unattenuated Sound Level, dB(A)</u> |
|----------------------------------|--|
| 50                               | 89                                     |
| 1,600                            | 61.5                                   |

Unattenuated sound level at 1,800 feet from the towers:

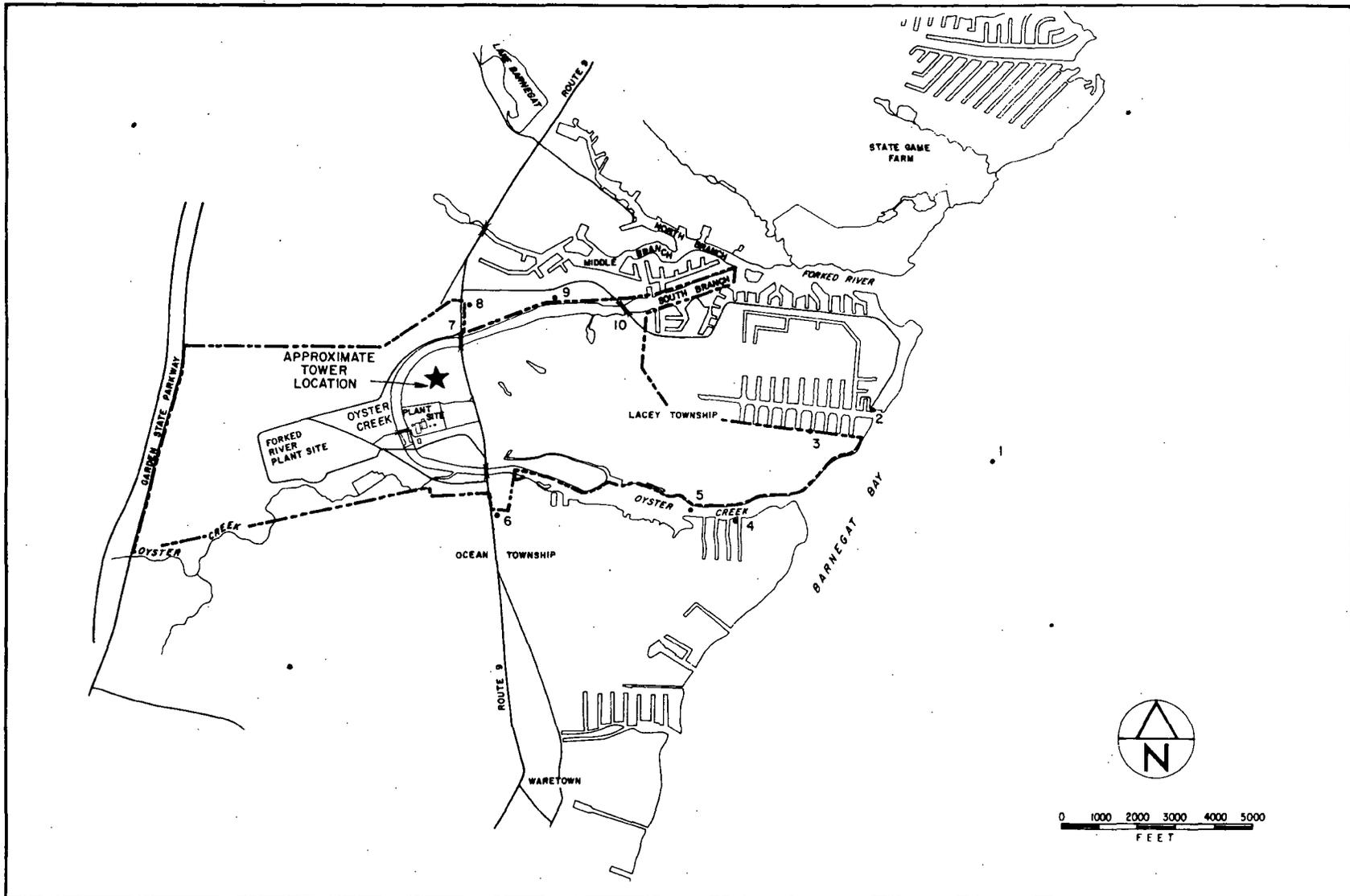
| Octave Band Center Frequency (Hz) | 31.5 | 63   | 125  | 250  | 500 | 1K   | 2K   | 4K   | 8K  | A Scale |
|-----------------------------------|------|------|------|------|-----|------|------|------|-----|---------|
| Sound Pressure Level (dB)         |      |      |      |      |     |      |      |      |     |         |
| Re-0.0002 Microbars               | 67   | 67.5 | 63.5 | 62.5 | 58  | 54.5 | 49.5 | 38.5 | 6.5 | 60      |

Attenuated sound level at 1,800 feet distance from two towers:

| Octave Band Center Frequency (Hz) | 31.5 | 63   | 125 | 250 | 500  | 1K   | 2K | 4K | 8K  | A Scale |
|-----------------------------------|------|------|-----|-----|------|------|----|----|-----|---------|
| Sound Pressure Level (dB)         |      |      |     |     |      |      |    |    |     |         |
| Re-0.0002 Microbars               | 55   | 51.5 | 46  | 45  | 43.5 | 40.5 | 34 | 22 | 0.5 | 45      |

ROUND MECHANICAL DRAFT COOLING TOWERS

| <u>Distance From Tower, Feet</u> | <u>Unattenuated Sound Level, dB(A)</u> |
|----------------------------------|--|
| 100                              | 74                                     |
| 600                              | 62                                     |



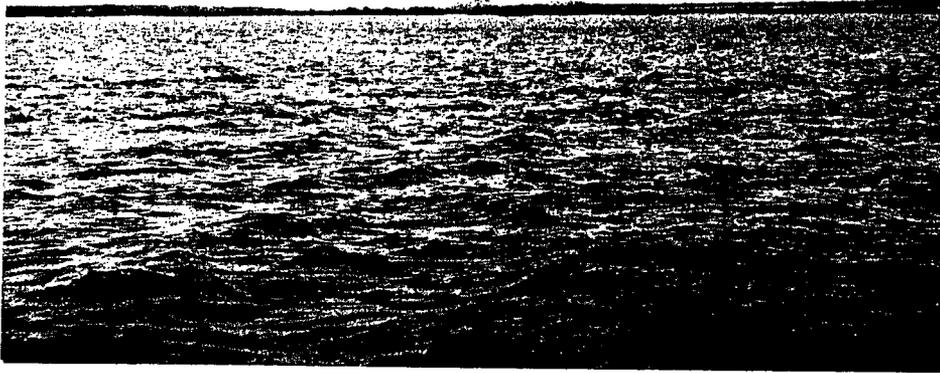
JERSEY CENTRAL  
POWER & LIGHT COMPANY

EBASCO SERVICES INCORPORATED  
New York

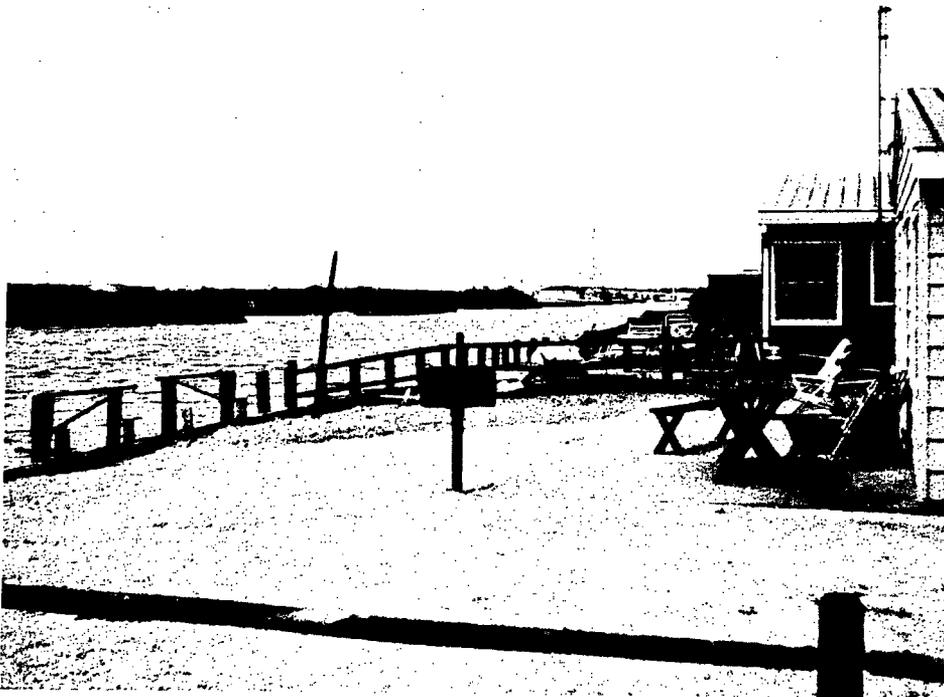
MAP OF PHOTOGRAPH LOCATIONS  
FOR VISUAL/ESTHETIC ANALYSIS  
NATURAL DRAFT HYPERBOLIC COOLING TOWER

EXHIBIT

129



LOCATION No. 1 - VIEW FROM ABOUT 3/4 MILE FROM SHORE IN BARNEGAT BAY.



LOCATION No. 2 - VIEW FROM RESIDENCE AT BEACH BLVD. AND BINNACLE PT.

JERSEY CENTRAL  
POWER & LIGHT COMPANY

EBASCO SERVICES INCORPORATED  
New York

PHOTOGRAPHIC ANALYSIS-  
NATURAL DRAFT COOLING TOWER  
VISUAL ASSESSMENT

EXHIBIT  
130



LOCATION No. 3 - VIEW FROM RESIDENCE AT ORLANDO DRIVE AND PENGUIN, CT.



LOCATION No. 4 - VIEW FROM LAST RESIDENCE ON COMPASS RD. -  
LOOKING ACROSS OYSTER CREEK.

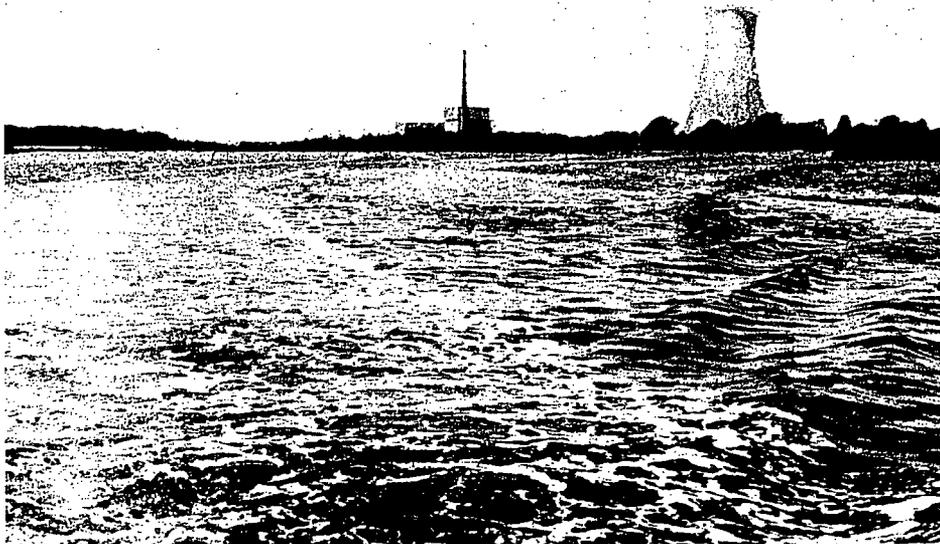
JERSEY CENTRAL  
POWER & LIGHT COMPANY

EBASCO SERVICES INCORPORATED  
New York

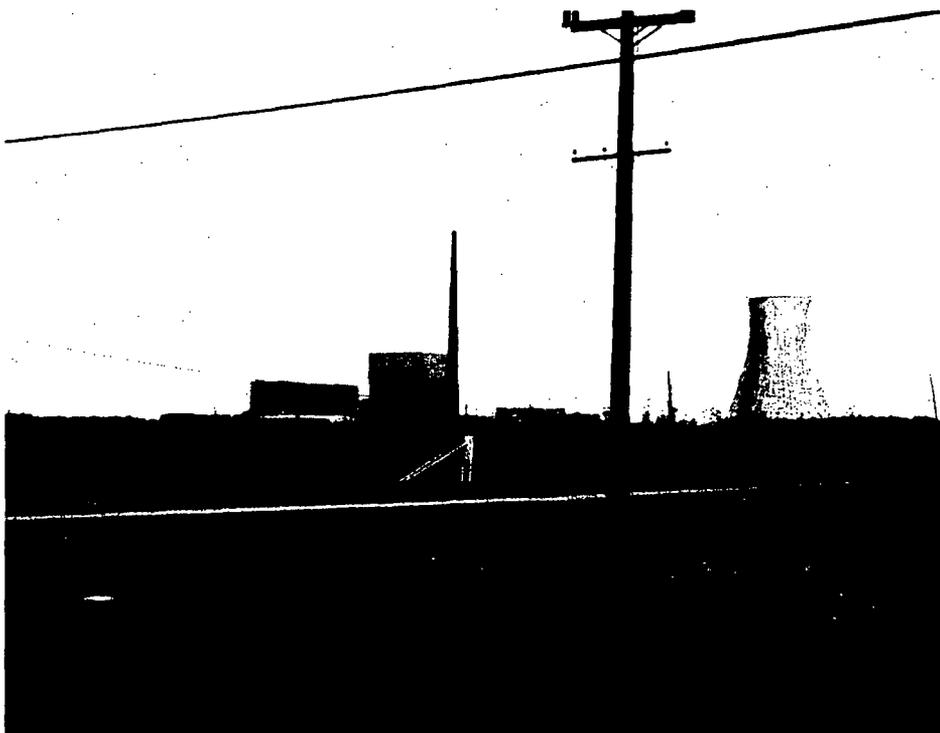
PHOTOGRAPHIC ANALYSIS-  
NATURAL DRAFT COOLING TOWER  
VISUAL ASSESSMENT

EXHIBIT

131



LOCATION No. 5 - VIEW TAKEN FROM A BOAT IN OYSTER CREEK -  
LOOKING WEST



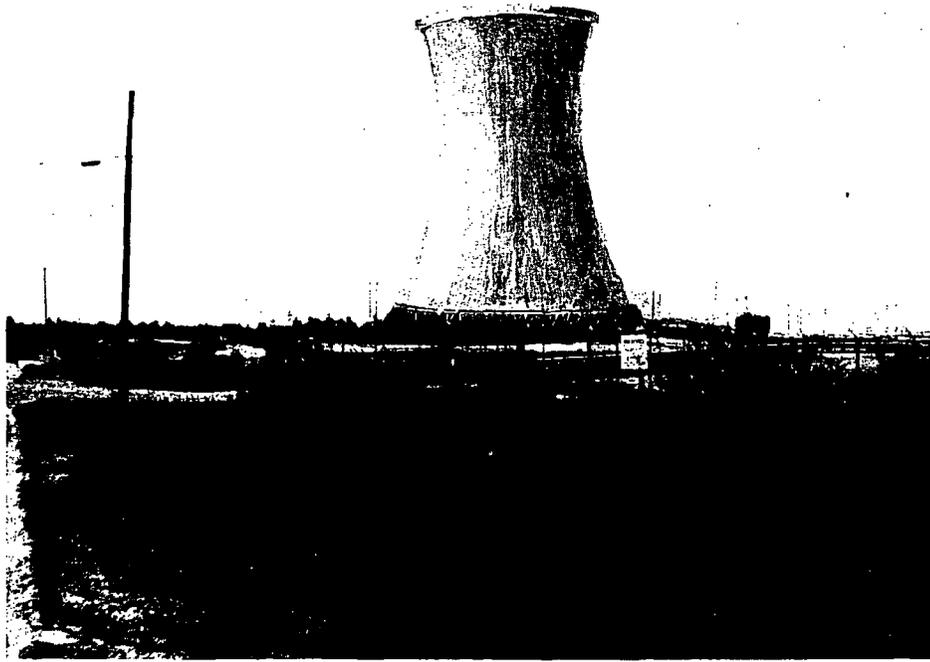
LOCATION No. 6 - VIEW TAKEN FROM NE CORNER OF BAY  
PARKWAY AND ROUTE 9

JERSEY CENTRAL  
POWER & LIGHT COMPANY

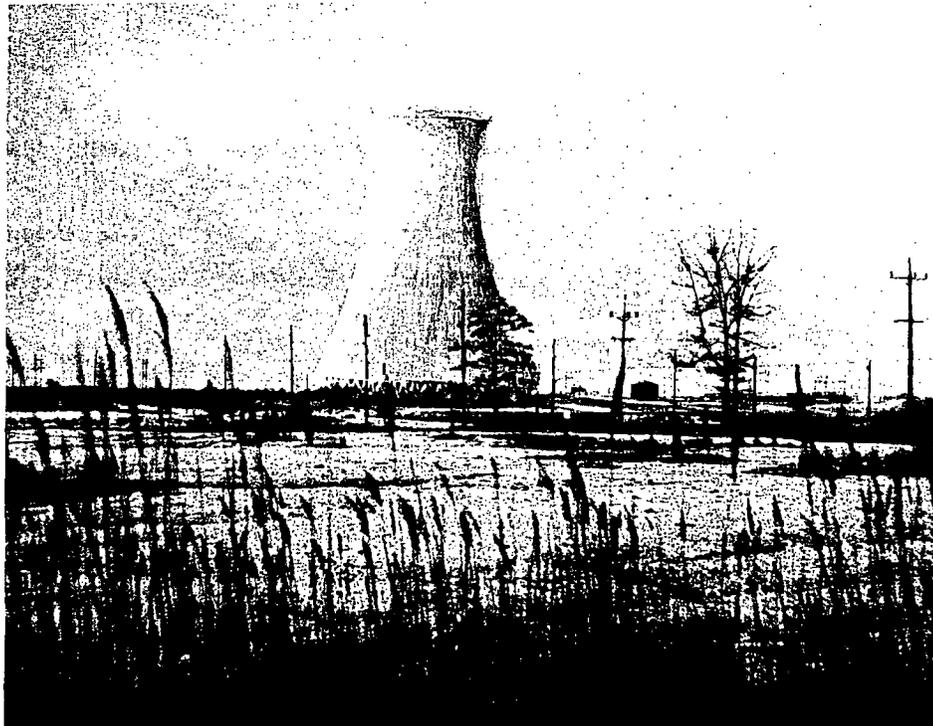
EBASCO SERVICES INCORPORATED  
New York

PHOTOGRAPHIC ANALYSIS -  
NATURAL DRAFT COOLING TOWER  
VISUAL ASSESSMENT

EXHIBIT  
132



LOCATION No. 7 - VIEW FROM ROUTE 9 AT ABOUT 4/10 THS. MILE  
NORTH OF EX. PLANT



LOCATION No. 8 - VIEW FROM BACKYARD OF RESIDENCE AT  
NANTUCKET RD. AND BISCAYNE DR.

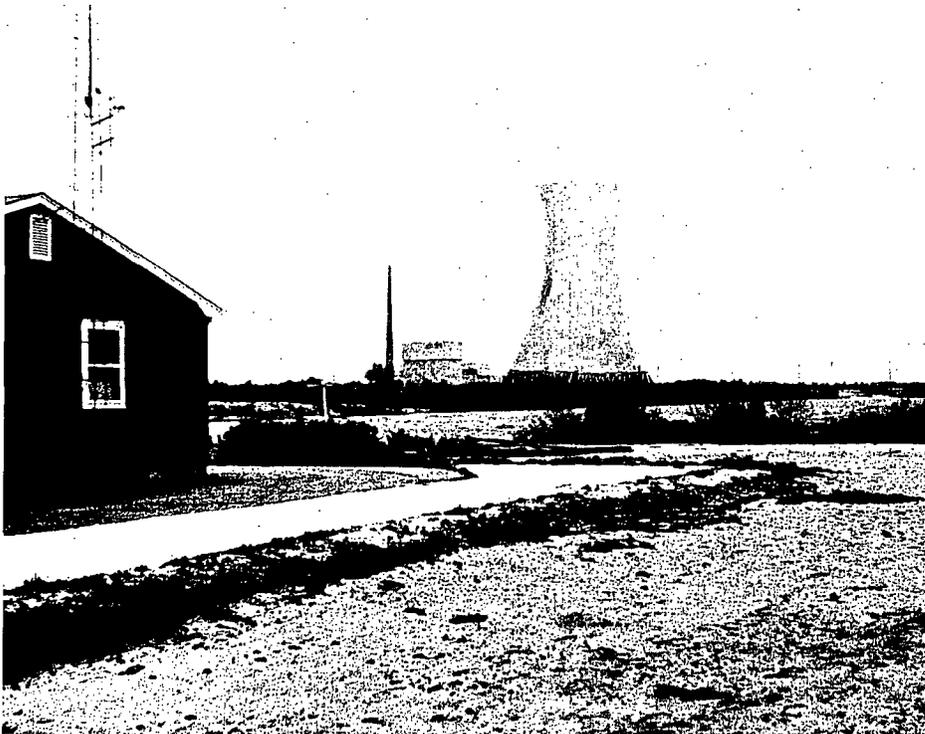
JERSEY CENTRAL  
POWER & LIGHT COMPANY

EBASCO SERVICES INCORPORATED  
New York

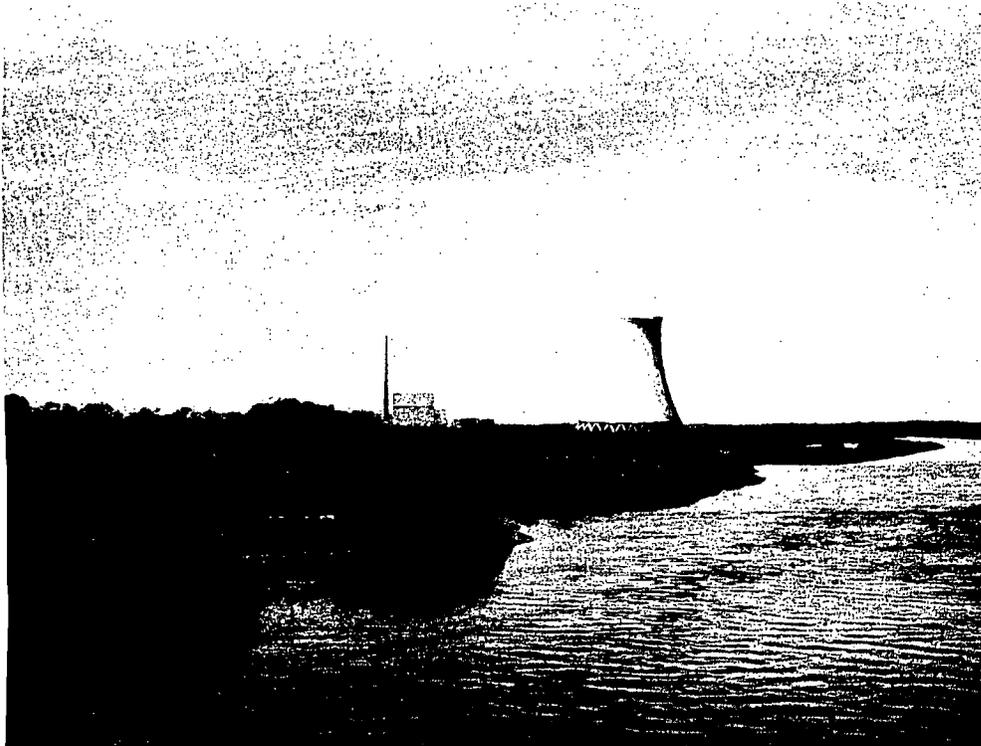
PHOTOGRAPHIC ANALYSIS-  
NATURAL DRAFT COOLING TOWER  
VISUAL ASSESSMENT

EXHIBIT

133



LOCATION No. 9 - VIEW FROM NANTUCKET AND BERMUDA DRIVES



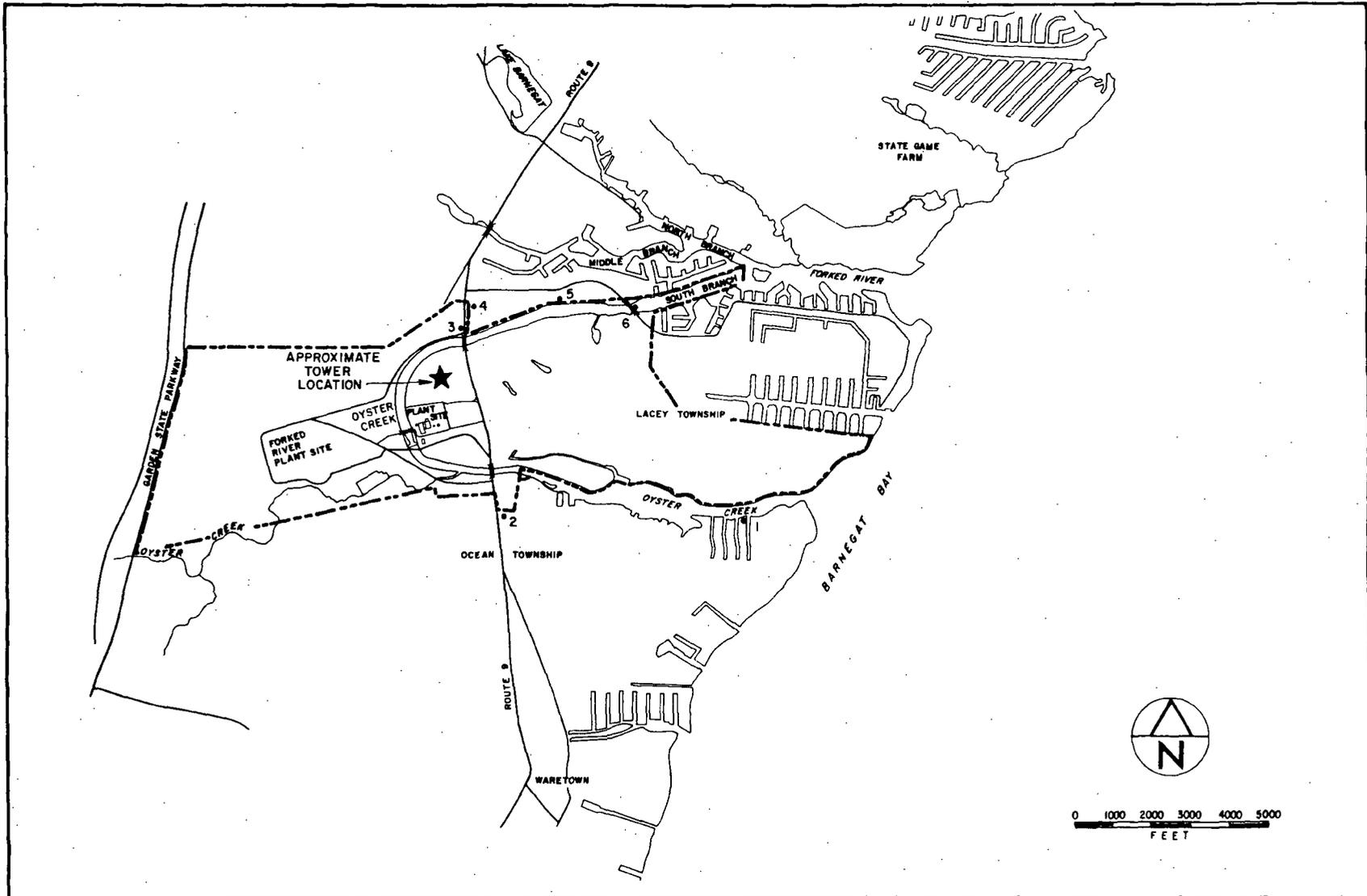
LOCATION No. 10 - VIEW FROM BEACH BLVD. BRIDGE OVER SOUTH BRANCH OF FORKED RIVER

JERSEY CENTRAL  
POWER & LIGHT COMPANY

EBASCO SERVICES INCORPORATED  
New York

PHOTOGRAPHIC ANALYSIS-  
NATURAL DRAFT COOLING TOWER  
VISUAL ASSESSMENT

EXHIBIT  
134



JERSEY CENTRAL  
POWER & LIGHT COMPANY

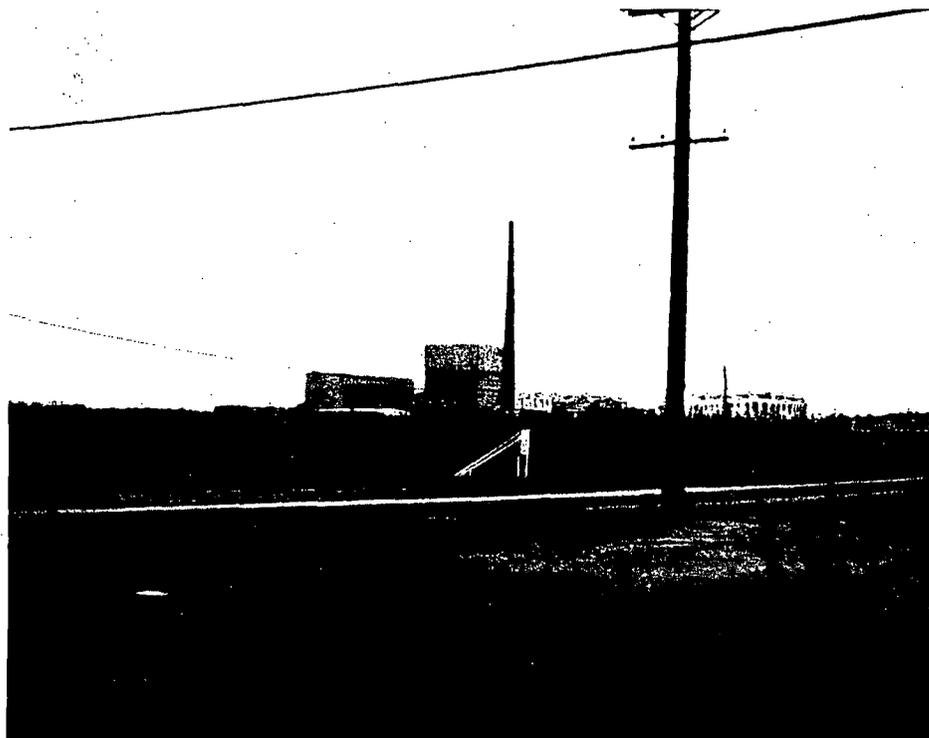
EBASCO SERVICES INCORPORATED  
New York

MAP OF PHOTOGRAPH LOCATIONS  
FOR VISUAL/ESTHETIC ANALYSIS  
ROUND MECHANICAL DRAFT COOLING TOWERS

EXHIBIT  
135



LOCATION No. 1 - VIEW FROM LAST RESIDENCE ON COMPASS RD. -  
LOOKING ACROSS OYSTER CREEK



LOCATION No. 2 - VIEW TAKEN FROM NE CORNER OF BAY  
PARKWAY AND ROUTE 9

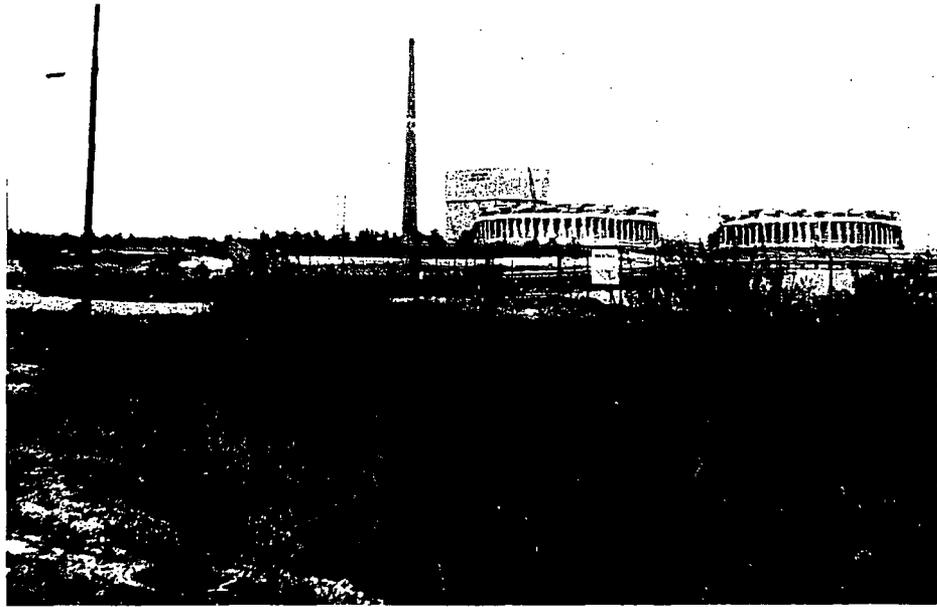
JERSEY CENTRAL  
POWER & LIGHT COMPANY

EBASCO SERVICES INCORPORATED  
New York

PHOTOGRAPHIC ANALYSIS-  
ROUND MECHANICAL COOLING  
TOWERS VISUAL ASSESSMENT

EXHIBIT

136



LOCATION No. 3 - VIEW FROM ROUTE 9 AT ABOUT 4/10 THS. MILE  
NORTH OF EX. PLANT



LOCATION No. 4 - VIEW FROM BACKYARD OF RESIDENCE AT  
NANTUCKET RD. AND BISCAYNE DR.

JERSEY CENTRAL  
POWER & LIGHT COMPANY

EBASCO SERVICES INCORPORATED  
New York

PHOTOGRAPHIC ANALYSIS-  
ROUND MECHANICAL COOLING  
TOWERS VISUAL ASSESSMENT

EXHIBIT  
137



LOCATION No. 5 - VIEW FROM NANTUCKET AND BERMUDA DRIVES

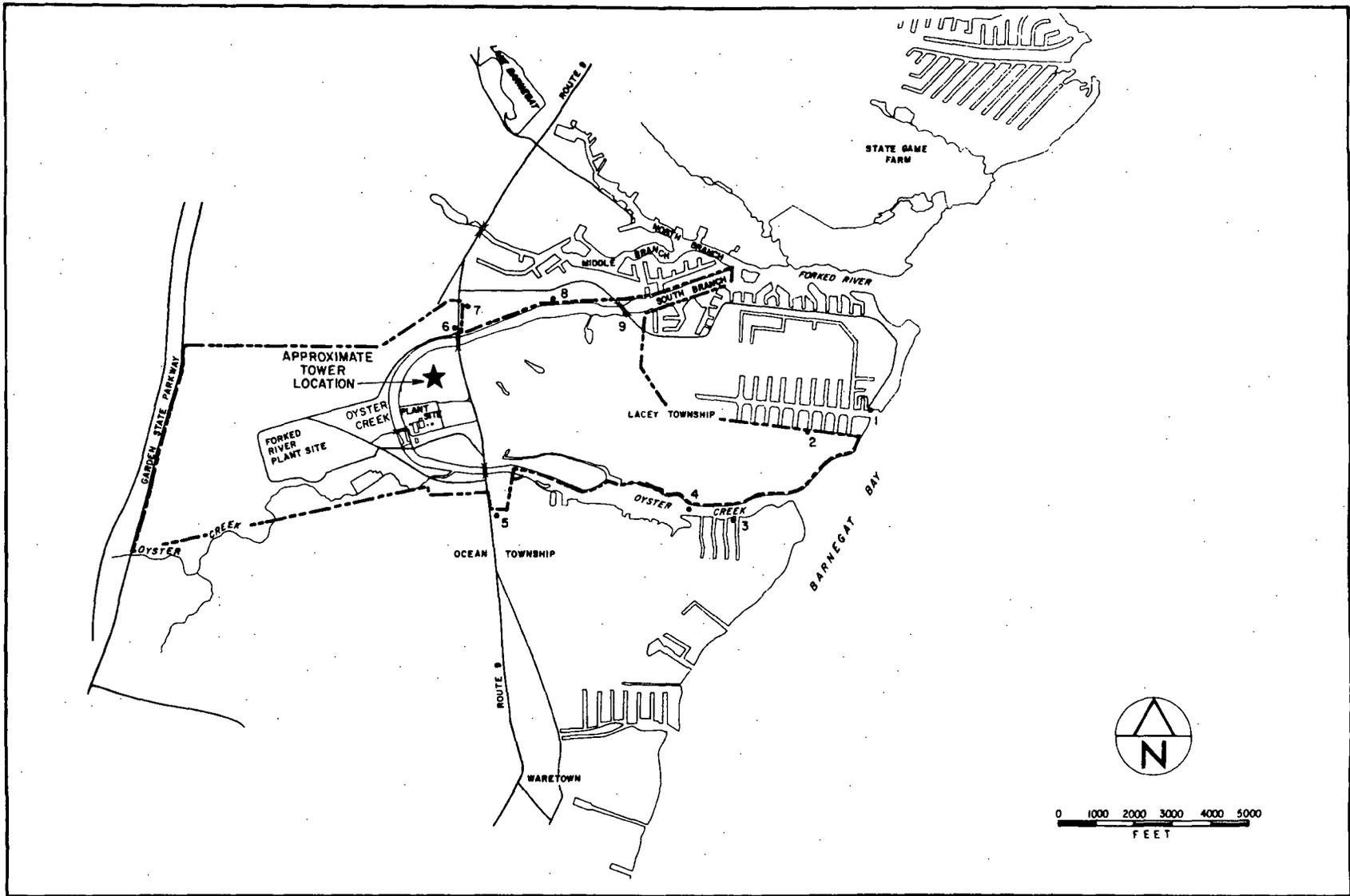


LOCATION No. 6 - VIEW FROM BEACH BLVD. BRIDGE OVER SOUTH BRANCH OF FORKED RIVER

JERSEY CENTRAL  
POWER & LIGHT COMPANY  
EBASCO SERVICES INCORPORATED  
New York

PHOTOGRAPHIC ANALYSIS-  
ROUND MECHANICAL COOLING  
TOWERS VISUAL ASSESSMENT

EXHIBIT  
138



JERSEY CENTRAL  
POWER & LIGHT COMPANY

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EBASCO SERVICES INCORPORATED  
New York

MAP OF PHOTOGRAPH LOCATIONS  
FOR VISUAL/ESTHETIC ANALYSIS  
FAN-ASSISTED N. D. COOLING TOWERS

EXHIBIT  
139



LOCATION No. 1 - VIEW FROM RESIDENCE AT BEACH BLVD. AND  
BINNACLE PT.



LOCATION No. 2 - VIEW FROM RESIDENCE AT ORLANDO DRIVE  
AND PENGUIN CT.

JERSEY CENTRAL  
POWER & LIGHT COMPANY

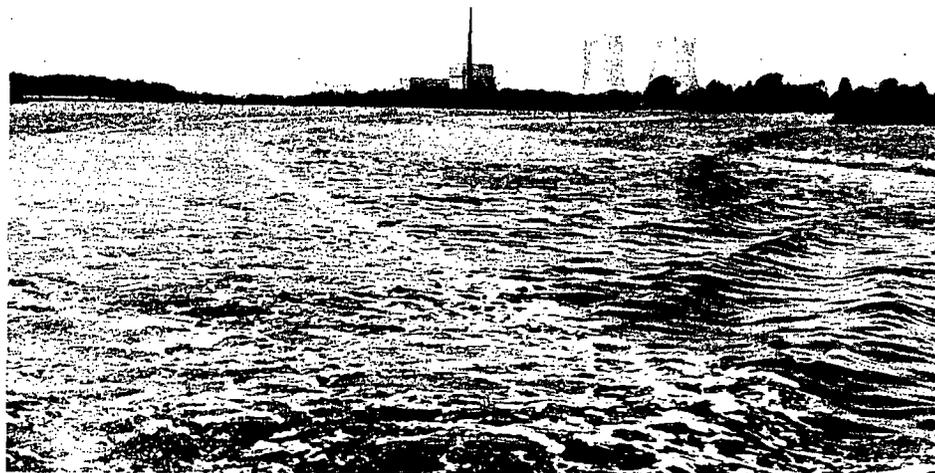
EBASCO SERVICES INCORPORATED  
New York

PHOTOGRAPHIC ANALYSIS - FAN-  
ASSISTED NATURAL DRAFT COOLING  
TOWERS VISUAL ASSESSMENT

EXHIBIT  
140



LOCATION No. 3 - VIEW FROM LAST RESIDENCE ON COMPASS RD. -  
LOOKING ACROSS OYSTER CREEK



LOCATION No. 4 - VIEW TAKEN FROM A BOAT IN OYSTER CREEK -  
LOOKING WEST

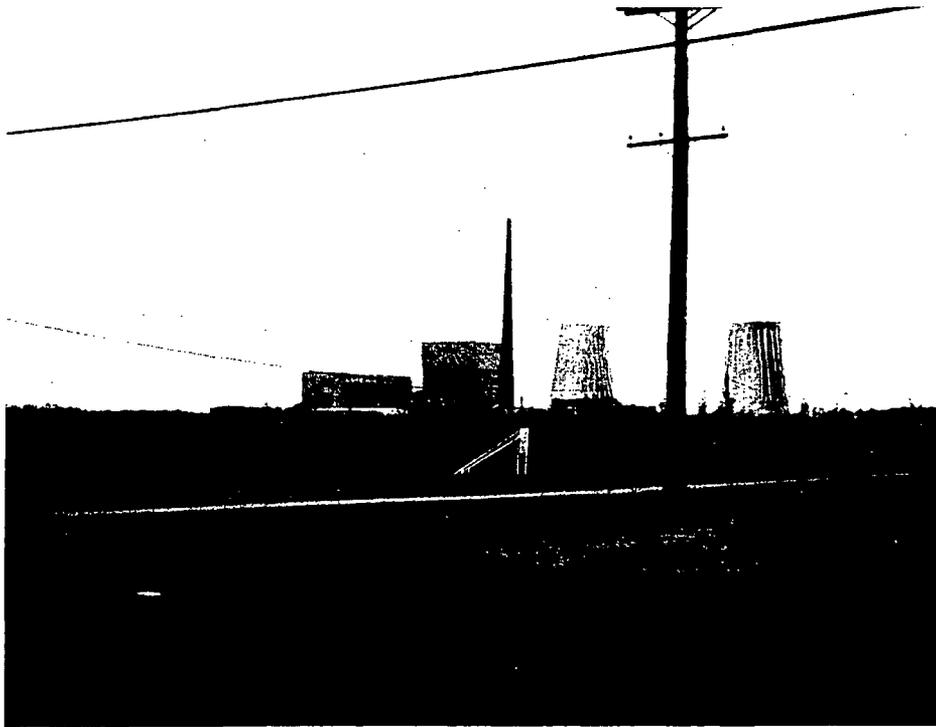
JERSEY CENTRAL  
POWER & LIGHT COMPANY

EBASCO SERVICES INCORPORATED  
New York

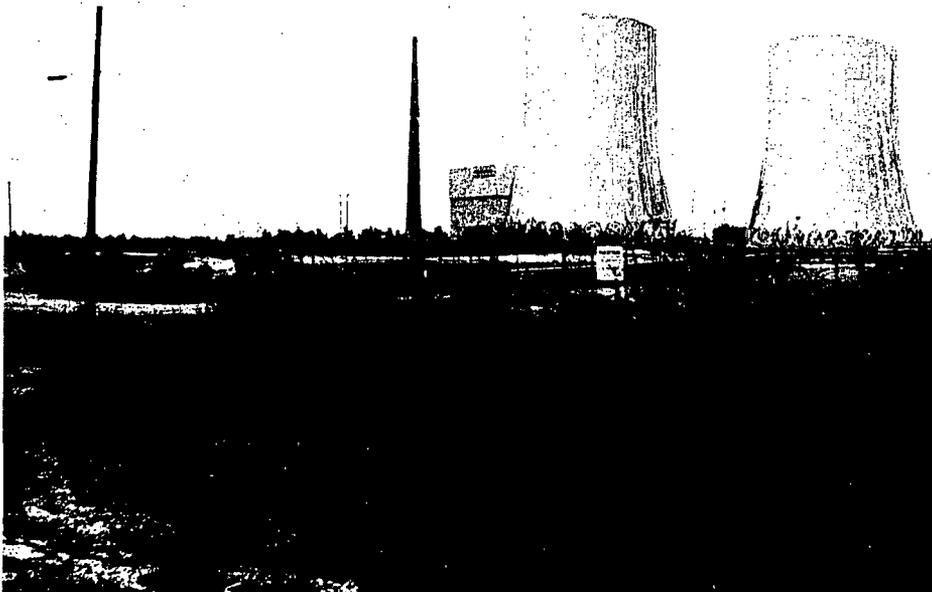
PHOTOGRAPHIC ANALYSIS - FAN-  
ASSISTED NATURAL DRAFT COOLING  
TOWERS VISUAL ASSESSMENT

EXHIBIT

141



LOCATION No. 5 - VIEW TAKEN FROM NE CORNER OF BAY PARKWAY  
AND ROUTE 9



LOCATION No. 6 - VIEW FROM ROUTE 9 AT ABOUT 4/10 THS. MILE  
NORTH OF EX. PLANT

JERSEY CENTRAL  
POWER & LIGHT COMPANY

EBASCO SERVICES INCORPORATED  
New York

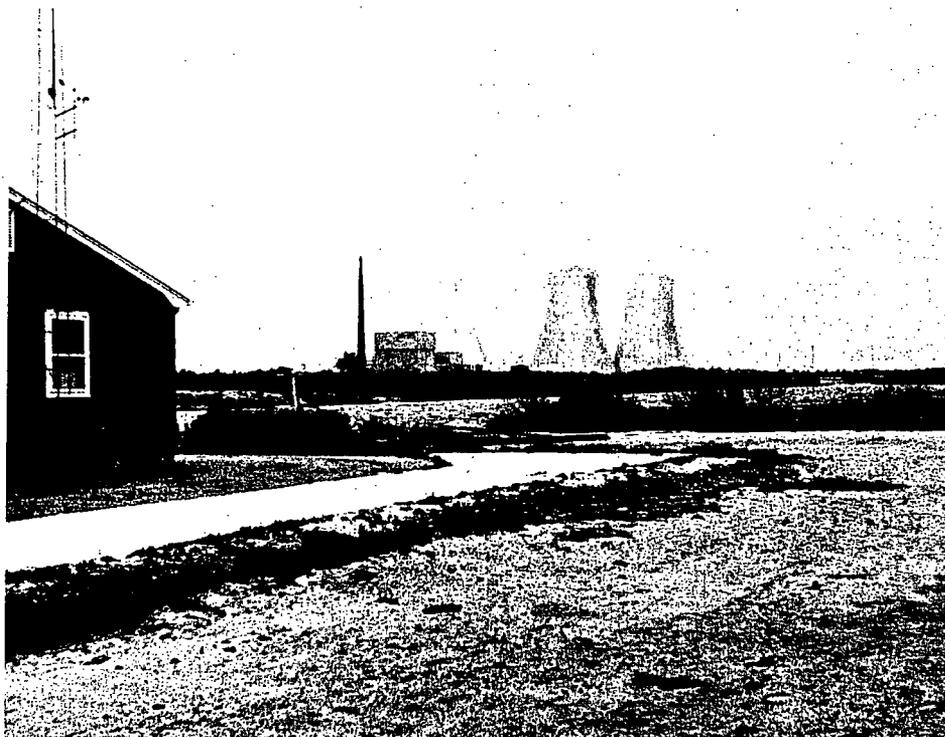
PHOTOGRAPHIC ANALYSIS - FAN-  
ASSISTED NATURAL DRAFT COOLING  
TOWERS VISUAL ASSESSMENT

EXHIBIT

142



LOCATION No.7 - VIEW FROM BACKYARD OF RESIDENCE AT NANTUCKET RD. AND BISCAYNE DR.



LOCATION No.8 - VIEW FROM NANTUCKET AND BERMUDA DRIVES

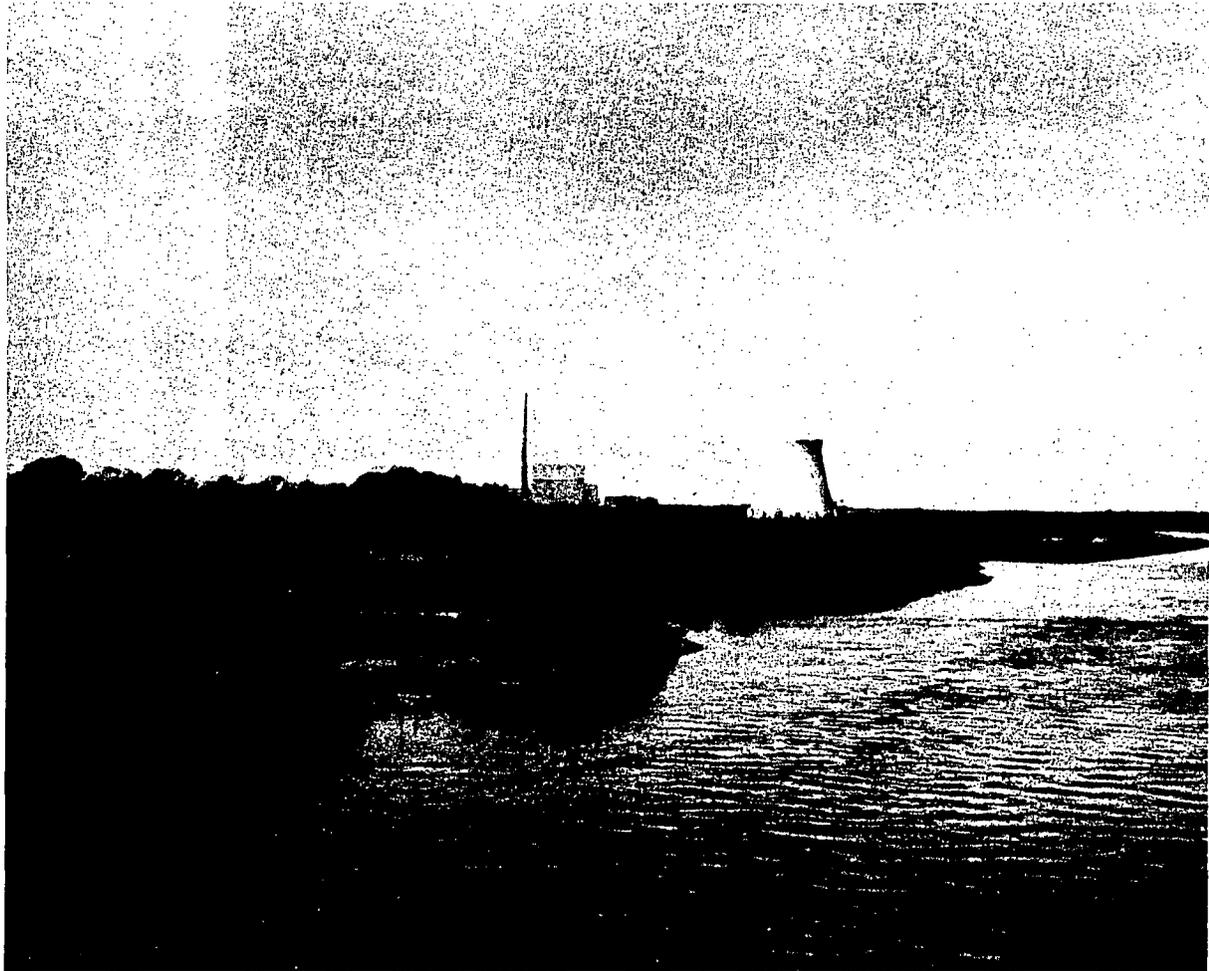
JERSEY CENTRAL  
POWER & LIGHT COMPANY

EBASCO SERVICES INCORPORATED  
New York

PHOTOGRAPHIC ANALYSIS - FAN-  
ASSISTED NATURAL DRAFT COOLING  
TOWERS VISUAL ASSESSMENT

EXHIBIT

143



LOCATION No. 9 - VIEW FROM BEACH BLVD. BRIDGE OVER SOUTH  
BRANCH OF FORKED RIVER

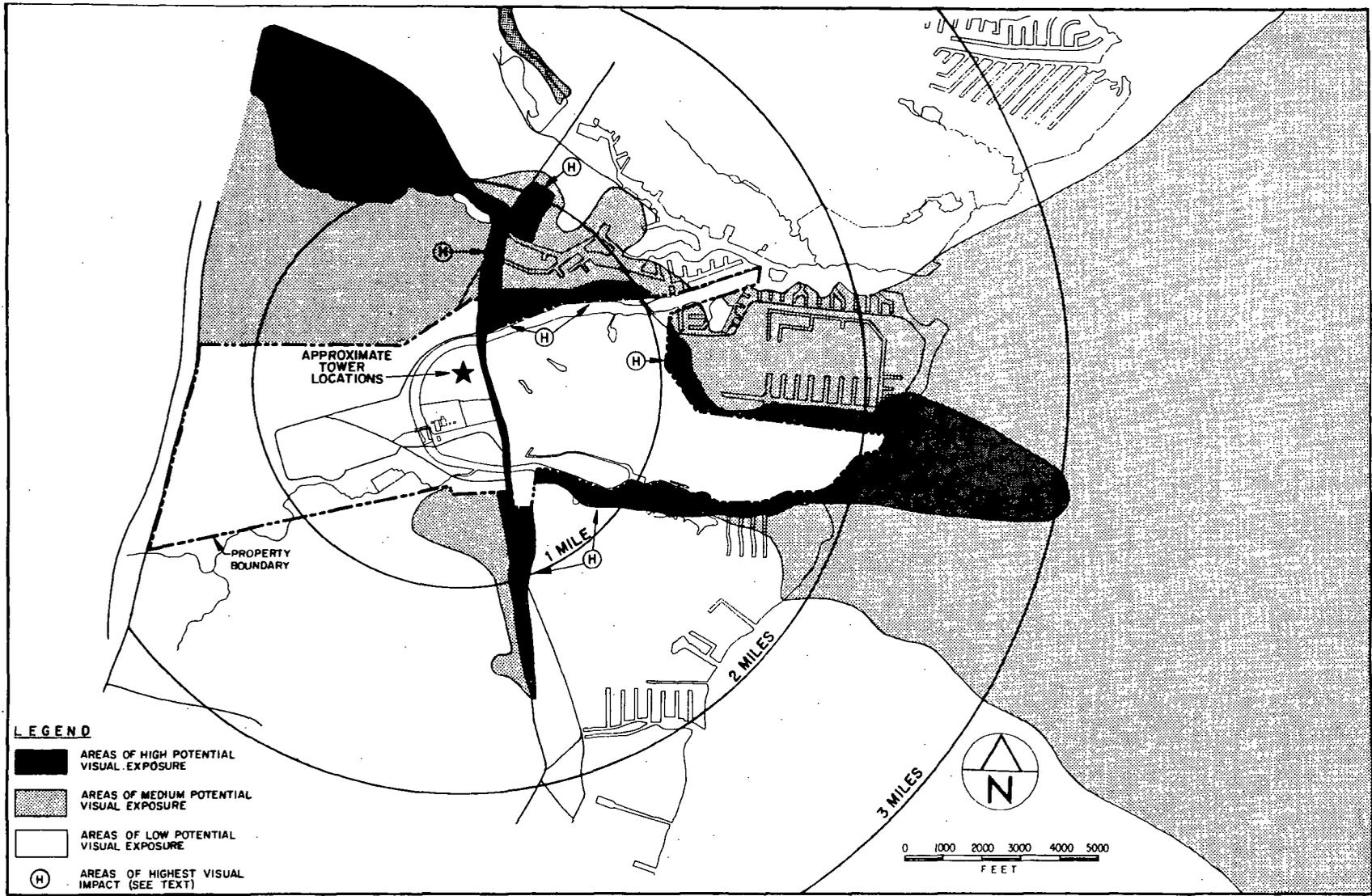
JERSEY CENTRAL  
POWER & LIGHT COMPANY

EBASCO SERVICES INCORPORATED  
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PHOTOGRAPHIC ANALYSIS - FAN-  
ASSISTED NATURAL DRAFT COOLING  
TOWERS VISUAL ASSESSMENT

EXHIBIT

144



JERSEY CENTRAL  
POWER & LIGHT COMPANY

EBASCO SERVICES INCORPORATED  
New York

AREAS OF POTENTIAL VISUAL EXPOSURE  
TO POWER PLANT ELEMENTS

EXHIBIT  
145

## Exhibit 146

## COMPARISON OF THE FOUR SPECIES OF TEREDINIDS KNOWN FROM BARNEGAT BAY

| Species                 | Mode of Larval Development | Distribution in Barnegat Bay  | Tolerances  |                        |   |  | Development   |   |                                 |  |                            |
|-------------------------|----------------------------|---|---|------------------------|---|--|---|---|---------------------------------|--|----------------------------|
|                         |                            |   | Adult   |                        | Larvae Response to Gelbstoff  | Spawning                                     | Egg to Pediveliger Stage Planktonic Period                | Salinity Optimum Growth                                     | Temperature Greatest Settlement | Time from Settlement to Sexual Maturity                                | Generation Time            |
|                         |                            |   | Salinity  | Temperature            |   |  |   |   |                                 |  |                            |
| <u>Bankia gouldi</u>    | oviparous (T&J)            | Most abundant species found throughout Barnegat Bay (T3)                            | 10-35 ppt <sup>(T4)</sup><br>9-30 ppt <sup>(S&amp;T)</sup>                                | 5-33 C <sup>(T4)</sup> | Sensitive <sup>(C)</sup>  | 17.5-30 C at 30 ppt salinity <sup>(T4)</sup> | 25 days @ 25 C 30 ppt salinity <sup>(T4)</sup>            | Does well above 19 ppt, tolerates 10-35 ppt <sup>(T4)</sup> | 24-27 C <sup>(R&amp;N)</sup>    | 33 days at 22-25 C and 30 ppt salinity <sup>(T4)</sup>                 | 2-3 months <sup>(T4)</sup> |
| <u>Teredo navalis</u>   | larviparous (T&J)          | Baywide, most common along eastern portion of bay where Gelbstoff in low conc. (T3) | 5-32 ppt <sup>(B)</sup>   | 2-35 C <sup>(B)</sup>  | Highly sensitive and may limit larval dispersion by premature settling <sup>(C)</sup> | Young re-leased at 13-30 C <sup>(B)</sup>    | About 15 days at 25 C and 30 ppt salinity <sup>(T4)</sup> | Does well above 15 ppt, tolerated 10-32 ppt <sup>(T4)</sup> |                                 | 33 days at 22-25 C <sup>(T4)</sup> , 24 days at 27-30 C <sup>(P)</sup> | 2-3 months <sup>(T4)</sup> |
| <u>Teredo furcifera</u> | larviparous (T&J)          | Maniawick area, Sedge Island, Oyster Creek, Forked River                            | (H, T&R; R, R, B&H <sup>(a)</sup> ; R, R, B&H <sup>(b)</sup> ; R, R, B&H <sup>(c)</sup> ) |                        |   |  | Up to 22 days <sup>(T&amp;J)</sup>                        |   |                                 |  |                            |
| <u>Teredo bartschi</u>  | larviparous (C&K)          | Oyster Creek only   | (H, T&R; R, R, B&H <sup>(a)</sup> ; R, R, B&H <sup>(b)</sup> ; R, R, B&H <sup>(c)</sup> ) |                        |   |  | Short ≈ 4 days <sup>(T&amp;J)</sup>                       |   |                                 |  |                            |

Exhibit Source: Masnik (197)

Sources: T&amp;J: Turner and Johnson, 1971.

C&amp;K: Clapp and Kenk, 1963.

T3: Turner, 1973.

H, T&amp;R: Hoagland, Turner and Rochester (no date).

R, R, B&H<sup>(a)</sup>: Richards, Rehm, Bellmore and Hillman, 1976a.R, R, B&H<sup>(b)</sup>: Richards, Rehm, Bellmore and Hillman, 1976b.R, R, B&H<sup>(c)</sup>: Richards, Rehm, Bellmore and Hillman, 1976c.

T4: Turner, 1974.

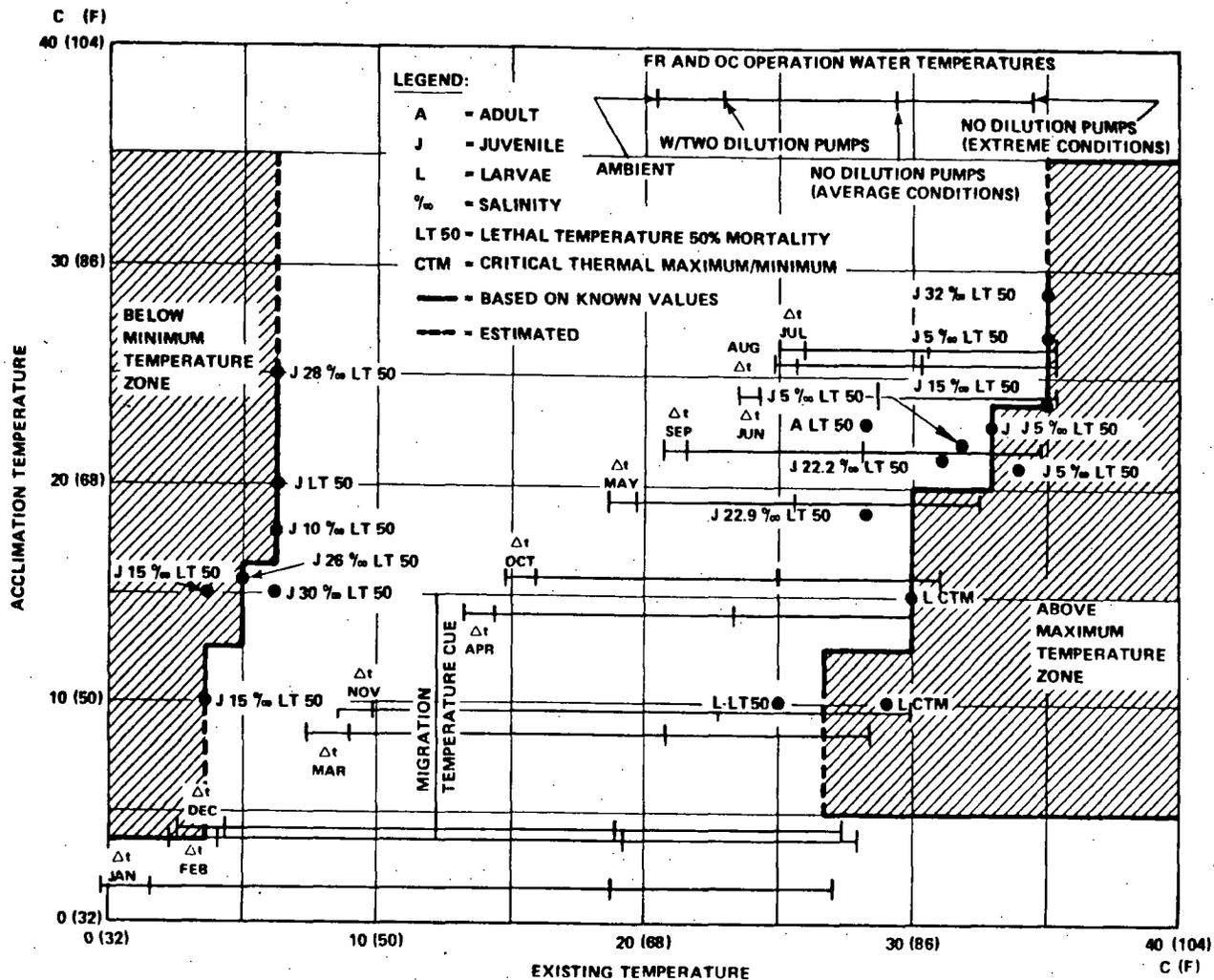
S&amp;T: Scheltema and Truitt, 1954.

B: Blum, 1923.

C: Culliney, 1973.

R&amp;N: Ryabchikov and Nikolayeva, 1963

P: Potts, 1921.

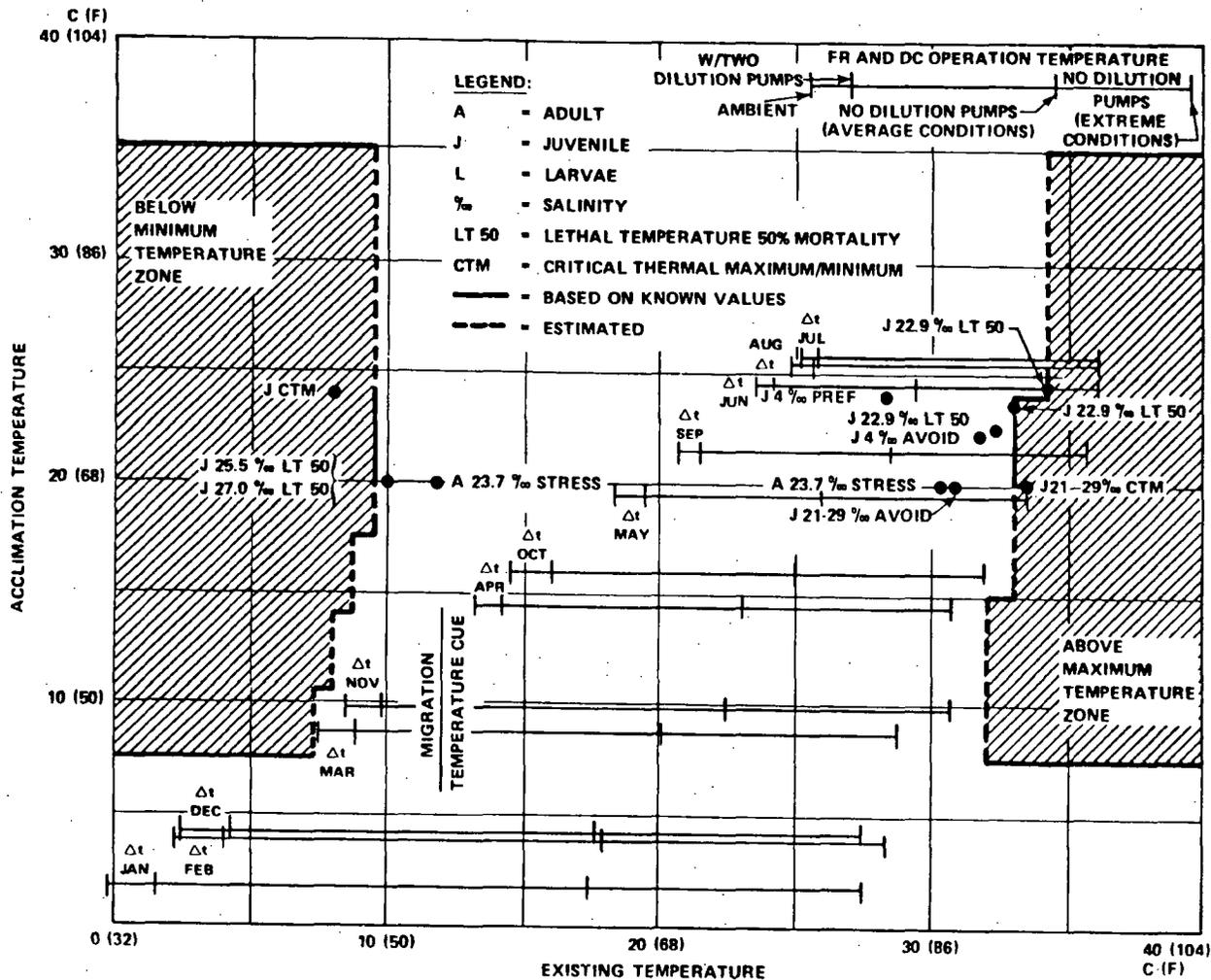


REFER TO EXHIBIT 149 FOR LEGEND SUMMARY

JERSEY CENTRAL  
POWER & LIGHT COMPANY  
EBASCO SERVICES INCORPORATED  
New York

TEMPERATURE TOLERANCES FOR THE ATLANTIC MENHADEN  
(BREVOORTIA TYRANNUS)  
(PREFERRED COOLING TOWER SYSTEM)

EXHIBIT  
147



REFER TO EXHIBIT 150 FOR LEGEND SUMMARY

JERSEY CENTRAL  
POWER & LIGHT COMPANY  
EBASCO SERVICES INCORPORATED  
New York

TEMPERATURE TOLERANCES OF THE BLUEFISH  
(POMATOMUS SALTATRIX)  
(PREFERRED COOLING TOWER SYSTEM)

EXHIBIT  
148

Exhibit 149

TEMPERATURE EXPERIENCE - TEMPERATURE LIMIT RELATIONSHIPS  
(Species: Brevoortia tyrannus)

| Accl<br>Temp<br>(°C) | Fish<br>Stage | Salin-<br>ity | Publ<br>Source | Temperature Limits (C) |                       |
|----------------------|---------------|---------------|----------------|------------------------|-----------------------|
|                      |               |               |                | High                   | Low                   |
| 29                   | J             | 32            | (L&H)          | 34.8 LT50              |                       |
| 28                   |               |               |                |                        |                       |
| 27.2                 | J             | 3.2           | (M&G)          | 32.2 Avoid temp        |                       |
| 27                   | J             | 5             | (L&H)          | 35.0 LT50              |                       |
| 26.1                 | J             | 4             | (M&G)          |                        | Fish preferred 21.1 C |
| 26                   |               |               |                |                        |                       |
| 25                   | { J           | 3.2           | (M&G)          | 29.4 Avoid temp        |                       |
|                      | { J           | 28            | (W)            |                        | 10.0 LT50             |
| 24                   | J             | 15            | (L&H)          | 35.0 LT50              |                       |
| 23                   | J             | 5             | (L&H)          | 33.0 LT50              |                       |
| 22.9                 | A             |               | (P)            | 28.3 LT50              |                       |
| 22.2                 | J             | 4             | (M&G)          | 28.3 Avoid temp        |                       |
| 22                   | J             | 5             | (L&H)          | 31.9 LT50              |                       |
| 21.6                 | J             | 22.2          | (P)            | 31.1 LT50              |                       |
| 21.1                 | J             | 1             | (M&G)          | 30.0 Avoid temp        |                       |
| 21                   | J             | 5             | (L&H)          | 34.0 LT50              |                       |
| 20.6                 | J             | 4             | (M&G)          | 25.6 Avoid temp        |                       |
| 20                   | J             | 29            | (W)            |                        | 10.0 LT50             |
| 19                   | J             | 22.9          | (P)            | 28.2 LT50              |                       |
| 18                   | J             | 10            | (L&H)          |                        | 6.0 LT50              |
| 17                   |               |               |                |                        |                       |
| 16                   | J             | 26            | (L&H)          |                        | 5.0 LT50              |
|                      | { L           |               | (H)            | 29.7                   |                       |
|                      | { J           | 30            | (L&H)          |                        | 6.0 LT50              |
| 15                   | { J           | 15            | (L)            |                        | 4.0 LT50              |
|                      | { J           | 25.5          | (W)            |                        | 7.0 LT50              |
| 14                   |               |               |                |                        |                       |
| 13                   |               |               |                |                        |                       |
| 12                   |               |               |                |                        |                       |
| 11                   |               |               |                |                        |                       |
| 10                   | J             | 15            | (L)            |                        | 4.0 LT50              |
|                      | L             |               | (H)            | 25.0 LT50              |                       |
|                      |               |               |                | 28.9 CTM               |                       |
| 9                    |               |               |                |                        |                       |
| 8                    |               |               |                |                        |                       |
| 7                    |               |               |                |                        |                       |
| 6                    |               |               |                |                        |                       |
| 5                    |               |               |                |                        |                       |
| 4                    |               |               |                |                        |                       |
| 3                    |               |               |                |                        |                       |
| 2                    |               |               |                |                        |                       |
| 1                    |               |               |                |                        |                       |
| 0                    |               |               |                |                        |                       |

A = Adult; J = Juvenile; L = Larvae; Salinity in parts per thousand

LT50 = lethal temperature (50% mortality)

CTM = critical thermal maximum

Publication Sources: W = Wyllie, et al 1976 H = Hoss, et al 1973

L = Lewis, 1966

P = Powers, 1977

L&H = Lewis & Hettler, 1968

Exhibit 150

TEMPERATURE EXPERIENCE - TEMPERATURE LIMIT RELATIONSHIPS  
(Species: Pomatomus saltatrix)

| Accl<br>Temp<br>(°C) | Fish<br>Stage    | Salin-<br>ity | Publ<br>Source | Temperature Limits (C) |               |
|----------------------|------------------|---------------|----------------|------------------------|---------------|
|                      |                  |               |                | High                   | Low           |
| 29                   |                  |               |                |                        |               |
| 28                   |                  |               |                |                        |               |
| 27                   |                  |               |                |                        |               |
| 26                   |                  |               |                |                        |               |
| 25                   |                  |               |                |                        |               |
| 24.2                 | J                | 22.9          | (P)            | 34.2 LT50              |               |
| 24                   | J                |               | (M)            |                        | 7.9 CTM       |
| 23.9                 | J                | 4             | (M&G)          | 28.3 pref temp         |               |
| 23.7                 | J                | 22.9          | (P)            | 33.1 LT50              |               |
| 23                   |                  |               |                |                        |               |
| 22.5                 | J                | 22.9          | (P)            | 32.3 LT50              |               |
| 22.2                 | J                | 4             | (M&G)          | 31.7 Avoid temp        |               |
| 22                   |                  |               |                |                        |               |
| 21                   |                  |               |                |                        |               |
|                      | A<br>J<br>J<br>J | 23.7          | (O&S)          | (30.4 Stress)          | (11.9 Stress) |
| 20                   |                  | 25.5          | (W)            |                        | 10.0 LT50     |
|                      |                  | 27            | (W)            | 30.7 Avoid temp        | 10.0 LT50     |
|                      |                  | 21-29         | (G&W)          | 33.4 CTM               |               |
| 19                   |                  |               |                |                        |               |
| 18                   |                  |               |                |                        |               |
| 17                   |                  |               |                |                        |               |
| 16                   |                  |               |                |                        |               |
| 15                   |                  |               |                |                        |               |
| 14                   |                  |               |                |                        |               |
| 13                   |                  |               |                |                        |               |
| 12                   |                  |               |                |                        |               |
| 11                   |                  |               |                |                        |               |
| 10                   |                  |               |                |                        |               |
| 9                    |                  |               |                |                        |               |
| 8                    |                  |               |                |                        |               |
| 7                    |                  |               |                |                        |               |
| 6                    |                  |               |                |                        |               |
| 5                    |                  |               |                |                        |               |
| 4                    |                  |               |                |                        |               |
| 3                    |                  |               |                |                        |               |
| 2                    |                  |               |                |                        |               |
| 1                    |                  |               |                |                        |               |
| 0                    |                  |               |                |                        |               |

A = Adult; J = Juvenile; Salinity in parts per thousand

LT50 = lethal temperature (50% mortality)

CTM = critical thermal maximum

Publication Source: W = Wyllie, et al 1976

M = Murnyak, 1973

G&W = Gift & Westman, 1971

O&S = Olla & Studholme, 1971

M&G = Meldrim & Gift, 1971

P = Powers, 1977

Exhibit 151

REPRESENTATIVE IMPORTANT SPECIES (RIS) FOR THE FORKED RIVER, OYSTER CREEK,  
BARNEGAT BAY AREA

FISH

| <u>Common Name</u>     | <u>Scientific Name</u>               |
|------------------------|--------------------------------------|
| Atlantic menhaden      | <u>Brevoortia tyrannus</u>           |
| Bay anchovy            | <u>Anchoa mitchilli</u>              |
| Atlantic silversides   | <u>Menidia menidia</u>               |
| Threespine stickleback | <u>Gasterosteus aculeatus</u>        |
| Northern pipefish      | <u>Syngnathus floridae</u>           |
| Striped bass           | <u>Morone saxatilis</u>              |
| Bluefish               | <u>Pomatomus saltatrix</u>           |
| Weakfish               | <u>Cynoscion regalis</u>             |
| Northern kingfish      | <u>Menticirrhus saxatilis</u>        |
| Sand lance             | <u>Anmodytes sp.</u>                 |
| Summer flounder        | <u>Paralichthyes dentatus</u>        |
| Winter flounder        | <u>Pseudopleuronectes americanus</u> |
| Northern puffer        | <u>Sphoeroides maculatus</u>         |

INVERTEBRATES

|                         |   |
|-------------------------|---|
| Shipworms               | { <u>Teredo navalis</u><br><u>Bankia gouldi</u> |
| Cherrystone             | <u>Mercenaria mercenaria</u>                    |
| Blue crab               | <u>Callinectes sapidus</u>                      |
| Opossum shrimp (Mysids) | <u>Neomysis americana</u>                       |
| Sand shrimp             | <u>Crangon septemspinosa</u>                    |
| Arrowworms              | <u>Sagitta elegans</u>                          |

## Exhibit 152

## SPECIES COMPOSITION (%) OF HAULS BY VARIOUS GEAR TYPES &amp; LOCATIONS (1976)

| Month                      | T-FR  | S-FR  | GN-FR | T-DC  | S-OC  | GN-OC | T-BBW | S-BBW | T-BBCR | S-BBCR | DN-BBCR | DD    | IMP   |
|----------------------------|-------|-------|-------|-------|-------|-------|-------|-------|--------|--------|---------|-------|-------|
| <u>Atlantic Menhaden</u>   |       |       |       |       |       |       |       |       |        |        |         |       |       |
| May                        | 0     | 0     | 0     | .07   | 0     | 0     | 0     | 0     | 0      | 0      | 79.37   | 1.43  | .05   |
| June                       | .17   | 1.23  | 17.78 | 0     | 0     | 75.00 | 0     | 0     | 0      | 0      | 61.64   | 1.73  | .03   |
| July                       | 0     | .39   | 4.00  | .30   | 0     | 14.29 | 0     | 0     | 0      | 0      | 46.82   | 2.35  | .43   |
| August                     | 0     | 0     | 17.95 | 0     | 0     | 17.65 | 0     | 0     | .62    | 0      | 26.35   | 1.99  | .11   |
| <u>Bay Anchovy</u>         |       |       |       |       |       |       |       |       |        |        |         |       |       |
| May                        | 40.99 | 42.66 | 0     | 68.57 | 8.37  | 0     | 94.03 | 57.22 | 91.15  | 0      | 0       | 59.66 | 27.08 |
| June                       | 55.97 | 50.74 | 0     | 64.99 | 41.43 | 0     | 95.81 | 79.03 | 80.16  | 2.33   | 0       | 6.71  | 1.64  |
| July                       | 79.61 | 22.57 | 0     | 56.54 | 7.87  | 0     | 91.09 | 24.03 | 87.17  | 5.54   | 0       | .21   | .57   |
| August                     | 59.75 | 16.61 | 0     | 69.80 | 7.63  | 0     | 75.84 | 30.76 | 85.21  | 15.47  | 0       | 0     | 1.08  |
| <u>Atlantic Silverside</u> |       |       |       |       |       |       |       |       |        |        |         |       |       |
| May                        | 0     | 12.39 | 0     | .22   | 41.87 | 0     | .58   | 15.75 | .55    | 49.48  | 0       | .13   | .21   |
| June                       | 0     | 24.02 | 0     | 0     | 17.35 | 0     | 0     | 6.20  | 0      | 81.40  | 0       | .22   | .02   |
| July                       | .10   | 41.60 | 0     | 0     | 57.69 | 0     | 0     | 46.75 | .18    | 82.03  | 0       | 0     | 0     |
| August                     | 1.40  | 27.56 | 0     | 0     | 22.76 | 0     | 0     | 39.88 | 2.11   | 25.60  | 0       | 0     | 0     |
| <u>Northern Pipefish</u>   |       |       |       |       |       |       |       |       |        |        |         |       |       |
| May                        | 1.56  | 3.67  | 0     | .65   | 0     | 0     | .58   | 2.62  | .55    | 7.22   | 0       | .13   | .15   |
| June                       | .84   | .49   | 0     | 2.67  | .41   | 0     | .48   | 1.77  | .26    | 0      | 0       | 0     | .10   |
| July                       | .14   | .26   | 0     | 0     | .35   | 0     | 0     | 1.30  | .27    | .96    | 0       | 0     | .04   |
| August                     | .98   | 0     | 0     | .66   | 0     | 0     | 0     | 2.20  | .26    | .17    | 0       | 0     | .01   |
| <u>Spot</u>                |       |       |       |       |       |       |       |       |        |        |         |       |       |
| May                        | .14   | 13.76 | 0     | 0     | 2.46  | 0     | 0     | .79   | 0      | 0      | 0       | 0     | 0     |
| June                       | 21.51 | 12.75 | 0     | 2.08  | 9.59  | 0     | .81   | 6.35  | 8.78   | 5.94   | 0       | 11.47 | 1.60  |
| July                       | 14.24 | 5.91  | 12.00 | 33.98 | 13.99 | 10.71 | 4.46  | 14.55 | 6.37   | 2.87   | 25.91   | 20.58 | .04   |
| August                     | 20.06 | 4.59  | 23.08 | 19.26 | 1.71  | 29.41 | 8.72  | 2.00  | 2.64   | 2.13   | 16.97   | 10.61 | .50   |
| <u>Winter Flounder</u>     |       |       |       |       |       |       |       |       |        |        |         |       |       |
| May                        | 0     | 0     | 0     | .07   | 6.40  | 0     | 0     | 0     | 0      | 0      | 0       | .65   | .01   |
| June                       | 0     | 0     | 0     | 2.08  | 2.04  | 0     | 0     | 0     | .18    | .52    | 0       | 0     | .08   |
| July                       | 0     | .26   | 0     | .15   | 1.75  | 0     | .58   | 0     | .18    | .57    | 0       | .11   | .01   |
| August                     | .42   | 0     | 0     | .22   | .66   | 0     | 2.01  | .20   | 1.14   | 1.73   | 0       | 0     | .01   |
| <u>Sand Shrimp</u>         |       |       |       |       |       |       |       |       |        |        |         |       |       |
| May                        | 28.79 | 6.88  | 0     | 25.79 | 14.78 | 0     | 2.89  | 9.97  | 3.17   | 6.19   | 0       | 2.08  | 43.63 |
| June                       | 5.38  | 0     | 0     | 15.73 | 1.63  | 0     | .81   | 1.03  | .18    | 0      | 0       | .43   | 16.42 |
| July                       | .37   | 1.57  | 0     | 0     | .52   | 0     | 0     | .65   | .27    | .48    | 0       | 0     | .25   |
| August                     | 1.12  | 0     | 0     | .22   | 47.76 | 0     | 0     | 12.02 | 1.23   | 24.53  | 0       | 0     | 0     |
| <u>Blue Crab</u>           |       |       |       |       |       |       |       |       |        |        |         |       |       |
| May                        | 28.09 | 20.64 | 7.69  | 4.55  | 26.11 | 66.67 | 1.93  | 12.34 | 3.17   | 23.71  | 4.76    | 32.81 | 26.29 |
| June                       | 15.80 | 10.29 | 35.56 | 12.17 | 27.55 | 0     | 2.09  | 5.61  | 6.15   | 9.04   | 36.30   | 74.89 | 73.08 |
| July                       | 4.19  | 8.92  | 72.00 | 8.72  | 16.61 | 71.43 | 3.88  | 11.95 | 4.19   | 6.60   | 21.36   | 68.02 | 96.74 |
| August                     | 11.08 | 43.11 | 41.03 | 7.66  | 18.82 | 29.41 | 6.71  | 11.02 | 4.67   | 25.87  | 28.89   | 82.26 | 95.73 |

Gear Type: T = Trawl  
S = Seine  
GN = Gill Net

Stations: FR = Forked River  
OC = Oyster Creek  
BBW = Barnegat Bay at Waretown  
BBCR = Barnegat Bay at Creek Mouths

DF = Dilution Pumps  
IMP = Impingement Collections

EXHIBIT 153

POTENTIALLY INJURIOUS AIRBORNE  
SALT CONCENTRATIONS AND DEPOSITION RATES

- Threshold For Development of Toxic Soil Salinity \*

| <u>THRESHOLD LEVEL</u>   | <u>SOURCE</u>   | <u>COMMENT</u>  |
|--|---|---|
| 56,000 kg/km <sup>2</sup><br>Annual Average<br>(4,670 kg/km <sup>3</sup> /month) | University of Maryland<br>(cited in John Hopkins<br>University, 1972) | Conclusion derived from<br>literature review, refers<br>to soils of Chalk Point |

- Thresholds For Occurrence of Direct Injury to Vegetation\*

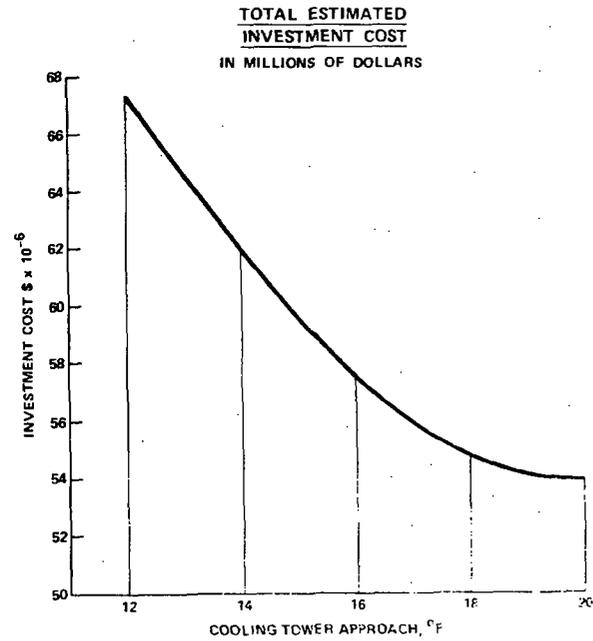
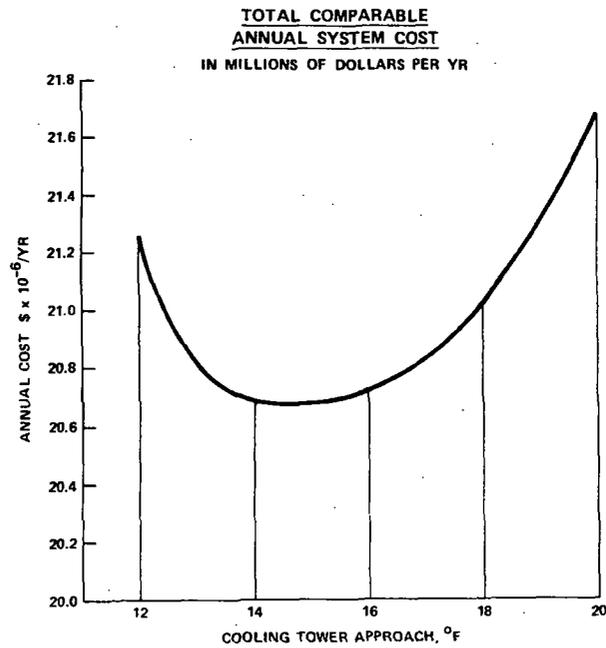
| <u>THRESHOLD LEVEL</u>                              | <u>SOURCE</u>                                    | <u>COMMENT</u>  |
|---|--|---|
| Short-term Levels                                   |  |   |
| Less than 60 ug/m <sup>3</sup><br>for Several Hours | Rutgers University<br>(Moser and Swain,<br>1971) | Level not likely to cause<br>injury; suggested by B Moser,<br>based primarily on one sea-<br>son's observations at Island<br>Beach State Park (NJ)  |
| 100 ug/m <sup>3</sup> for<br>Several Hours          | Rutgers University<br>(Moser and Swain,<br>1971) | Level at which injury to<br>sensitive spp would be ex-<br>pected  |
| 387 kg/km <sup>2</sup> for<br>1 Hour                | McCune et al., 1974                              | Occurrence of foliar lesions<br>on bush bean growing under<br>laboratory conditions   |
| Monthly and Annual Levels                           |  |   |
| 40 ug/m <sup>3</sup> /month                         | Rutgers University<br>(Moser and Swain,<br>1971) | No visible injury observed<br>on vegetation of Island Beach<br>State Park, when summer month<br>concentrations <sub>3</sub> averaged this<br>level <sub>3</sub> (80 ug/m <sup>3</sup> at surf, 14<br>ug/m <sup>3</sup> at leeward side of island) |

EXHIBIT 153  
(Cont'd)

| <u>THRESHOLD LEVEL</u>  | <u>SOURCE</u>   | <u>COMMENT</u>   |
|---|---|--|
| 3200 kg/km <sup>2</sup> /month  | Mulchi and Armbruster,<br>1975  | Significant decrease in yield of soybean and corn, growing under field conditions after weekly application of spray solution for 8 weeks; corn may be effected at lower rates. |
| 13,200 kg/km <sup>2</sup><br>Annual Average<br>(1100 kg/km <sup>2</sup> /month) | University of Maryland<br>(cited in John Hopkins<br>University, 1972) | Level at which caution should be exercised; refers to aerial deposition of salt spray or crystals and is based on literature review  |

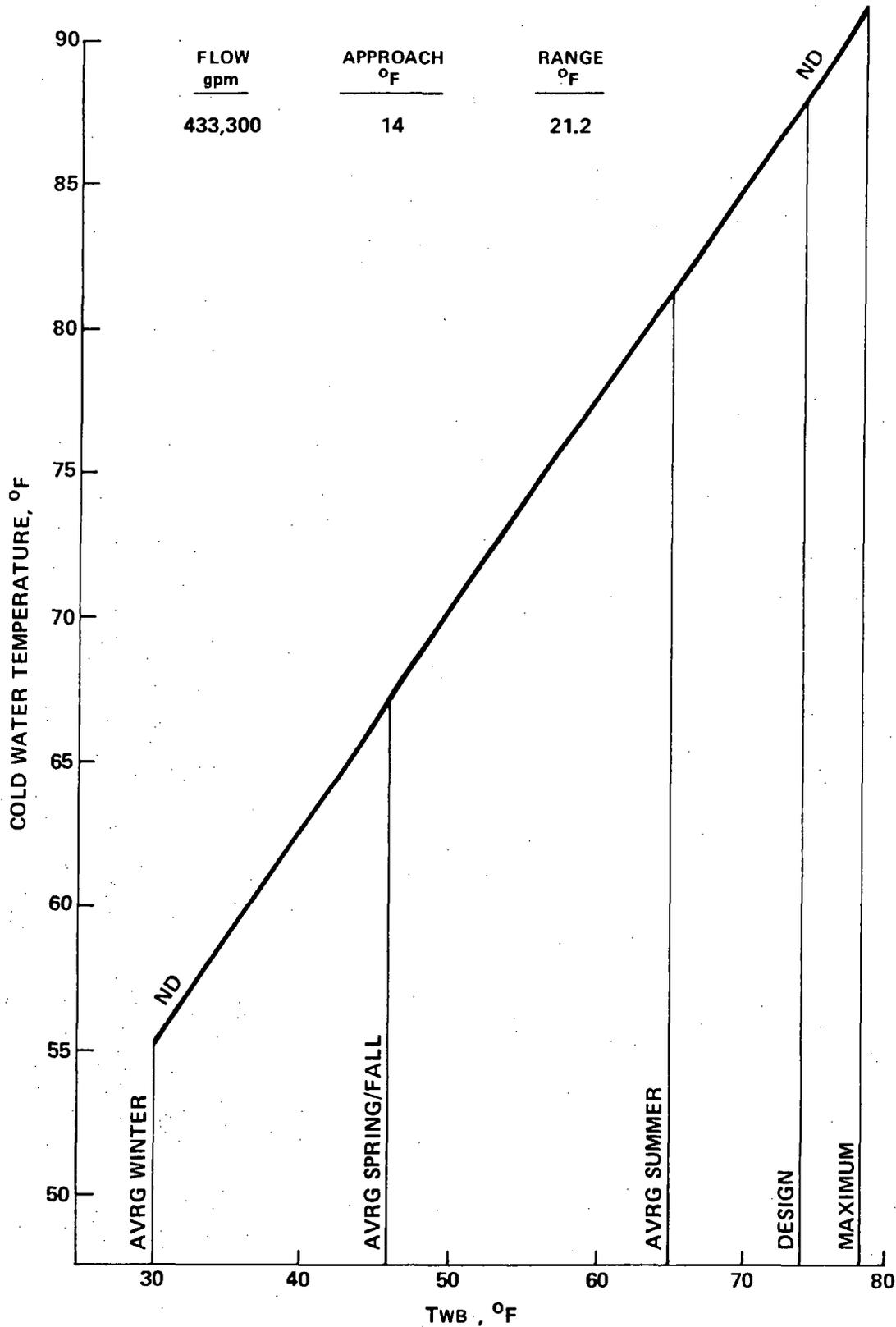
\* See text for discussion of assumptions and applicability of reported thresholds.

**JERSEY CENTRAL POWER & LIGHT COMPANY  
 OYSTER CREEK NUCLEAR GENERATING STATION  
 ALTERNATIVE COOLING WATER SYSTEM STUDY  
 NATURAL DRAFT COOLING TOWER SYSTEM  
 ECONOMICS FOR BEST CASES VERSUS COOLING TOWER APPROACH**

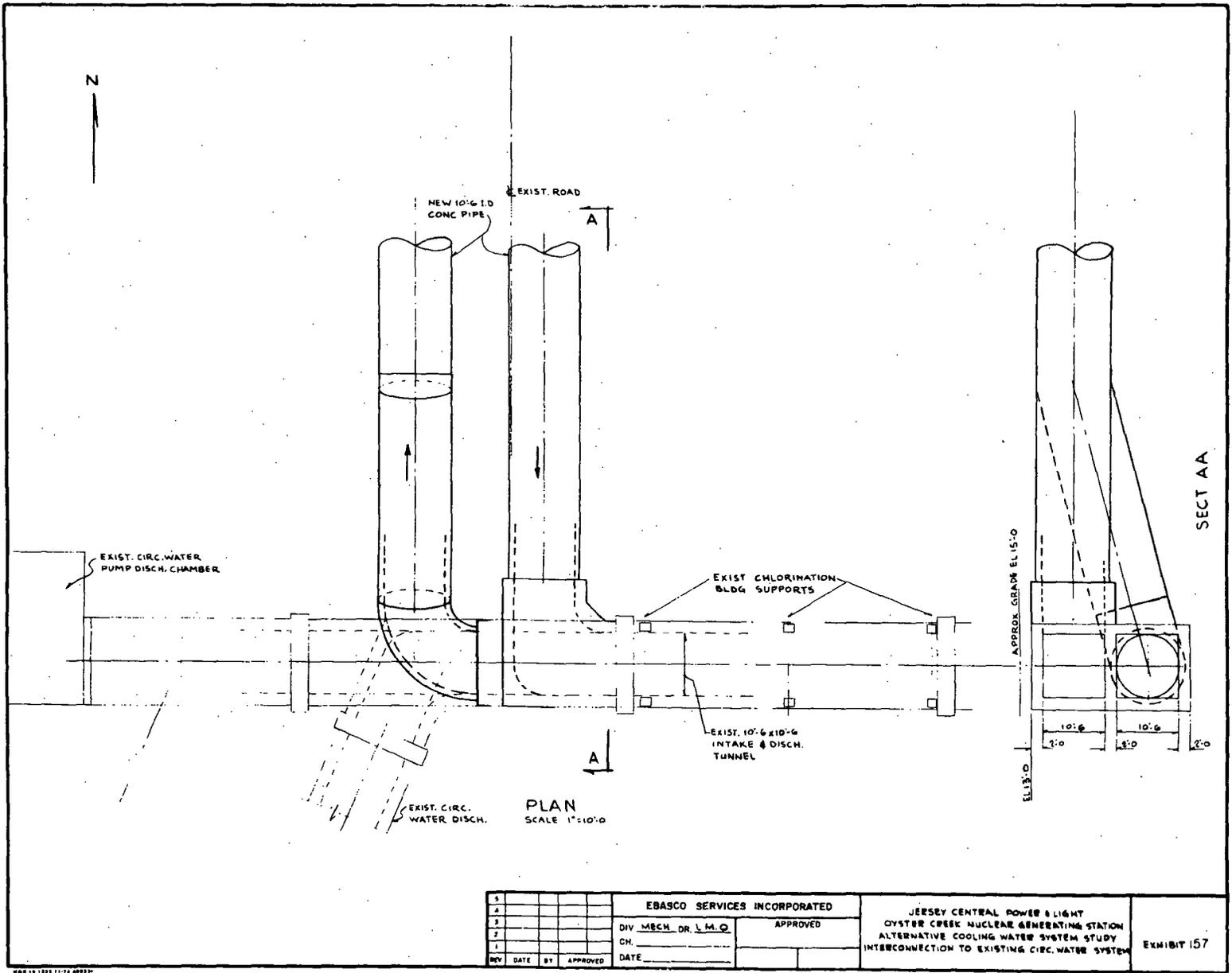


# JCP&L OYSTER CREEK NGS NATURAL DRAFT COOLING TOWER THERMAL PERFORMANCE AT FULL LOAD OPERATION

EXHIBIT 155







PLAN  
SCALE 1"=10'-0"

SECT AA

| <table border="1"> <tr><td>5</td><td></td><td></td><td></td></tr> <tr><td>4</td><td></td><td></td><td></td></tr> <tr><td>3</td><td></td><td></td><td></td></tr> <tr><td>2</td><td></td><td></td><td></td></tr> <tr><td>1</td><td></td><td></td><td></td></tr> <tr> <th>REV</th> <th>DATE</th> <th>BY</th> <th>APPROVED</th> </tr> </table> |      |    |          | 5 |  |  |  | 4 |  |  |  | 3 |  |  |  | 2 |  |  |  | 1 |  |  |  | REV | DATE | BY | APPROVED | <b>EBASCO SERVICES INCORPORATED</b><br>DIV. MECH. DR. <u>V.M.O.</u><br>CH. _____<br>DATE _____ |  | APPROVED<br>_____<br>_____ |  | <b>JERSEY CENTRAL POWER &amp; LIGHT</b><br><b>OYSTER CREEK NUCLEAR GENERATING STATION</b><br>ALTERNATIVE COOLING WATER SYSTEM STUDY<br>INTERCONNECTION TO EXISTING CIRC. WATER SYSTEM |  | <b>EXHIBIT 157</b> |
|--|------|----|----------|---|--|--|--|---|--|--|--|---|--|--|--|---|--|--|--|---|--|--|--|-----|------|----|----------|--|--|----------------------------|--|---|--|--------------------|
| 5  |      |    |          |   |  |  |  |   |  |  |  |   |  |  |  |   |  |  |  |   |  |  |  |     |      |    |          |  |  |                            |  |   |  |                    |
| 4  |      |    |          |   |  |  |  |   |  |  |  |   |  |  |  |   |  |  |  |   |  |  |  |     |      |    |          |  |  |                            |  |   |  |                    |
| 3  |      |    |          |   |  |  |  |   |  |  |  |   |  |  |  |   |  |  |  |   |  |  |  |     |      |    |          |  |  |                            |  |   |  |                    |
| 2  |      |    |          |   |  |  |  |   |  |  |  |   |  |  |  |   |  |  |  |   |  |  |  |     |      |    |          |  |  |                            |  |   |  |                    |
| 1  |      |    |          |   |  |  |  |   |  |  |  |   |  |  |  |   |  |  |  |   |  |  |  |     |      |    |          |  |  |                            |  |   |  |                    |
| REV  | DATE | BY | APPROVED |   |  |  |  |   |  |  |  |   |  |  |  |   |  |  |  |   |  |  |  |     |      |    |          |  |  |                            |  |   |  |                    |

NOV 18 1957 7:32 AM



THE FOLLOWING APPLIES TO ALL CONDENSING SYSTEM CASES:

UNIT: BASED ON GE-TC6F-38"LSR RATED 640MW @ 1.0" HGA

|                               |        |
|-------------------------------|--------|
| CONDENSER:                    |        |
| TUBE MATERIAL                 | TITAN  |
| TUBE GAUGE                    | .22    |
| TUBE CLEANLINESS FACTOR       | 0.900  |
| SINGLE OR MULTI BACK PRESSURE | SINGLE |
| NO. OF CONDENSER SHELLS       | 3      |
| NO. OF PUMPS                  | 4      |
| TYPE OF PUMPS                 | VERT.  |
| ECONOMIC FACTORS              |        |
| RATE OF RETURN (%)            | 0.00   |
| FIXED CHARGE RATE (%)         | 22.25  |

|  |         |
|--|---------|
| SELECTED BASE FOR COOLING SYSTEM DIFFERENTIAL CALCULATIONS |         |
| CONDENSER TUBE O.D. (IN)                                   | 0.875   |
| CONDENSER TUBE LENGTH (FT)                                 | 42.5    |
| NO. OF CONDENSER TUBES                                     | 14562   |
| COOLING TOWER FANS KW                                      | 0       |
| CIRCULATING WATER PUMPS KW                                 | 2666    |
| ESTIMATED AUX. POWER REQUIREMENT EXCL. CW SYSTEM           | 17.50   |
| TURBINE GENERATOR CAPABILITY (MW)                          | 670.0   |
| UNIT NET CAPABILITY (MW)                                   | 620.00  |
| CAPABILITY ADJUSTMENT (\$/KW)                              | 0.0     |
| UNIT NET ANNUAL GENERATION (MWH/YR)                        | 3539729 |
| GENERATION ADJUSTMENT (BTU/KWH)                            | 10400   |

TYPE OF COOLING SYSTEM: NATURAL DRAFT COOLING TOWER SYSTEM

|                           |       |
|---------------------------|-------|
| DESIGN WET BULB TEMP. (F) | 74.00 |
| DESIGN DRY BULB TEMP. (F) | 88.90 |
| DESIGN APPROACH TEMP. (F) | 14.90 |

|                                      |      |
|--------------------------------------|------|
| USER'S SELECTED SYSTEM LIMITATIONS   |      |
| MAX. CONDENSER BACK PRESS. (IN. HGA) | 5.00 |
| MAX. TEMPERATURE RISE (F)            | 25.0 |

CASES NUMBERED 1 TO 1000 SHOW CONDENSING SYSTEMS WITHIN A RANGE OF PLUS OR MINUS 0.25 IN. HGA OF AN AVERAGE BACK PRESSURE OF 2.00 IN. HGA

THE OTHER CASES ARE WITHIN A RANGE OF PLUS OR MINUS 0.25 IN. HGA OF THE FOLLOWING AVERAGE DESIGN BACK PRESSURES:

| AVERAGE DESIGN<br>BACK PRESSURE | CASES        |
|---------------------------------|--------------|
| -----                           | -----        |
| 2.50                            | 1001 TO 2000 |
| 3.00                            | 2001 TO 3000 |
| 3.50                            | 3001 TO 4000 |
| 4.00                            | 4001 TO 5000 |
| 4.50                            | 5001 TO 6000 |

CASES NUMBERED 6001 TO 6075 SHOW SMALLER VARIATIONS OF SURFACE AREA AND TUBE VELOCITY FOR THE PREVIOUS THREE BEST CASES BASED ON ANNUAL COST INCLUDING CAPABILITY AND GENERATION ADJUSTMENTS

\*\*\* FOR ZERO RATE OF RETURN IF MORE THAN ONE LINE IS FILLED IN UNDER LOADING PERIOD DATA THEN ANNUAL FUEL COST IS THE AVERAGE OF ALL THE YEARS' FUEL COSTS

SORT IN ASCENDING ORDER OF ANNUAL COST INCLUDING CAPABILITY & GENERATION ADJUSTMENTS

| CASE NO | ANNUAL SYSTEM COSTS |                      |         | INVESTMENT COSTS |                  | PERFORMANCE AT DESIGN CONDITIONS |                            |                  |                     |                  | PERFORMANCE AT PEAK LOAD CONDITION |                 |                       |                      |
|---------|---------------------|----------------------|---------|------------------|------------------|----------------------------------|----------------------------|------------------|---------------------|------------------|------------------------------------|-----------------|-----------------------|----------------------|
|         | WITHOUT ADJUSTMENTS | INCLUDES ADJUSTMENTS | INITIAL | TOTAL            | TG CAPABIL. (MW) | AVG BACK PRESS IN HG             | TOTAL SURFACE AREA (SQ FT) | COND RISE ACROSS | TOTAL FLOW 1000 GPM | TUBE VFLUC (FPS) | TUBE LGTH (FT)                     | TUBE TOTAL (TN) | JIT DET CAPABIL. (MW) | DET BACK PRESS IN HG |
| 1       | 14409               | 20368                | 38941   | 60602            | 613.74           | 3.61                             | 423000                     | 21.2             | 423.3               | 5.90             | 43                                 | 1,875           | 544.92                | 3.86                 |

|                                  |   |                                    |
|----------------------------------|---|------------------------------------|
| SPECIFICATIONS FOR CASE NO.      | 1 NATURAL DRAFT COOLING TOWER SYSTEM            | ASC DEPT & J UNSTD 11/10/77 PAGE 7 |
| CW INLET DESIGN TEMPERATURE (F)  | 88.00 PERFORMANCE AT DESIGN CONDITIONS;         | NO. OF COOLING TOWERS=CT 1         |
| CONDENSER TEMPERATURE RISE (F)   | 21.18 TG CAPABILITY (MW) 613.74                 | NO. OF CELLS PER CT 0              |
| TUBE DIAMETER (INCHES)/GAUGE     | 0.875/22 AVG CONDENSED PRESSURE (IN.HGA) 3.61   | CT DESIGN APPROACH TEMP (F) 14.00  |
| TOTAL TUBE LENGTH (FT/SHELL)     | 42.50   | TOTAL CT FAN MOTOR INPUT KW 0      |
| NO. OF TUBES PER SHELL/SHELLS    | 14562/3   | TOTAL CW PUMP MOTOR INPUT KW 9221  |
| NO. OF TUBE PASSES/PRESS ZONES   | 1/1 PERFORMANCE AT MAX SUMMER TEMPERATURE       | CW PUMP MOTOR RATING (HP) 3000     |
| TOTAL SURFACE AREA (SQ.FT)       | 423000 TG CAPABILITY (MW) 608.64                | CW SYSTEM TDH (FT) 80.38           |
| CIRCULATING WATER FLOW (GPM)     | 423300 AVG CONDENSED PRESSURE (IN.HGA) 3.86     | CW MAIN CONDUIT DIAM (FT) 10.00    |
| TUBE VEL. AT ABOVE CW FLOW (FPS) | 5.90  | NO. OF CW PUMPS 4                  |
|                                  | AVG SEASONAL COND PRESS (IN.HGA) 1.52 2.03 3.02 | TOTAL DILUTION PUMP INPUT KW 1000  |

| ACCOUNT CODE | INITIAL INVESTMENT POST ITEMS                 | ESTIMATED INITIAL INVESTMENT COST |              | TODAY'S INSTALLATION COST |              | ESCALATION 100% |              |
|--------------|---|-----------------------------------|--------------|---------------------------|--------------|-----------------|--------------|
|              |   | UNIT                              | TOTAL 1000\$ | UNIT                      | TOTAL 1000\$ | MATERIAL        | INSTALLATION |
| 1.11         | MAJOR SITE DEVELOPMENT                        |                                   | 4820         |                           | 1635         | 1630            | 767          |
| 2.1          | LOCAL IMPROVEMENT TO SITE-CLEARING            |                                   |              | 13/ACRE                   | 0            |                 | 0            |
| 2.5          | LOCAL GRADING                                 |                                   |              | 2.50\$/CU YD              | 103          |                 | 37           |
| 3.42         | PILING  | 1.45\$/SQ FT                      | 209          | 1.00\$/SQ FT              | 144          | 55              | 52           |
| 3.42         | INTAKE STRUCTURE                              | 4.10\$/CU FT                      | 480          | 10.75\$/CU FT             | 1260         | 162             | 739          |
| 3.7          | CIRCULATING WATER CONDUIT: MAIN               | 329\$/LIN FT                      | 691          | 232.00\$/LIN FT           | 487          | 234             | 286          |
| 3.7          | BRANCHES                                      | 0.00\$/LIN FT                     | 0            | 0.00\$/LIN FT             | 0            | 0               | 0            |
| 3.32         | DISCHARGE STRUCTURE                           | 0.00\$/CU FT                      | 0            | 0.00\$/CU FT              | 0            | 0               | 0            |
| 3.41         | COOLING TOWER BASIN                           | 0.80\$/SQ FT                      | 116          | 8.20\$/SQ FT              | 1184         | 39              | 556          |
| 3.44         | COOLING TOWER SUPERSTRUCTURE                  | 563803\$/EACH                     | 5638         | 6890926\$/EACH            | 6891         | 2360            | 4044         |
| 5.1          | TG BUILDING (DIFFERENTIAL)                    | 0.00\$/CU FT                      | 0            | 0.00\$/CU FT              | 0            | 0               | 0            |
| 4.18         | TG PEDESTAL (DIFFERENTIAL)                    | 0\$/FT HT                         | 0            | 0\$/FT HT                 | 0            | 0               | 0            |
| 7.1          | TG & ACCESSORIES (DIFFERENTIAL)               | 0.00\$/KVA                        | 0            | 0.00\$/KVA                | 0            | 0               | 0            |
| 10.211       | CONDENSER SHELL                               | 0\$/EACH                          | 0            | 0\$/EACH                  | 0            | 0               | 0            |
| 10.213       | CONDENSER TUBE (TITAN)                        | 0.0000\$/FT                       | 0            | 0.0000\$/FT               | 0            | 0               | 0            |
| 10.221       | CIRCULATING WATER PUMP                        | 245280\$/EACH                     | 981          | 24528\$/EACH              | 98           | 332             | 58           |
| 15.4         | CIRCULATING WATER PUMP MOTOR                  | 206375\$/EACH                     | 826          | 8255\$/EACH               | 33           | 279             | 19           |
| 14.1         | INSTRUMENTATION & CONTROL                     | 2500.00\$/EACH                    | 10           | 1200.00\$/EACH            | 5            | 3               | 3            |
| 15.11        | START-UP & STANDBY TRANSFORMER (DIFFERENTIAL) | 0\$/MVA                           | 0            | 0\$/MVA                   | 0            | 0               | 0            |
| 15.12        | UNIT AUXILIARY TRANSFORMER (DIFFERENTIAL)     | 6700\$/MVA                        | 49           | 1200\$/MVA                | 9            | 17              | 5            |
| 15.21        | CIRCULATING WATER SWITCHGEAR                  | 43000\$/PUMP                      | 172          | 18000\$/PUMP              | 72           | 58              | 42           |
| 15.6         | WIRING FOR CIRCULATING WATER SYSTEM           | 23050\$/MVA                       | 236          | 57525\$/MVA               | 589          | 80              | 346          |
| 15.1         | UNIT MAIN POWER TRANSFORMER (DIFFERENTIAL)    | 0\$/MVA                           | 0            | 0\$/MVA                   | 0            | 0               | 0            |
| 15.23        | FAN MOTOR POWER CENTER + REQ'D SWGR & FEEDER  | 0\$/CENTER                        | 0            | 0\$/CENTER                | 0            | 0               | 0            |
|              | TOTAL   |                                   | 14228        |                           | 12516        | 5249            | 6954         |

TOTAL DIRECT ESCALATED COST: MATERIAL PLUS 0.00% SALES/USE TAX PLUS INSTALLATION 38941  
 INDIRECT CONSTRUCTION COST INCLUDING PROFESSIONAL SERVICES 6036  
 CONTINGENCY (14.00% OF DIRECT PLUS INDIRECT COST) 6297  
 UTILITY'S EXPENSES, INTEREST DURING CONSTRUCTION, & LAND 9330

TOTAL ESTIMATED INVESTMENT COST 1000\$ 60602

| ESTIMATED COMPARABLE INVESTMENT & ANNUAL COSTS                            |       |       |         | 1000\$/YH MILLS/KWH |  |
|---|-------|-------|---------|---------------------|--|
| UNIT NET CAPABILITY W/SF/S/P (MW)   | 627.5 | 620.9 | 598.1   | 580.9               | CW SYSTEM FUEL COST (BASE VALUE) 163                     |
| DIFFERENTIAL UNIT NET CAPABILITY (MW)                                     |       |       | 39.09   |                     | ANNUAL FIXED CHARGES (AT RATE 0.2225) 13464              |
| UNIT NET ANNUAL GENERATION (MWH/YR)                                       |       |       | 3444835 |                     | WATER COST (AT 0.00\$/MILLION GALLONS + CHEMICALS) 156   |
| DIFFERENTIAL UNIT NET GENERATION (MWH/YR)                                 |       |       | 94894   |                     | MAINTENANCE (1.00% OF TOTAL INV + 0\$/YEAR) 606          |
| WATER CONSUMPTION (MILLION GALLONS/YR)                                    |       |       | 6234    |                     | SUBTOTAL ANNUAL COST 14409                               |
| TOTAL ANNUAL UNIT FUEL COST (AT 0.6500\$/MILLION BTU) (1000\$)            |       |       | 23981   |                     | NET PRODUCTION COST 4.183                                |
| TOTAL COMPARABLE INVESTMENT COST INCLUDING CAPABILITY ADJUSTMENT (1000\$) |       |       | 64455   |                     | ADJUSTMENT FOR DIFFERENTIAL CAPABILITY 457               |
|   |       |       |         |                     | ADJUSTMENT FOR DIFFERENTIAL NET ANNUAL GENERATION 5102   |
|   |       |       |         |                     | TOTAL COMPARABLE ANNUAL COST INCLUDING ADJUSTMENTS 20368 |
|   |       |       |         |                     | FOR EQUALIZED CAPABILITY & NET ANNUAL GENERATION 20368   |
|   |       |       |         |                     | COMPARABLE NET PRODUCTION COST (ICL. ADJUSTMENTS) 5.754  |

JERSEY CENTRAL POWER & LIGHT COMPANY  
OYSTER CREEK NUCLEAR GENERATING STATION  
TIME AND FEE REQUIREMENTS TO OBTAIN NECESSARY PERMITS  
FOR PREFERRED COOLING SYSTEMS

| ACTIVITY  | PREFERRED COOLING<br>TOWER SYSTEMS |   | CANAL-TO-BAY SYSTEM             |  |
|---|------------------------------------|---|---------------------------------|--|
|   | TIME<br>(MONTHS) <sup>(4)</sup>    | FEEES (\$)  | TIME<br>(MONTHS) <sup>(4)</sup> | FEEES (\$)   |
| NRC-EIS Process                                     | 24                                 | N. A.   | 24                              | N. A.  |
| NPDES Permit  | 6                                  | N. A.   | 6                               | \$100.   |
| Section 401<br>Certification                        | 6                                  | N. A.   | 6                               | N. A.  |
| Corps of Engrs<br>Sect 404 Permit                   | N.A. <sup>(1)</sup>                | N. A.   | 3-6 <sup>(2)</sup>              | \$100.   |
| Corps of Engrs<br>Sect 10 Permit                    | N.A.                               | N. A.   | 3-6 <sup>(2)</sup>              | \$100.   |
| N J CAFRA Permit                                    | 4                                  | \$1,000. +<br>\$10/Acre to be<br>developed                      | 4                               | \$1,000. +<br>\$10/Acre to be<br>developed   |
| Riparian Permit                                     | N.A.                               | N. A.   | 3-4 <sup>(3)</sup>              | ½ of 1% of con-<br>struction cost<br>min. \$100.   |
| Wetlands Permit                                     | N.A.                               | N. A.   | 3-4 <sup>(3)</sup>              | ½ of 1% of con-<br>struction cost<br>min. \$300.   |
| Stream Encroach-<br>ment Permit                     | N.A.                               | N. A.   | 3-4 <sup>(3)</sup>              | \$400. for each<br>structure outside<br>canal + \$400. for<br>each 1,000 ft. of<br>canal affected by<br>major activities<br>in canal |
| Soil Erosion &<br>Sediment Control<br>Certification | 1                                  | Fees set by<br>Soil Conserva-<br>tion District<br>based on cost | 1                               | Fees set by Soil<br>Conservation<br>District based<br>on cost  |
| N J Wastewater<br>Permit (WPI)                      | 6                                  | N. A.   | 6                               | N. A.  |

## Notes:

- (1) Not Applicable
- (2) Conditional until all state and other federal permits and certifications are issued.
- (3) Conditional until N J CAFRA permit is issued.
- (4) Statutory times; contingency time not included.

EXHIBIT 161

COOLING TOWER CHARACTERISTICS USED IN FOGGING AND ELEVATED PLUME ANALYSES  
OYSTER CREEK NUCLEAR GENERATING STATION

| <u>Characteristic</u>                                  | <u>Natural Draft</u> | <u>Fan-Assisted Natural Draft</u> | <u>Round Mechanical Draft</u> |
|--|----------------------|-----------------------------------|-------------------------------|
| Height (ft)  | 540                  | 300                               | 69                            |
| Base Diameter (ft)                                     | 430                  | 230                               | 237                           |
| Exit Diameter (ft)                                     | 230                  | 170                               | 122 <sup>(2)</sup>            |
| Circulating Water Flow (gpm) <sup>(1)</sup>            | 433,300              | 229,250                           | 216,650                       |
| Unit Rating (mw)                                       | 640                  | 320                               | 320                           |
| No. of Towers  | 1                    | 2                                 | 2                             |
| Heat Load (Btu/mw-hour) <sup>(1)</sup>                 | $6.94 \times 10^6$   | $6.94 \times 10^6$                | $6.94 \times 10^6$            |
| Exit Air Velocity (fpm)                                | 720                  | 700                               | 1,317                         |
| Exit Fan Volume (ft <sup>3</sup> /hour) <sup>(1)</sup> | 0.0                  | $4.68 \times 10^8$                | $1.17 \times 10^9$            |
| No. of Fans <sup>(1)</sup>                             | -                    | 24                                | 19                            |
| Load Factor (%)  | 100                  | 100                               | 100                           |
| Fan Diameter (ft)                                      | -                    | 24                                | 28                            |

(1) Value per tower

(2) Equivalent exit diameter



EXHIBIT 162  
OYSTER CREEK NUCLEAR GENERATING STATION NATURAL DRAFT  
TOWER IMPACTS  
TABLE 2

PREDICTED MAXIMUM PEAK SHORT-TERM NEAR  
GROUND AIRBORNE CONCENTRATION ( $\mu\text{g}/\text{m}^3$ ) OF SALT RESULTING  
FROM OPERATION OF ONE NATURAL DRAFT COOLING TOWER  
AT THE OYSTER CREEK NUCLEAR GENERATING STATION

| <u>Month</u> | <u>Hours of Persistence</u> | <u>Direction<sup>(a)</sup></u> | <u>Distance (miles)</u> | <u>Near Ground Airborne Concentration (<math>\mu\text{g}/\text{m}^3</math>)</u> |
|--------------|-----------------------------|--------------------------------|-------------------------|---|
| January      | 10                          | W                              | 0.16                    | 6.6   |
| February     | 5                           | SW                             | 0.16                    | 3.6   |
| March        | 5                           | E                              | 0.16                    | 5.5   |
| April        | 5                           | NNW                            | 0.16                    | 3.1   |
| May          | 7                           | WSW                            | 0.16                    | 6.6   |
| June         | 12                          | ENE                            | 0.16                    | 1.6   |
| July         | 14                          | ENE                            | 0.16                    | 1.4   |
| August       | 5                           | S                              | 2.5                     | 0.9   |
| September    | 5                           | ENE                            | 0.16                    | 1.5   |
| October      | 5                           | ESE                            | 0.16                    | 2.3   |
| November     | 7                           | WSW                            | 0.16                    | 5.3   |
| December     | 6                           | SE                             | 0.16                    | 4.3   |

(a) Indicates direction where salt is deposited - winds come from opposite direction

Source: Pickard, Lowe and Garrick, Inc.,  
 October 1977.

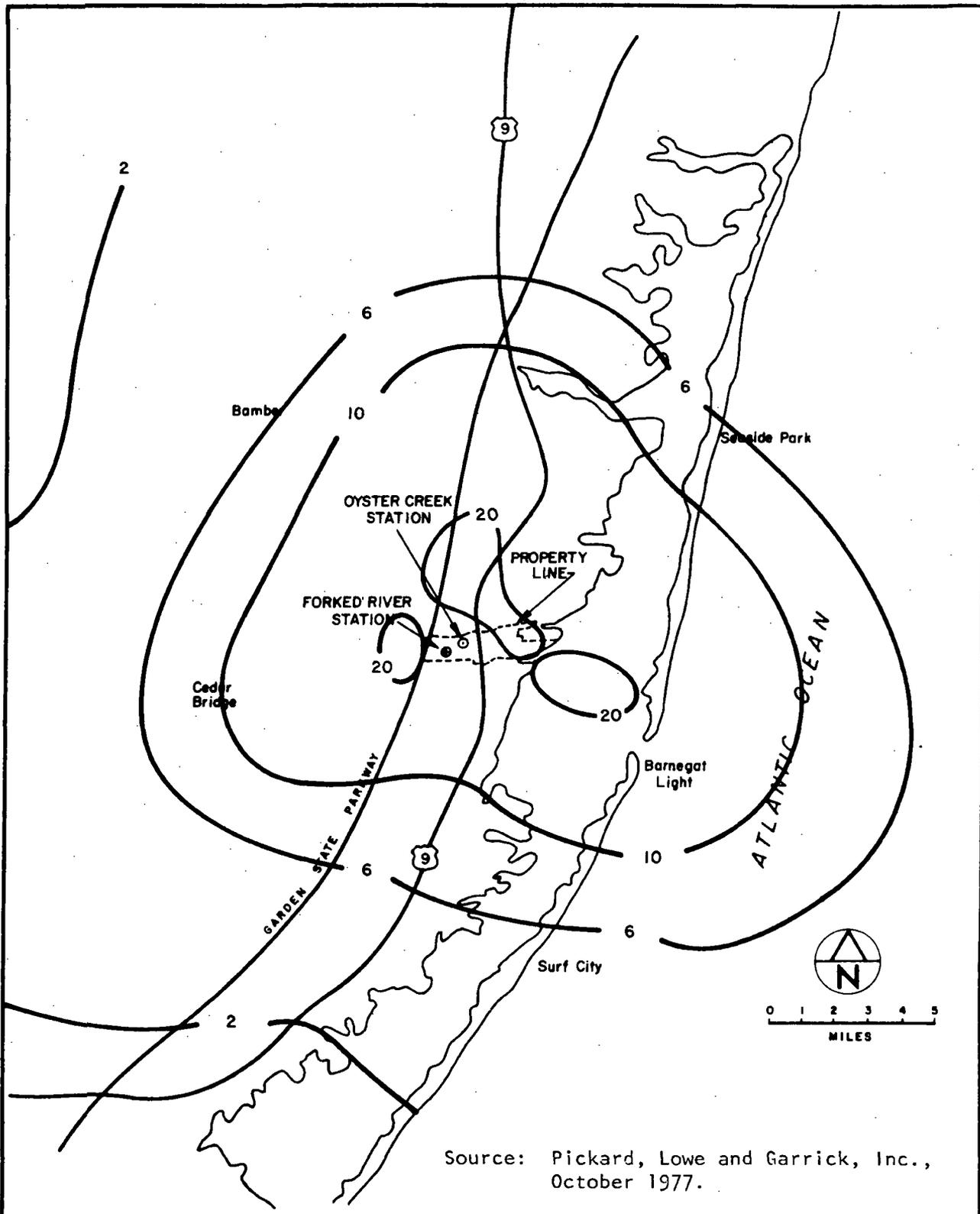
EXHIBIT 162  
OYSTER CREEK NATURAL DRAFT  
TOWER IMPACTS  
TABLE 3

PREDICTED MAXIMUM PEAK SHORT-TERM NEAR GROUND AIRBORNE  
CONCENTRATION ( $\mu\text{g}/\text{m}^3$ ) OF SALT RESULTING FROM OPERATION OF ONE  
NATURAL DRAFT COOLING TOWER AT THE OYSTER CREEK NUCLEAR GENERATING STATION AND  
ONE NATURAL DRAFT COOLING TOWER AT THE FORKED RIVER NUCLEAR GENERATING STATION

| <u>Month</u> | <u>Hours of Persistence</u> | <u>Direction (a)</u> | <u>Distance (miles)</u> | <u>Near Ground Airborne Concentration (<math>\mu\text{g}/\text{m}^3</math>)</u> |
|--------------|-----------------------------|----------------------|-------------------------|---|
| January      | 10                          | W                    | 0.16                    | 6.6   |
| February     | 5                           | SW                   | 0.75                    | 4.5   |
| March        | 9                           | WSW                  | 3.0                     | 10.4  |
| April        | 5                           | NNW                  | 0.16                    | 3.1   |
| May          | 7                           | WSW                  | 0.75                    | 8.8   |
| June         | 12                          | ENE                  | 0.16                    | 2.1   |
| July         | 14                          | ENE                  | 0.16                    | 1.8   |
| August       | 5                           | S                    | 2.5                     | 2.0   |
| September    | 5                           | ENE                  | 0.16                    | 1.9   |
| October      | 5                           | S                    | 4.0                     | 4.2   |
| November     | 7                           | WSW                  | 0.75                    | 7.0   |
| December     | 6                           | SE                   | 0.16                    | 4.3   |

(a) Indicates direction where salt is deposited - winds come from opposite direction

Source: Pickard, Lowe and Garrick, Inc.,  
October 1977.

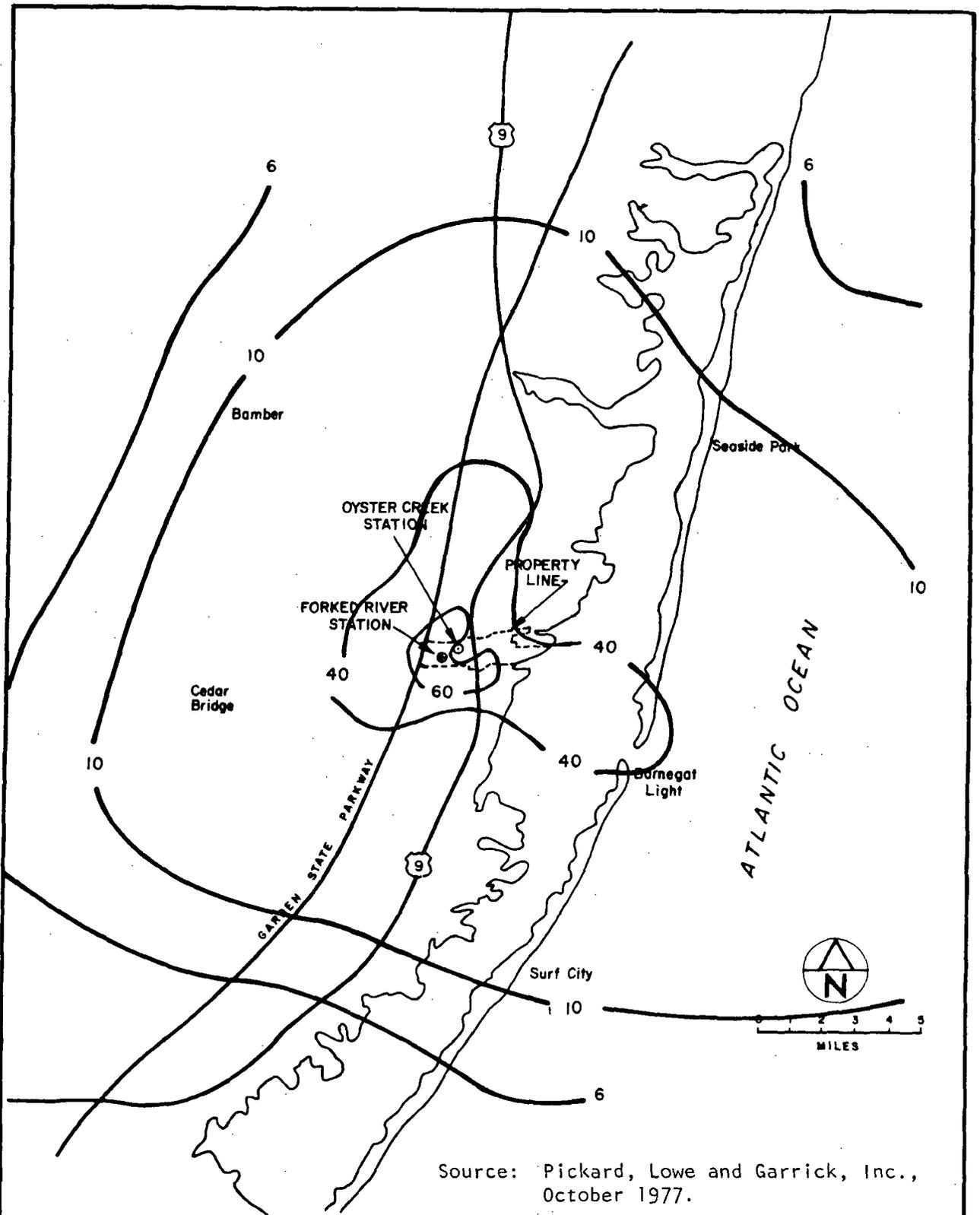


Source: Pickard, Lowe and Garrick, Inc.,  
October 1977.

**JERSEY CENTRAL  
POWER & LIGHT COMPANY**  
**EBASCO SERVICES INCORPORATED**  
New York

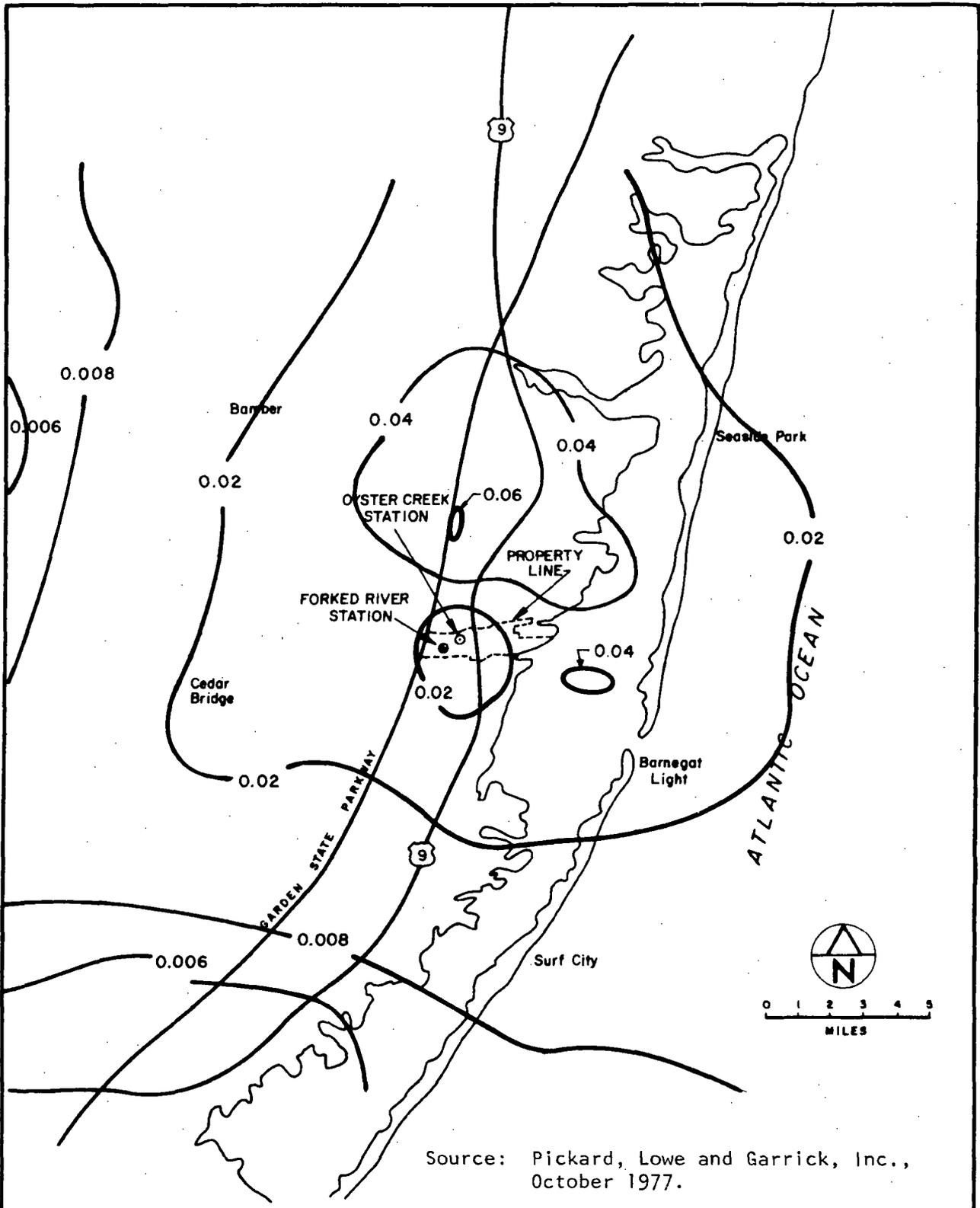
**ANNUAL AVERAGE SALT DEPOSITION RATE  
(Kg/Km<sup>2</sup>-Month) FROM ONE NATURAL DRAFT  
TOWER AT THE OYSTER CREEK  
SITE (0-15 MILES)**

**EXHIBIT  
163**



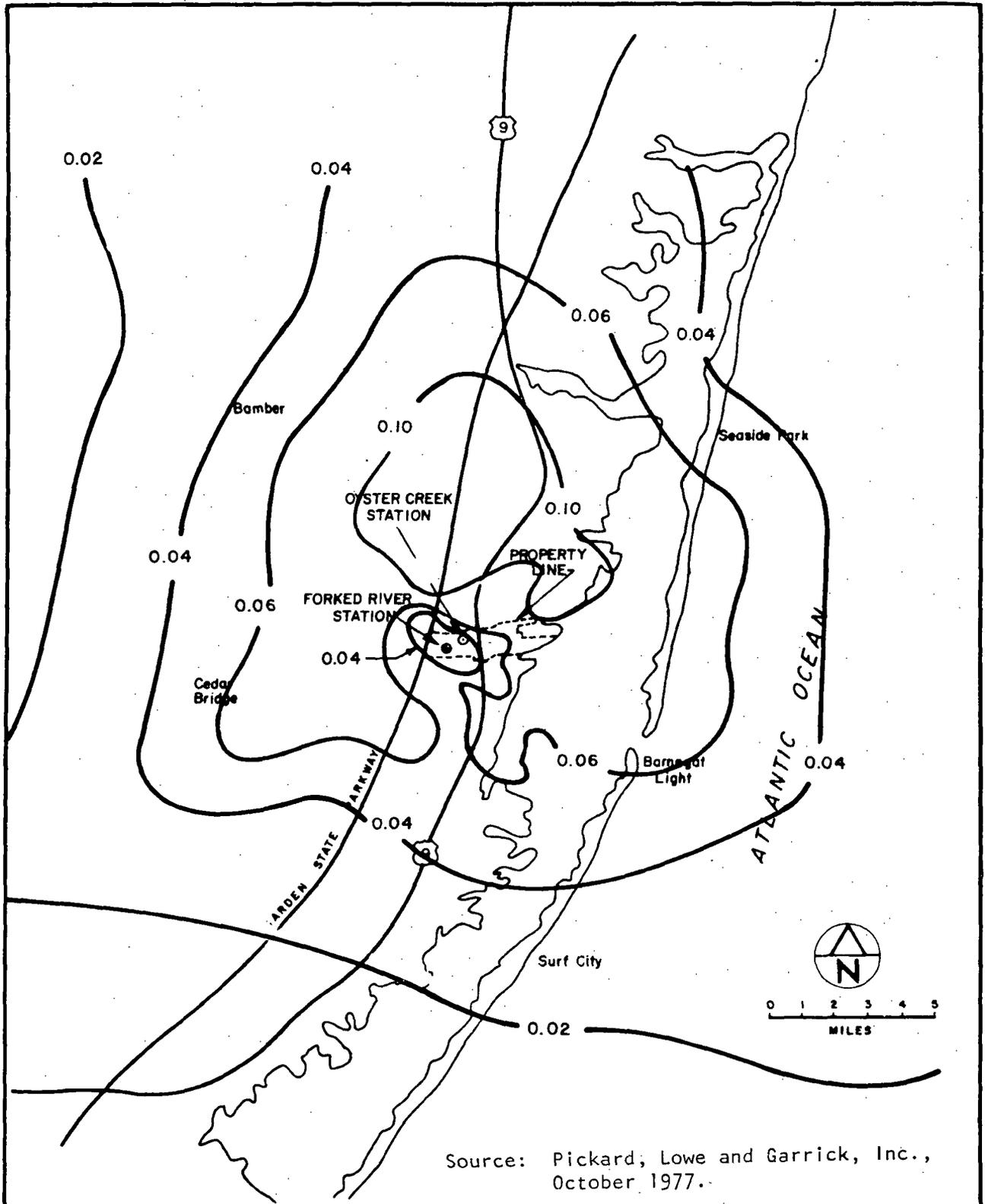
Source: Pickard, Lowe and Garrick, Inc.,  
October 1977.

|   |   |                        |
|---|---|------------------------|
| <b>JERSEY CENTRAL<br/>POWER &amp; LIGHT COMPANY</b> | <b>ANNUAL AVERAGE SALT DEPOSITION RATE<br/>(<math>\text{Kg/Km}^2\text{-Month}</math>) FROM ONE NATURAL DRAFT<br/>TOWER AT OYSTER CREEK SITE AND ONE<br/>NATURAL DRAFT TOWER AT FORKED RIVER<br/>SITE (0-15 MILES)</b> | <b>EXHIBIT<br/>164</b> |
| <b>EBASCO SERVICES INCORPORATED<br/>New York</b>    |   |                        |



Source: Pickard, Lowe and Garrick, Inc.,  
October 1977.

|   |  |                        |
|---|--|------------------------|
| <p>JERSEY CENTRAL<br/>POWER &amp; LIGHT COMPANY</p> | <p>AVERAGE SUMMER AIRBORNE SALT<br/>CONCENTRATIONS (ug/m<sup>3</sup>) FROM ONE NATURAL<br/>DRAFT TOWER AT THE OYSTER CREEK SITE<br/>(0 - 15 MILES)</p> | <p>EXHIBIT<br/>165</p> |
| <p>EBASCO SERVICES INCORPORATED<br/>New York</p>    |  |                        |



|   |   |                        |
|---|---|------------------------|
| <p>JERSEY CENTRAL<br/>POWER &amp; LIGHT COMPANY</p> | <p>AVERAGE SUMMER AIRBONE SALT<br/>CONCENTRATIONS (<math>\mu\text{g}/\text{m}^3</math>) FROM ONE NATURAL<br/>DRAFT TOWER AT THE OYSTER CREEK SITE<br/>AND ONE NATURAL DRAFT TOWER AT THE<br/>FORKED RIVER SITE (0-15 MILES)</p> | <p>EXHIBIT<br/>166</p> |
| <p>EBASCO SERVICES INCORPORATED<br/>New York</p>    |   |                        |

DISCHARGE PARAMETERS UNDER AVERAGE CONDITIONSNATURAL DRAFT TOWER

| <u>Month</u> | <u>Oyster Creek NGS<br/>Discharge Flow<br/>GPM</u> | <u>Forked River NGS<br/>Discharge Flow<br/>GPM</u> | <u>Required*<br/>Dilution Flow<br/>GPM</u> | <u>Combined Flow<br/>to Oyster Creek<br/>GPM</u> | <u>Combined<br/>Temperature Rise<br/>in Oyster Creek<br/>Deg F</u> |
|--------------|--|--|--|--|--|
| January      | 16,000   | 26,400   | 520,000                                    | 562,400  | 2.3  |
| February     | 16,000   | 26,200   | 260,000                                    | 302,200  | 3.7  |
| March        | 15,900   | 25,600   | 260,000                                    | 301,500  | 3.0  |
| April        | 15,400   | 25,000   | 260,000                                    | 300,400  | 2.1  |
| May          | 14,800   | 24,600   | 260,000                                    | 299,400  | 1.5  |
| June         | 14,500   | 24,100   | 260,000                                    | 298,600  | 1.1  |
| July         | 14,400   | 23,800   | 260,000                                    | 298,200  | 1.1  |
| August       | 14,400   | 23,800   | 260,000                                    | 298,200  | 1.1  |
| September    | 14,600   | 24,200   | 260,000                                    | 298,800  | 1.6  |
| October      | 15,000   | 24,700   | 260,000                                    | 299,700  | 2.3  |
| November     | 15,500   | 25,100   | 260,000                                    | 300,600  | 3.2  |
| December     | 16,000   | 26,200   | 260,000                                    | 302,200  | 3.7  |

\*Based on number of dilution pumps required  
to Meet Thermal Criteria in Oyster Creek

Exhibit 168

DISCHARGE PARAMETERS UNDER EXTREME CONDITIONS

NATURAL DRAFT TOWER

| <u>Month</u> | <u>Oyster Creek NGS<br/>Discharge Flow<br/>GPM</u> | <u>Forked River NGS<br/>Discharge Flow<br/>GPM</u> | <u>Required*<br/>Dilution Flow<br/>GPM</u> | <u>Combined Flow<br/>to Oyster Creek<br/>GPM</u> | <u>Combined<br/>Temperature Rise<br/>in Oyster Creek<br/>Deg F</u> |
|--------------|--|--|--|--|--|
| January      | 14,700   | 24,400   | 520,000                                    | 559,100  | 3.5  |
| February     | 14,600   | 24,300   | 520,000                                    | 558,900  | 3.3  |
| March        | 14,500   | 24,200   | 520,000                                    | 558,700  | 2.7  |
| April        | 14,400   | 23,800   | 520,000                                    | 558,200  | 2.2  |
| May          | 14,100   | 23,100   | 260,000                                    | 297,200  | 3.3  |
| June         | 13,500   | 22,100   | 520,000                                    | 555,600  | 1.5  |
| July         | 13,500   | 22,100   | 520,000                                    | 555,600  | 1.3  |
| August       | 13,500   | 22,100   | 520,000                                    | 555,600  | 1.3  |
| September    | 13,600   | 22,300   | 260,000                                    | 295,900  | 3.3  |
| October      | 14,300   | 23,500   | 260,000                                    | 297,800  | 3.9  |
| November     | 14,400   | 23,800   | 520,000                                    | 558,200  | 2.7  |
| December     | 14,700   | 24,400   | 520,000                                    | 559,100  | 3.2  |

\* Based on number of dilution pumps required to Meet Thermal Criteria in Oyster Creek

Exhibit 169

MONTHLY DISCHARGE FLOWS, EVAPORATION LOSSES AND CONCENTRATION FACTORS FOR  
THE CLOSED CYCLE COOLING SYSTEMS<sup>(1)</sup> (CCCS)

| Mode                           | Month | Pumps | Evaporation Loss (gpm) |                    | Concentration Factor |                    | Discharge Flow (gpm) |                    |
|--------------------------------|-------|-------|------------------------|--------------------|----------------------|--------------------|----------------------|--------------------|
|                                |       |       | Avg <sup>(2)</sup>     | Max <sup>(3)</sup> | Avg <sup>(2)</sup>   | Max <sup>(3)</sup> | Avg <sup>(2)</sup>   | Max <sup>(3)</sup> |
| Oyster<br>Creek<br>NGS<br>Only | Jan   | 1     | 4,790                  | 6,320              | 1.02                 | 1.02               | 276,210              | 274,680            |
|                                |       | 2     | "                      | "                  | 1.01                 | 1.01               | 536,210              | 534,680            |
|                                | Feb   | 1     | 4,810                  | 6,420              | 1.02                 | 1.02               | 276,190              | 274,580            |
|                                |       | 2     | "                      | "                  | 1.01                 | 1.01               | 536,190              | 534,580            |
|                                | Mar   | 1     | 5,050                  | 6,450              | 1.02                 | 1.02               | 275,950              | 274,550            |
|                                |       | 2     | "                      | "                  | 1.01                 | 1.01               | 535,950              | 534,550            |
|                                | Apr   | 1     | 5,640                  | 6,620              | 1.02                 | 1.02               | 275,360              | 274,380            |
|                                |       | 2     | "                      | "                  | 1.01                 | 1.01               | 535,360              | 534,550            |
|                                | May   | 1     | 6,160                  | 6,930              | 1.02                 | 1.03               | 274,840              | 274,070            |
|                                |       | 2     | "                      | "                  | 1.01                 | 1.01               | 534,840              | 534,070            |
|                                | Jun   | 1     | 6,500                  | 7,530              | 1.02                 | 1.03               | 274,500              | 273,470            |
|                                |       | 2     | "                      | "                  | 1.01                 | 1.01               | 534,500              | 533,470            |
|                                | Jul   | 1     | 6,640                  | 7,530              | 1.02                 | 1.03               | 274,360              | 273,470            |
|                                |       | 2     | "                      | "                  | 1.01                 | 1.01               | 534,360              | 533,470            |
|                                | Aug   | 1     | 6,620                  | 7,530              | 1.02                 | 1.03               | 274,380              | 273,470            |
|                                |       | 2     | "                      | "                  | 1.01                 | 1.01               | 534,380              | 533,470            |
|                                | Sep   | 1     | 6,430                  | 7,400              | 1.02                 | 1.03               | 274,570              | 273,600            |
|                                |       | 2     | "                      | "                  | 1.01                 | 1.01               | 534,570              | 533,600            |
|                                | Oct   | 1     | 6,010                  | 6,750              | 1.02                 | 1.02               | 274,990              | 274,250            |
|                                |       | 2     | "                      | "                  | 1.01                 | 1.01               | 534,990              | 534,250            |
|                                | Nov   | 1     | 5,490                  | 6,620              | 1.02                 | 1.02               | 275,510              | 274,380            |
|                                |       | 2     | "                      | "                  | 1.01                 | 1.01               | 535,510              | 534,380            |
|                                | Dec   | 1     | 4,810                  | 6,350              | 1.02                 | 1.02               | 276,190              | 274,650            |
|                                |       | 2     | "                      | "                  | 1.01                 | 1.01               | 536,190              | 534,650            |

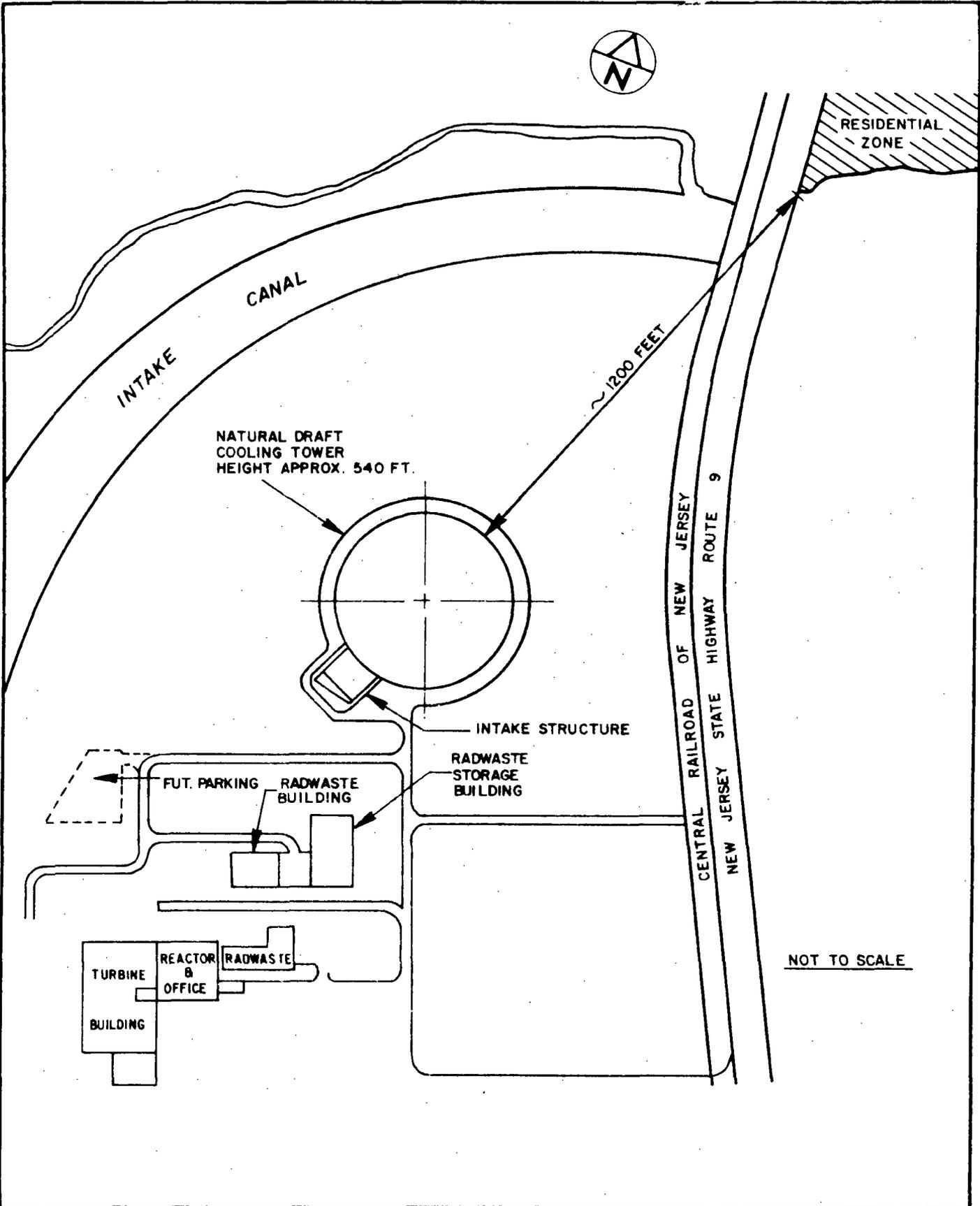
(continued)

Exhibit 169 (Cont'd)

MONTHLY DISCHARGE FLOWS, EVAPORATION LOSSES AND CONCENTRATION FACTORS FOR THE CLOSED CYCLE COOLING SYSTEMS (1) (CCCS)

| Mode             | Month | No. Pumps | Evaporation Loss (gpm) |         | Concentration Factor |         | Discharge Flow (gpm) |         |
|------------------|-------|-----------|------------------------|---------|----------------------|---------|----------------------|---------|
|                  |       |           | Avg (2)                | Max (3) | Avg (2)              | Max (3) | Avg (2)              | Max (3) |
| Oyster Creek NGS | Jan   | 1         | 14,400                 | 17,900  | 1.05                 | 1.06    | 302,600              | 299,100 |
|                  |       | 2         | "                      | "       | 1.03                 | 1.02    | 562,600              | 559,100 |
| &                | Feb   | 1         | 14,600                 | 18,200  | 1.05                 | 1.06    | 302,400              | 298,800 |
|                  |       | 2         | "                      | "       | 1.03                 | 1.03    | 562,400              | 558,800 |
| Forked River NGS | Mar   | 1         | 15,500                 | 18,200  | 1.05                 | 1.06    | 301,500              | 298,800 |
|                  |       | 2         | "                      | "       | 1.03                 | 1.03    | 561,500              | 558,800 |
|                  | Apr   | 1         | 16,700                 | 18,800  | 1.06                 | 1.06    | 300,300              | 298,200 |
|                  |       | 2         | "                      | "       | 1.03                 | 1.03    | 560,300              | 558,200 |
|                  | May   | 1         | 17,600                 | 19,800  | 1.06                 | 1.07    | 299,400              | 297,200 |
|                  |       | 2         | "                      | "       | 1.03                 | 1.04    | 559,400              | 557,200 |
|                  | Jun   | 1         | 18,400                 | 21,400  | 1.06                 | 1.07    | 298,600              | 295,600 |
|                  |       | 2         | "                      | "       | 1.03                 | 1.04    | 558,600              | 555,600 |
|                  | Jul   | 1         | 18,900                 | 21,400  | 1.06                 | 1.07    | 298,100              | 295,600 |
|                  |       | 2         | "                      | "       | 1.03                 | 1.04    | 558,100              | 555,600 |
|                  | Aug   | 1         | 18,800                 | 21,400  | 1.06                 | 1.07    | 298,200              | 295,600 |
|                  |       | 2         | "                      | "       | 1.03                 | 1.04    | 558,200              | 555,600 |
|                  | Sep   | 1         | 18,200                 | 21,100  | 1.06                 | 1.07    | 298,800              | 295,900 |
|                  |       | 2         | "                      | "       | 1.03                 | 1.04    | 558,800              | 555,900 |
|                  | Oct   | 1         | 17,300                 | 19,200  | 1.06                 | 1.06    | 299,700              | 297,800 |
|                  |       | 2         | "                      | "       | 1.03                 | 1.03    | 559,700              | 557,800 |
|                  | Nov   | 1         | 16,400                 | 18,800  | 1.05                 | 1.06    | 300,600              | 298,200 |
|                  |       | 2         | "                      | "       | 1.03                 | 1.03    | 560,600              | 558,200 |
|                  | Dec   | 1         | 14,600                 | 18,000  | 1.05                 | 1.06    | 302,400              | 299,000 |
|                  |       | 2         | "                      | "       | 1.03                 | 1.03    | 562,400              | 559,000 |

- Notes: (1) The CCCS include the natural draft, round mechanical draft and fan-assisted natural draft cooling towers with saltwater makeup.  
 (2) Average ambient conditions, i.e., average wet and dry bulb temperatures.  
 (3) Maximum ambient conditions, i.e., maximum wet bulb and minimum dry bulb temperatures.



JERSEY CENTRAL  
POWER & LIGHT COMPANY

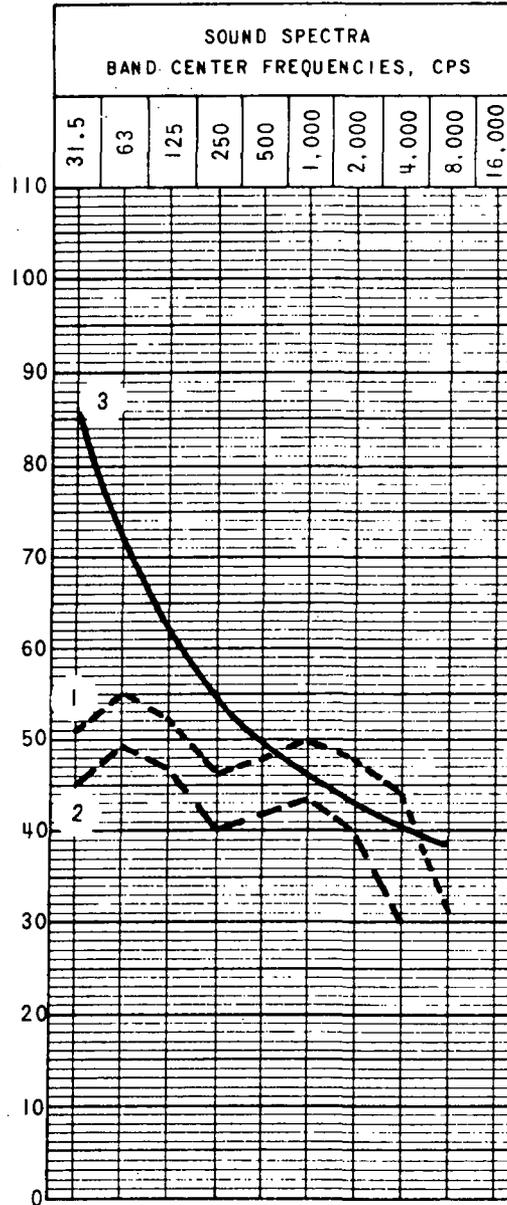
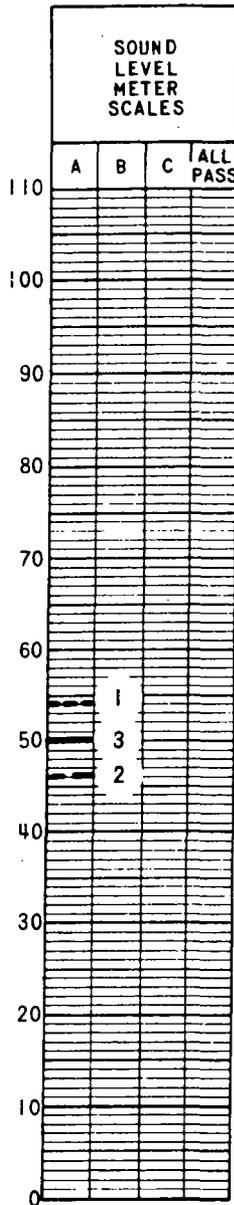
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EBASCO SERVICES INCORPORATED  
New York

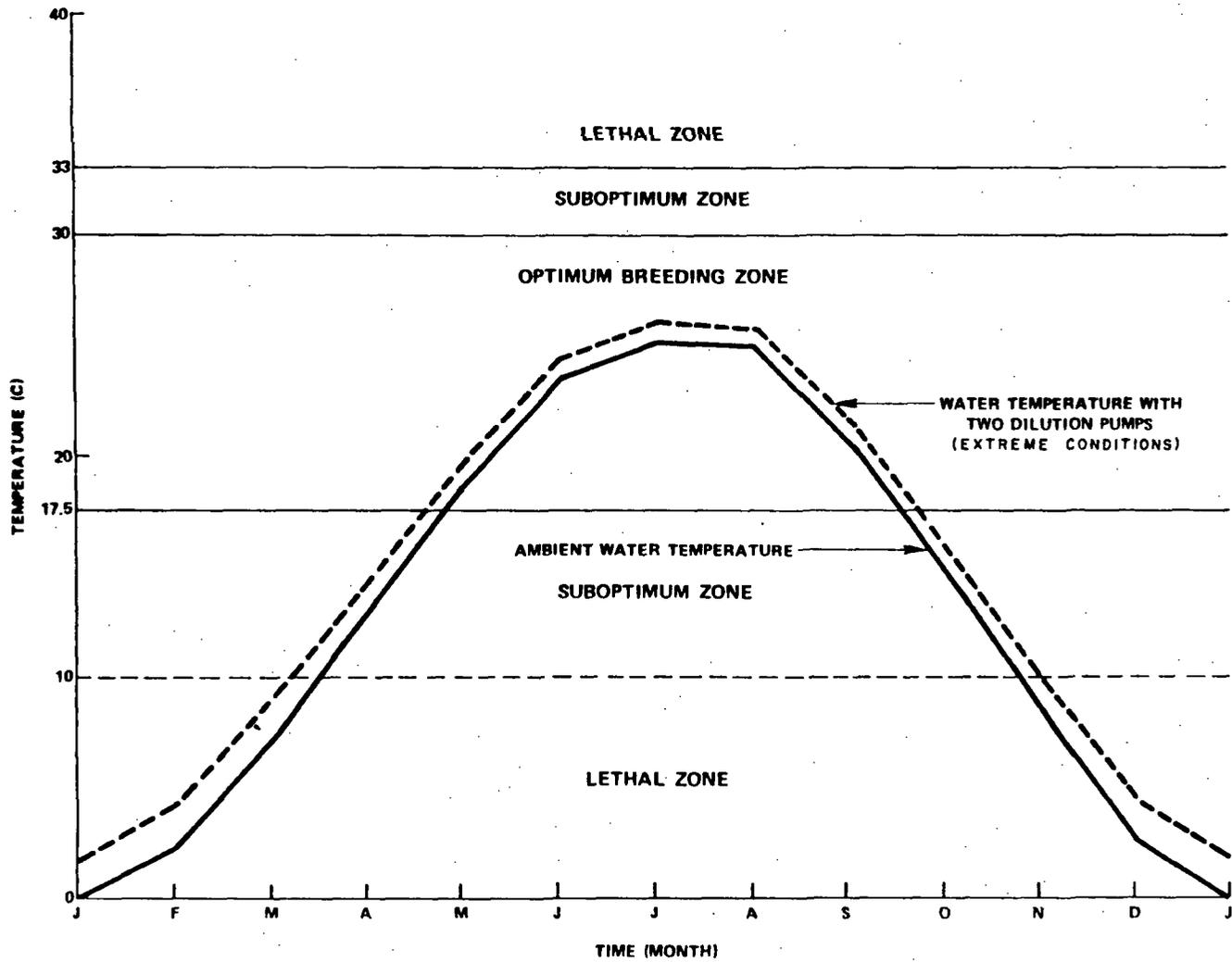
LOCATION OF  
NATURAL DRAFT COOLING TOWER  
WITH RESPECT TO NEAREST RESIDENTIAL ZONE

EXHIBIT  
170

SOUND PRESSURE LEVEL - DECIBELS (db - Re 0.0002 Microbars)



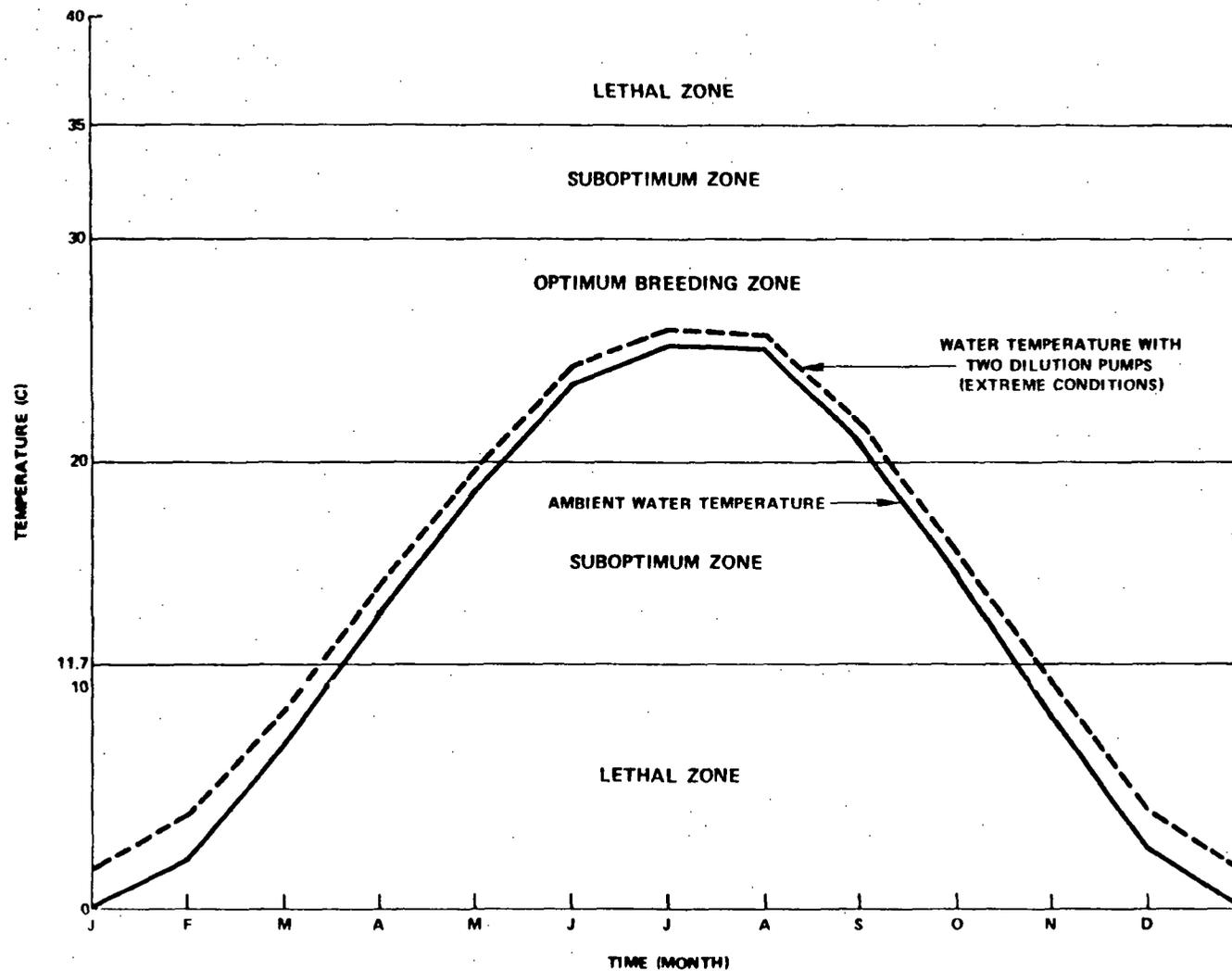
1. UNATTENUATED SPL AT A DISTANCE OF ABOUT 1200 FT FROM THE TOWER
2. UNATTENUATED SPL AT A DISTANCE OF ABOUT 2500 FT FROM THE TOWER
3. NEW JERSEY NIGHTTIME CRITERION



JERSEY CENTRAL  
POWER & LIGHT COMPANY  
EBASCO SERVICES INCORPORATED  
New York

OPTIMUM BREEDING AND LETHAL WATER  
TEMPERATURE ZONES FOR BANKIA GOULDI  
(PREFERRED COOLING TOWER SYSTEMS)

EXHIBIT  
172



JERSEY CENTRAL  
POWER & LIGHT COMPANY

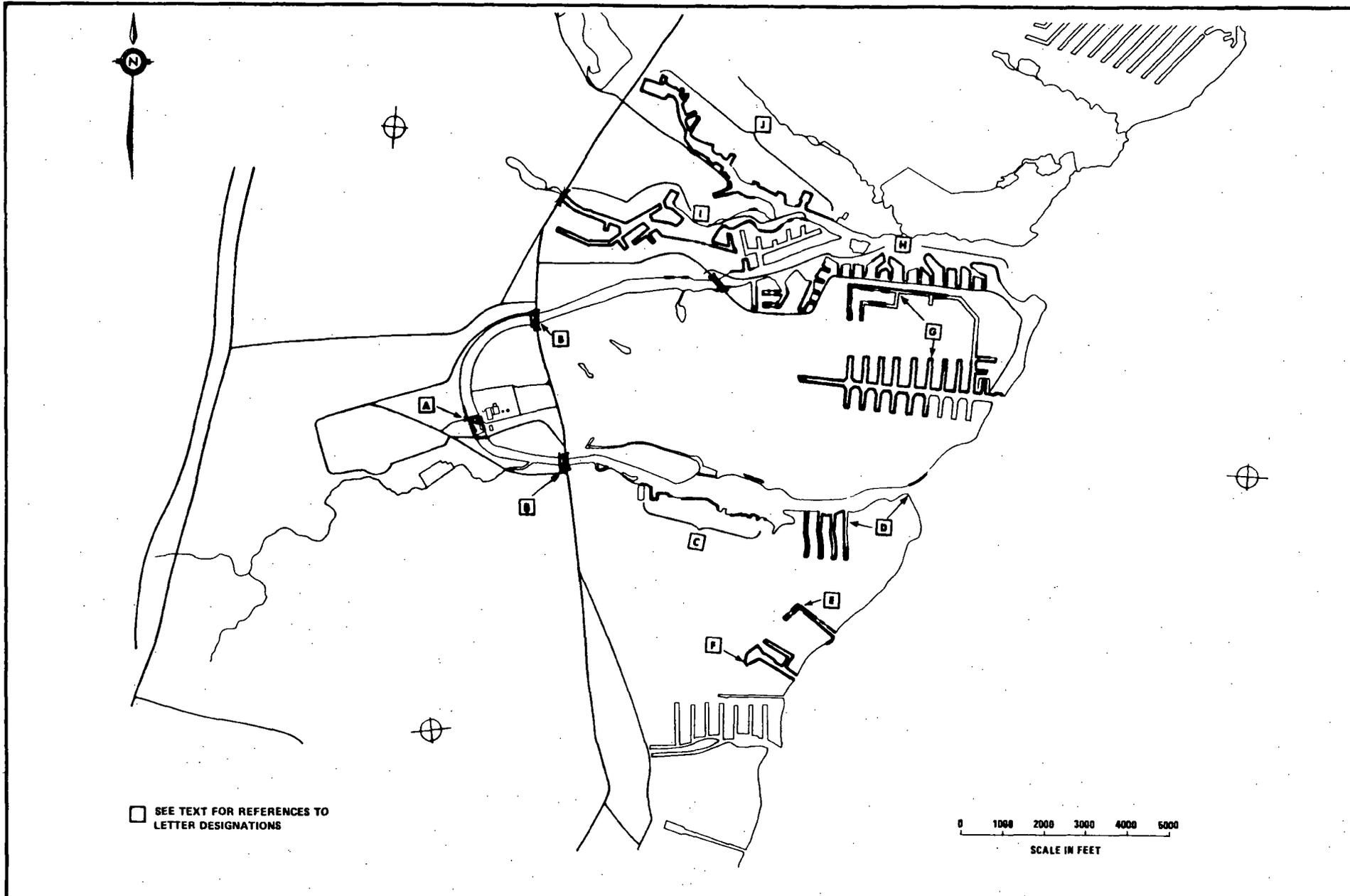
EBASCO SERVICES INCORPORATED

New York

OPTIMUM BREEDING AND LETHAL WATER  
TEMPERATURE ZONES FOR TEREDO NAUALIS  
(PREFERRED COOLING TOWER SYSTEMS)

EXHIBIT

173



□ SEE TEXT FOR REFERENCES TO LETTER DESIGNATIONS

0 1000 2000 3000 4000 5000  
SCALE IN FEET

JERSEY CENTRAL  
POWER & LIGHT COMPANY  
EBASCO SERVICES INCORPORATED  
New York

AREAS OF WOOD BULKHEADING, DOCKAGE AND PIERS  
IN THE VICINITY OF THE DOCKS

EXHIBIT  
174

## EXHIBIT 175

ENTRAINMENT ESTIMATES FOR CONDENSER CIRCULATING WATER AND DILUTION WATER  
for Mercenaria mercenaria-umbo and hinge stages

| Month<br>1975-1976 | Data for Existing System                         |   |   |                                |                                  | Projected<br>Daily Entrainment                  |                         | Projected<br>Daily Mortality     |                                  | Dilution<br>Water<br>(gpm x 10 <sup>3</sup> ) | Sample Days <sup>(1)</sup><br>per Month | Mean<br>Density<br>in No/m <sup>3</sup><br>Station 11 <sup>(2)</sup> | Actual<br>Dilution<br>Water Daily<br>Entrainment | Daily<br>Entrainment <sup>(5)</sup><br>Through Two<br>Dilution Pumps<br>(560 x 10 <sup>6</sup> gpm) |
|--------------------|--|---|---|--------------------------------|----------------------------------|---|-------------------------|----------------------------------|----------------------------------|---|---|--|--|---|
|                    | Circulating<br>Water<br>(gpm x 10 <sup>3</sup> ) | Sample Days <sup>(1)</sup><br>per Month | Daily <sup>(2)</sup><br>Sample<br>Entrainment | Condenser<br>Mortality<br>Rate | Sample<br>Condenser<br>Mortality | Canal-Bay/ <sup>(3)</sup><br>Existing<br>System | Cooling<br>Towers       | Canal-Bay/<br>Existing<br>System | Cooling <sup>(4)</sup><br>Towers |   |   |  |  |   |
| Sep                | 345  | 21/30                                   | -   | No                             | -                                | -   | -                       | -                                | -                                | 250   | 26/30                                   | -  | -  | -   |
| Oct                | 345  | 29/31                                   | -   | Determinations                 | -                                | -   | -                       | -                                | -                                | 500<br>250                                    | 11/31<br>14/31                          | -  | -  | -   |
| Nov                | 345<br>0   | 24/30<br>5/30                           | -   | -                              | -                                | -   | -                       | -                                | -                                | 500   | 24/30                                   | -  | -  | -   |
| Dec                | 345<br>0   | 23/31<br>3/31                           | 4.47 x 10 <sup>9</sup>                        | -                              | -                                | 5.95 x 10 <sup>9</sup>                          | 2.72 x 10 <sup>8</sup>  | -                                | 2.72 x 10 <sup>8</sup>           | 500   | 25/31                                   | 9  | 6.48 x 10 <sup>6</sup>                           | 6.48 x 10 <sup>6</sup>  |
| Jan                | 345  | 23/30                                   | -   | -                              | -                                | -   | -                       | -                                | -                                | 500   | 24/31                                   | -  | -  | -   |
| Feb                | 345  | 25/29                                   | -   | -                              | -                                | -   | -                       | -                                | -                                | 500   | 25/29                                   | -  | -  | -   |
| Mar                | 460<br>345<br>0                                  | 15/31<br>8/31<br>3/31                   | -   | -                              | -                                | -   | -                       | -                                | -                                | 500<br>250                                    | 18/31<br>11/31                          | -  | -  | -   |
| Apr                | 460  | 30/30                                   | 6.11 x 10 <sup>11</sup>                       | -                              | -                                | 6.11 x 10 <sup>11</sup>                         | 2.79 x 10 <sup>10</sup> | -                                | 2.79 x 10 <sup>10</sup>          | 500<br>250                                    | 23/30<br>7/30                           | 923  | 5.87 x 10 <sup>8</sup>                           | 6.65 x 10 <sup>8</sup>  |
| May                | 460  | 29/31                                   | 1.99 x 10 <sup>10</sup>                       | -                              | -                                | 1.99 x 10 <sup>10</sup>                         | 9.08 x 10 <sup>8</sup>  | -                                | 9.08 x 10 <sup>8</sup>           | 250   | 25/31                                   | 30   | 1.08 x 10 <sup>7</sup>                           | 2.16 x 10 <sup>7</sup>  |
| Jun                | 460  | 26/30                                   | 1.06 x 10 <sup>10</sup>                       | -                              | -                                | 1.06 x 10 <sup>10</sup>                         | 4.84 x 10 <sup>8</sup>  | -                                | 4.84 x 10 <sup>8</sup>           | 500<br>250                                    | 19/30<br>7/30                           | 16   | 9.95 x 10 <sup>6</sup>                           | 1.15 x 10 <sup>7</sup>  |
| Jul                | 460  | 31/31                                   | -   | -                              | -                                | -   | -                       | -                                | -                                | 500<br>250                                    | 25/31<br>4/31                           | -  | -  | -   |
| Aug                | 460  | 31/31                                   | 5.7 x 10 <sup>10</sup>                        | -                              | -                                | 5.7 x 10 <sup>10</sup>                          | 2.6 x 10 <sup>9</sup>   | -                                | 2.6 x 10 <sup>9</sup>            | 500   | 25/31                                   | 86   | 6.19 x 10 <sup>7</sup>                           | 6.19 x 10 <sup>7</sup>  |

(1) Unaccounted for days showed variable daily flow

(3) Assumes circulating water flow at 460 x 10<sup>6</sup> gpm

(2) Based on IA, 1977, Table 7-CWS discharge sample basis

(4) Assumes 100% mortality

(5) Entrainment halved with operation of one dilution pump at 260 x 10<sup>6</sup> gpm

## EXHIBIT 175

## ENTRAINMENT ESTIMATES FOR CONDENSER CIRCULATING WATER AND DILUTION WATER

## for Teredinid-larvae

| Month<br>1975-1976 | Data for Existing System                         |   |   |                                |                                  | Projected<br>Daily Entrainment                  |                        | Projected<br>Daily Mortality     |                                  | Dilution<br>Water<br>(gpm x 10 <sup>3</sup> ) | Sample Days <sup>(1)</sup><br>per Month | Mean<br>Density<br>in No/m <sup>3</sup><br>Station B <sup>(2)</sup> | Actual<br>Dilution<br>Water Daily<br>Entrainment | Daily<br>Entrainment <sup>(5)</sup><br>Through Two<br>Dilution Pumps<br>(360 x 10 <sup>6</sup> gpm) |
|--------------------|--|---|---|--------------------------------|----------------------------------|---|------------------------|----------------------------------|----------------------------------|---|---|---|--|---|
|                    | Circulating<br>Water<br>(gpm x 10 <sup>3</sup> ) | Sample Days <sup>(1)</sup><br>per Month | Daily <sup>(2)</sup><br>Sample<br>Entrainment | Condenser<br>Mortality<br>Rate | Sample<br>Condenser<br>Mortality | Canal-Bay/ <sup>(3)</sup><br>Existing<br>System | Cooling<br>Towers      | Canal-Bay/<br>Existing<br>System | Cooling <sup>(4)</sup><br>Towers |   |   |   |  |   |
| Jun                | 345  | 21/30                                   | 0   | No                             | 0                                | 0   | 0                      | 0                                | 0                                | -   |   | 0   | 0  | 0   |
| Jul                | 345  | 29/31                                   | 3.40 x 10 <sup>9</sup>                        | Determinations                 | -                                | 4.52 x 10 <sup>9</sup>                          | 2.06 x 10 <sup>8</sup> | -                                | 2.06 x 10 <sup>8</sup>           | 500   | 11/31                                   | 6.84  | 4.92 x 10 <sup>9</sup>                           | 4.92 x 10 <sup>9</sup>  |
| Aug                | 345<br>0   | 24/30<br>5/30                           | 8.45 x 10 <sup>7</sup>                        |                                | -                                | 1.12 x 10 <sup>8</sup>                          | 5.11 x 10 <sup>6</sup> | -                                | 5.11 x 10 <sup>6</sup>           | 500<br>250                                    | 26/31<br>5/31                           | 0.17  | 1.22 x 10 <sup>8</sup>                           | 1.22 x 10 <sup>8</sup>  |
| Sep                | 345<br>0   | 23/31<br>3/31                           | 0   |                                | 0                                | 0   | 0                      | 0                                | 0                                | 250   | 26/31                                   | 0   | 0  | 0   |
| Oct                | 345  | 23/30                                   | 9.99 x 10 <sup>8</sup>                        |                                | -                                | 1.33 x 10 <sup>9</sup>                          | 6.07 x 10 <sup>7</sup> | -                                | 6.07 x 10 <sup>7</sup>           | 500<br>250                                    | 11/31<br>14/31                          | 2.01  | 1.09 x 10 <sup>9</sup>                           | 1.45 x 10 <sup>9</sup>  |
| Nov                | 345  | 25/29                                   | 0   |                                | 0                                | 0   | 0                      | 0                                | 0                                | 500   | 24/30                                   | 0   | 0  | 0   |
| Dec                | 345  | 26/31                                   | 0   |                                | 0                                | 0   | 0                      | 0                                | 0                                | 500   | 25/31                                   | 0   | 0  | 0   |
| Jan                | 500  | 30/30                                   | -   |                                | -                                | -   | -                      | -                                | -                                | 500   | 24/31                                   | -   | -  | -   |
| Feb                | 500  | 29/31                                   | -   |                                | -                                | -   | -                      | -                                | -                                | 500   | 25/29                                   | -   | -  | -   |
| Mar                | 460<br>345<br>0                                  | 26/30                                   | 0   |                                | 0                                | 0   | 0                      | 0                                | 0                                | 500<br>250                                    | 18/31<br>11/31                          | 0   | 0  | 0   |
| Apr                | 460  | 31/31                                   | 0   |                                | 0                                | 0   | 0                      | 0                                | 0                                | 500<br>250                                    | 23/30<br>7/30                           | 0   | 0  | 0   |
| May                | 460  | 31/31                                   | 0   |                                | 0                                | 0   | 0                      | 0                                | 0                                | 250   | 25/31                                   | 0   | 0  | 0   |

(1) Unaccounted for days showed variable daily flow

(2) Based on Clapp Lab, 1976 - day and night samples

(3) Assumes circulating water flow at 460 x 10<sup>6</sup> gpm

(4) Assumes 100% mortality

(5) Entrainment halved with operation of one dilution pump at 260 x 10<sup>6</sup> gpm

## EXHIBIT 175

## ENTRAINMENT ESTIMATES FOR CONDENSER CIRCULATING WATER AND DILUTION WATER

for *Neomysis americana*

| Month<br>1975-1976 | Data for Existing System                         |   |   |                                |                                  | Projected<br>Daily Entrainment                  |                        | Projected<br>Daily Mortality     |                                  | Dilution<br>Water<br>(gpm x 10 <sup>3</sup> ) | Sample Days <sup>(1)</sup><br>per Month | Mean<br>Density<br>Station 11 <sup>(2)</sup><br>(in No./1000 m <sup>3</sup> ) | Actual<br>Dilution<br>Water Daily<br>Entrainment | Daily<br>Entrainment <sup>(5)</sup><br>Through Two<br>Dilution Pumps<br>(560 x 10 <sup>6</sup> gpm) |
|--------------------|--|---|---|--------------------------------|----------------------------------|---|------------------------|----------------------------------|----------------------------------|---|---|---|--|---|
|                    | Circulating<br>Water<br>(gpm x 10 <sup>3</sup> ) | Sample Days <sup>(1)</sup><br>per Month | Daily <sup>(2)</sup><br>Sample<br>Entrainment | Condenser<br>Mortality<br>Rate | Sample<br>Condenser<br>Mortality | Canal-Bay/ <sup>(3)</sup><br>Existing<br>System | Cooling<br>Towers      | Canal-Bay/<br>Existing<br>System | Cooling <sup>(4)</sup><br>Towers |   |   |   |  |   |
| Sep                | 345  | 21/30                                   | 3.95 x 10 <sup>9</sup>                        | .665                           | 2.63 x 10 <sup>9</sup>           | 5.25 x 10 <sup>9</sup>                          | 2.4 x 10 <sup>8</sup>  | 3.49 x 10 <sup>9</sup>           | 2.4 x 10 <sup>8</sup>            | 250   | 26/30                                   | 8,030   | 2.89 x 10 <sup>9</sup>                           | 5.78 x 10 <sup>9</sup>  |
| Oct                | 345  | 29/31                                   | 6.24 x 10 <sup>9</sup>                        | .007                           | 4.37 x 10 <sup>7</sup>           | 8.30 x 10 <sup>9</sup>                          | 3.79 x 10 <sup>8</sup> | 5.81 x 10 <sup>7</sup>           | 3.79 x 10 <sup>8</sup>           | 500<br>250                                    | 11/31<br>14/31                          | 12,793  | 6.91 x 10 <sup>9</sup>                           | 9.21 x 10 <sup>9</sup>  |
| Nov                | 345<br>0   | 24/30<br>5/30                           | 8.88 x 10 <sup>9</sup>                        | .066                           | 5.86 x 10 <sup>8</sup>           | 1.18 x 10 <sup>10</sup>                         | 5.39 x 10 <sup>8</sup> | 7.79 x 10 <sup>8</sup>           | 5.39 x 10 <sup>8</sup>           | 500   | 24/30                                   | 17,987  | 1.30 x 10 <sup>10</sup>                          | 1.30 x 10 <sup>10</sup>   |
| Dec                | 345<br>0   | 23/31<br>3/31                           | 1.41 x 10 <sup>10</sup>                       | .183                           | 2.58 x 10 <sup>9</sup>           | 1.88 x 10 <sup>10</sup>                         | 8.58 x 10 <sup>8</sup> | 3.44 x 10 <sup>9</sup>           | 8.58 x 10 <sup>8</sup>           | 500   | 25/31                                   | 28,419  | 2.05 x 10 <sup>10</sup>                          | 2.05 x 10 <sup>10</sup>   |
| Jan                | 345  | 23/30                                   | 2.50 x 10 <sup>9</sup>                        | -                              | -                                | 3.33 x 10 <sup>9</sup>                          | 1.52 x 10 <sup>8</sup> | -                                | 1.52 x 10 <sup>8</sup>           | 500   | 24/31                                   | 7,332   | 5.28 x 10 <sup>9</sup>                           | 5.28 x 10 <sup>9</sup>  |
| Feb                | 345  | 25/29                                   | 8.28 x 10 <sup>9</sup>                        | -                              | -                                | 1.10 x 10 <sup>10</sup>                         | 5.02 x 10 <sup>8</sup> | -                                | 5.02 x 10 <sup>8</sup>           | 500   | 25/29                                   | 24,180  | 1.74 x 10 <sup>10</sup>                          | 1.74 x 10 <sup>10</sup>   |
| Mar                | 460<br>345<br>0                                  | 15/31<br>8/31<br>3/31                   | 4.12 x 10 <sup>10</sup>                       | .01                            | 4.12 x 10 <sup>8</sup>           | 3.61 x 10 <sup>10</sup>                         | 1.65 x 10 <sup>9</sup> | 3.61 x 10 <sup>8</sup>           | 1.65 x 10 <sup>9</sup>           | 500<br>250                                    | 18/31<br>11/31                          | 70,080  | 3.79 x 10 <sup>10</sup>                          | 5.05 x 10 <sup>10</sup>   |
| Apr                | 460  | 30/30                                   | 5.49 x 10 <sup>9</sup>                        | .01                            | 5.49 x 10 <sup>7</sup>           | 5.49 x 10 <sup>9</sup>                          | 2.51 x 10 <sup>8</sup> | 5.49 x 10 <sup>7</sup>           | 2.51 x 10 <sup>8</sup>           | 500<br>250                                    | 23/30<br>7/30                           | 8,431   | 5.36 x 10 <sup>9</sup>                           | 6.07 x 10 <sup>9</sup>  |
| May                | 460  | 29/31                                   | 3.75 x 10 <sup>9</sup>                        | .02                            | 7.5 x 10 <sup>7</sup>            | 3.75 x 10 <sup>9</sup>                          | 1.71 x 10 <sup>8</sup> | 7.5 x 10 <sup>7</sup>            | 1.71 x 10 <sup>8</sup>           | 250   | 25/31                                   | 5,737   | 2.07 x 10 <sup>9</sup>                           | 4.13 x 10 <sup>9</sup>  |
| Jun                | 460  | 26/30                                   | 2.37 x 10 <sup>10</sup>                       | .22                            | 5.21 x 10 <sup>9</sup>           | 2.37 x 10 <sup>10</sup>                         | 1.08 x 10 <sup>9</sup> | 5.21 x 10 <sup>9</sup>           | 1.08 x 10 <sup>9</sup>           | 500<br>250                                    | 19/30<br>7/30                           | 36,340  | 2.27 x 10 <sup>10</sup>                          | 2.62 x 10 <sup>10</sup>   |
| Jul                | 460  | 31/31                                   | 1.37 x 10 <sup>10</sup>                       | .67                            | 9.18 x 10 <sup>9</sup>           | 1.37 x 10 <sup>10</sup>                         | 6.25 x 10 <sup>8</sup> | 9.18 x 10 <sup>9</sup>           | 6.25 x 10 <sup>8</sup>           | 500<br>250                                    | 25/31<br>4/31                           | 21,368  | 1.54 x 10 <sup>10</sup>                          | 1.54 x 10 <sup>10</sup>   |
| Aug                | 460  | 31/31                                   | 2.65 x 10 <sup>10</sup>                       | .81                            | 2.15 x 10 <sup>10</sup>          | 2.65 x 10 <sup>10</sup>                         | 1.21 x 10 <sup>9</sup> | 2.15 x 10 <sup>10</sup>          | 1.21 x 10 <sup>9</sup>           | 500   | 25/31                                   | 41,453  | 2.98 x 10 <sup>10</sup>                          | 2.98 x 10 <sup>10</sup>   |

(1) Unaccounted for days showed variable daily flow

(3) Assumes circulating water flow at 460 x 10<sup>6</sup> gpm

(2) Based on IA, 1977, Table 13 - discharge sample basis

(4) Assumes 100% mortality

(5) Entrainment halved with operation of one dilution pump at 260 x 10<sup>6</sup> gpm

## EXHIBIT 175

## ENTRAINMENT ESTIMATES FOR CONDENSER CIRCULATING WATER AND DILUTION WATER

for Mysids and gravid Mysids

| Month<br>1975-1976 | Data for Existing Systems                        |   |   |                                |                                  | Projected<br>Daily Entrainment                  |                        | Projected<br>Daily Mortality     |                                  | Dilution<br>Water<br>(gpm x 10 <sup>3</sup> ) | Sample Days <sup>(1)</sup><br>per Month | Mean<br>Density<br>in No/m <sup>3</sup><br>Station | Actual<br>Dilution<br>Water Daily<br>Entrainment | Daily<br>Entrainment<br>Through Two<br>Dilution Pumps<br>(560 x 10 <sup>6</sup> gpm) |
|--------------------|--|---|---|--------------------------------|----------------------------------|---|------------------------|----------------------------------|----------------------------------|---|---|--|--|--|
|                    | Circulating<br>Water<br>(gpm x 10 <sup>3</sup> ) | Sample Days <sup>(1)</sup><br>per Month | Daily <sup>(2)</sup><br>Sample<br>Entrainment | Condenser<br>Mortality<br>Rate | Sample<br>Condenser<br>Mortality | Canal-Bay/ <sup>(3)</sup><br>Existing<br>System | Cooling<br>Towers      | Canal-Bay/<br>Existing<br>System | Cooling <sup>(4)</sup><br>Towers |   |   |  |  |  |
| Sep                | 345  | 21/30                                   | 2.07 x 10 <sup>7</sup>                        | .665 <sup>+</sup>              | 1.38 x 10 <sup>7</sup>           | 2.75 x 10 <sup>7</sup>                          | 1.26 x 10 <sup>6</sup> | 1.83 x 10 <sup>7</sup>           | 1.26 x 10 <sup>6</sup>           |   |   |  |  |  |
| Oct                | 345  | 29/31                                   | 2.8 x 10 <sup>7</sup>                         | .007 <sup>+</sup>              | 1.96 x 10 <sup>5</sup>           | 3.72 x 10 <sup>7</sup>                          | 1.70 x 10 <sup>6</sup> | 2.6 x 10 <sup>5</sup>            | 1.7 x 10 <sup>6</sup>            |   |   |  |  |  |
| Nov                | 345<br>0   | 24/30<br>5/30                           | 3.2 x 10 <sup>7</sup>                         | .066 <sup>+</sup>              | 2.11 x 10 <sup>6</sup>           | 4.26 x 10 <sup>7</sup>                          | 1.94 x 10 <sup>6</sup> | 2.81 x 10 <sup>6</sup>           | 1.94 x 10 <sup>6</sup>           |   |   |  |  |  |
| Dec                | 345<br>0   | 23/31<br>3/31                           | 3.9 x 10 <sup>7</sup>                         | .183 <sup>+</sup>              | 7.14 x 10 <sup>6</sup>           | 5.19 x 10 <sup>7</sup>                          | 2.37 x 10 <sup>6</sup> | 9.5 x 10 <sup>6</sup>            | 2.37 x 10 <sup>6</sup>           |   |   |  |  |  |
| Jan                | 345  | 23/30                                   | 1.80 x 10 <sup>7</sup>                        | -                              | -                                | 2.39 x 10 <sup>7</sup>                          | 1.09 x 10 <sup>6</sup> | -                                | 1.09 x 10 <sup>6</sup>           |   |   |  |  |  |
| Feb                | 345  | 25/29                                   | 5.48 x 10 <sup>7</sup>                        | -                              | -                                | 7.29 x 10 <sup>7</sup>                          | 3.33 x 10 <sup>6</sup> | -                                | 3.33 x 10 <sup>6</sup>           |   |   |  |  |  |
| Mar                | 460<br>345<br>0                                  | 15/31<br>8/31<br>3/31                   | 1.22 x 10 <sup>8</sup>                        | .01 <sup>++</sup>              | 1.22 x 10 <sup>6</sup>           | 1.22 x 10 <sup>8</sup>                          | 5.57 x 10 <sup>6</sup> | 1.22 x 10 <sup>6</sup>           | 5.57 x 10 <sup>6</sup>           |   |   |  |  |  |
| Apr                | 460  | 30/30                                   | 1.42 x 10 <sup>7</sup>                        | .01 <sup>++</sup>              | 1.42 x 10 <sup>5</sup>           | 1.42 x 10 <sup>7</sup>                          | 6.48 x 10 <sup>5</sup> | 1.42 x 10 <sup>5</sup>           | 6.48 x 10 <sup>5</sup>           |   |   |  |  |  |
| May                | 460  | 29/31                                   | 9.62 x 10 <sup>6</sup>                        | .02 <sup>++</sup>              | 1.92 x 10 <sup>5</sup>           | 9.62 x 10 <sup>6</sup>                          | 4.39 x 10 <sup>5</sup> | 1.92 x 10 <sup>5</sup>           | 4.39 x 10 <sup>5</sup>           |   |   |  |  |  |
| Jun                | 460  | 26/30                                   | 5.54 x 10 <sup>7</sup>                        | .22 <sup>++</sup>              | 1.22 x 10 <sup>7</sup>           | 5.54 x 10 <sup>7</sup>                          | 2.53 x 10 <sup>7</sup> | 1.22 x 10 <sup>7</sup>           | 2.53 x 10 <sup>7</sup>           |   |   |  |  |  |
| Jul                | 460  | 31/31                                   | 4.21 x 10 <sup>7</sup>                        | .67 <sup>++</sup>              | 2.82 x 10 <sup>7</sup>           | 4.21 x 10 <sup>7</sup>                          | 1.92 x 10 <sup>6</sup> | 2.82 x 10 <sup>7</sup>           | 1.92 x 10 <sup>6</sup>           |   |   |  |  |  |
| Aug                | 460  | 31/31                                   | 7.73 x 10 <sup>7</sup>                        | .81 <sup>++</sup>              | 6.26 x 10 <sup>7</sup>           | 7.73 x 10 <sup>7</sup>                          | 3.53 x 10 <sup>6</sup> | 6.26 x 10 <sup>7</sup>           | 3.53 x 10 <sup>6</sup>           |   |   |  |  |  |

(1) Unaccounted for days showed variable daily flow

(3) Assumes circulating water flow at 460 x 10<sup>6</sup> gpm

(2) Based on IA, 1977, Table 17 - Annual basis

(4) Assumes 100% mortality

+ Based on IA, 1975, Table 5

++ Based on IA, 1977, Table 18

## EXHIBIT 175

## ENTRAINMENT ESTIMATES FOR CONDENSER CIRCULATING WATER AND DILUTION WATER

for *Corophium* sp.

| Month<br>1975-1976 | Data for Existing System                         |                              |                                    |                                |                                  | Projected<br>Daily Entrainment      |                        | Projected<br>Daily Mortality     |                        | Dilution<br>Water<br>(gpm x 10 <sup>3</sup> ) | Sample Days (1)<br>per Month | Mean<br>Density<br>Station 11 (2)<br>(in No. /1000 m <sup>3</sup> ) | Actual<br>Dilution<br>Water Daily<br>Entrainment | Daily<br>Entrainment (5)<br>Through Two<br>Dilution Pumps<br>(560 x 10 <sup>6</sup> gpm) |
|--------------------|--|------------------------------|------------------------------------|--------------------------------|----------------------------------|-------------------------------------|------------------------|----------------------------------|------------------------|---|------------------------------|---|--|--|
|                    | Circulating<br>Water<br>(gpm x 10 <sup>3</sup> ) | Sample Days (1)<br>per Month | Daily (2)<br>Sample<br>Entrainment | Condenser<br>Mortality<br>Rate | Sample<br>Condenser<br>Mortality | Canal-Bay/(3)<br>Existing<br>System | Cooling<br>Towers      | Canal-Bay/<br>Existing<br>System | Cooling (4)<br>Towers  |   |                              |   |  |  |
| Sep                | 345  | 21/30                        | 6.46 x 10 <sup>6</sup>             | -                              | -                                | 8.59 x 10 <sup>6</sup>              | 3.92 x 10 <sup>5</sup> | -                                | 3.92 x 10 <sup>5</sup> | 250   | 26/30                        | 13  | 4.68 x 10 <sup>6</sup>                           | 9.36 x 10 <sup>6</sup>   |
| Oct                | 345  | 29/31                        | 3.48 x 10 <sup>6</sup>             | -                              | -                                | 4.63 x 10 <sup>6</sup>              | 2.11 x 10 <sup>5</sup> | -                                | 2.11 x 10 <sup>5</sup> | 500<br>250                                    | 11/31<br>14/31               | 7   | 3.78 x 10 <sup>6</sup>                           | 5.04 x 10 <sup>6</sup>   |
| Nov                | 345<br>0   | 24/30<br>5/30                | 5.66 x 10 <sup>7</sup>             | -                              | -                                | 7.53 x 10 <sup>7</sup>              | 3.44 x 10 <sup>6</sup> | -                                | 3.44 x 10 <sup>6</sup> | 500   | 24/30                        | 114   | 8.21 x 10 <sup>7</sup>                           | 8.21 x 10 <sup>7</sup>   |
| Dec                | 345<br>0   | 23/31<br>3/31                | 3.67 x 10 <sup>8</sup>             | -                              | -                                | 4.88 x 10 <sup>8</sup>              | 2.23 x 10 <sup>7</sup> | -                                | 2.23 x 10 <sup>7</sup> | 500   | 25/31                        | 739   | 5.32 x 10 <sup>8</sup>                           | 5.32 x 10 <sup>8</sup>   |
| Jan                | 345  | 23/30                        | 2.68 x 10 <sup>7</sup>             | -                              | -                                | 2.47 x 10 <sup>7</sup>              | 1.13 x 10 <sup>6</sup> | -                                | 1.13 x 10 <sup>6</sup> | 500   | 24/31                        | 54  | 3.89 x 10 <sup>7</sup>                           | 3.89 x 10 <sup>7</sup>   |
| Feb                | 345  | 25/29                        | 1.64 x 10 <sup>7</sup>             | -                              | -                                | 1.51 x 10 <sup>7</sup>              | 6.89 x 10 <sup>5</sup> | -                                | 6.89 x 10 <sup>5</sup> | 500   | 25/29                        | 33  | 2.38 x 10 <sup>7</sup>                           | 2.38 x 10 <sup>7</sup>   |
| Mar                | 460<br>345<br>0                                  | 15/31<br>8/31<br>3/31        | -                                  | -                              | -                                | -                                   | -                      | -                                | -                      | 500<br>250                                    | 18/31<br>11/31               | -   | -  | -  |
| Apr                | 460  | 30/30                        | 1.64 x 10 <sup>7</sup>             | -                              | -                                | 1.64 x 10 <sup>7</sup>              | 7.49 x 10 <sup>5</sup> | -                                | 7.49 x 10 <sup>5</sup> | 500<br>250                                    | 23/30<br>7/30                | 33  | 2.06 x 10 <sup>7</sup>                           | 2.38 x 10 <sup>7</sup>   |
| May                | 460  | 29/31                        | 1.13 x 10 <sup>9</sup>             | -                              | -                                | 1.13 x 10 <sup>9</sup>              | 5.16 x 10 <sup>5</sup> | -                                | 5.16 x 10 <sup>5</sup> | 250   | 25/31                        | 2,279   | 8.2 x 10 <sup>8</sup>                            | 1.64 x 10 <sup>9</sup>   |
| Jun                | 460  | 26/30                        | 1.69 x 10 <sup>9</sup>             | -                              | -                                | 1.69 x 10 <sup>9</sup>              | 7.72 x 10 <sup>7</sup> | -                                | 7.72 x 10 <sup>7</sup> | 500<br>250                                    | 19/30<br>7/30                | 3,402   | 2.12 x 10 <sup>9</sup>                           | 2.45 x 10 <sup>9</sup>   |
| Jul                | 460  | 31/31                        | 7.73 x 10 <sup>8</sup>             | -                              | -                                | 7.73 x 10 <sup>8</sup>              | 3.53 x 10 <sup>8</sup> | -                                | 3.53 x 10 <sup>8</sup> | 500<br>250                                    | 25/31<br>4/31                | 1,560   | 1.12 x 10 <sup>9</sup>                           | 1.12 x 10 <sup>9</sup>   |
| Aug                | 460  | 31/31                        | 3.70 x 10 <sup>8</sup>             | -                              | -                                | 3.70 x 10 <sup>8</sup>              | 1.69 x 10 <sup>9</sup> | -                                | 1.69 x 10 <sup>9</sup> | 500   | 25/31                        | 745   | 5.36 x 10 <sup>8</sup>                           | 5.36 x 10 <sup>8</sup>   |

(1) Unaccounted for days showed variable daily flow

(3) Assumes circulating water flow at 460 x 10<sup>6</sup> gpm

(2) Based on IA, 1977, Table 13 - discharge density basis

(4) Assumes 100% mortality

(5) Entrainment halved with operation of one dilution pump at 260 x 10<sup>6</sup> gpm

## EXHIBIT 175

## ENTRAINMENT ESTIMATES FOR CONDENSER CIRCULATING WATER AND DILUTION WATER

for Crangon septempinnosa-adults/juveniles

| Month<br>1975-1976 | Data for Existing Systems                        |   |   |                                |                                  | Projected<br>Daily Entrainment                  |                        | Projected<br>Daily Mortality     |                                  | Dilution<br>Water<br>(gpm x 10 <sup>3</sup> ) | Sample Days <sup>(1)</sup><br>per Month | Mean<br>Density <sub>3</sub><br>in No/m <sup>3</sup><br>Station 11 | Actual<br>Dilution<br>Water Daily<br>Entrainment | Daily<br>Entrainment<br>Through Two<br>Dilution Pumps<br>(560 x 10 <sup>6</sup> gpm) |
|--------------------|--|---|---|--------------------------------|----------------------------------|---|------------------------|----------------------------------|----------------------------------|---|---|--|--|--|
|                    | Circulating<br>Water<br>(gpm x 10 <sup>3</sup> ) | Sample Days <sup>(1)</sup><br>per Month | Daily <sup>(2)</sup><br>Sample<br>Entrainment | Condenser<br>Mortality<br>Rate | Sample<br>Condenser<br>Mortality | Canal-Bay/ <sup>(3)</sup><br>Existing<br>System | Cooling<br>Towers      | Canal-Bay/<br>Existing<br>System | Cooling <sup>(4)</sup><br>Towers |   |   |  |  |  |
| Sep                | 345  | 21/30                                   | 6.77 x 10 <sup>4</sup>                        | -                              | -                                | 9 x 10 <sup>4</sup>                             | 4.11 x 10 <sup>3</sup> | -                                | 4.11 x 10 <sup>3</sup>           |   |   |  |  |  |
| Oct                | 345  | 29/31                                   | 0   | -                              | 0                                | 0   | 0                      | 0                                | 0                                |   |   |  |  |  |
| Nov                | 345<br>0   | 24/30<br>5/30                           | 0   | -                              | 0                                | 0   | 0                      | 0                                | 0                                |   |   |  |  |  |
| Dec                | 345<br>0   | 23/31<br>3/31                           | 4.36 x 10 <sup>5</sup>                        | -                              | -                                | 5.8 x 10 <sup>5</sup>                           | 2.65 x 10 <sup>4</sup> | -                                | 2.65 x 10 <sup>4</sup>           |   |   |  |  |  |
| Jan                | 345  | 23/30                                   | 6.33 x 10 <sup>5</sup>                        | -                              | -                                | 8.42 x 10 <sup>5</sup>                          | 3.84 x 10 <sup>4</sup> | -                                | 3.84 x 10 <sup>4</sup>           |   |   |  |  |  |
| Feb                | 345  | 25/29                                   | 6.15 x 10 <sup>5</sup>                        | -                              | -                                | 8.18 x 10 <sup>5</sup>                          | 3.73 x 10 <sup>4</sup> | -                                | 3.73 x 10 <sup>4</sup>           |   |   |  |  |  |
| Mar                | 460<br>345<br>0                                  | 15/31<br>8/31<br>3/31                   | 1.39 x 10 <sup>6</sup>                        | -                              | -                                | 1.85 x 10 <sup>6</sup>                          | 8.45 x 10 <sup>4</sup> | -                                | 8.45 x 10 <sup>4</sup>           |   |   |  |  |  |
| Apr                | 460  | 30/30                                   | 1.69 x 10 <sup>5</sup>                        | .295                           | 4.99 x 10 <sup>4</sup>           | 1.69 x 10 <sup>5</sup>                          | 7.72 x 10 <sup>3</sup> | 4.99 x 10 <sup>4</sup>           | 7.72 x 10 <sup>3</sup>           |   |   |  |  |  |
| May                | 460  | 29/31                                   | 2.43 x 10 <sup>5</sup>                        | .128                           | 3.11 x 10 <sup>4</sup>           | 2.43 x 10 <sup>5</sup>                          | 1.11 x 10 <sup>4</sup> | 3.11 x 10 <sup>4</sup>           | 1.11 x 10 <sup>4</sup>           |   |   |  |  |  |
| Jun                | 460  | 26/30                                   | 2.16 x 10 <sup>5</sup>                        | .64                            | 1.38 x 10 <sup>5</sup>           | 2.16 x 10 <sup>5</sup>                          | 9.86 x 10 <sup>3</sup> | 1.38 x 10 <sup>5</sup>           | 9.86 x 10 <sup>3</sup>           |   |   |  |  |  |
| Jul                | 460  | 31/31                                   | 3.04 x 10 <sup>5</sup>                        | .75                            | 2.28 x 10 <sup>5</sup>           | 3.04 x 10 <sup>5</sup>                          | 1.04 x 10 <sup>4</sup> | 2.28 x 10 <sup>5</sup>           | 1.04 x 10 <sup>4</sup>           |   |   |  |  |  |
| Aug                | 460  | 31/31                                   | 1.02 x 10 <sup>6</sup>                        | .50                            | 5.1 x 10 <sup>5</sup>            | 1.02 x 10 <sup>6</sup>                          | 4.66 x 10 <sup>4</sup> | 5.1 x 10 <sup>5</sup>            | 4.66 x 10 <sup>4</sup>           |   |   |  |  |  |

(1) Unaccounted for days showed variable daily flow

(3) Assumes circulating water flow at 460 x 10<sup>6</sup> gpm

(2) Based on IA, 1977, Table 17-day and night discharge samples

(4) Assumes 100% mortality

## EXHIBIT 175

## ENTRAINMENT ESTIMATES FOR CONDENSER CIRCULATING WATER AND DILUTION WATER

for *Crangon septemspinosus*-macroplankton

| Month<br>1975-1976 | Data for Existing Systems                        |   |   |                                |                                  | Projected<br>Daily Entrainment                  |                   | Projected<br>Daily Mortality     |                   | Dilution<br>Water<br>(gpm x 10 <sup>3</sup> ) | Sample Days <sup>(1)</sup><br>per Month | Mean<br>Density<br>Station 7 <sup>(2)</sup><br>(in No. <sub>3</sub><br>/1000 m <sup>3</sup> ) | Actual<br>Dilution<br>Water Daily<br>Entrainment | Daily<br>Entrainment <sup>(3)</sup><br>Through Two<br>Dilution Pumps<br>(560 x 10 <sup>6</sup> gpm) |
|--------------------|--|---|---|--------------------------------|----------------------------------|---|-------------------|----------------------------------|-------------------|---|---|---|--|---|
|                    | Circulating<br>Water<br>(gpm x 10 <sup>3</sup> ) | Sample Days <sup>(1)</sup><br>per Month | Daily <sup>(2)</sup><br>Sample<br>Entrainment | Condenser<br>Mortality<br>Rate | Sample<br>Condenser<br>Mortality | Canal-Bay/ <sup>(3)</sup><br>Existing<br>System | Cooling<br>Towers | Canal-Bay/<br>Existing<br>System | Cooling<br>Towers |   |   |   |  |   |
| Sep                |  |   |   |                                |                                  |   |                   |                                  |                   | 250   | 26/30                                   | 62  | 2.23 x 10 <sup>7</sup>                           | 4.46 x 10 <sup>7</sup>  |
| Oct                |  |   |   |                                |                                  |   |                   |                                  |                   | 500<br>250                                    | 11/31<br>14/31                          | -   | -  | -   |
| Nov                |  |   |   |                                |                                  |   |                   |                                  |                   | 500   | 24/30                                   | 14  | 1 x 10 <sup>7</sup>                              | 1 x 10 <sup>7</sup>   |
| Dec                |  |   |   |                                |                                  |   |                   |                                  |                   | 500   | 25/31                                   | 147   | 1.06 x 10 <sup>8</sup>                           | 1.06 x 10 <sup>8</sup>  |
| Jan                |  |   |   |                                |                                  |   |                   |                                  |                   | 500   | 24/31                                   | 289   | 2.08 x 10 <sup>8</sup>                           | 2.08 x 10 <sup>8</sup>  |
| Feb                |  |   |   |                                |                                  |   |                   |                                  |                   | 500   | 25/29                                   | 298   | 2.15 x 10 <sup>8</sup>                           | 2.15 x 10 <sup>8</sup>  |
| Mar                |  |   |   |                                |                                  |   |                   |                                  |                   | 500<br>250                                    | 18/31<br>11/31                          | 1,475   | 7.95 x 10 <sup>8</sup>                           | 1.06 x 10 <sup>9</sup>  |
| Apr                |  |   |   |                                |                                  |   |                   |                                  |                   | 500<br>250                                    | 23/30<br>7/30                           | 89  | 5.66 x 10 <sup>7</sup>                           | 6.41 x 10 <sup>7</sup>  |
| May                |  |   |   |                                |                                  |   |                   |                                  |                   | 250   | 25/31                                   | 98  | 3.53 x 10 <sup>7</sup>                           | 7.06 x 10 <sup>7</sup>  |
| Jun                |  |   |   |                                |                                  |   |                   |                                  |                   | 500<br>250                                    | 19/30<br>7/30                           | 96  | 5.98 x 10 <sup>7</sup>                           | 6.91 x 10 <sup>7</sup>  |
| Jul                |  |   |   |                                |                                  |   |                   |                                  |                   | 500<br>250                                    | 25/31<br>4/31                           | 153   | 1.10 x 10 <sup>8</sup>                           | 1.10 x 10 <sup>8</sup>  |
| Aug                |  |   |   |                                |                                  |   |                   |                                  |                   | 500   | 25/31                                   | 349   | 2.51 x 10 <sup>8</sup>                           | 2.51 x 10 <sup>8</sup>  |

(1) Unaccounted for days showed variable daily flow

(3) Entrainment halved with operation of one dilution pump at 260 x 10<sup>6</sup> gpm

(2) Based on IA, 1977, Table 10-day and night samples

EXHIBIT 175

ENTRAINMENT ESTIMATES FOR CONDENSER CIRCULATING WATER AND DILUTION WATER

for Crangon septemspinosa-zoea

| Month<br>1975-1976 | Data for Existing System                         |   |   |                                |                                  | Projected<br>Daily Entrainment                  |                        | Projected<br>Daily Mortality     |                                  | Dilution<br>Water<br>(gpm x 10 <sup>3</sup> ) | Sample Days <sup>(1)</sup><br>per Month | Mean<br>Density<br>Station 7<br>(in No. 3<br>/1000 m <sup>3</sup> ) | Actual<br>Dilution<br>Water Daily<br>Entrainment | Daily<br>Entrainment <sup>(6)</sup><br>Through Two<br>Dilution Pumps<br>(560 x 10 <sup>6</sup> gpm) |
|--------------------|--|---|---|--------------------------------|----------------------------------|---|------------------------|----------------------------------|----------------------------------|---|---|---|--|---|
|                    | Circulating<br>Water<br>(gpm x 10 <sup>3</sup> ) | Sample Days <sup>(1)</sup><br>per Month | Daily <sup>(2)</sup><br>Sample<br>Entrainment | Condenser<br>Mortality<br>Rate | Sample<br>Condenser<br>Mortality | Canal-Bay/ <sup>(3)</sup><br>Existing<br>System | Cooling<br>Towers      | Canal-Bay/<br>Existing<br>System | Cooling <sup>(4)</sup><br>Towers |   |   |   |  |   |
| Sep                | 345  | 21/30                                   | 3.76 x 10 <sup>3</sup>                        | No                             | -                                | 5 x 10 <sup>3</sup>                             | 2.28 x 10 <sup>2</sup> | -                                | 2.28 x 10 <sup>2</sup>           | 250   | 26/30                                   | 2   | 7.2 x 10 <sup>5</sup>                            | 1.44 x 10 <sup>6</sup>  |
| Oct                | 345  | 29/31                                   | 4.18 x 10 <sup>5</sup>                        | Determinations                 | -                                | 5.56 x 10 <sup>5</sup>                          | 2.54 x 10 <sup>4</sup> | -                                | 2.54 x 10 <sup>4</sup>           | 500<br>250                                    | 11/31<br>14/31                          | 249   | 1.34 x 10 <sup>8</sup>                           | 1.79 x 10 <sup>8</sup>  |
| Nov                | 345<br>0   | 24/30<br>5/30                           | 2.63 x 10 <sup>5</sup>                        |                                | -                                | 3.50 x 10 <sup>5</sup>                          | 1.60 x 10 <sup>4</sup> | -                                | 1.60 x 10 <sup>4</sup>           | 500   | 24/30                                   | 120   | 8.64 x 10 <sup>7</sup>                           | 8.64 x 10 <sup>7</sup>  |
| Dec                | 345<br>0   | 23/31<br>3/31                           | 2.87 x 10 <sup>6</sup>                        |                                | -                                | 3.82 x 10 <sup>6</sup>                          | 1.74 x 10 <sup>5</sup> | -                                | 1.74 x 10 <sup>5</sup>           | 500   | 25/31                                   | 1,379   | 9.93 x 10 <sup>8</sup>                           | 9.93 x 10 <sup>8</sup>  |
| Jan                | 345  | 23/30                                   | 2.83 x 10 <sup>5</sup>                        |                                | -                                | 3.76 x 10 <sup>5</sup>                          | 1.72 x 10 <sup>5</sup> | -                                | 1.72 x 10 <sup>4</sup>           | 500   | 24/31                                   | 124   | 8.93 x 10 <sup>7</sup>                           | 8.93 x 10 <sup>7</sup>  |
| Feb                | 345  | 25/29                                   | 1.45 x 10 <sup>6</sup>                        |                                | -                                | 1.93 x 10 <sup>6</sup>                          | 8.81 x 10 <sup>4</sup> | -                                | 8.81 x 10 <sup>4</sup>           | 500   | 25/29                                   | 629   | 4.53 x 10 <sup>8</sup>                           | 4.53 x 10 <sup>8</sup>  |
| Mar                | 460<br>345<br>0                                  | 15/31<br>8/31<br>3/31                   | 8.32 x 10 <sup>6</sup>                        |                                | -                                | 9.65 x 10 <sup>6</sup>                          | 4.41 x 10 <sup>5</sup> | -                                | 4.41 x 10 <sup>5</sup>           | 500<br>250                                    | 18/31<br>11/31                          | 3,928   | 2.12 x 10 <sup>9</sup>                           | 2.83 x 10 <sup>9</sup>  |
| Apr                | 460  | 30/30                                   | 7.35 x 10 <sup>7</sup>                        |                                | -                                | 7.35 x 10 <sup>7</sup>                          | 3.36 x 10 <sup>6</sup> | -                                | 3.36 x 10 <sup>6</sup>           | 500<br>250                                    | 23/30<br>7/30                           | 29,478  | 1.87 x 10 <sup>10</sup>                          | 2.12 x 10 <sup>10</sup>   |
| May                | 460  | 29/31                                   | 1.80 x 10 <sup>8</sup>                        |                                | -                                | 1.80 x 10 <sup>8</sup>                          | 8.2 x 10 <sup>6</sup>  | -                                | 8.2 x 10 <sup>6</sup>            | 250   | 25/31                                   | 82,501  | 2.97 x 10 <sup>10</sup>                          | 5.94 x 10 <sup>10</sup>   |
| Jun                | 460  | 26/30                                   | 5.15 x 10 <sup>7</sup>                        |                                | -                                | 5.15 x 10 <sup>7</sup>                          | 2.35 x 10 <sup>6</sup> | -                                | 2.35 x 10 <sup>6</sup>           | 500<br>250                                    | 19/30<br>7/30                           | 27,076  | 1.69 x 10 <sup>10</sup>                          | 1.95 x 10 <sup>10</sup>   |
| Jul                | 460  | 31/31                                   | 3.24 x 10 <sup>6</sup>                        |                                | -                                | 3.24 x 10 <sup>6</sup>                          | 1.48 x 10 <sup>5</sup> | -                                | 1.48 x 10 <sup>5</sup>           | 500<br>250                                    | 25/31<br>4/31                           | 885   | 6.37 x 10 <sup>8</sup>                           | 6.37 x 10 <sup>8</sup>  |
| Aug                | 460  | 31/31                                   | 3.18 x 10 <sup>5</sup>                        |                                | -                                | 3.18 x 10 <sup>5</sup>                          | 1.45 x 10 <sup>4</sup> | -                                | 1.45 x 10 <sup>4</sup>           | 500   | 25/31                                   | 165   | 1.19 x 10 <sup>8</sup>                           | 1.19 x 10 <sup>8</sup>  |

(1) Unaccounted for days showed variable daily flow

(3) Assumes circulating water flow at 460 x 10<sup>6</sup> gpm

(6) Entrainment halved with operation of one dilution pump at 260 x 10<sup>6</sup> gpm

(2) Based on IA, 1977, Table 17 - day and night intake samples

(4) Assumes 100% mortality

(5) Based on IA, 1977, Table 10 - day and night samples

## EXHIBIT 175

## ENTRAINMENT ESTIMATES FOR CONDENSER CIRCULATING WATER AND DILUTION WATER

for *Callinectes sapidus-megalopa*

| Month<br>1975-1976 | Data for Existing Systems                        |   |   |                                |                                  | Projected<br>Daily Entrainment                  |                        | Projected<br>Daily Mortality     |                                  | Dilution<br>Water<br>(gpm x 10 <sup>3</sup> ) | Sample Days <sup>(1)</sup><br>per Month | Mean<br>Density <sup>3</sup><br>in No/m <sup>3</sup><br>Station | Actual<br>Dilution<br>Water Daily<br>Entrainment | Daily<br>Entrainment<br>Through Two<br>Dilution Pumps<br>(560 x 10 <sup>6</sup> gpm) |
|--------------------|--|---|---|--------------------------------|----------------------------------|---|------------------------|----------------------------------|----------------------------------|---|---|---|--|--|
|                    | Circulating<br>Water<br>(gpm x 10 <sup>3</sup> ) | Sample Days <sup>(1)</sup><br>per Month | Daily <sup>(2)</sup><br>Sample<br>Entrainment | Condenser<br>Mortality<br>Rate | Sample<br>Condenser<br>Mortality | Canal-Bay/ <sup>(3)</sup><br>Existing<br>System | Cooling<br>Towers      | Canal-Bay/<br>Existing<br>System | Cooling <sup>(4)</sup><br>Towers |   |   |   |  |  |
| Sep                | 345  | 21/30                                   | 1.88 x 10 <sup>6</sup>                        | 0                              | 0                                | 2.5 x 10 <sup>6</sup>                           | 1.14 x 10 <sup>5</sup> | 0                                | 1.14 x 10 <sup>5</sup>           |   |   |   |  |  |
| Oct                | 345  | 29/31                                   | 2.15 x 10 <sup>5</sup>                        | 0                              | 0                                | 2.86 x 10 <sup>5</sup>                          | 1.31 x 10 <sup>4</sup> | 0                                | 1.31 x 10 <sup>4</sup>           |   |   |   |  |  |
| Nov                | 345<br>0   | 24/30<br>5/30                           | 0   | -                              | 0                                | 0   | 0                      | 0                                | 0                                |   |   |   |  |  |
| Dec                | 345<br>0   | 23/31<br>3/31                           | 0   | -                              | 0                                | 0   | 0                      | 0                                | 0                                |   |   |   |  |  |
| Jan                | 345  | 23/30                                   | 0   | -                              | 0                                | 0   | 0                      | 0                                | 0                                |   |   |   |  |  |
| Feb                | 345  | 25/29                                   | 0   | 0                              | 0                                | 0   | 0                      | 0                                | 0                                |   |   |   |  |  |
| Mar                | 460<br>345<br>0                                  | 15/31<br>8/31<br>3/31                   | 0   | -                              | 0                                | 0   | 0                      | 0                                | 0                                |   |   |   |  |  |
| Apr                | 460  | 30/30                                   | 0   | -                              | 0                                | 0   | 0                      | 0                                | 0                                |   |   |   |  |  |
| May                | 460  | 29/31                                   | 0   | -                              | 0                                | 0   | 0                      | 0                                | 0                                |   |   |   |  |  |
| Jun                | 460  | 26/30                                   | 0   | -                              | 0                                | 0   | 0                      | 0                                | 0                                |   |   |   |  |  |
| Jul                | 460  | 31/31                                   | 0   | -                              | 0                                | 0   | 0                      | 0                                | 0                                |   |   |   |  |  |
| Aug                | 460  | 31/31                                   | 7.38 x 10 <sup>4</sup>                        | 0                              | 0                                | 7.38 x 10 <sup>4</sup>                          | 3.37 x 10 <sup>3</sup> | 0                                | 3.37 x 10 <sup>3</sup>           |   |   |   |  |  |

(1) Unaccounted for days showed variable daily flow

(3) Assumes circulating water flow at 460 x 10<sup>6</sup> gpm

(2) Based on IA, 1977, Table 17 - condenser discharge samples

(4) Assumes 100% mortality

## EXHIBIT 175

## ENTRAINMENT ESTIMATES FOR CONDENSER CIRCULATING WATER AND DILUTION WATER

for *Callinectes sapidus*-larvae and juveniles

| Month<br>1975-1976 | Data for Existing Systems                        |   |   |                                |                                  | Projected<br>Daily Entrainment                  |                        | Projected<br>Daily Mortality     |                                  | Dilution<br>Water<br>(gpm x 10 <sup>3</sup> ) | Sample Days <sup>(1)</sup><br>per Month | Mean<br>Density<br>in No/m <sup>3</sup><br>Station | Actual<br>Dilution<br>Water Daily<br>Entrainment | Daily<br>Entrainment<br>Through Two<br>Dilution Pumps<br>(560 x 10 <sup>6</sup> gpm) |
|--------------------|--|---|---|--------------------------------|----------------------------------|---|------------------------|----------------------------------|----------------------------------|---|---|--|--|--|
|                    | Circulating<br>Water<br>(gpm x 10 <sup>3</sup> ) | Sample Days <sup>(1)</sup><br>per Month | Daily <sup>(2)</sup><br>Sample<br>Entrainment | Condenser<br>Mortality<br>Rate | Sample<br>Condenser<br>Mortality | Canal-Bay/ <sup>(3)</sup><br>Existing<br>System | Cooling<br>Towers      | Canal-Bay/<br>Existing<br>System | Cooling <sup>(4)</sup><br>Towers |   |   |  |  |  |
| Sep                | 345  | 21/30                                   | 1.04 x 10 <sup>9</sup>                        | 0                              | 0                                | 1.38 x 10 <sup>9</sup>                          | 6.3 x 10 <sup>7</sup>  | 0                                | 6.3 x 10 <sup>7</sup>            |   |   |  |  |  |
| Oct                | 345  | 29/31                                   | 1.40 x 10 <sup>8</sup>                        | 0                              | 0                                | 1.86 x 10 <sup>8</sup>                          | 8.49 x 10 <sup>6</sup> | 0                                | 8.49 x 10 <sup>6</sup>           |   |   |  |  |  |
| Nov                | 345<br>0   | 24/30<br>5/30                           | 4.47 x 10 <sup>6</sup>                        | 0                              | 0                                | 5.95 x 10 <sup>6</sup>                          | 2.72 x 10 <sup>5</sup> | 0                                | 2.72 x 10 <sup>5</sup>           |   |   |  |  |  |
| Dec                | 345<br>0   | 23/31<br>3/31                           | -   | -                              | -                                | -   | -                      | -                                | -                                |   |   |  |  |  |
| Jan                | 345  | 23/30                                   | -   | -                              | -                                | -   | -                      | -                                | -                                |   |   |  |  |  |
| Feb                | 345  | 25/29                                   | -   | -                              | -                                | -   | -                      | -                                | -                                |   |   |  |  |  |
| Mar                | 460<br>345<br>0                                  | 15/31<br>8/31<br>3/31                   | -   | -                              | -                                | -   | -                      | -                                | -                                |   |   |  |  |  |
| Apr                | 460  | 30/30                                   | 7.95 x 10 <sup>6</sup>                        | 0                              | 0                                | 7.95 x 10 <sup>6</sup>                          | 3.63 x 10 <sup>5</sup> | 0                                | 3.63 x 10 <sup>5</sup>           |   |   |  |  |  |
| May                | 460  | 29/31                                   | 2.78 x 10 <sup>7</sup>                        | 0                              | 0                                | 2.78 x 10 <sup>7</sup>                          | 1.27 x 10 <sup>6</sup> | 0                                | 1.27 x 10 <sup>6</sup>           |   |   |  |  |  |
| Jun                | 460  | 26/30                                   | 1.13 x 10 <sup>8</sup>                        | 0                              | 0                                | 1.13 x 10 <sup>8</sup>                          | 5.16 x 10 <sup>6</sup> | 0                                | 5.16 x 10 <sup>6</sup>           |   |   |  |  |  |
| Jul                | 460  | 31/31                                   | 1.94 x 10 <sup>7</sup>                        | 0                              | 0                                | 1.94 x 10 <sup>7</sup>                          | 8.86 x 10 <sup>5</sup> | 0                                | 8.86 x 10 <sup>5</sup>           |   |   |  |  |  |
| Aug                | 460  | 31/31                                   | 9.44 x 10 <sup>7</sup>                        | 0                              | 0                                | 9.44 x 10 <sup>7</sup>                          | 4.31 x 10 <sup>6</sup> | 0                                | 4.31 x 10 <sup>6</sup>           |   |   |  |  |  |

(1) Unaccounted for days showed variable daily flow

(3) Assumes circulating water flow at 460 x 10<sup>6</sup> gpm

(2) Based on IA, 1977, Table 10 - Station 7 densities

(4) Assumes 100% mortality

## EXHIBIT 175

## ENTRAINMENT ESTIMATES FOR CONDENSER CIRCULATING WATER AND DILUTION WATER

for *Callinectes sapidus-megalopa*, juvenile, zoea

| Month<br>1975-1976 | Data for Existing Systems                        |   |   |                                | Projected<br>Daily Entrainment   |   | Projected<br>Daily Mortality |                                  | Dilution<br>Water<br>(gpm x 10 <sup>3</sup> ) | Sample Days <sup>(1)</sup><br>per Month | Mean<br>Density<br>Station 7<br>(in No. 3<br>/1000 m <sup>3</sup> ) | Actual<br>Dilution<br>Water Daily<br>Entrainment | Daily<br>Entrainment <sup>(3)</sup><br>Through Two<br>Dilution Pumps<br>(560 x 10 <sup>6</sup> gpm) |
|--------------------|--|---|---|--------------------------------|----------------------------------|---|------------------------------|----------------------------------|---|---|---|--|---|
|                    | Circulating<br>Water<br>(gpm x 10 <sup>3</sup> ) | Sample Days <sup>(1)</sup><br>per Month | Daily <sup>(2)</sup><br>Sample<br>Entrainment | Condenser<br>Mortality<br>Rate | Sample<br>Condenser<br>Mortality | Canal-Bay/ <sup>(3)</sup><br>Existing<br>System | Cooling<br>Towers            | Canal-Bay/<br>Existing<br>System |   |   |   |  |   |
| Sep                |  |   |   |                                |                                  |   |                              |                                  | 250   | 26/30                                   | 2,102   | 7.57 x 10 <sup>8</sup>                           | 1.51 x 10 <sup>9</sup>  |
| Oct                |  |   |   |                                |                                  |   |                              |                                  | 500<br>250                                    | 11/31<br>14/31                          | 281   | 1.52 x 10 <sup>8</sup>                           | 2.02 x 10 <sup>8</sup>  |
| Nov                |  |   |   |                                |                                  |   |                              |                                  | 500   | 24/30                                   | 9   | 6.48 x 10 <sup>6</sup>                           | 6.48 x 10 <sup>6</sup>  |
| Dec                |  |   |   |                                |                                  |   |                              |                                  | 500   | 25/31                                   | -   | -  | -   |
| Jan                |  |   |   |                                |                                  |   |                              |                                  | 500   | 24/31                                   | -   | -  | -   |
| Feb                |  |   |   |                                |                                  |   |                              |                                  | 500   | 25/29                                   | -   | -  | -   |
| Mar                |  |   |   |                                |                                  |   |                              |                                  | 500<br>250                                    | 18/31<br>11/31                          | -   | -  | -   |
| Apr                |  |   |   |                                |                                  |   |                              |                                  | 500<br>250                                    | 23/30<br>7/30                           | 16  | 1.02 x 10 <sup>7</sup>                           | 1.15 x 10 <sup>7</sup>  |
| May                |  |   |   |                                |                                  |   |                              |                                  | 250   | 25/31                                   | 56  | 2.02 x 10 <sup>7</sup>                           | 4.04 x 10 <sup>7</sup>  |
| Jun                |  |   |   |                                |                                  |   |                              |                                  | 500<br>250                                    | 19/30<br>7/30                           | 228   | 1.42 x 10 <sup>8</sup>                           | 1.64 x 10 <sup>8</sup>  |
| Jul                |  |   |   |                                |                                  |   |                              |                                  | 500<br>250                                    | 25/31<br>4/31                           | 39  | 2.81 x 10 <sup>7</sup>                           | 2.81 x 10 <sup>7</sup>  |
| Aug                |  |   |   |                                |                                  |   |                              |                                  | 500   | 25/31                                   | 190   | 1.37 x 10 <sup>8</sup>                           | 1.37 x 10 <sup>8</sup>  |

(1) Unaccounted for days showed variable daily flow

(3) Entrainment halved with operation of one dilution pump at 260 x 10<sup>6</sup> gpm

(2) Based on IA, 1977, Table 10-day and night samples

## EXHIBIT 175

## ENTRAINMENT ESTIMATES FOR CONDENSER CIRCULATING WATER AND DILUTION WATER

for *Sagitta elegans*

| Month<br>1975-1976 | Data for Existing System                         |   |   |                                |                                  | Projected<br>Daily Entrainment                  |                        | Projected<br>Daily Mortality     |                                  | Dilution<br>Water<br>(gpm x 10 <sup>3</sup> ) | Sample Days <sup>(1)</sup><br>per Month | Mean<br>Density<br>Station 7 <sup>(5)</sup><br>(in No. <sub>3</sub><br>/1000 m <sup>3</sup> ) | Actual<br>Dilution<br>Water Daily<br>Entrainment | Daily<br>Entrainment<br>Through Two<br>Dilution Pumps<br>(560 x 10 <sup>6</sup> gpm) <sup>(6)</sup> |
|--------------------|--|---|---|--------------------------------|----------------------------------|---|------------------------|----------------------------------|----------------------------------|---|---|---|--|---|
|                    | Circulating<br>Water<br>(gpm x 10 <sup>3</sup> ) | Sample Days <sup>(1)</sup><br>per Month | Daily <sup>(2)</sup><br>Sample<br>Entrainment | Condenser<br>Mortality<br>Rate | Sample<br>Condenser<br>Mortality | Canal-Bay/ <sup>(3)</sup><br>Existing<br>System | Cooling<br>Towers      | Canal-Bay/<br>Existing<br>System | Cooling <sup>(4)</sup><br>Towers |   |   |   |  |   |
| Sep                | 345  | 21/30                                   | 0   | No                             | 0                                | 0   | 0                      | 0                                | 0                                | 250   | 26/30                                   | -   | -  | -   |
| Oct                | 345  | 29/31                                   | 0   | Determinations                 | 0                                | 0   | 0                      | 0                                | 0                                | 500<br>250                                    | 11/31<br>14/31                          | -   | -  | -   |
| Nov                | 345<br>0   | 24/30<br>5/30                           | 0   |                                | 0                                | 0   | 0                      | 0                                | 0                                | 500   | 24/30                                   | 14  | 1.01 x 10 <sup>7</sup>                           | 1.01 x 10 <sup>7</sup>  |
| Dec                | 345<br>0   | 23/31<br>3/31                           | 5.28 x 10 <sup>5</sup>                        |                                | -                                | 7.02 x 10 <sup>5</sup>                          | 3.2 x 10 <sup>4</sup>  | -                                | 3.2 x 10 <sup>4</sup>            | 500   | 25/31                                   | 238   | 1.71 x 10 <sup>8</sup>                           | 1.71 x 10 <sup>8</sup>  |
| Jan                | 345  | 23/30                                   | 1.24 x 10 <sup>7</sup>                        |                                | -                                | 1.65 x 10 <sup>7</sup>                          | 7.53 x 10 <sup>5</sup> | -                                | 7.53 x 10 <sup>5</sup>           | 500   | 24/31                                   | 8,079   | 5.82 x 10 <sup>9</sup>                           | 5.82 x 10 <sup>9</sup>  |
| Feb                | 345  | 25/29                                   | 4.19 x 10 <sup>7</sup>                        |                                | -                                | 5.57 x 10 <sup>7</sup>                          | 2.54 x 10 <sup>6</sup> | -                                | 2.54 x 10 <sup>6</sup>           | 500   | 25/29                                   | 15,835  | 1.14 x 10 <sup>10</sup>                          | 1.14 x 10 <sup>10</sup>   |
| Mar                | 460<br>345<br>0                                  | 15/31<br>8/31<br>3/31                   | 2.32 x 10 <sup>7</sup>                        |                                | -                                | 3.09 x 10 <sup>7</sup>                          | 1.41 x 10 <sup>6</sup> | -                                | 1.41 x 10 <sup>6</sup>           | 500<br>250                                    | 18/31<br>11/31                          | 14,742  | 7.96 x 10 <sup>9</sup>                           | 1.06 x 10 <sup>10</sup>   |
| Apr                | 460  | 30/30                                   | 1.2 x 10 <sup>5</sup>                         |                                | -                                | 1.2 x 10 <sup>5</sup>                           | 5.48 x 10 <sup>3</sup> | -                                | 5.48 x 10 <sup>3</sup>           | 500<br>250                                    | 23/30<br>7/30                           | -   | -  | -   |
| May                | 460  | 29/31                                   | 0   |                                | 0                                | 0   | 0                      | 0                                | 0                                | 250   | 25/31                                   | -   | -  | -   |
| Jun                | 460  | 26/30                                   | 0   |                                | 0                                | 0   | 0                      | 0                                | 0                                | 500<br>250                                    | 19/30<br>7/30                           | -   | -  | -   |
| Jul                | 460  | 31/31                                   | 0   |                                | 0                                | 0   | 0                      | 0                                | 0                                | 500<br>250                                    | 25/31<br>4/31                           | -   | -  | -   |
| Aug                | 460  | 31/31                                   | 0   |                                | 0                                | 0   | 0                      | 0                                | 0                                | 500   | 25/31                                   | -   | -  | -   |

(1) Unaccounted for days showed variable daily flow

(3) Assumes circulating water flow at 460 x 10<sup>6</sup> gpm(6) Entrainment halved with operation of one dilution pump at 260 x 10<sup>6</sup> gpm

(2) Based on IA, 1977, Table 17 - day and night samples

(4) Assumes 100% mortality

(5) Based on IA, 1977, Table 10 - day and night samples

## EXHIBIT 175

## ENTRAINMENT ESTIMATES FOR CONDENSER CIRCULATING WATER AND DILUTION WATER

for *Brevortia tyrannus*-larvae

| Month<br>1975-1976 | Data for Existing Systems                        |   |   |                                | Projected<br>Daily Entrainment   |   | Projected<br>Daily Mortality |                                  | Dilution<br>Water<br>(gpm x 10 <sup>3</sup> ) | Sample Days<br>(1)<br>per Month | Mean<br>Density <sub>3</sub><br>in No/m <sup>3</sup><br>Station 7 <sup>(2)</sup> | Actual<br>Dilution<br>Water Daily<br>Entrainment | Daily<br>Entrainment <sup>(3)</sup><br>Through Two<br>Dilution Pumps<br>(560 x 10 <sup>6</sup> gpm) |
|--------------------|--|---|---|--------------------------------|----------------------------------|---|------------------------------|----------------------------------|---|---------------------------------|--|--|---|
|                    | Circulating<br>Water<br>(gpm x 10 <sup>3</sup> ) | Sample Days <sup>(1)</sup><br>per Month | Daily <sup>(2)</sup><br>Sample<br>Entrainment | Condenser<br>Mortality<br>Rate | Sample<br>Condenser<br>Mortality | Canal-Bay/ <sup>(3)</sup><br>Existing<br>System | Cooling<br>Towers            | Canal-Bay/<br>Existing<br>System |   |                                 |  |  |   |
| Sep                |  |   |   |                                |                                  |   |                              |                                  | 250   | 26/30                           | -  | -  | -   |
| Oct                |  |   |   |                                |                                  |   |                              |                                  | 500<br>250                                    | 11/31<br>14/31                  | 0.003  | 1.62 x 10 <sup>6</sup>                           | 2.16 x 10 <sup>6</sup>  |
| Nov                |  |   |   |                                |                                  |   |                              |                                  | 500   | 24/30                           | 0.002  | 1.44 x 10 <sup>6</sup>                           | 1.44 x 10 <sup>6</sup>  |
| Dec                |  |   |   |                                |                                  |   |                              |                                  | 500   | 25/31                           | 0.021  | 1.51 x 10 <sup>7</sup>                           | 1.51 x 10 <sup>7</sup>  |
| Jan                |  |   |   |                                |                                  |   |                              |                                  | 500   | 24/31                           | -  | -  | -   |
| Feb                |  |   |   |                                |                                  |   |                              |                                  | 500   | 25/29                           | -  | -  | -   |
| Mar                |  |   |   |                                |                                  |   |                              |                                  | 500<br>250                                    | 18/31<br>11/31                  | -  | -  | -   |
| Apr                |  |   |   |                                |                                  |   |                              |                                  | 500<br>250                                    | 23/30<br>7/30                   | 0.002  | 1.27 x 10 <sup>6</sup>                           | 1.44 x 10 <sup>6</sup>  |
| May                |  |   |   |                                |                                  |   |                              |                                  | 250   | 25/31                           | 0.002  | 7.2 x 10 <sup>5</sup>                            | 1.44 x 10 <sup>6</sup>  |
| Jun                |  |   |   |                                |                                  |   |                              |                                  | 500<br>250                                    | 19/30<br>7/30                   | -  | -  | -   |
| Jul                |  |   |   |                                |                                  |   |                              |                                  | 500<br>250                                    | 25/31<br>4/31                   | -  | -  | -   |
| Aug                |  |   |   |                                |                                  |   |                              |                                  | 500   | 25/31                           | -  | -  | -   |

(1) Unaccounted for days showed variable daily flow

(3) Entrainment halved with operation of one dilution pump at 260 x 10<sup>6</sup> gpm

(2) Based on IA, 1977, Table 21

## EXHIBIT 175

## ENTRAINMENT ESTIMATES FOR CONDENSER CIRCULATING WATER AND DILUTION WATER

for *Anchoa mitchilli*-eggs

| Month<br>1975-1976 | Data for Existing System                         |   |   |                                |                                  | Projected<br>Daily Entrainment                  |                        | Projected<br>Daily Mortality     |                                  | Dilution<br>Water<br>(gpm x 10 <sup>3</sup> ) | Sample Days <sup>(1)</sup><br>per Month | Mean<br>Density<br>in No/m <sup>3</sup> (5) | Actual<br>Dilution<br>Water Daily<br>Entrainment | Daily<br>Entrainment <sup>(6)</sup><br>Through Two<br>Dilution Pumps<br>(560 x 10 <sup>6</sup> gpm) |
|--------------------|--|---|---|--------------------------------|----------------------------------|---|------------------------|----------------------------------|----------------------------------|---|---|---|--|---|
|                    | Circulating<br>Water<br>(gpm x 10 <sup>3</sup> ) | Sample Days <sup>(1)</sup><br>per Month | Daily <sup>(2)</sup><br>Sample<br>Entrainment | Condenser<br>Mortality<br>Rate | Sample<br>Condenser<br>Mortality | Canal-Bay/ <sup>(3)</sup><br>Existing<br>System | Cooling<br>Towers      | Canal-Bay/<br>Existing<br>System | Cooling <sup>(4)</sup><br>Towers |   |   |   |  |   |
| Sep                | 345  | 21/30                                   | 0   | No                             | 0                                | 0   | 0                      | 0                                | 0                                | 250   | 26/30                                   | -   | -  | -   |
| Oct                | 345  | 29/31                                   | 0   | Determinations                 | 0                                | 0   | 0                      | 0                                | 0                                | 500<br>250                                    | 11/31<br>14/31                          | -   | -  | -   |
| Nov                | 345<br>0   | 24/30<br>5/30                           | 0   |                                | 0                                | 0   | 0                      | 0                                | 0                                | 500   | 24/30                                   | -   | -  | -   |
| Dec                | 345<br>0   | 23/31<br>3/31                           | 0   |                                | 0                                | 0   | 0                      | 0                                | 0                                | 500   | 25/31                                   | -   | -  | -   |
| Jan                | 345  | 23/30                                   | 0   |                                | 0                                | 0   | 0                      | 0                                | 0                                | 500   | 24/31                                   | -   | -  | -   |
| Feb                | 345  | 25/29                                   | 0   |                                | 0                                | 0   | 0                      | 0                                | 0                                | 500   | 25/29                                   | -   | -  | -   |
| Mar                | 460<br>345<br>0                                  | 15/31<br>8/31<br>3/31                   | 0   |                                | 0                                | 0   | 0                      | 0                                | 0                                | 500<br>250                                    | 18/31<br>11/31                          | -   | -  | -   |
| Apr                | 460  | 30/30                                   | 8.14 x 10 <sup>4</sup>                        |                                | -                                | 8.14 x 10 <sup>4</sup>                          | 3.72 x 10 <sup>3</sup> | -                                | 3.72 x 10 <sup>3</sup>           | 500<br>250                                    | 23/30<br>7/30                           | 0.034                                       | 8.19 x 10 <sup>4</sup>                           | 9.27 x 10 <sup>4</sup>  |
| May                | 460  | 29/31                                   | 8.15 x 10 <sup>7</sup>                        |                                | -                                | 8.15 x 10 <sup>7</sup>                          | 3.72 x 10 <sup>6</sup> | -                                | 3.72 x 10 <sup>6</sup>           | 250   | 25/31                                   | 38.682                                      | 5.27 x 10 <sup>7</sup>                           | 1.05 x 10 <sup>8</sup>  |
| Jun                | 460  | 26/30                                   | 3.38 x 10 <sup>8</sup>                        |                                | -                                | 3.38 x 10 <sup>8</sup>                          | 1.54 x 10 <sup>7</sup> | -                                | 1.54 x 10 <sup>7</sup>           | 500<br>250                                    | 19/30<br>7/30                           | 168.274                                     | 3.96 x 10 <sup>8</sup>                           | 4.58 x 10 <sup>8</sup>  |
| Jul                | 460  | 31/31                                   | 2.8 x 10 <sup>8</sup>                         |                                | -                                | 2.8 x 10 <sup>8</sup>                           | 1.28 x 10 <sup>7</sup> | -                                | 1.28 x 10 <sup>7</sup>           | 500<br>250                                    | 25/31<br>4/31                           | 106.213                                     | 2.89 x 10 <sup>8</sup>                           | 2.89 x 10 <sup>8</sup>  |
| Aug                | 460  | 31/31                                   | 2.47 x 10 <sup>7</sup>                        |                                | -                                | 2.47 x 10 <sup>7</sup>                          | 1.13 x 10 <sup>6</sup> | -                                | 1.13 x 10 <sup>6</sup>           | 500   | 25/31                                   | 14.409                                      | 3.93 x 10 <sup>7</sup>                           | 3.93 x 10 <sup>7</sup>  |

(1) Unaccounted for days showed variable daily flow

(2) Based on IA, 1977, Table 22 - day and night samples

(3) Assumes circulating water flow at 460 x 10<sup>6</sup> gpm

(4) Assumes 100% mortality

(5) Based on IA, 1977, Table 21 - day and night samples

(6) Entrainment halved with operation of one dilution pump at 260 x 10<sup>6</sup> gpm

## EXHIBIT 175

## ENTRAINMENT ESTIMATES FOR CONDENSER CIRCULATING WATER AND DILUTION WATER

for *Anchoa mitchilli*-larvae

| Month<br>1975-1976 | Data for Existing System                         |   |   |                                |                                  | Projected<br>Daily Entrainment                  |                        | Projected<br>Daily Mortality     |                                  | Dilution<br>Water<br>(gpm x 10 <sup>3</sup> ) | Sample Days <sup>(1)</sup><br>per Month | Mean<br>Density,<br>in No/m <sup>3</sup> (5)<br>Station 7 | Actual<br>Dilution<br>Water Daily<br>Entrainment | Daily<br>Entrainment <sup>(6)</sup><br>Through Two<br>Dilution Pumps<br>(560 x 10 <sup>6</sup> gpm) |
|--------------------|--|---|---|--------------------------------|----------------------------------|---|------------------------|----------------------------------|----------------------------------|---|---|---|--|---|
|                    | Circulating<br>Water<br>(gpm x 10 <sup>3</sup> ) | Sample Days <sup>(1)</sup><br>per Month | Daily <sup>(2)</sup><br>Sample<br>Entrainment | Condenser<br>Mortality<br>Rate | Sample<br>Condenser<br>Mortality | Canal-Bay/ <sup>(3)</sup><br>Existing<br>System | Cooling<br>Towers      | Canal-Bay/<br>Existing<br>System | Cooling <sup>(4)</sup><br>Towers |   |   |   |  |   |
| Sep                | 345  | 21/30                                   | 1.66 x 10 <sup>6</sup>                        | .646                           | 1.07 x 10 <sup>6</sup>           | 2.21 x 10 <sup>6</sup>                          | 1.01 x 10 <sup>5</sup> | 1.43 x 10 <sup>6</sup>           | 1.01 x 10 <sup>5</sup>           | 250   | 26/30                                   | 1.89  | 2.58 x 10 <sup>6</sup>                           | 5.16 x 10 <sup>6</sup>  |
| Oct                | 345  | 29/31                                   | 1.29 x 10 <sup>5</sup>                        | .134                           | 1.73 x 10 <sup>4</sup>           | 1.72 x 10 <sup>5</sup>                          | 7.85 x 10 <sup>3</sup> | 2.3 x 10 <sup>4</sup>            | 7.85 x 10 <sup>3</sup>           | 500<br>250                                    | 11/31<br>14/31                          | 0.248   | 5.07 x 10 <sup>5</sup>                           | 6.76 x 10 <sup>5</sup>  |
| Nov                | 345<br>0   | 24/30<br>5/30                           | 5.12 x 10 <sup>4</sup>                        | 0                              | 0                                | 6.8 x 10 <sup>4</sup>                           | 3.1 x 10 <sup>3</sup>  | 0                                | 3.1 x 10 <sup>3</sup>            | 500   | 24/30                                   | 0.029   | 7.9 x 10 <sup>4</sup>                            | 7.9 x 10 <sup>4</sup>   |
| Dec                | 345<br>0   | 23/31<br>3/31                           | 1.11 x 10 <sup>4</sup>                        | 0                              | 0                                | 1.5 x 10 <sup>4</sup>                           | 6.85 x 10 <sup>2</sup> | 0                                | 6.85 x 10 <sup>2</sup>           | 500   | 25/31                                   | 0.009   | 2.45 x 10 <sup>4</sup>                           | 2.45 x 10 <sup>4</sup>  |
| Jan                | 345  | 23/30                                   | 0   | -                              | 0                                | 0   | 0                      | 0                                | 0                                | 500   | 24/31                                   | -   | -  | -   |
| Feb                | 345  | 25/29                                   | 0   | -                              | 0                                | 0   | 0                      | 0                                | 0                                | 500   | 25/29                                   | -   | -  | -   |
| Mar                | 460<br>345<br>0                                  | 15/31<br>8/31<br>3/31                   | 0   | -                              | 0                                | 0   | 0                      | 0                                | 0                                | 500<br>250                                    | 18/31<br>11/31                          | -   | -  | -   |
| Apr                | 460  | 30/30                                   | 0   | -                              | 0                                | 0   | 0                      | 0                                | 0                                | 500<br>250                                    | 23/30<br>7/30                           | -   | -  | -   |
| May                | 460  | 29/31                                   | 3.83 x 10 <sup>4</sup>                        | 1.0                            | 3.83 x 10 <sup>4</sup>           | 3.8 x 10 <sup>4</sup>                           | 1.73 x 10 <sup>3</sup> | 3.8 x 10 <sup>4</sup>            | 1.73 x 10 <sup>3</sup>           | 250   | 25/31                                   | -   | -  | -   |
| Jun                | 460  | 26/30                                   | 5.75 x 10 <sup>6</sup>                        | .01                            | 5.75 x 10 <sup>4</sup>           | 5.75 x 10 <sup>6</sup>                          | 2.62 x 10 <sup>5</sup> | 5.8 x 10 <sup>4</sup>            | 2.62 x 10 <sup>5</sup>           | 500<br>250                                    | 19/30<br>7/30                           | 3.586   | 8.46 x 10 <sup>6</sup>                           | 9.77 x 10 <sup>6</sup>  |
| Jul                | 460  | 31/31                                   | 1.64 x 10 <sup>7</sup>                        | .029                           | 4.76 x 10 <sup>5</sup>           | 1.64 x 10 <sup>7</sup>                          | 7.49 x 10 <sup>5</sup> | 4.8 x 10 <sup>5</sup>            | 7.49 x 10 <sup>5</sup>           | 500<br>250                                    | 25/31<br>4/31                           | 10.171  | 2.77 x 10 <sup>7</sup>                           | 2.77 x 10 <sup>7</sup>  |
| Aug                | 460  | 31/31                                   | 6.74 x 10 <sup>6</sup>                        | 257                            | 1.73 x 10 <sup>6</sup>           | 6.74 x 10 <sup>6</sup>                          | 3.08 x 10 <sup>5</sup> | 1.7 x 10 <sup>6</sup>            | 3.08 x 10 <sup>5</sup>           | 500   | 25/31                                   | 4.056   | 1.11 x 10 <sup>7</sup>                           | 1.11 x 10 <sup>7</sup>  |

(1) Unaccounted for days showed variable daily flow

(3) Assumes circulating water flow at 460 x 10<sup>6</sup> gpm(6) Entrainment halved with operation of one dilution pump at 260 x 10<sup>6</sup> gpm

(2) Based on IA, 1977, Table 22 - day and night samples

(4) Assumes 100% mortality

(5) Based on IA, 1977, Table 21 - day and night samples

## EXHIBIT 175

## ENTRAINMENT ESTIMATES FOR CONDENSER CIRCULATING WATER AND DILUTION WATER

for *Syngnathus fuscus*-juveniles

| Month<br>1975-1976 | Data for Existing System                         |                             |                                   |                                |                                  | Projected<br>Daily Entrainment      |                        | Projected<br>Daily Mortality     |                        | Dilution<br>Water<br>(gpm x 10 <sup>3</sup> ) | Sample Days(1)<br>per Month | Mean<br>Density<br>in No/m <sup>3</sup> (5) | Actual<br>Dilution<br>Water Daily<br>Entrainment | Daily<br>Entrainment(6)<br>Through Two<br>Dilution Pumps<br>(560 x 10 <sup>6</sup> gpm) |
|--------------------|--|-----------------------------|-----------------------------------|--------------------------------|----------------------------------|-------------------------------------|------------------------|----------------------------------|------------------------|---|-----------------------------|---|--|---|
|                    | Circulating<br>Water<br>(gpm x 10 <sup>3</sup> ) | Sample Days(1)<br>per Month | Daily(2)<br>Sample<br>Entrainment | Condenser<br>Mortality<br>Rate | Sample<br>Condenser<br>Mortality | Canal-Bay/(3)<br>Existing<br>System | Cooling<br>Towers      | Canal-Bay/<br>Existing<br>System | Cooling(4)<br>Towers   |   |                             |   |  |   |
| Sep                | 345  | 21/30                       | 4.19 x 10 <sup>4</sup>            | .133                           | 5.57 x 10 <sup>3</sup>           | 5.58 x 10 <sup>4</sup>              | 2.55 x 10 <sup>3</sup> | 7.42 x 10 <sup>8</sup>           | 2.55 x 10 <sup>3</sup> | 250   | 26/30                       | 0.025                                       | 559  | 1,118   |
| Oct                | 345  | 29/31                       | 9.56 x 10 <sup>3</sup>            | 0                              | 0                                | 1.27 x 10 <sup>4</sup>              | 5.80 x 10 <sup>2</sup> | 0                                | 5.80 x 10 <sup>2</sup> | 500<br>250                                    | 11/31<br>14/31              | 0.006                                       | 202  | 269   |
| Nov                | 345<br>0   | 24/30<br>5/30               | 0                                 | -                              | 0                                | 0                                   | 0                      | 0                                | 0                      | 500   | 24/30                       | -   | -  | -   |
| Dec                | 345<br>0   | 23/31<br>3/31               | 0                                 | -                              | 0                                | 0                                   | 0                      | 0                                | 0                      | 500   | 25/31                       | -   | -  | -   |
| Jan                | 345  | 23/30                       | 0                                 | -                              | 0                                | 0                                   | 0                      | 0                                | 0                      | 500   | 24/31                       | -   | -  | -   |
| Feb                | 345  | 25/29                       | 0                                 | -                              | 0                                | 0                                   | 0                      | 0                                | 0                      | 500   | 25/29                       | -   | -  | -   |
| Mar                | 460<br>345<br>0                                  | 15/31<br>8/31<br>3/31       | 0                                 | -                              | 0                                | 0                                   | 0                      | 0                                | 0                      | 500<br>250                                    | 18/31<br>11/31              | -   | -  | -   |
| Apr                | 460  | 30/30                       | 1.63 x 10 <sup>4</sup>            | 0                              | 0                                | 1.63 x 10 <sup>4</sup>              | 7.44 x 10 <sup>2</sup> | 0                                | 7.44 x 10 <sup>2</sup> | 500<br>250                                    | 23/30<br>7/30               | -   | -  | -   |
| May                | 460  | 29/31                       | 3.04 x 10 <sup>5</sup>            | .394                           | 1.2 x 10 <sup>5</sup>            | 3.04 x 10 <sup>5</sup>              | 1.39 x 10 <sup>4</sup> | 1.2 x 10 <sup>5</sup>            | 1.39 x 10 <sup>4</sup> | 250   | 25/31                       | 0.199                                       | 4.45 x 10 <sup>3</sup>                           | 8.9 x 10 <sup>3</sup>   |
| Jun                | 460  | 26/30                       | 7.87 x 10 <sup>5</sup>            | .334                           | 2.63 x 10 <sup>5</sup>           | 7.87 x 10 <sup>5</sup>              | 3.59 x 10 <sup>4</sup> | 2.63 x 10 <sup>5</sup>           | 3.59 x 10 <sup>4</sup> | 500<br>250                                    | 19/30<br>7/30               | 0.573                                       | 1.35 x 10 <sup>6</sup>                           | 1.56 x 10 <sup>6</sup>  |
| Jul                | 460  | 31/31                       | 4.0 x 10 <sup>5</sup>             | .641                           | 2.56 x 10 <sup>5</sup>           | 4.0 x 10 <sup>5</sup>               | 1.83 x 10 <sup>4</sup> | 2.56 x 10 <sup>5</sup>           | 1.83 x 10 <sup>4</sup> | 500<br>250                                    | 25/31<br>4/31               | 0.132                                       | 3.6 x 10 <sup>5</sup>                            | 1.8 x 10 <sup>5</sup>   |
| Aug                | 460  | 31/31                       | 5.37 x 10 <sup>4</sup>            | .444                           | 2.38 x 10 <sup>4</sup>           | 5.37 x 10 <sup>4</sup>              | 2.45 x 10 <sup>3</sup> | 2.38 x 10 <sup>4</sup>           | 2.45 x 10 <sup>3</sup> | 500   | 25/31                       | 0.102                                       | 2.78 x 10 <sup>5</sup>                           | 2.78 x 10 <sup>5</sup>  |

(1) Unaccounted for days showed variable daily flow

(3) Assumes circulating water flow at 460 x 10<sup>6</sup> gpm(6) Entrainment halved with operation of one dilution pump at 260 x 10<sup>6</sup> gpm

(2) Based on IA, 1977, Table 22 day and night samples

(4) Assumes 100% mortality

(5) Based on IA, 1977, Table 21 - day and night samples

## EXHIBIT 175

## ENTRAINMENT ESTIMATES FOR CONDENSER CIRCULATING WATER AND DILUTION WATER

for *Pseudopleuronectes americanus*-larvae

| Month<br>1975-1976 | Data for Existing Systems                        |   |   |                                |                                  | Projected<br>Daily Entrainment                  |                        | Projected<br>Daily Mortality     |                                  | Dilution<br>Water<br>(gpm x 10 <sup>3</sup> ) | Sample Days <sup>(1)</sup><br>per Month | Mean<br>Density<br>in No/m <sup>3</sup><br>Station | Actual<br>Dilution<br>Water Daily<br>Entrainment | Daily<br>Entrainment<br>Through Two<br>Dilution Pumps<br>(560 x 10 <sup>6</sup> gpm) |
|--------------------|--|---|---|--------------------------------|----------------------------------|---|------------------------|----------------------------------|----------------------------------|---|---|--|--|--|
|                    | Circulating<br>Water<br>(gpm x 10 <sup>3</sup> ) | Sample Days <sup>(1)</sup><br>per Month | Daily <sup>(2)</sup><br>Sample<br>Entrainment | Condenser<br>Mortality<br>Rate | Sample<br>Condenser<br>Mortality | Canal-Bay/ <sup>(3)</sup><br>Existing<br>System | Cooling<br>Towers      | Canal-Bay/<br>Existing<br>System | Cooling <sup>(4)</sup><br>Towers |   |   |  |  |  |
| Sep                | 345  | 21/30                                   | 0   | -                              | 0                                | 0   | 0                      | 0                                | 0                                |   |   |  |  |  |
| Oct                | 345  | 29/31                                   | 0   | -                              | 0                                | 0   | 0                      | 0                                | 0                                |   |   |  |  |  |
| Nov                | 345<br>0   | 24/30<br>5/30                           | 0   | -                              | 0                                | 0   | 0                      | 0                                | 0                                |   |   |  |  |  |
| Dec                | 345<br>0   | 23/31<br>3/31                           | 0   | -                              | 0                                | 0   | 0                      | 0                                | 0                                |   |   |  |  |  |
| Jan                | 345  | 23/30                                   | 0   | -                              | 0                                | 0   | 0                      | 0                                | 0                                |   |   |  |  |  |
| Feb                | 345  | 25/29                                   | 6.49 x 10 <sup>5</sup>                        | -                              | -                                | 8.63 x 10 <sup>5</sup>                          | 3.94 x 10 <sup>4</sup> | 0                                | 3.94 x 10 <sup>4</sup>           |   |   |  |  |  |
| Mar                | 460<br>345<br>0                                  | 15/31<br>8/31<br>3/31                   | 4.49 x 10 <sup>6</sup>                        | .058                           | 2.6 x 10 <sup>5</sup>            | 5.97 x 10 <sup>6</sup>                          | 2.73 x 10 <sup>5</sup> | 3.46 x 10 <sup>5</sup>           | 2.73 x 10 <sup>5</sup>           |   |   |  |  |  |
| Apr                | 460  | 30/30                                   | 1.39 x 10 <sup>5</sup>                        | .325                           | 4.5 x 10 <sup>4</sup>            | 1.39 x 10 <sup>5</sup>                          | 6.35 x 10 <sup>3</sup> | 4.5 x 10 <sup>4</sup>            | 6.35 x 10 <sup>3</sup>           |   |   |  |  |  |
| May                | 460  | 29/31                                   | 0   | -                              | 0                                | 0   | 0                      | 0                                | 0                                |   |   |  |  |  |
| Jun                | 460  | 26/30                                   | 0   | -                              | 0                                | 0   | 0                      | 0                                | 0                                |   |   |  |  |  |
| Jul                | 460  | 31/31                                   | 0   | -                              | 0                                | 0   | 0                      | 0                                | 0                                |   |   |  |  |  |
| Aug                | 460  | 31/31                                   | 0   | -                              | 0                                | 0   | 0                      | 0                                | 0                                |   |   |  |  |  |

(1) Unaccounted for days showed variable daily flow

(3) Assumes circulating water flow at 460 x 10<sup>6</sup> gpm

(2) Based on IA, 1977, Table 22-day and night samples

(4) Assumes 100% mortality

## EXHIBIT 175

## ENTRAINMENT ESTIMATES FOR CONDENSER CIRCULATING WATER AND DILUTION WATER

for total fish-larvae

| Month<br>1975-1976 | Data for Existing Systems                        |   |   |                                |                                  | Projected<br>Daily Entrainment                  |                        | Projected<br>Daily Mortality     |                                  | Dilution<br>Water<br>(gpm x 10 <sup>3</sup> ) | Sample Days <sup>(1)</sup><br>per Month | Mean<br>Density <sub>3</sub><br>In No/m <sup>3</sup><br>Station | Actual<br>Dilution<br>Water Daily<br>Entrainment | Daily<br>Entrainment<br>Through Two<br>Dilution Pumps<br>(560 x 10 <sup>6</sup> gpm) |
|--------------------|--|---|---|--------------------------------|----------------------------------|---|------------------------|----------------------------------|----------------------------------|---|---|---|--|--|
|                    | Circulating<br>Water<br>(gpm x 10 <sup>3</sup> ) | Sample Days <sup>(1)</sup><br>per Month | Daily <sup>(2)</sup><br>Sample<br>Entrainment | Condenser<br>Mortality<br>Rate | Sample<br>Condenser<br>Mortality | Canal-Bay/ <sup>(3)</sup><br>Existing<br>System | Cooling<br>Towers      | Canal-Bay/<br>Existing<br>System | Cooling <sup>(4)</sup><br>Towers |   |   |   |  |  |
| Sep                | 345  | 21/30                                   | 3.10 x 10 <sup>6</sup>                        | Not                            | -                                | 4.12 x 10 <sup>6</sup>                          | 1.88 x 10 <sup>5</sup> | -                                | 1.88 x 10 <sup>5</sup>           |   |   |   |  |  |
| Oct                | 345  | 29/31                                   | 2.65 x 10 <sup>5</sup>                        | Quantified                     | -                                | 3.52 x 10 <sup>5</sup>                          | 1.61 x 10 <sup>4</sup> | -                                | 1.61 x 10 <sup>4</sup>           |   |   |   |  |  |
| Nov                | 345<br>0   | 24/30<br>5/30                           | 6.93 x 10 <sup>4</sup>                        |                                | -                                | 9.2 x 10 <sup>4</sup>                           | 4.20 x 10 <sup>3</sup> | -                                | 4.20 x 10 <sup>3</sup>           |   |   |   |  |  |
| Dec                | 345<br>0   | 23/31<br>3/31                           | 3.14 x 10 <sup>4</sup>                        |                                | -                                | 4.2 x 10 <sup>4</sup>                           | 1.92 x 10 <sup>3</sup> | -                                | 1.92 x 10 <sup>3</sup>           |   |   |   |  |  |
| Jan                | 345  | 23/30                                   | 3.50 x 10 <sup>6</sup>                        |                                | -                                | 4.66 x 10 <sup>6</sup>                          | 2.13 x 10 <sup>5</sup> | -                                | 2.13 x 10 <sup>5</sup>           |   |   |   |  |  |
| Feb                | 345  | 25/29                                   | 2.92 x 10 <sup>6</sup>                        |                                | -                                | 3.88 x 10 <sup>6</sup>                          | 1.77 x 10 <sup>5</sup> | -                                | 1.77 x 10 <sup>5</sup>           |   |   |   |  |  |
| Mar                | 460<br>345<br>0                                  | 15/31<br>8/31<br>3/31                   | 5.92 x 10 <sup>6</sup>                        |                                | -                                | 7.87 x 10 <sup>6</sup>                          | 3.59 x 10 <sup>5</sup> | -                                | 3.59 x 10 <sup>5</sup>           |   |   |   |  |  |
| Apr                | 460  | 30/30                                   | 4.81 x 10 <sup>5</sup>                        |                                | -                                | 4.81 x 10 <sup>5</sup>                          | 2.2 x 10 <sup>4</sup>  | -                                | 2.2 x 10 <sup>4</sup>            |   |   |   |  |  |
| May                | 460  | 29/31                                   | 6.9 x 10 <sup>5</sup>                         |                                | -                                | 6.9 x 10 <sup>5</sup>                           | 3.15 x 10 <sup>4</sup> | -                                | 3.14 x 10 <sup>4</sup>           |   |   |   |  |  |
| Jun                | 460  | 26/30                                   | 1.72 x 10 <sup>7</sup>                        |                                | -                                | 1.72 x 10 <sup>7</sup>                          | 7.85 x 10 <sup>5</sup> | -                                | 7.85 x 10 <sup>5</sup>           |   |   |   |  |  |
| Jul                | 460  | 31/31                                   | 2.66 x 10 <sup>7</sup>                        |                                | -                                | 2.66 x 10 <sup>7</sup>                          | 1.21 x 10 <sup>6</sup> | -                                | 1.21 x 10 <sup>6</sup>           |   |   |   |  |  |
| Aug                | 460  | 31/31                                   | 1 x 10 <sup>7</sup>                           |                                | -                                | 1 x 10 <sup>7</sup>                             | 4.57 x 10 <sup>5</sup> | -                                | 4.57 x 10 <sup>5</sup>           |   |   |   |  |  |

(1) Unaccounted for days showed variable daily flow

(3) Assumes circulating water flow at 460 x 10<sup>6</sup> gpm

(2) Based on IA, 1977, Table 22 - day and night samples

(4) Assumes 100% mortality

## EXHIBIT 175

ENTRAINMENT ESTIMATES FOR CONDENSER CIRCULATING WATER AND DILUTION WATER  
for Cynoscion regalis-larvae

| Month<br>1975-1976 | Data for Existing Systems                        |   |   |                                |                                  | Projected<br>Daily Entrainment                  |                   | Projected<br>Daily Mortality     |                   | Dilution<br>Water<br>(gpm x 10 <sup>3</sup> ) | Sample Days <sup>(1)</sup><br>per Month | Mean<br>Density<br>in No/m <sup>3</sup><br>Station 7 <sup>(2)</sup> | Actual<br>Dilution<br>Water Daily<br>Entrainment | Daily<br>Entrainment <sup>(3)</sup><br>Through Two<br>Dilution Pumps<br>(560 x 10 <sup>6</sup><br>gpm) |
|--------------------|--|---|---|--------------------------------|----------------------------------|---|-------------------|----------------------------------|-------------------|---|---|---|--|--|
|                    | Circulating<br>Water<br>(gpm x 10 <sup>3</sup> ) | Sample Days <sup>(1)</sup><br>per Month | Daily <sup>(2)</sup><br>Sample<br>Entrainment | Condenser<br>Mortality<br>Rate | Sample<br>Condenser<br>Mortality | Canal-Bay/ <sup>(3)</sup><br>Existing<br>System | Cooling<br>Towers | Canal-Bay/<br>Existing<br>System | Cooling<br>Towers |   |   |   |  |  |
| Sep                |  |   |   |                                |                                  |   |                   |                                  |                   | 250   | 26/30                                   | -   | -  | -  |
| Oct                |  |   |   |                                |                                  |   |                   |                                  |                   | 500<br>250                                    | 11/31<br>14/31                          | -   | -  | -  |
| Nov                |  |   |   |                                |                                  |   |                   |                                  |                   | 500   | 24/30                                   | -   | -  | -  |
| Dec                |  |   |   |                                |                                  |   |                   |                                  |                   | 500   | 25/31                                   | -   | -  | -  |
| Jan                |  |   |   |                                |                                  |   |                   |                                  |                   | 500   | 24/31                                   | -   | -  | -  |
| Feb                |  |   |   |                                |                                  |   |                   |                                  |                   | 500   | 25/29                                   | -   | -  | -  |
| Mar                |  |   |   |                                |                                  |   |                   |                                  |                   | 500<br>250                                    | 18/31<br>11/31                          | -   | -  | -  |
| Apr                |  |   |   |                                |                                  |   |                   |                                  |                   | 500<br>250                                    | 23/30<br>7/30                           | -   | -  | -  |
| May                |  |   |   |                                |                                  |   |                   |                                  |                   | 250   | 25/31                                   | -   | -  | -  |
| Jun                |  |   |   |                                |                                  |   |                   |                                  |                   | 500<br>250                                    | 19/30<br>7/30                           | -   | -  | -  |
| Jul                |  |   |   |                                |                                  |   |                   |                                  |                   | 500<br>250                                    | 25/31<br>4/31                           | 0.006   | 4.02 x 10 <sup>6</sup>                           | 4.32 x 10 <sup>6</sup>   |
| Aug                |  |   |   |                                |                                  |   |                   |                                  |                   | 500   | 25/31                                   | 0.004   | 2.88 x 10 <sup>6</sup>                           | 2.88 x 10 <sup>6</sup>   |

(1) Unaccounted for days showed variable daily flow

(2) Based on IA, 1977, Table 21 - day and night samples

(3) Entrainment halved with operation of one dilution pump at 260 x 10<sup>6</sup> gpm

## EXHIBIT 175

## ENTRAINMENT ESTIMATES FOR CONDENSER CIRCULATING WATER AND DILUTION WATER

for *Tautoga onitis*-eggs

| Month<br>1975-1976 | Data for Existing Systems                        |                              |                                    |                                | Projected<br>Daily Entrainment   |                                     | Projected<br>Daily Mortality |                                  | Dilution<br>Water<br>(gpm x 10 <sup>3</sup> ) | Sample Days (1)<br>per Month | Mean<br>Density<br>in No/m <sup>3</sup><br>Station 7 (2) | Actual<br>Dilution<br>Water Daily<br>Entrainment | Daily<br>Entrainment (3)<br>Through Two<br>Dilution Pumps<br>(560 x 10 <sup>6</sup> gpm) |
|--------------------|--|------------------------------|------------------------------------|--------------------------------|----------------------------------|-------------------------------------|------------------------------|----------------------------------|---|------------------------------|--|--|--|
|                    | Circulating<br>Water<br>(gpm x 10 <sup>3</sup> ) | Sample Days (1)<br>per Month | Daily (2)<br>Sample<br>Entrainment | Condenser<br>Mortality<br>Rate | Sample<br>Condenser<br>Mortality | Canal-Bay/(3)<br>Existing<br>System | Cooling<br>Towers            | Canal-Bay/<br>Existing<br>System |   |                              |  |  |  |
| Sep                |  |                              |                                    |                                |                                  |                                     |                              |                                  | 250   | 26/30                        | -  | -  | -  |
| Oct                |  |                              |                                    |                                |                                  |                                     |                              |                                  | 500<br>250                                    | 11/31<br>14/31               | -  | -  | -  |
| Nov                |  |                              |                                    |                                |                                  |                                     |                              |                                  | 500   | 24/30                        | -  | -  | -  |
| Dec                |  |                              |                                    |                                |                                  |                                     |                              |                                  | 500   | 25/31                        | -  | -  | -  |
| Jan                |  |                              |                                    |                                |                                  |                                     |                              |                                  | 500   | 24/31                        | -  | -  | -  |
| Feb                |  |                              |                                    |                                |                                  |                                     |                              |                                  | 500   | 25/29                        | -  | -  | -  |
| Mar                |  |                              |                                    |                                |                                  |                                     |                              |                                  | 500<br>250                                    | 18/31<br>11/31               | -  | -  | -  |
| Apr                |  |                              |                                    |                                |                                  |                                     |                              |                                  | 500<br>250                                    | 23/30<br>7/30                | 0.283  | 1.80 x 10 <sup>8</sup>                           | 2.04 x 10 <sup>8</sup>   |
| May                |  |                              |                                    |                                |                                  |                                     |                              |                                  | 250   | 25/31                        | 0.271  | 8.2 x 10 <sup>8</sup>                            | 1.64 x 10 <sup>9</sup>   |
| Jun                |  |                              |                                    |                                |                                  |                                     |                              |                                  | 500<br>250                                    | 19/30<br>7/30                | 0.152  | 9.43 x 10 <sup>7</sup>                           | 1.09 x 10 <sup>8</sup>   |
| Jul                |  |                              |                                    |                                |                                  |                                     |                              |                                  | 500<br>250                                    | 25/31<br>4/31                | 0.044  | 3.17 x 10 <sup>7</sup>                           | 3.17 x 10 <sup>7</sup>   |
| Aug                |  |                              |                                    |                                |                                  |                                     |                              |                                  | 500   | 25/31                        | 0.005  | 3.6 x 10 <sup>6</sup>                            | 3.6 x 10 <sup>6</sup>  |

(1) Unaccounted for days showed variable daily flow

(2) Based on IA, 1977, Table 21 - day and night samples

(3) Entrainment halved with operation of one dilution pump at 260 x 10<sup>6</sup> gpm

## EXHIBIT 175

## ENTRAINMENT ESTIMATES FOR CONDENSER CIRCULATING WATER AND DILUTION WATER

for *Ammodytes* sp - eggs and larvae

| Month<br>1975-1976 | Data for Existing Systems                        |   |   |                                | Projected<br>Daily Entrainment   |   | Projected<br>Daily Mortality |                                  | Dilution<br>Water<br>(gpm x 10 <sup>3</sup> ) | Sample Days <sup>(1)</sup><br>per Month | Mean<br>Density<br>in No/m <sup>3</sup> <sup>(2)</sup><br>Station 7 | Actual<br>Dilution<br>Water Daily<br>Entrainment | Daily<br>Entrainment<br>Through Two<br>Dilution Pumps<br>(560 x 10 <sup>6</sup> gpm) |
|--------------------|--|---|---|--------------------------------|----------------------------------|---|------------------------------|----------------------------------|---|---|---|--|--|
|                    | Circulating<br>Water<br>(gpm x 10 <sup>3</sup> ) | Sample Days <sup>(1)</sup><br>per Month | Daily <sup>(2)</sup><br>Sample<br>Entrainment | Condenser<br>Mortality<br>Rate | Sample<br>Condenser<br>Mortality | Canal-Bay/ <sup>(3)</sup><br>Existing<br>System | Cooling<br>Towers            | Canal-Bay/<br>Existing<br>System |   |   |   |  |  |
| Sep                |  |   |   |                                |                                  |   |                              |                                  | 250   | 26/30                                   | -   | -  | -  |
| Oct                |  |   |   |                                |                                  |   |                              |                                  | 500<br>250                                    | 11/31<br>14/31                          | -   | -  | -  |
| Nov                |  |   |   |                                |                                  |   |                              |                                  | 500   | 24/30                                   | -   | -  | -  |
| Dec                |  |   |   |                                |                                  |   |                              |                                  | 500   | 25/31                                   | -   | -  | -  |
| Jan                |  |   |   |                                |                                  |   |                              |                                  | 500   | 24/31                                   | 1.853   | 1.33 x 10 <sup>9</sup>                           | 1.33 x 10 <sup>9</sup>   |
| Feb                |  |   |   |                                |                                  |   |                              |                                  | 500   | 25/29                                   | 1.003   | 7.22 x 10 <sup>8</sup>                           | 7.22 x 10 <sup>8</sup>   |
| Mar                |  |   |   |                                |                                  |   |                              |                                  | 500<br>250                                    | 18/31<br>11/31                          | 0.256   | 1.49 x 10 <sup>8</sup>                           | 1.84 x 10 <sup>8</sup>   |
| Apr                |  |   |   |                                |                                  |   |                              |                                  | 500<br>250                                    | 23/30<br>7/30                           | 0.024   | 1.53 x 10 <sup>7</sup>                           | 1.73 x 10 <sup>7</sup>   |
| May                |  |   |   |                                |                                  |   |                              |                                  | 250   | 25/31                                   | -   | -  | -  |
| Jun                |  |   |   |                                |                                  |   |                              |                                  | 500<br>250                                    | 19/30<br>7/30                           | -   | -  | -  |
| Jul                |  |   |   |                                |                                  |   |                              |                                  | 500<br>250                                    | 25/31<br>4/31                           | -   | -  | -  |
| Aug                |  |   |   |                                |                                  |   |                              |                                  | 500   | 25/31                                   | -   | -  | -  |

(1) Unaccounted for days showed variable daily flow

(2) Based on IA, 1977, Table 21 - day and night samples

(3) Entrainment halved with operation of one dilution pump at 260 x 10<sup>6</sup> gpm

## EXHIBIT 175

ENTRAINMENT ESTIMATES FOR CONDENSER CIRCULATING WATER AND DILUTION WATER  
for *Pseudopleuronectes* sp - larvae

| Month<br>1975-1976 | Data for Existing Systems                        |   |   |                                | Projected<br>Daily Entrainment   |   | Projected<br>Daily Mortality |                                  | Dilution<br>Water<br>(gpm x 10 <sup>3</sup> ) | Sample Days <sup>(1)</sup><br>per Month | Mean<br>Density,<br>in No/m <sup>3</sup><br>Station 7 <sup>(2)</sup> | Actual<br>Dilution<br>Water Daily<br>Entrainment | Daily<br>Entrainment <sup>(3)</sup><br>Through Two<br>Dilution Pumps<br>(560 x 10 <sup>6</sup> gpm) |
|--------------------|--|---|---|--------------------------------|----------------------------------|---|------------------------------|----------------------------------|---|---|--|--|---|
|                    | Circulating<br>Water<br>(gpm x 10 <sup>3</sup> ) | Sample Days <sup>(1)</sup><br>per Month | Daily <sup>(2)</sup><br>Sample<br>Entrainment | Condenser<br>Mortality<br>Rate | Sample<br>Condenser<br>Mortality | Canal-Bay/ <sup>(3)</sup><br>Existing<br>System | Cooling<br>Towers            | Canal-Bay/<br>Existing<br>System |   |   |  |  |   |
| Sep                |  |   |   |                                |                                  |   |                              |                                  | 250   | 26/30                                   | -  | -  | -   |
| Oct                |  |   |   |                                |                                  |   |                              |                                  | 500<br>250                                    | 11/31<br>14/31                          | -  | -  | -   |
| Nov                |  |   |   |                                |                                  |   |                              |                                  | 500   | 24/30                                   | -  | -  | -   |
| Dec                |  |   |   |                                |                                  |   |                              |                                  | 500   | 25/31                                   | -  | -  | -   |
| Jan                |  |   |   |                                |                                  |   |                              |                                  | 500   | 24/31                                   | -  | -  | -   |
| Feb                |  |   |   |                                |                                  |   |                              |                                  | 500   | 25/29                                   | 0.298  | 8.12 x 10 <sup>5</sup>                           | 8.12 x 10 <sup>5</sup>  |
| Mar                |  |   |   |                                |                                  |   |                              |                                  | 500<br>250                                    | 18/31<br>11/31                          | 1.645  | 4.48 x 10 <sup>6</sup>                           | 4.48 x 10 <sup>6</sup>  |
| Apr                |  |   |   |                                |                                  |   |                              |                                  | 500<br>250                                    | 23/30<br>7/30                           | 0.079  | 2.15 x 10 <sup>5</sup>                           | 2.15 x 10 <sup>5</sup>  |
| May                |  |   |   |                                |                                  |   |                              |                                  | 250   | 25/31                                   | -  | -  | -   |
| Jun                |  |   |   |                                |                                  |   |                              |                                  | 500<br>250                                    | 19/30<br>7/30                           | -  | -  | -   |
| Jul                |  |   |   |                                |                                  |   |                              |                                  | 500<br>250                                    | 25/31<br>4/31                           | -  | -  | -   |
| Aug                |  |   |   |                                |                                  |   |                              |                                  | 500   | 25/31                                   | -  | -  | -   |

(1) Unaccounted for days showed variable daily flow

(2) Based on IA, 1977, Table 21 - day and night samples

(3) Entrainment halved with operation of one dilution pump at 260 x 10<sup>6</sup> gpm

## EXHIBIT 175

## ENTRAINMENT ESTIMATES FOR CONDENSER CIRCULATING WATER AND DILUTION WATER

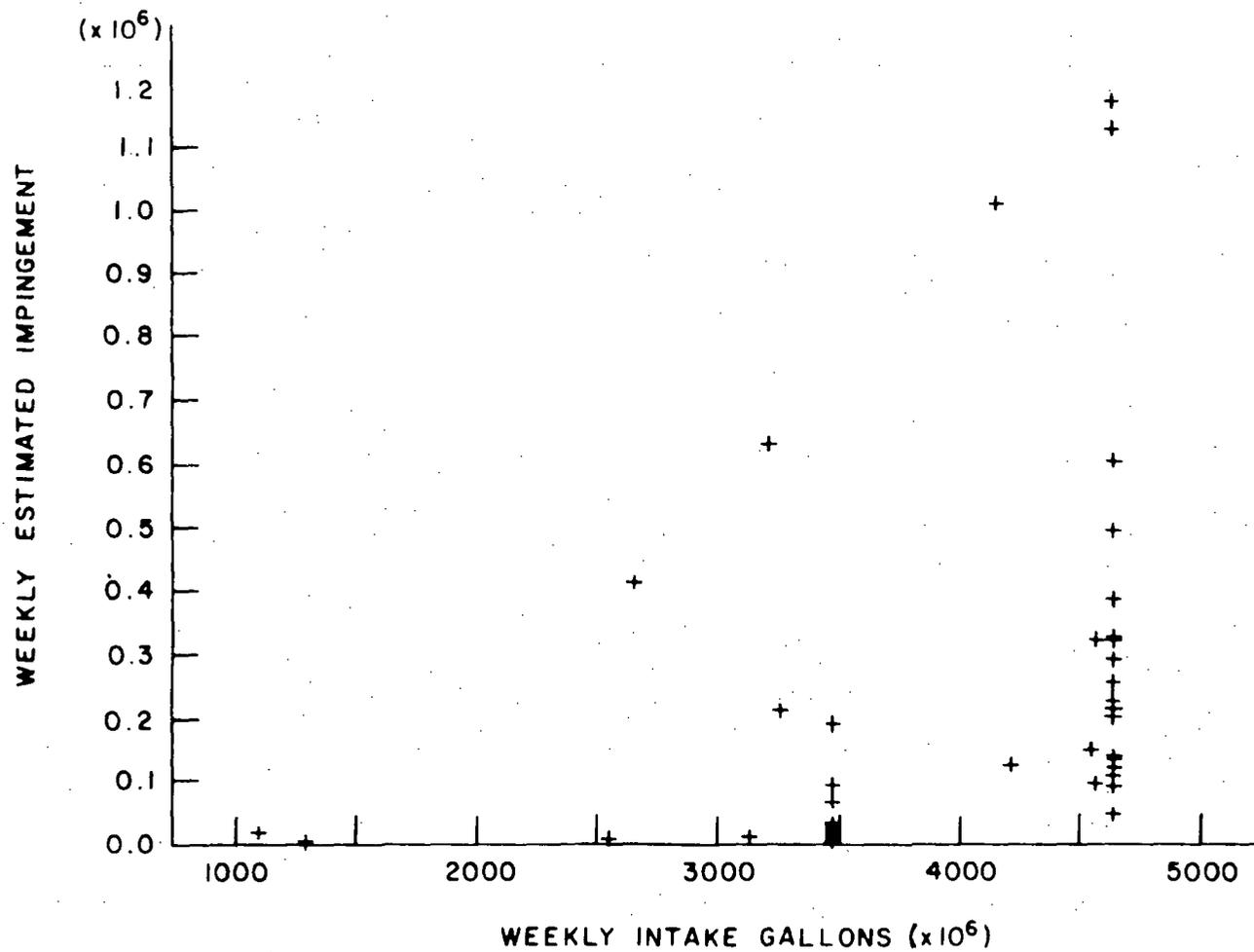
for *Sphaeroides maculatus*-larvae

| Month<br>1975-1976 | Data for Existing Systems                        |   |   |                                | Projected<br>Daily Entrainment   |   | Projected<br>Daily Mortality |                                  | Dilution<br>Water<br>(gpm x 10 <sup>3</sup> ) | Sample Days <sup>(1)</sup><br>per Month | Mean<br>Density <sub>3</sub><br>in No/m <sup>3</sup> <sup>(2)</sup><br>Station 7 <sup>(2)</sup> | Actual<br>Dilution<br>Water Daily<br>Entrainment | Daily<br>Entrainment <sup>(3)</sup><br>Through Two<br>Dilution Pumps<br>(560 x 10 <sup>6</sup> gpm) |
|--------------------|--|---|---|--------------------------------|----------------------------------|---|------------------------------|----------------------------------|---|---|---|--|---|
|                    | Circulating<br>Water<br>(gpm x 10 <sup>3</sup> ) | Sample Days <sup>(1)</sup><br>per Month | Daily <sup>(2)</sup><br>Sample<br>Entrainment | Condenser<br>Mortality<br>Rate | Sample<br>Condenser<br>Mortality | Canal-Bay/ <sup>(3)</sup><br>Existing<br>System | Cooling<br>Towers            | Canal-Bay/<br>Existing<br>System |   |   |   |  |   |
| Sep                |  |   |   |                                |                                  |   |                              |                                  | 250   | 26/30                                   | -   | -  | -   |
| Oct                |  |   |   |                                |                                  |   |                              |                                  | 500<br>250                                    | 11/31<br>14/31                          | -   | -  | -   |
| Nov                |  |   |   |                                |                                  |   |                              |                                  | 500   | 24/30                                   | -   | -  | -   |
| Dec                |  |   |   |                                |                                  |   |                              |                                  | 500   | 25/31                                   | -   | -  | -   |
| Jan                |  |   |   |                                |                                  |   |                              |                                  | 500   | 24/31                                   | -   | -  | -   |
| Feb                |  |   |   |                                |                                  |   |                              |                                  | 500   | 25/29                                   | -   | -  | -   |
| Mar                |  |   |   |                                |                                  |   |                              |                                  | 500<br>250                                    | 18/31<br>11/31                          | -   | -  | -   |
| Apr                |  |   |   |                                |                                  |   |                              |                                  | 500<br>250                                    | 23/30<br>7/30                           | -   | -  | -   |
| May                |  |   |   |                                |                                  |   |                              |                                  | 250   | 25/31                                   | 0.041   | 1.48 x 10 <sup>7</sup>                           | 2.96 x 10 <sup>7</sup>  |
| Jun                |  |   |   |                                |                                  |   |                              |                                  | 500<br>250                                    | 19/30<br>7/30                           | 0.042   | 2.61 x 10 <sup>7</sup>                           | 3.02 x 10 <sup>7</sup>  |
| Jul                |  |   |   |                                |                                  |   |                              |                                  | 500<br>250                                    | 25/31<br>4/31                           | -   | -  | -   |
| Aug                |  |   |   |                                |                                  |   |                              |                                  | 500   | 25/31                                   | -   | -  | -   |

(1) Unaccounted for days showed variable daily flow

(2) Based on IA, 1977, Table 21

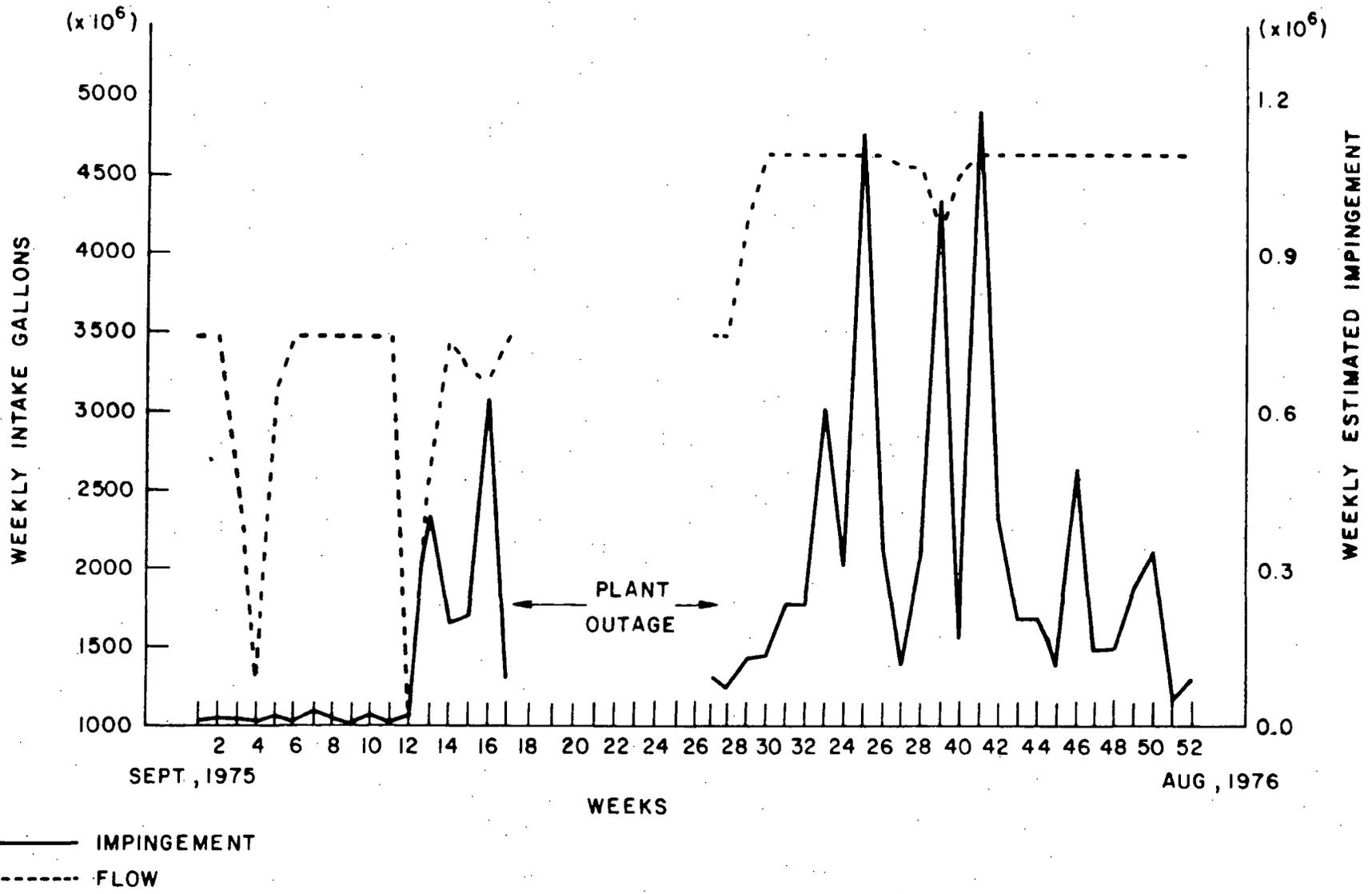
(3) Entrainment halved with operation of one dilution pump at 260 x 10<sup>6</sup> gpm



JERSEY CENTRAL  
 POWER & LIGHT COMPANY  
 EBASCO SERVICES INCORPORATED  
 New York

RELATIONSHIP OF IMPINGEMENT AND FLOW AT OCNGS FROM  
 SEPTEMBER, 1975 TO SEPTEMBER, 1976

EXHIBIT  
 176



JERSEY CENTRAL  
POWER & LIGHT COMPANY  
EBASCO SERVICES INCORPORATED  
New York

IMPINGEMENT AND FLOW AT OCNGS FROM  
SEPTEMBER, 1975 TO SEPTEMBER, 1976

EXHIBIT  
177

## Exhibit 178

COEFFICIENTS OF THE ANNUAL IMPINGEMENT REGRESSION EQUATIONS\*, BY SPECIES

|                     | Water<br>Temp<br>erature | Salin-<br>ity | DO     | pH     | Time<br>of Day | Wind<br>Speed | Wind<br>Direc-<br>tion | No. of<br>Screens | Water<br>Flow |
|---------------------|--------------------------|---------------|--------|--------|----------------|---------------|------------------------|-------------------|---------------|
| Atlantic menhaden   |                          |               |        | - .486 | .173           | .131          |                        |                   |               |
| Atlantic silverside | - .203                   |               |        |        | .170           | .268          | - .083                 | - .395            | .005          |
| Bay anchovy         | - .105                   | - .366        |        | 1.110  | .442           | .172          |                        | - .726            | .029          |
| Blue crab           | .112                     |               | - .108 | .349   | 1.001          | .248          |                        | -0.280            | .013          |
| Bluefish            |                          |               |        |        | .123           |               | - .087                 | -1.131            | .007          |
| Northern pipefish   | - .054                   |               | .133   |        | .435           | .244          | - .080                 | .362              |               |
| Sand shrimp         | - .163                   | .201          |        | - .798 | 1.023          | .407          | - .130                 |                   | .009          |

\* Significant F - value for variation around regression plane ( $P < .01$ ) for all species.

Taken from: Oyster Creek Generating Station, Final Report of Ecological Studies, September 1975-  
August 1976, Vol 1, Part 2, Fin- and Shellfish, p 235.

MONTHLY MORTALITY AND IMPINGEMENT ESTIMATES FOR OCNGS ALTERNATE COOLING SYSTEMS, BY SPECIESAtlantic menhaden (Brevoortia tyrannus)

I - Screen mortality rate: 31%

II - Screen mortality rate with Ristroph buckets: 7%

| Existing and<br>Canal-to-Bay<br>Systems | Jan          | Feb | Mar | Apr | May | Jun | Jul   | Aug   | Sep | Oct | Nov | Dec    | 10 Month<br>Total |
|---|--------------|-----|-----|-----|-----|-----|-------|-------|-----|-----|-----|--------|-------------------|
|   | No. Impinged |     |     | 105 | 923 | 976 | 577   | 4,233 | 881 | 27  | 21  | 214    | 11,646            |
| No. Killed (I)                          |              |     | 33  | 286 | 303 | 179 | 1,312 | 273   | 8   | 7   | 66  | 3,610  | 5,611             |
| No. Killed (II)                         |              |     | 7   | 65  | 68  | 40  | 296   | 62    | 2   | 1   | 15  | 815    | 1,267             |
| <u>Cooling<br/>Tower<br/>Systems</u>    |              |     |     |     |     |     |       |       |     |     |     |        |                   |
| No. Impinged                            |              |     | 98  | 861 | 911 | 538 | 3,949 | 822   | 25  | 20  | 200 | 10,866 | 16,889            |
| No. Killed (I)                          |              |     | 30  | 267 | 282 | 167 | 1,224 | 255   | 8   | 6   | 62  | 3,368  | 5,235             |
| No. Killed (II)                         |              |     | 7   | 60  | 64  | 38  | 276   | 58    | 2   | 1   | 14  | 760    | 1,182             |

MONTHLY MORTALITY AND IMPINGEMENT ESTIMATES FOR OCNGS ALTERNATE COOLING SYSTEMS, BY SPECIES

Atlantic silverside (*Menidia menidia*)

I - Screen mortality rate: 40%

II - Screen mortality rate with Ristroph buckets: 6%

| Existing and<br>Canal-to-Bay<br>Systems | Jan | Feb | Mar    | Apr   | May   | Jun | Jul | Aug | Sep | Oct | Nov | Dec    | 10 Month<br>Total |
|---|-----|-----|--------|-------|-------|-----|-----|-----|-----|-----|-----|--------|-------------------|
| No. Impinged                            |     |     | 26,513 | 4,070 | 4,696 | 321 | 2   | 1   | 3   | 37  | 977 | 24,705 | 58,138            |
| No. Killed (I)                          |     |     | 10,605 | 1,628 | 1,878 | 128 | 1   | 0   | 1   | 15  | 391 | 8,607  | 23,255            |
| No. Killed (II)                         |     |     | 1,591  | 244   | 282   | 19  | 0   | 0   | 0   | 2   | 59  | 1,291  | 3,488             |
| <u>Cooling<br/>Tower<br/>Systems</u>    |     |     |        |       |       |     |     |     |     |     |     |        |                   |
| No. Impinged                            |     |     | 25,373 | 3,895 | 4,029 | 307 | 2   | 1   | 3   | 35  | 935 | 23,643 | 55,172            |
| No. Killed (I)                          |     |     | 10,149 | 1,558 | 1,612 | 123 | 1   | 0   | 1   | 14  | 374 | 9,457  | 22,069            |
| No. Killed (II)                         |     |     | 1,522  | 234   | 242   | 18  | 0   | 0   | 0   | 2   | 56  | 1,418  | 3,310             |

MONTHLY MORTALITY AND IMPINGEMENT ESTIMATES FOR OCNGS ALTERNATE COOLING SYSTEMS, BY SPECIESBay anchovy (Anchoa mitchilli)

I - Screen mortality rate: 77%

II - Screen mortality rate with Ristroph buckets: 20%

| Existing and<br>Canal-to-Bay<br>Systems | Jan          | Feb | Mar    | Apr     | May     | Jun     | Jul    | Aug   | Sep    | Oct   | Nov    | Dec   | 10 Month<br>Total |
|---|--------------|-----|--------|---------|---------|---------|--------|-------|--------|-------|--------|-------|-------------------|
|   | No. Impinged |     |        | 45,744  | 943,067 | 583,726 | 33,119 | 7,158 | 10,420 | 2,584 | 11,440 | 2,231 | 773               |
| No. Killed (I)                          |              |     | 35,223 | 726,162 | 449,469 | 25,502  | 5,512  | 8,023 | 1,990  | 8,809 | 1,718  | 595   | 1,263,002         |
| No. Killed (II)                         |              |     | 9,149  | 188,613 | 116,745 | 6,624   | 1,432  | 2,084 | 517    | 2,288 | 446    | 155   | 328,052           |
| <u>Cooling<br/>Tower<br/>Systems</u>    |              |     |        |         |         |         |        |       |        |       |        |       |                   |
| No. Impinged                            |              |     | 35,497 | 731,820 | 29,186  | 27,886  | 5,555  | 8,086 | 1,318  | 8,877 | 1,731  | 600   | 850,556           |
| No. Killed (I)                          |              |     | 27,333 | 563,501 | 22,473  | 21,472  | 4,277  | 6,226 | 1,015  | 6,835 | 1,333  | 462   | 654,927           |
| No. Killed (II)                         |              |     | 7,099  | 146,364 | 5,837   | 5,577   | 1,111  | 1,617 | 264    | 1,775 | 346    | 120   | 170,110           |



MONTHLY MORTALITY AND IMPINGEMENT ESTIMATES FOR OCNGS ALTERNATE COOLING SYSTEMS, BY SPECIESBluefish (*Pomatomus saltatrix*)

I - Screen mortality rate: 61%

II - Screen mortality rate with Ristroph buckets: 21%

| Existing and<br>Canal-to-Bay<br>Systems | Jan          | Feb | Mar | Apr | May   | Jun   | Jul   | Aug | Sep | Oct | Nov | Dec | 10 Month<br>Total |
|---|--------------|-----|-----|-----|-------|-------|-------|-----|-----|-----|-----|-----|-------------------|
|   | No. Impinged |     |     |     |       | 3,704 | 6,697 | 659 | 793 | 145 |     |     |                   |
| No. Killed (I)                          |              |     |     |     | 2,259 | 4,085 | 402   | 483 | 88  |     |     |     | 7,319             |
| No. Killed (II)                         |              |     |     |     | 778   | 1,406 | 138   | 166 | 30  |     |     |     | 2,519             |
| <u>Cooling<br/>Tower<br/>Systems</u>    |              |     |     |     |       |       |       |     |     |     |     |     |                   |
| No. Impinged                            |              |     |     |     | 3,485 | 6,302 | 620   | 746 | 140 |     |     |     | 11,293            |
| No. Killed (I)                          |              |     |     |     | 2,126 | 3,844 | 378   | 455 | 85  |     |     |     | 6,888             |
| No. Killed (II)                         |              |     |     |     | 732   | 1,323 | 130   | 156 | 29  |     |     |     | 2,370             |





Exhibit 180

CORRECTION FACTORS (%) TO COMPUTE IMPINGEMENT FOR  
CLOSED CYCLE SYSTEMS OPERATING AT 23,000 gpm

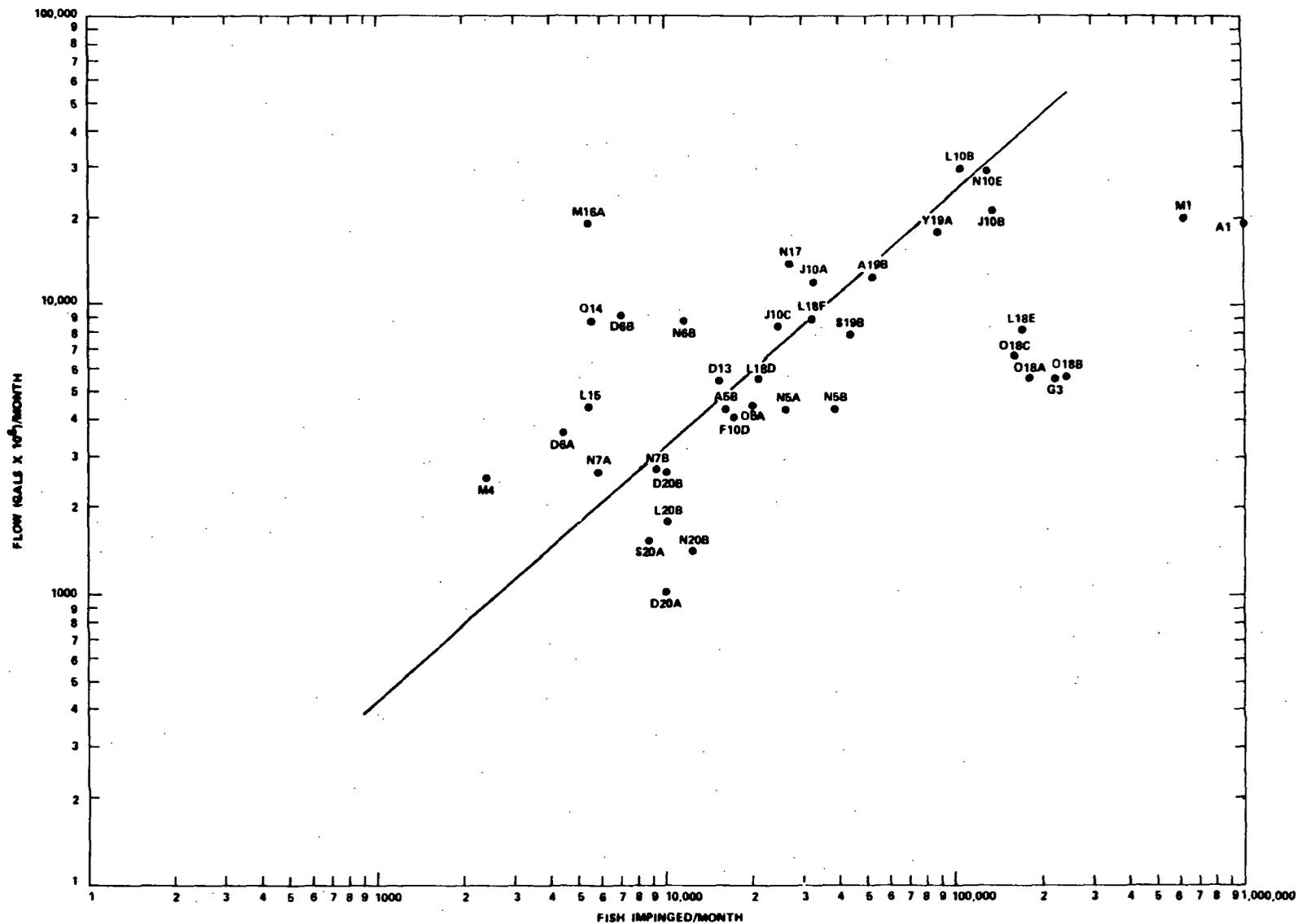
|                     | May  | June | September | Annual |
|---------------------|------|------|-----------|--------|
| Atlantic menhaden   | *    | *    | 93.3      | *      |
| Atlantic silverside | 85.8 | *    | *         | 95.7   |
| Bay anchovy         | 5.0  | 84.2 | 51.0      | 77.6   |
| Blue crab           | 7.7  | 0.3  | 31.6      | 89.2   |
| Bluefish            | *    | *    | 96.3      | 94.1   |
| Northern pipefish   | 97.3 | 98.4 | *         | *      |
| Sand Shrimp         | 5.5  | *    | *         | 92.4   |
| All Species         | 20.0 | 1.2  | 25.7      | 86.9   |

\* denotes non-significant regression.

## Exhibit 181

## PLANT CHARACTERISTICS OF INTAKES ALONG NORTH ATLANTIC ESTUARIES

| Utility                    | Plant                    | Water Body                   | MWe                   | Maximum Flow                | Intake      | Imp Sampling     | Frequency                 | Comments   |
|----------------------------|--------------------------|------------------------------|-----------------------|-----------------------------|-------------|------------------|---------------------------|--|
| JCP&L (N J)                | Oyster Creek             | Barnegat Bay                 | 620                   | 460,000 gpm                 | Canal       | 9/75 - 8/76      | 3 X / Week                | 4 diel sampling periods, 10 min screen washes every 2 hrs (20-185 min/sample) 1 (37 samples), 2(36), 3(74), 4(44) = 191 samples 3/8 - 4/30/76. April peak.     |
| LILCO (N Y)                | Far Rockaway             | Jamaica Bay                  | 115                   | 57,000 gpm                  | Shoreline   | 35 samples, 1976 | 96 hrs/mo                 | Unit 4 only. No peaks.   |
|                            | E F Barret               | Great South Bay              | 190 1                 | 102,000 gpm                 | Shoreline   | 33 samples, 1976 | 96 hrs/mo                 | Units 1 & 2 monitored separately. No-  |
|                            |                          | Port Jefferson               | Port Jefferson Harbor | 190 2                       | 102,000 gpm | Shoreline        | 33 samples, 1976          | 96 hrs/mo  |
|                            | Glenwood                 | Hempstead Harbor             | 98                    | 80,000 gpm                  | Shoreline   | 62 samples, 1976 | 96 hrs/mo                 | Units 1, 2 and 3, 4 monitored separately   |
| JCP&L (N J)                | Sayreville               | Raritan River                | 392                   | 204,000 gpm                 | Shoreline   | 50 samples, 1976 | 96 hrs/mo                 | Units 4 & 5 monitored separately   |
|                            |                          |                              | 113.5                 | 62,000 gpm                  | Shoreline   |                  |                           | Killifish/silversides/no real period/ or abundance. November peak.   |
| Con Ed (N Y)               | Indian Point Unit 1      | Hudson River                 | 376                   | 150,000 gpm for Units 4 & 5 | Shoreline   | Aug - Nov 1976   | 1½ days/mo                | (1) 24 hr sample + (1) 12 hr sample per month; screens at Units 3 & 4 were washed once every hour or more during sampling; 88% mortality. Summer peak.         |
|                            |                          |                              | 873                   | 840,000 gpm                 | Shoreline   | 6/72 - 1975      | Daily                     | Continuous sampling done due to extreme impingement rates - reduced pumping in effect. June peaks for all 3 units.   |
|                            |                          |                              | 1,033                 | 840,000 gpm                 | Shoreline   | 6/72 - 1975      | Daily                     |  |
| Northeast Utilities (Conn) | Devon                    | Housatonic River - L I Sound | 475                   | 20,138 gpm                  | Shoreline   | 8/75 - 8/76      | 2 - 4 days/mo             | 24 hr samples weekly from Apr to Sep & bimonthly Oct to Mar; Jan, June peaks.  |
|                            |                          |                              | 338                   | 150,000 gpm                 | Canal       | 8/75 - 8/76      | 2 - 4 days/mo             | 24 hr samples weekly (Apr - Sep) & bi-weekly (Oct - Mar) - winter flounder most abundant. October peak.  |
|                            | Monteville 5 & 6         | Thames R I/ L I Sound        | 75                    | 39,027 gpm                  | Canal       | 8/75 - 8/76      | 2 - 4 days/mo             | 24 hr samples weekly (Apr - Sep) & bi-weekly (Oct - Mar) - tomcod most abundant. July, Oct peak.   |
|                            |                          |                              | 410                   | 124,791 gpm                 | Canal       |                  |                           |  |
| Boston Edison              | Pilgrim                  | Cape Cod Bay                 | 652                   | 419,657 gpm                 | Shoreline   | 1/76 - 9/76      | Daily                     | Intakes include shoreline continuity, cutoff walls extending below normal low water & minimal approach velocities. May peak.                                   |
|                            |                          |                              | 830                   | 547,574 gpm                 | Shoreline   | 1/76 - 9/76      | Daily                     |  |
| Delmarva Pwr               | Edge Moor 1&2 3&4        | Delaware River               | 391                   | 144,000 gpm                 | Shoreline   | 9/72 - 9/76      | 48 hrs/wk                 | November peak, Aug sub-peak  |
|                            |                          |                              | 5                     | 396,000 gpm                 | Shoreline   | 4/74 - 9/75      | 122 weekly samples (1975) | 2 X / mo twice weekly for A M collections, semi-monthly. Oct peak, July sub-peak, 1974.  |
| Maine Yankee               | Maine Yankee             | Montsweag Bay                | 400                   | 396,000 gpm                 | Shoreline   |                  |                           | 24 hr samples; invertebrates counted. June peak, 1975.   |
|                            |                          |                              | 830                   | 403,920 gpm                 | Shoreline   | 44 samples, '75  | 1 day/wk                  | (1) 24 hr sample; 4 screens washed continuously. Jan peak, Apr sub-peak  |
| Central Maine              | William F Wyman 1, 2 & 3 | Casco Bay                    | 224                   | 48,000 gpm                  | Shoreline   | 48 samples, '76  |                           |  |
|                            |                          |                              |                       | 25,000 gpm                  | Shoreline   | 29 samples, '75  | 1 day/wk                  | 3 units; (1) 24 hr sample per week per unit; screens washed every 2 hrs for 24 hrs; increased impingement with lower temperatures. July, Sep, Nov., Dec peaks. |
|                            |                          |                              |                       | 25,000 gpm                  | Shoreline   | 37 samples, '76  |                           |  |



- SEE EXHIBIT 183 FOR LEGEND

JERSEY CENTRAL  
POWER & LIGHT COMPANY  
EBASCO SERVICES INCORPORATED  
New York

INTAKE FLOW VS. IMPINGEMENT  
AT NORTH ATLANTIC INTAKES  
DURING MONTHS OF MAXIMUM IMPINGEMENT

EXHIBIT  
182

## EXHIBIT 183

LEGEND FOR EXHIBIT 182INTAKE FLOW VS IMPINGEMENTAT NORTH ATLANTIC INTAKESDURING MONTHS OF MAXIMUMIMPINGEMENT

| <u>CODE</u> | <u>DESCRIPTION</u>  |
|-------------|---|
| Y19A        | January - Maine Yankee Atomic Power Co. - Maine Yankee              |
| F10D        | February - Consolidated Edison - Indian Point Unit 1                |
| A1          | April - Jersey Central Power & Light Co. - Oyster Creek             |
| A5B         | April - Long Island Lighting Co. - E.F. Barret Unit 2               |
| A19B        | April - Maine Yankee Atomic Power Co. - Maine Yankee                |
| M1          | May - Jersey Central Power & Light Co. - Oyster Creek               |
| M4          | May - Long Island Lighting Co. - Far Rockaway Unit 4                |
| M16A        | May - Northeast Utilities Service Co. - Millstone Unit 1            |
| J10A        | June - Consolidated Edison - Indian Point Unit 1                    |
| J10B        | June - Consolidated Edison - Indian Point Unit 2                    |
| J10C        | June - Consolidated Edison - Indian Point Unit 3                    |
| L10B        | July - Consolidated Edison - Indian Point Unit 2                    |
| L15         | July - Northeast Utilities Service Co. - Montville Plant            |
| L18D        | July - Delmarva Power Co. - Edge Moor Units 1 & 2                   |
| L18E        | July - Delmarva Power Co. - Edge Moor Units 3 & 4                   |
| L18F        | July - Delmarva Power Co. - Edge Moor Unit 5                        |
| L20B        | July - Central Maine Power Co. - W. F. Wyman Units 1, 2 & 3         |
| G3          | August - Jersey Central Power & Light Co. - Sayreville              |
| S19B        | September - Maine Yankee Atomic Power Co. - Maine Yankee            |
| S20A        | September - Central Maine Power Co. - W. F. Wyman Units<br>1, 2 & 3 |
| 05A         | October - Long Island Lighting Co. - E. F. Barret Unit 1            |
| 014         | October - Northeast Utilities Service Co. - Norwalk Harbor          |
| 018A        | October - Delmarva Power Co. - Edge Moor Units 1 & 2                |
| 018B        | October - Delmarva Power Co. - Edge Moor Units 3 & 4                |
| 018C        | October - Delmarva Power Co. - Edge Moor Units 5                    |
| N5A         | November - Long Island Lighting Co. - E. F. Barret Unit 1           |

Legend For Exhibit ... cont'd

| <u>CODE</u> | <u>DESCRIPTION</u>   |
|-------------|--|
| N5B         | November - Long Island Lighting Co. - E. F. Barret Unit 2              |
| N6B         | November - Long Island Lighting Co. - Port Jefferson<br>Units 1 & 2    |
| N7A         | November - Long Island Lighting Co. - Glenwood Unit 4                  |
| N7B         | November - Long Island Lighting Co. - Glenwood Unit 5                  |
| N10E        | November - Consolidated Edison - Indian Point Unit 2                   |
| N17         | November - Boston Edison - Pilgrim Plant                               |
| N20B        | November - Central Maine Power Company - W. F. Wyman<br>Units 1, 2 & 3 |
| D6A         | December - Long Island Lighting Co. - Port Jefferson<br>Units 1 & 2    |
| D6B         | December - Long Island Lighting Co. - Port Jefferson<br>Units 3 & 4    |
| D13         | December - Northeast Utilities Service Co. - Devon Plant               |
| D20A        | December - Central Maine Power Company - W. F. Wyman<br>Units 1, 2 & 3 |
| D20B        | December - Central Maine Power Company - W. F. Wyman<br>Units 1, 2 & 3 |

Exhibit 184

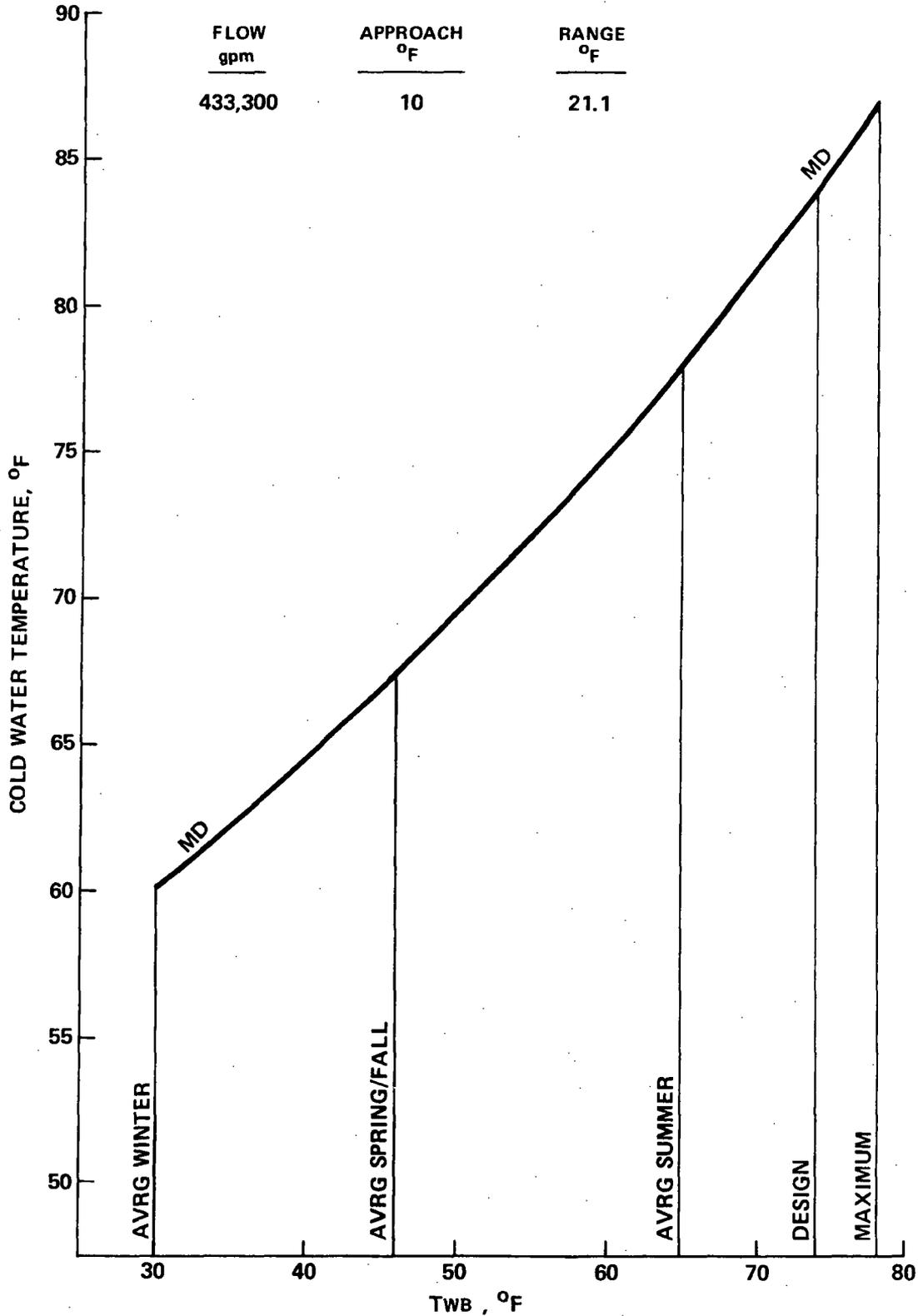
SLOPES AND CORRELATION COEFFICIENTS FOR THE REGRESSION LINE  
LOG (IMPINGEMENT) = m LOG (FLOW) + b, BY MONTH FOR ALL PLANTS

| <u>Month</u> | <u>Slope</u> | <u>Correlation Coefficient</u> |
|--------------|--------------|--------------------------------|
| January      | 1.88         | .60                            |
| February     | 1.00         | .35                            |
| March        | 1.85         | .62                            |
| April        | 1.73         | .55                            |
| May          | 1.48         | .54                            |
| June         | 1.26         | .45                            |
| July         | .97          | .34                            |
| August       | 1.24         | .36                            |
| September    | .34          | .13                            |
| October      | 1.26         | .42                            |
| November     | .86          | .39                            |
| December     | 1.06         | .43                            |
| Annual       | 1.19         | .41                            |

# JCP&L OYSTER CREEK NGS

EXHIBIT 185

## ROUND MECHANICAL DRAFT COOLING TOWER THERMAL PERFORMANCE AT FULL LOAD OPERATION

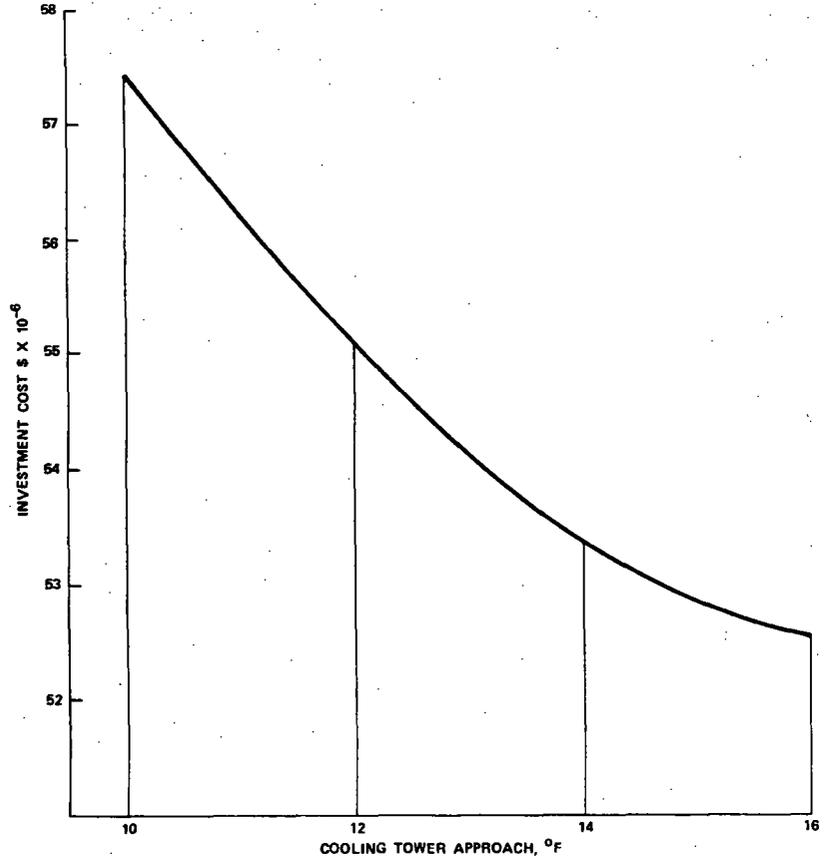




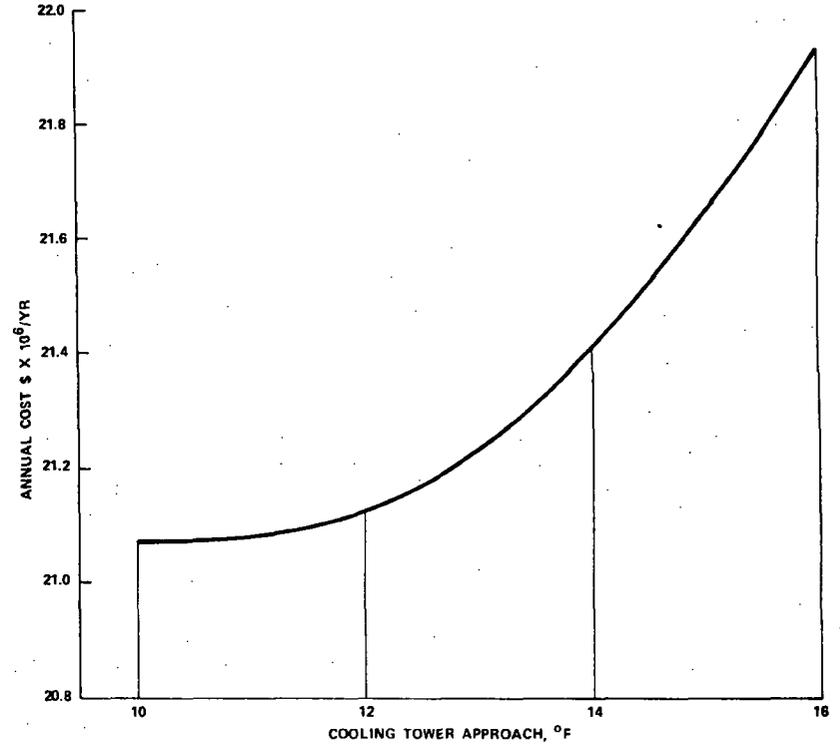
JCP&L OYSTER CREEK NUCLEAR GENERATING STATION  
ALTERNATIVE COOLING WATER SYSTEM STUDY

OPTIMUM MECHANICAL DRAFT ROUND COOLING TOWER SYSTEM  
ECONOMICS

TOTAL INVESTMENT COST  
IN MILLIONS OF DOLLARS



TOTAL COMPARABLE ANNUAL COST  
IN MILLIONS OF DOLLARS PER YEAR



## E B A S C O S E R V I C E S I N C O R P O R A T E D

PAGE 5  
A&C DEPT. A J MUSTO 11/67/77

THE FOLLOWING APPLIES TO ALL CONDENSING SYSTEM CASES:

UNIT: BASED ON GE-TC6P-38"LSB RATED 640MW @ 1.0"HGA

|                               |        |  |         |
|-------------------------------|--------|--|---------|
| CONDENSER:                    |        | SELECTED BASE FOR COOLING SYSTEM DIFFERENTIAL CALCULATIONS |         |
| TUBE MATERIAL                 | TITAN  | CONDENSER TUBE O.D. (IN)                                   | 4.875   |
| TUBE GAUGE                    | 22     | CONDENSER TUBE LENGTH (FT)                                 | 42.5    |
| TUBE CLEANLINESS FACTOR       | 0.900  | NO. OF CONDENSER TUBES                                     | 14562   |
| SINGLE OR MULTI BACK PRESSURE | SINGLE | COOLING TOWER FANS KW                                      | 0       |
| NO. OF CONDENSER SHELLS       | 3      | CIRCULATING WATER PUMPS KW                                 | 2666    |
|                               |        | ESTIMATED AUX. POWER REQUIREMENT EXCL. CR SYSTEM           | 17.50   |
| NO. OF PUMPS                  | 4      | TURBINE GENERATOR CAPABILITY (MW)                          | 670.0   |
| TYPE OF PUMPS                 | VEPT.  | UNIT NET CAPABILITY (MW)                                   | 620.00  |
|                               |        | CAPABILITY ADJUSTMENT (\$/KW)                              | 0.0     |
| ECONOMIC FACTORS              |        | UNIT NET ANNUAL GENERATION (MWH/YR)                        | 3539729 |
| RATE OF RETURN (%)            | 0.00   | GENERATION ADJUSTMENT (BTU/KWH)                            | 10400   |
| FIXED CHARGE RATE (%)         | 22.25  |  |         |

## TYPE OF COOLING SYSTEM: MECHANICAL DRAFT ROUND CT SYSTEM

|                           |       |
|---------------------------|-------|
| DESIGN WET BULB TEMP. (F) | 74.00 |
| DESIGN DRY BULB TEMP. (F) | 82.90 |
| DESIGN APPROACH TEMP. (F) | 10.00 |

## USER'S SELECTED SYSTEM LIMITATIONS

|                                     |      |
|-------------------------------------|------|
| MAX. CONDENSER BACK PRESS. (IN.HGA) | 5.00 |
| MAX. TEMPERATURE RISE (F)           | 25.0 |

CASES NUMBERED 1 TO 1000 SHOW CONDENSING SYSTEMS WITHIN A RANGE OF PLUS OR MINUS 0.25 IN.HGA OF AN AVERAGE BACK PRESSURE OF 2.00 IN.HGA

THE OTHER CASES ARE WITHIN A RANGE OF PLUS OR MINUS 0.25 IN.HGA OF THE FOLLOWING AVERAGE DESIGN BACK PRESSURES:

| AVERAGE DESIGN<br>BACK PRESSURE | CASES        |
|---------------------------------|--------------|
| -----                           | -----        |
| 2.50                            | 1001 TO 2000 |
| 3.00                            | 2001 TO 3000 |
| 3.50                            | 3001 TO 4000 |
| 4.00                            | 4001 TO 5000 |
| 4.50                            | 5001 TO 6000 |

CASES NUMBERED 6001 TO 6075 SHOW SMALLER VARIATIONS OF SURFACE AREA AND TUBE VELOCITY FOR THE PREVIOUS THREE BEST CASES BASED ON ANNUAL COST INCLUDING CAPABILITY AND GENERATION ADJUSTMENTS

\*\*\* FOR ZERO RATE OF RETURN IF MORE THAN ONE LINE IS FILLED IN UNDER LOADING PERIOD DATA THEN ANNUAL FUEL COST IS THE AVERAGE OF ALL THE YEARS' FUEL COSTS

SORT IN ASCENDING ORDER OF ANNUAL COST INCLUDING CAPABILITY & GENERATION ADJUSTMENTS

48C DEPT A J MUSTO 11/07/77

| CASE NO | ANNUAL SYSTEM COSTS |                     |         | INVESTMENT COSTS |                  | PERFORMANCE AT DESIGN CONDITIONS |                            |                                 |                     | PERFORMANCE AT PEAK LOAD CONDITION |                |                |                        |                      |
|---------|---------------------|---------------------|---------|------------------|------------------|----------------------------------|----------------------------|---------------------------------|---------------------|------------------------------------|----------------|----------------|------------------------|----------------------|
|         | WITHOUT ADJUSTMNTS  | INCLUDES ADJUSTMNTS | INITIAL | TOTAL            | TG CAPABIL. (MW) | AVG BACK PRESS IN HG             | TOTAL SURFACE AREA (SQ FT) | CONDENSER TEMP RISE ACROSS COND | TOTAL FLOW 1000 GPM | TUBE VELOC (FPS)                   | TUBE LGTH (FT) | TUBE DIAM (IN) | UNIT NET CAPABIL. (MW) | AVG BACK PRESS IN HG |
| 1       | 13529               | 20868               | 36105   | 56015            | 621.42           | 3.23                             | 423000                     | 21.1                            | 423.3               | 5.90                               | 43             | 0.875          | 584.04                 | 3.41                 |

|  |          |   |
|--|----------|---|
| SPECIFICATIONS FOR CASE NO. 1 MECHANICAL DRAFT ROUND CT SYSTEM |          | ABC DEPT A J MASTO 11/07/77 PAGE 7              |
| CW INLET DESIGN TEMPERATURE (F)                                | 84.00    | PERFORMANCE AT DESIGN CONDITIONS:               |
| CONDENSER TEMPERATURE RISE (F)                                 | 21.05    | TG CAPABILITY (MW) 621.42                       |
| TUBE DIAMETER (INCHES)/GAUGE                                   | 0.875/22 | AVG CONDENSER PRESSURE (IN.HGA) 3.23            |
| TOTAL TUBE LENGTH (FT/SHELL)                                   | 42,50    |   |
| NO. OF TUBES PER SHELL/SHELLS                                  | 14562/3  |   |
| NO. OF TUBE PASSES/PRESS ZONES                                 | 1/1      | PERFORMANCE AT MAX SUMMER TEMPERATURE           |
| TOTAL SURFACE AREA (SQ FT)                                     | 423000   | TG CAPABILITY (MW) 617.64                       |
| CIRCULATING WATER FLOW (GPM)                                   | 423300   | AVG CONDENSER PRESSURE (IN.HGA) 3.41            |
| TUBE VEL. AT ABOVE CW FLOW (FPS)                               | 5.90     |   |
|  |          | AVG SEASONAL COND PRESS (IN.HGA) 1.70 2.04 2.73 |

|                              |       |
|------------------------------|-------|
| NO. OF COOLING TOWERS-CT     | 2     |
| NO. OF CELLS PER CT          | 10    |
| CT DESIGN APPROACH TEMP (F)  | 10.00 |
| TOTAL CT FAN MOTOR INPUT KW  | 6343  |
| TOTAL CW PUMP MOTOR INPUT KW | 8757  |
| CW PUMP MOTOR RATING (HP)    | 3000  |
| CW SYSTEM TDH (FT)           | 84.80 |
| CW MAIN CONDUIT DIAM (FT)    | 10.00 |
| NO. OF CW PUMPS              | 4     |
| TOTAL DILUTION PUMP INPUT KW | 1000  |

| ACCOUNT CODE | INITIAL INVESTMENT COST ITEMS                 | ESTIMATED INITIAL INVESTMENT COST |              | TODAY'S INSTALLATION COST |              | ESCALATION 1000% |              |
|--------------|---|-----------------------------------|--------------|---------------------------|--------------|------------------|--------------|
|              |   | UNIT                              | TOTAL 1000\$ | UNIT                      | TOTAL 1000\$ | MATERIAL         | INSTALLATION |
| 1.11         | MAJOR SITE DEVELOPMENT                        |                                   | 4000         |                           | 1600         | 1300             | 751          |
|              | LOCAL IMPROVEMENT TO SITE-CLEARING            |                                   |              | 0\$/ACRE                  | 0            |                  | 0            |
| 2.1          | LOCAL GRADING                                 |                                   |              | 2.50\$/CU YD              | 27           |                  | 10           |
| 2.5          | PILING  | 0.00\$/SQ FT                      | 0            | 0.00\$/SQ FT              | 0            | 0                | 0            |
| 3.42         | INTAKE STRUCTURE                              | 4.10\$/CU FT                      | 480          | 10.75\$/CU FT             | 1260         | 162              | 739          |
| 3.2          | CIRCULATING WATER CONDUIT: MAIN               | 329\$/LIN FT                      | 526          | 232.00\$/LIN FT           | 371          | 178              | 218          |
|              | BRANCHES                                      | 65.00\$/LIN FT                    | 156          | 65.21\$/LIN FT            | 157          | 53               | 92           |
| 3.32         | DISCHARGE STRUCTURE                           | 0.00\$/CU FT                      | 0            | 0.00\$/CU FT              | 0            | 0                | 0            |
| 3.41         | COOLING TOWER BASIN                           | 0.80\$/SQ FT                      | 69           | 8.20\$/SQ FT              | 704          | 23               | 331          |
| 3.44         | COOLING TOWER SUPERSTRUCTURE                  | 2653050\$/EACH                    | 5306         | 2170677\$/EACH            | 4341         | 2221             | 2508         |
| 5.1          | TG BUILDING (DIFFERENTIAL)                    | 0.00\$/CU FT                      | 0            | 0.00\$/CU FT              | 0            | 0                | 0            |
| 4.18         | TG PEDESTAL (DIFFERENTIAL)                    | 0\$/FT HT                         | 0            | 0\$/FT HT                 | 0            | 0                | 0            |
| 7.1          | TG & ACCESSORIES (DIFFERENTIAL)               | 0.00\$/KVA                        | 0            | 0.00\$/KVA                | 0            | 0                | 0            |
| 10.211       | CONDENSER SHELL                               | 0\$/EACH                          | 0            | 0\$/EACH                  | 0            | 0                | 0            |
| 10.213       | CONDENSER TUBE (TITAN)                        | 0.0000\$/FT                       | 0            | 0.0000\$/FT               | 0            | 0                | 0            |
| 10.221       | CIRCULATING WATER PUMP                        | 245280\$/EACH                     | 981          | 245280\$/EACH             | 98           | 332              | 58           |
| 15.3         | CIRCULATING WATER PUMP MOTOR                  | 206375\$/EACH                     | 826          | 8255\$/EACH               | 33           | 279              | 19           |
| 14.1         | INSTRUMENTATION & CONTROL                     | 1504.76\$/EACH                    | 63           | 1019.05\$/EACH            | 43           | 21               | 25           |
| 15.11        | START-UP & STANDBY TRANSFORMER (DIFFERENTIAL) | 0\$/MVA                           | 0            | 0\$/MVA                   | 0            | 0                | 0            |
| 15.12        | UNIT AUXILIARY TRANSFORMER (DIFFERENTIAL)     | 6700\$/MVA                        | 93           | 1200\$/MVA                | 17           | 31               | 10           |
| 15.21        | CIRCULATING WATER SWITCHGEAR                  | 43000\$/PUMP                      | 172          | 18000\$/PUMP              | 72           | 59               | 47           |
| 15.6         | WIRING FOR CIRCULATING WATER SYSTEM           | 39887\$/MVA                       | 669          | 113812\$/MVA              | 1910         | 226              | 1121         |
| 15.1         | UNIT MAIN POWER TRANSFORMER (DIFFERENTIAL)    | 0\$/MVA                           | 0            | 0\$/MVA                   | 0            | 0                | 0            |
| 15.23        | FAN MOTOR POWER CENTER + REVD SWGR & FEEDER   | 166000\$/CENTER                   | 664          | 37000\$/CENTER            | 108          | 225              | 87           |
|              | TOTAL   |                                   | 14085        |                           | 10780        | 5190             | 6050         |

TOTAL DIRECT ESCALATED COST, MATERIAL PLUS 0.00% SALES/USE TAX PLUS INSTALLATION 36105  
 INDIRECT CONSTRUCTION COST INCLUDING PROFESSIONAL SERVICES 5462  
 CONTINGENCY (14.00% OF DIRECT PLUS INDIRECT COST) 5019  
 UTILITY'S EXPENSES, INTEREST DURING CONSTRUCTION, & LAND 8029

TOTAL ESTIMATED INVESTMENT COST 1000\$ 56015

| ESTIMATED COMPARABLE INVESTMENT & ANNUAL COSTS                            |                         | 1000\$/YR MILLS/KWH   |       |
|---|-------------------------|---|-------|
| UNIT NET CAPABILITY #/SF/S/P (MW)   | 619.1 614.8 599.0 584.0 | CW SYSTEM FUEL COST (BASE VALUE)  | 163   |
| DIFFERENTIAL UNIT NET CAPABILITY (MW)                                     | 35.96                   | ANNUAL FIXED CHARGES (AT RATE 0.2225)   | 12463 |
|   |                         | WATER COST (AT 0.00\$/MILLION GALLONS + CHEMICALS)  | 155   |
| UNIT NET ANNUAL GENERATION (MWH/YR)                                       | 3423282                 | MAINTENANCE (1.20% OF TOTAL INV + 2009\$/FAN)   | 748   |
| DIFFERENTIAL UNIT NET GENERATION (MWH/YR)                                 | 116447                  | SUBTOTAL ANNUAL COST  | 13529 |
|   |                         | NET PRODUCTION COST   | 3.952 |
| WATER CONSUMPTION (MILLION GALLONS/YR)                                    | 6192                    |   |       |
| TOTAL ANNUAL UNIT FUEL COST (AT 0.6500\$/MILLION BTU)                     | (1000\$) 23981          | ADJUSTMENT FOR DIFFERENTIAL CAPABILITY  | 1017  |
| TOTAL COMPARABLE INVESTMENT COST INCLUDING CAPABILITY ADJUSTMENT (1000\$) | 60587                   | ADJUSTMENT FOR DIFFERENTIAL NET ANNUAL GENERATION   | 6261  |
|   |                         | TOTAL COMPARABLE ANNUAL COST INCLUDING ADJUSTMENTS FOR EQUALIZED CAPABILITY & NET ANNUAL GENERATION | 20808 |
|   |                         | COMPARABLE NET PRODUCTION COST INCL. ADJUSTMENTS  | 5.876 |



## Exhibit 189

OYSTER CREEK ROUND MECHANICALDRAFT TOWER IMPACTSTABLE 2

PREDICTED MAXIMUM PEAK SHORT-TERM NEAR  
GROUND AIRBORNE CONCENTRATION ( $\mu\text{g}/\text{m}^3$ ) OF SALT RESULTING  
FROM OPERATION OF TWO ROUND MECHANICAL DRAFT COOLING  
TOWERS AT THE OYSTER CREEK SITE

| <u>Month</u> | <u>Hours of Persistence</u> | <u>Direction (a)</u> | <u>Distance (miles)</u> | <u>Near Ground Airborne Concentration (<math>\mu\text{g}/\text{m}^3</math>)</u> |
|--------------|-----------------------------|----------------------|-------------------------|---|
| January      | 9                           | ESE                  | .5                      | 33.8  |
| February     | 10                          | ESE                  | .5                      | 17.2  |
| March        | 5                           | E                    | .5                      | 36.0  |
| April        | 7                           | E                    | .5                      | 19.6  |
| May          | 15                          | WSW                  | .5                      | 23.6  |
| June         | 5                           | NE                   | .75                     | 9.4   |
| July         | 5                           | NW                   | 1.25                    | 10.4  |
| August       | 7                           | SE                   | 1.25                    | 8.6   |
| September    | 5                           | ENE                  | .75                     | 12.2  |
| October      | 5                           | ESE                  | .75                     | 13.8  |
| November     | 7                           | WSW                  | .5                      | 21.2  |
| December     | 7                           | SE                   | .5                      | 24.0  |

(a) Indicates direction where salt is deposited - winds come from opposite direction

Source: Pickard, Lowe and Garrick, Inc.,  
 October 1977.

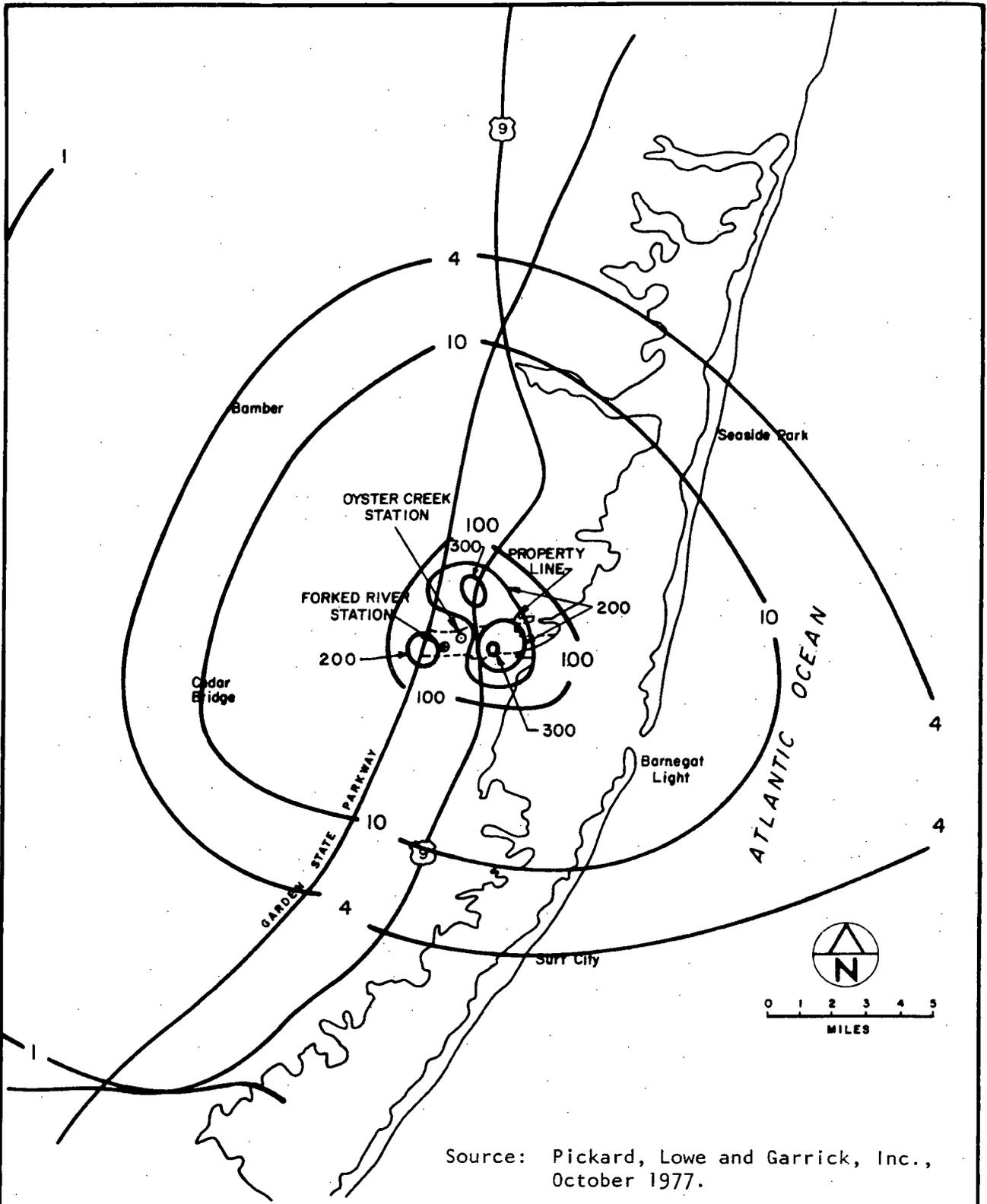
Exhibit 189  
OYSTER CREEK ROUND MECHANICAL  
DRAFT TOWER IMPACTS  
TABLE 3

PREDICTED MAXIMUM PEAK SHORT-TERM NEAR GROUND AIRBORNE  
CONCENTRATION (ug/m<sup>3</sup>) OF SALT RESULTING FROM OPERATION OF TWO  
ROUND MECHANICAL DRAFT COOLING TOWERS AT THE OYSTER CREEK  
SITE AND ONE NATURAL DRAFT COOLING TOWER AT THE FORKED RIVER SITE

| <u>Month</u> | <u>Hours of Persistence</u> | <u>Direction (a)</u> | <u>Distance (miles)</u> | <u>Near Ground Airborne Concentration (ug/m<sup>3</sup>)</u> |
|--------------|-----------------------------|----------------------|-------------------------|--|
| January      | 9                           | ESE                  | 0.5                     | 33.8   |
| February     | 10                          | ESE                  | 0.5                     | 17.2   |
| March        | 5                           | E                    | 0.5                     | 36.0   |
| April        | 7                           | E                    | 0.5                     | 19.6   |
| May          | 15                          | WSW                  | 0.5                     | 23.6   |
| June         | 5                           | NE                   | 0.75                    | 9.6  |
| July         | 5                           | NW                   | 1.25                    | 10.4   |
| August       | 7                           | SE                   | 1.25                    | 8.6  |
| September    | 5                           | ENE                  | 0.75                    | 12.5   |
| October      | 5                           | ESE                  | 0.75                    | 13.8   |
| November     | 7                           | WSW                  | 0.5                     | 21.2   |
| December     | 7                           | SE                   | 0.5                     | 24.0   |

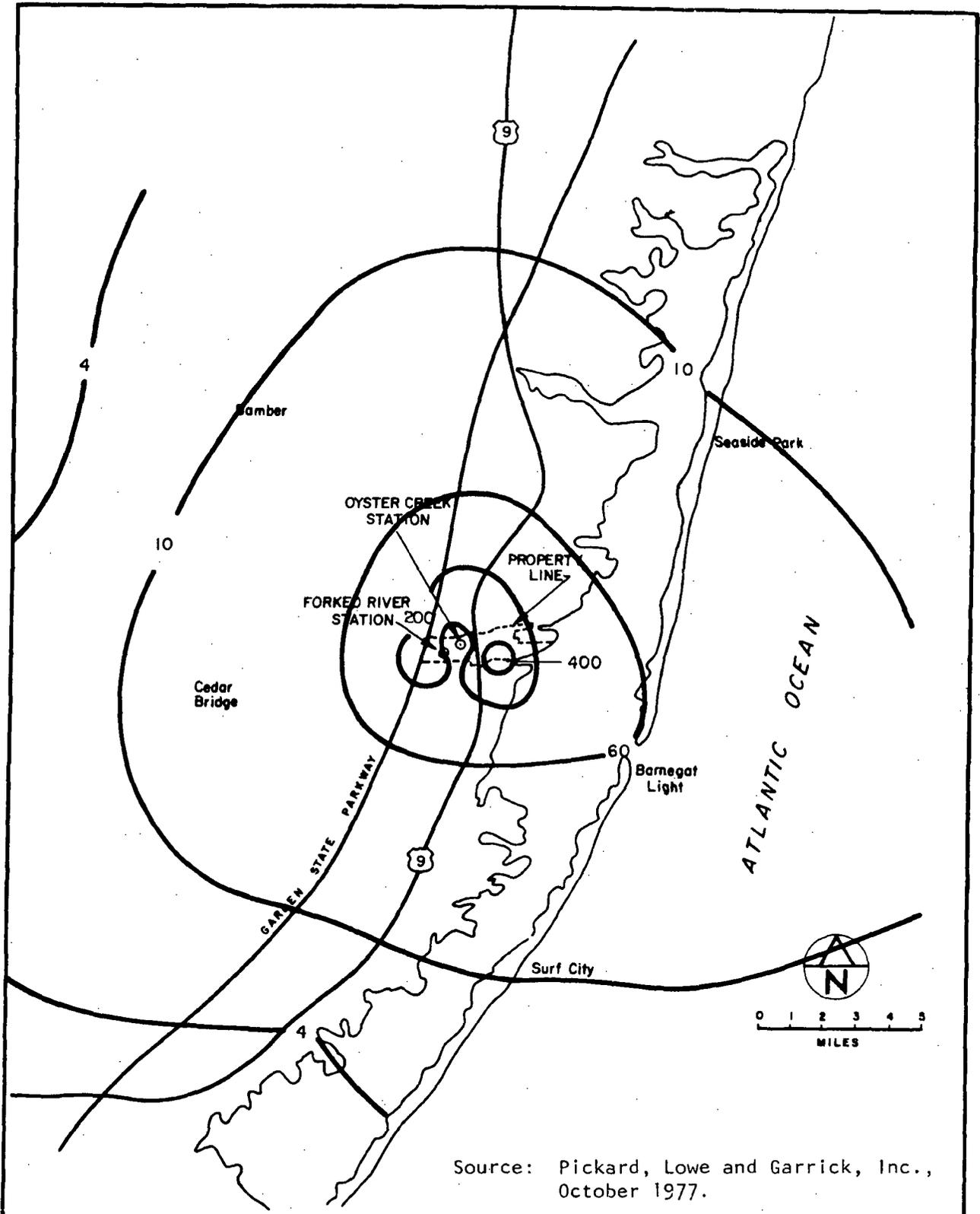
(a) Indicates direction where salt is deposited - winds come from opposite direction

Source: Pickard, Lowe and Garrick, Inc.,  
 October 1977.



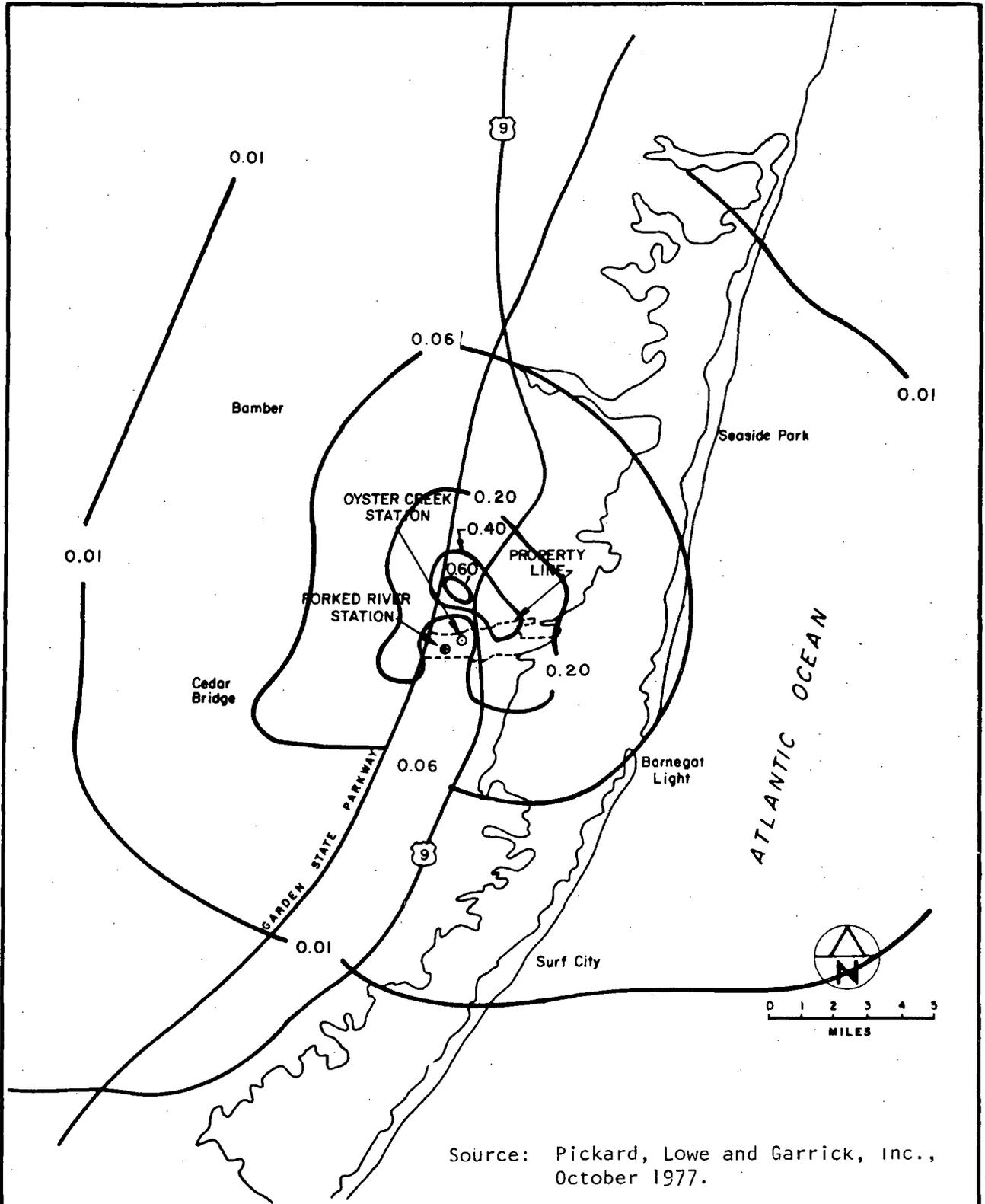
Source: Pickard, Lowe and Garrick, Inc.,  
October 1977.

|   |  |                        |
|---|--|------------------------|
| <p>JERSEY CENTRAL<br/>POWER &amp; LIGHT COMPANY</p> | <p>ANNUAL AVERAGE SALT DEPOSITION<br/>RATE (kg/km<sup>2</sup>-MONTH) FROM TWO<br/>ROUND TOWERS AT THE OYSTER<br/>CREEK SITE (0-15 MILES)</p> | <p>EXHIBIT<br/>190</p> |
| <p>EBASCO SERVICES INCORPORATED<br/>New York</p>    |  |                        |

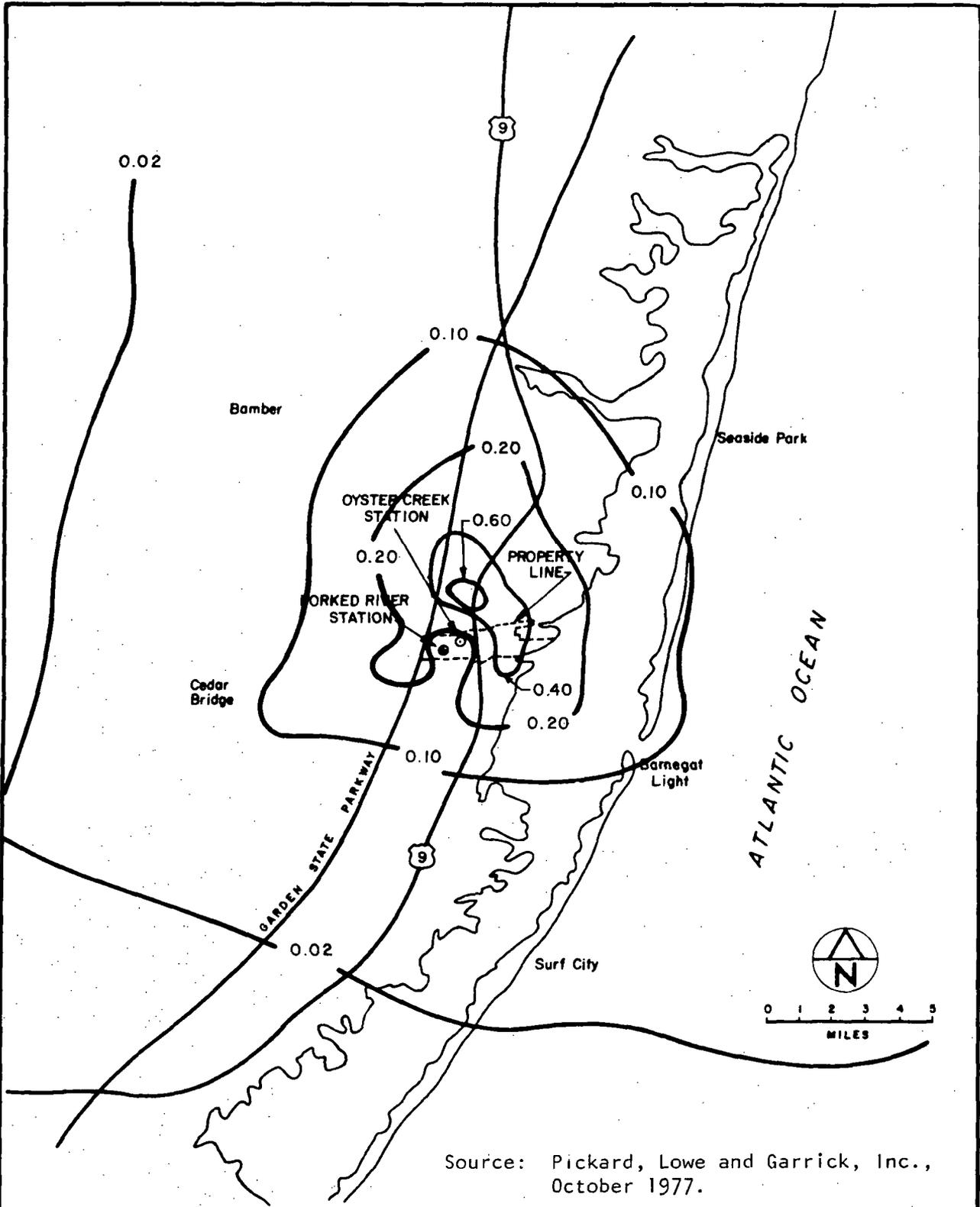


Source: Pickard, Lowe and Garrick, Inc.,  
October 1977.

|  |  |         |
|--|--|---------|
| JERSEY CENTRAL<br>POWER & LIGHT COMPANY  | ANNUAL AVERAGE SALT DEPOSITION<br>RATE (kg/km <sup>2</sup> -month) FROM TWO<br>ROUND TOWERS AT OYSTER CREEK<br>AND ONE NATURAL DRAFT TOWER<br>AT FORKED RIVER (0-15 MILES) | EXHIBIT |
| EBASCO SERVICES INCORPORATED<br>New York |  | 191     |



|   |  |                |
|---|--|----------------|
| <p>JERSEY CENTRAL<br/>POWER &amp; LIGHT COMPANY</p> | <p>AVERAGE SUMMER AIRBORNE SALT<br/>CONCENTRATIONS (<math>\mu\text{g}/\text{m}^3</math>) FROM TWO<br/>ROUND TOWERS AT THE OYSTER<br/>CREEK SITE (0-15 MILES)</p> | <p>EXHIBIT</p> |
| <p>EDASCO SERVICES INCORPORATED<br/>New York</p>    |  | <p>192</p>     |



Source: Pickard, Lowe and Garrick, Inc.,  
October 1977.

|   |  |                |
|---|--|----------------|
| <p>JERSEY CENTRAL<br/>POWER &amp; LIGHT COMPANY</p> | <p>AVERAGE SUMMER AIRBORNE SALT<br/>CONCENTRATIONS (ug/m<sup>3</sup>) FROM TWO<br/>ROUND TOWERS AT THE OYSTER<br/>CREEK AND ONE NATURAL DRAFT<br/>TOWER AT FORKED RIVER (0-15 MILES)</p> | <p>EXHIBIT</p> |
| <p>EBASCO SERVICES INCORPORATED<br/>New York</p>    |  | <p>193</p>     |

Exhibit 194

AVERAGE CONDITIONS

ROUND MECHANICAL DRAFT TOWERS

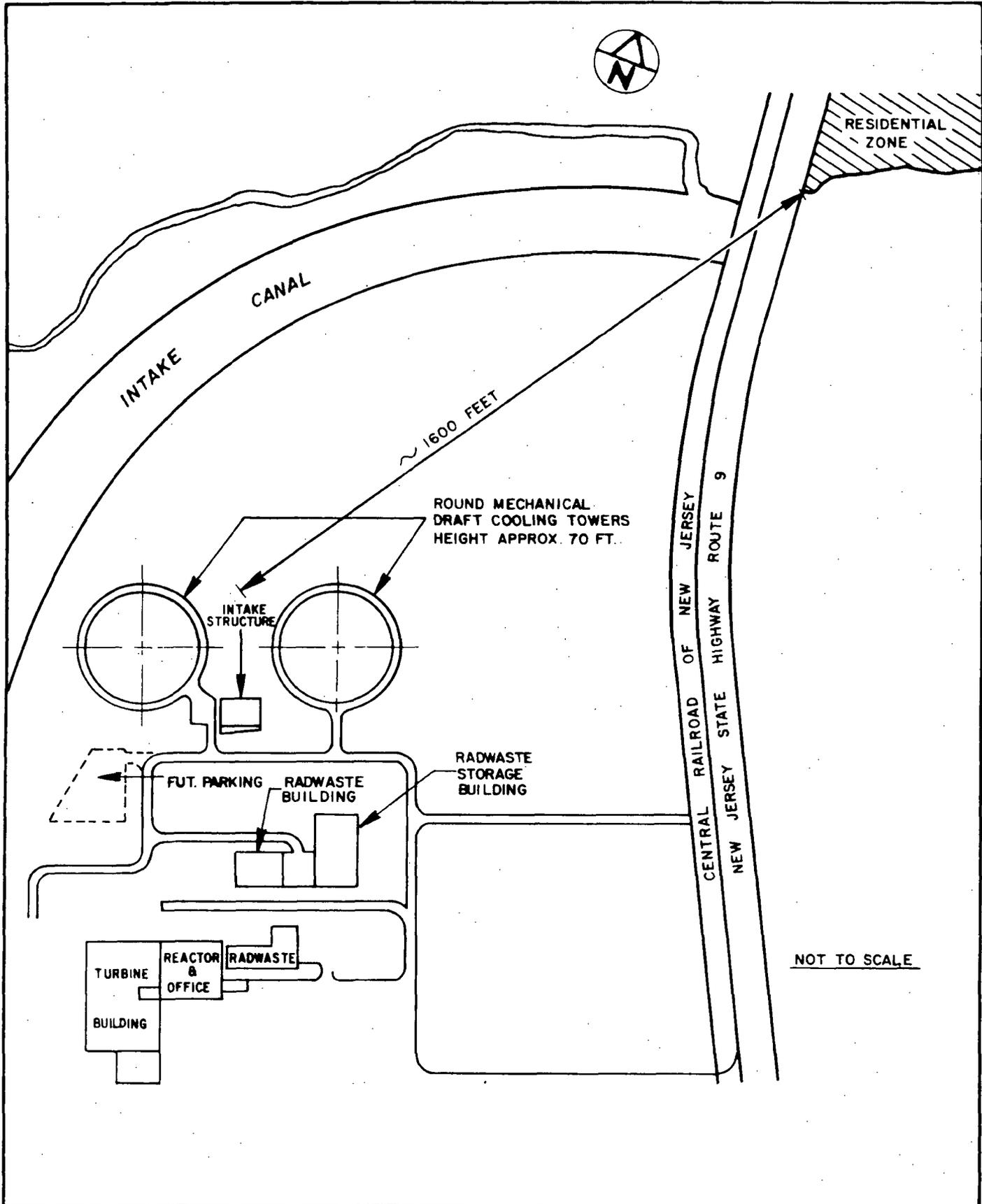
| <u>Month</u> | <u>Oyster Creek NGS<br/>Discharge Flow<br/>GPM</u> | <u>Forked River NGS<br/>Discharge Flow<br/>GPM</u> | <u>Required*<br/>Dilution Flow<br/>GPM</u> | <u>Combined Flow<br/>to Oyster Creek<br/>GPM</u> | <u>Combined<br/>Temperature Rise<br/>in Oyster Creek<br/>Deg F</u> |
|--------------|--|--|--|--|--|
| January      | 16,200   | 26,400   | 520,000                                    | 562,600  | 2.5  |
| February     | 16,200   | 26,200   | 260,000                                    | 302,400  | 3.9  |
| March        | 16,000   | 25,600   | 260,000                                    | 301,600  | 3.1  |
| April        | 15,400   | 25,000   | 260,000                                    | 300,400  | 2.2  |
| May          | 14,800   | 24,600   | 260,000                                    | 299,400  | 1.4  |
| June         | 14,500   | 24,100   | 260,000                                    | 298,600  | 1.0  |
| July         | 14,400   | 23,800   | 260,000                                    | 298,200  | 0.9  |
| August       | 14,400   | 23,800   | 260,000                                    | 298,200  | 1.0  |
| September    | 14,600   | 24,200   | 260,000                                    | 298,800  | 1.5  |
| October      | 15,000   | 24,700   | 260,000                                    | 299,700  | 2.2  |
| November     | 15,500   | 25,100   | 260,000                                    | 300,600  | 3.2  |
| December     | 16,200   | 26,200   | 260,000                                    | 302,400  | 3.9  |

\* Required to Meet Thermal Criteria in  
Oyster Creek with Respect to Temperature Rise

EXTREME CONDITIONSROUND MECHANICAL DRAFT TOWERS

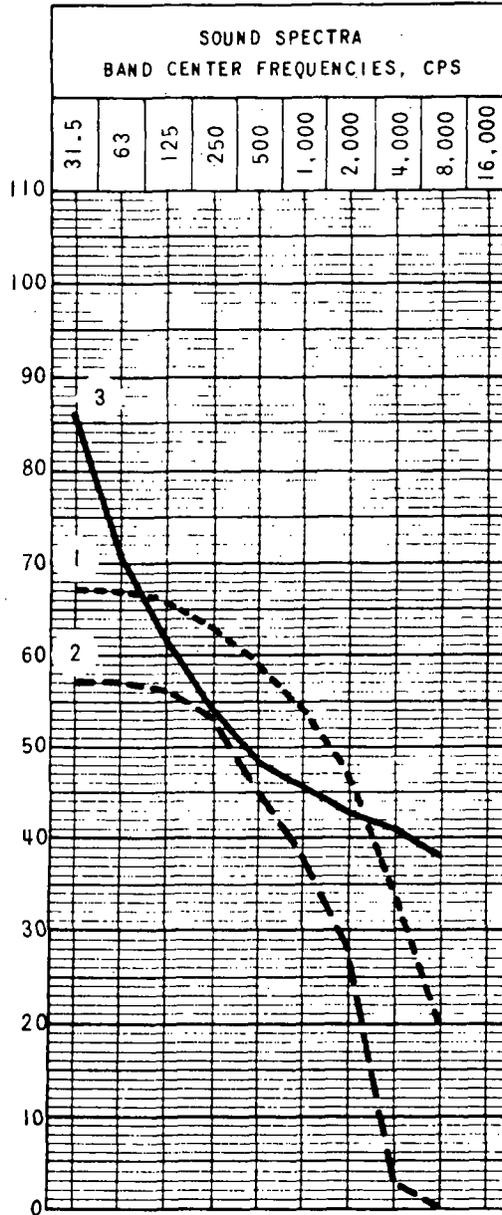
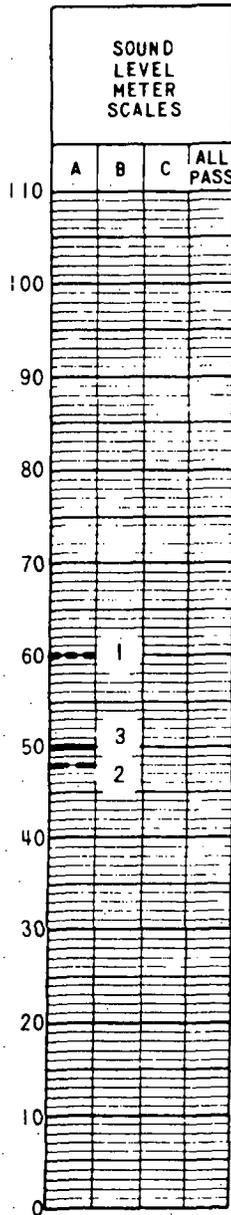
| <u>Month</u> | <u>Oyster Creek NGS<br/>Discharge Flow<br/>GPM</u> | <u>Forked River NGS<br/>Discharge Flow<br/>GPM</u> | <u>Required*<br/>Dilution Flow<br/>GPM</u> | <u>Combined Flow<br/>to Oyster Creek<br/>GPM</u> | <u>Combined<br/>Temperature Rise<br/>in Oyster Creek<br/>Deg F</u> |
|--------------|--|--|--|--|--|
| January      | 14,700   | 24,400   | 520,000                                    | 559,100  | 3.4  |
| February     | 14,600   | 24,300   | 520,000                                    | 558,900  | 3.2  |
| March        | 14,500   | 24,200   | 520,000                                    | 558,700  | 2.6  |
| April        | 14,400   | 23,800   | 260,000                                    | 298,200  | 3.9  |
| May          | 14,100   | 23,100   | 260,000                                    | 297,200  | 3.1  |
| June         | 13,500   | 22,100   | 520,000                                    | 555,600  | 1.4  |
| July         | 13,500   | 22,100   | 520,000                                    | 555,600  | 1.2  |
| August       | 13,500   | 22,100   | 520,000                                    | 555,600  | 1.2  |
| September    | 13,600   | 22,300   | 260,000                                    | 295,900  | 3.1  |
| October      | 14,300   | 23,500   | 260,000                                    | 297,800  | 3.7  |
| November     | 14,400   | 23,800   | 520,000                                    | 558,200  | 2.7  |
| December     | 14,600   | 24,400   | 520,000                                    | 559,000  | 3.1  |

\* Required to Meet Thermal Criteria in  
Oyster Creek with Respect to Temperature Rise



|   |   |                |
|---|---|----------------|
| <p>JERSEY CENTRAL<br/>POWER &amp; LIGHT COMPANY</p> | <p>LOCATION OF<br/>ROUND MECHANICAL DRAFT COOLING TOWERS<br/>WITH RESPECT TO NEAREST RESIDENTIAL ZONE</p> | <p>EXHIBIT</p> |
| <p>EBASCO SERVICES INCORPORATED<br/>New York</p>    |   | <p>196</p>     |

SOUND PRESSURE LEVEL - DECIBELS (db - Re 0.0002 Microbars)



1. UNATTENUATED SPL AT A DISTANCE OF ABOUT 1600 FT FROM TWO TOWERS
2. UNATTENUATED SPL AT A DISTANCE OF ABOUT 5000 FT FROM TWO TOWERS
3. NEW JERSEY NIGHTTIME CRITERION

JERSEY CENTRAL  
POWER & LIGHT COMPANY

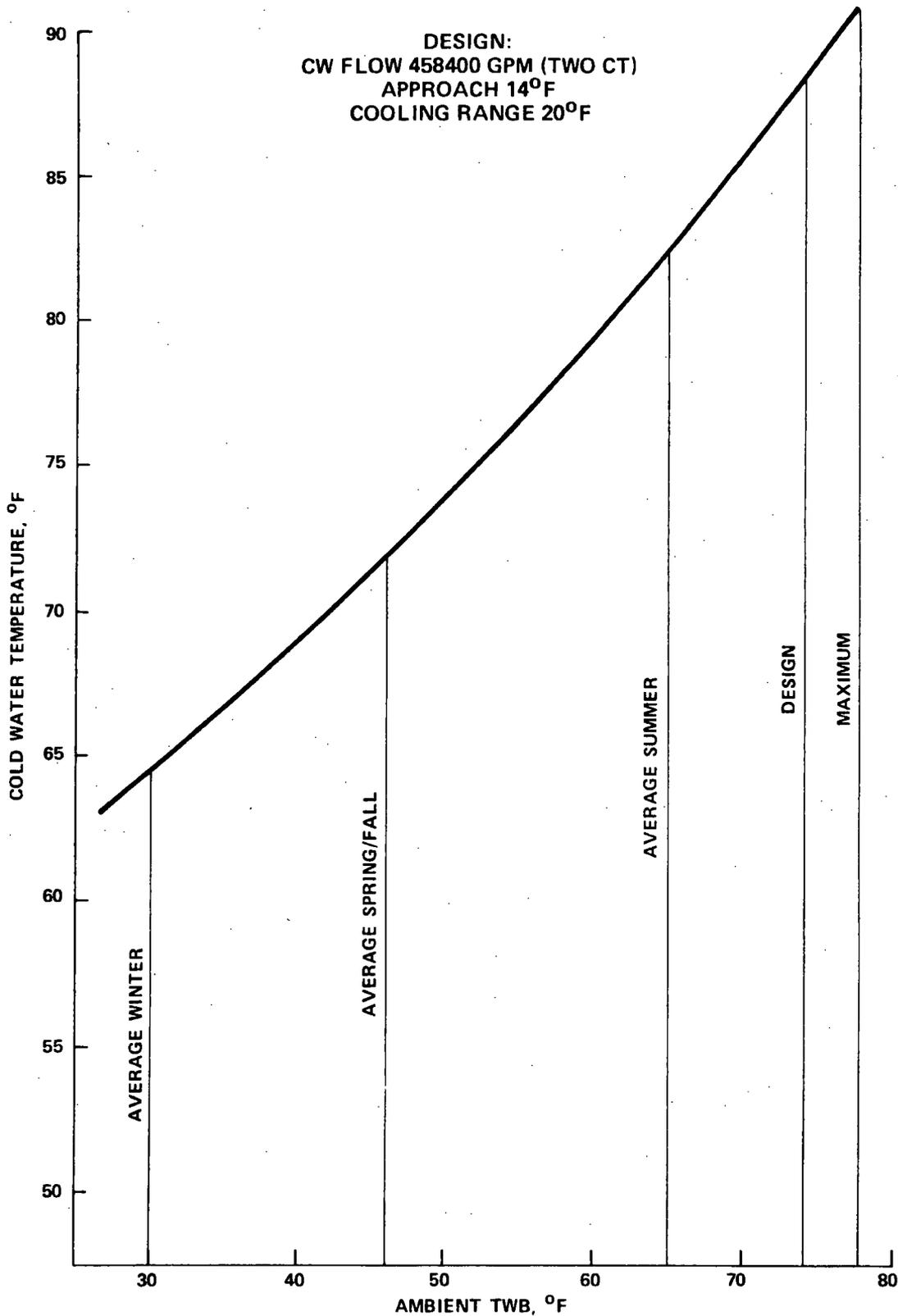
EBASCO SERVICES INCORPORATED  
New York

NOISE DATA FOR MECHANICAL  
COUNTERFLOW ROUND TOWERS

EXHIBIT

197

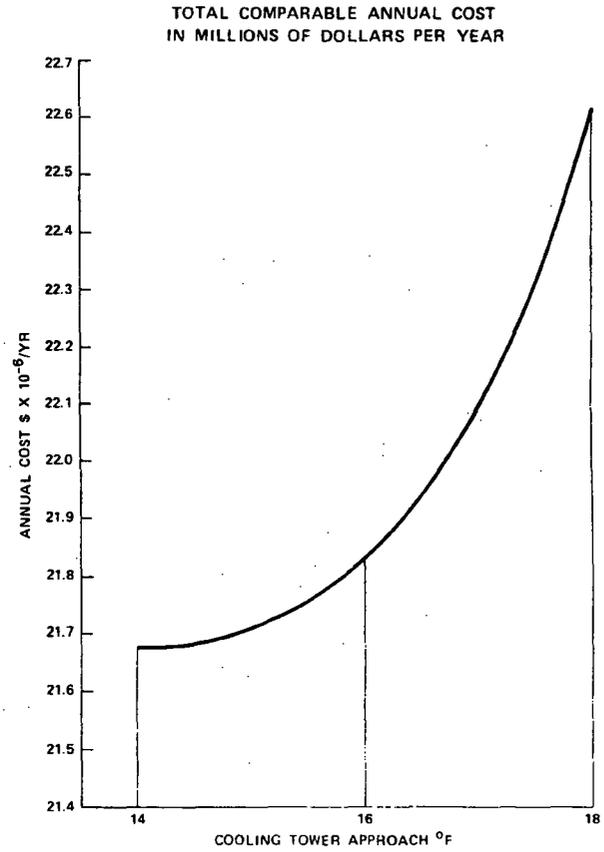
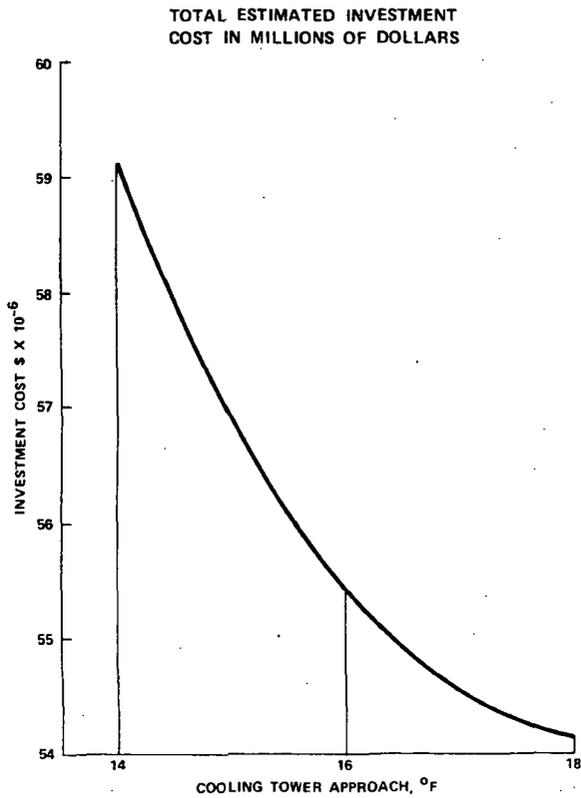
# ICP&L OYSTER CREEK NGS FAN ASSISTED COOLING TOWER THERMAL PERFORMANCE AT FULL LOAD OPERATION AND 100% FAN POWER





JCP&L OYSTER CREEK NUCLEAR GENERATING STATION  
ALTERNATIVE COOLING WATER SYSTEM STUDY

OPTIMUM FAN - ASSISTED COOLING TOWER SYSTEM  
ECONOMICS



## E B A S I C O S E R V I C E S I N C O R P O R A T E D

PAGE 5

A&amp;C DEPT. A J MUSTO 11/10/77

THE FOLLOWING APPLIES TO ALL CONDENSING SYSTEM CASES:

UNIT: BASED ON GE-TC6F-38"LSR RATED 640MW @ 1.0"HGA

## CONDENSER:

|                               |        |
|-------------------------------|--------|
| TUBE MATERIAL                 | TITAN  |
| TUBE GAUGE                    | 22     |
| TUBE CLEANLINESS FACTOR       | 0.900  |
| SINGLE OR MULTI BACK PRESSURE | SINGLE |
| NO. OF CONDENSER SHELLS       | 3      |

|               |       |
|---------------|-------|
| NO. OF PUMPS  | 4     |
| TYPE OF PUMPS | VERT. |

## ECONOMIC FACTORS

|                       |       |
|-----------------------|-------|
| RATE OF RETURN (%)    | 0.00  |
| FIXED CHARGE RATE (%) | 22.25 |

## SELECTED BASE FOR COOLING SYSTEM DIFFERENTIAL CALCULATIONS

|  |         |
|--|---------|
| CONDENSER TUBE O.D. (IN)                         | 0.875   |
| CONDENSER TUBE LENGTH (FT)                       | 42.5    |
| NO. OF CONDENSER TUBES                           | 14562   |
| COOLING TOWER FANS KW                            | 0       |
| CIRCULATING WATER PUMPS KW                       | 2666    |
| ESTIMATED AUX. POWER REQUIREMENT EXCL. CW SYSTEM | 17.50   |
| TURBINE GENERATOR CAPABILITY (MW)                | 670.0   |
| UNIT NET CAPABILITY (MW)                         | 620.00  |
| CAPABILITY ADJUSTMENT (\$/KW)                    | 0.0     |
| UNIT NET ANNUAL GENERATION (MWH/YR)              | 3539729 |
| GENERATION ADJUSTMENT (BTU/KWH)                  | 10400   |

## TYPE OF COOLING SYSTEM: FAN ASSISTED NO COOLING TOWER SYSTEM

|                           |       |
|---------------------------|-------|
| DESIGN WET BULB TEMP. (F) | 74.00 |
| DESIGN DRY BULB TEMP. (F) | 88.00 |
| DESIGN APPROACH TEMP. (F) | 14.00 |

## USER'S SELECTED SYSTEM LIMITATIONS

|                                     |      |
|-------------------------------------|------|
| MAX. CONDENSER BACK PRESS. (IN.HGA) | 5.00 |
| MAX. TEMPERATURE RISE (F)           | 25.0 |

CASES NUMBERED 1 TO 1000 SHOW CONDENSING SYSTEMS WITHIN A RANGE OF PLUS OR MINUS 0.25 IN.HGA OF AN AVERAGE BACK PRESSURE OF 2.00 IN.HGA

THE OTHER CASES ARE WITHIN A RANGE OF PLUS OR MINUS 0.25 IN.HGA OF THE FOLLOWING AVERAGE DESIGN BACK PRESSURES:

| AVERAGE DESIGN<br>BACK PRESSURE | CASES        |
|---------------------------------|--------------|
| -----                           | -----        |
| 2.50                            | 1001 TO 2000 |
| 3.00                            | 2001 TO 3000 |
| 3.50                            | 3001 TO 4000 |
| 4.00                            | 4001 TO 5000 |
| 4.50                            | 5001 TO 6000 |

CASES NUMBERED 6001 TO 6075 SHOW SMALLER VARIATIONS OF SURFACE AREA AND TUBE VELOCITY FOR THE PREVIOUS THREE BEST CASES BASED ON ANNUAL COST INCLUDING CAPABILITY AND GENERATION ADJUSTMENTS

\*\*\* FOR ZERO RATE OF RETURN IF MORE THAN ONE LINE IS FILLED IN UNDER LOADING PERIOD DATA THEN ANNUAL FUEL COST IS THE AVERAGE OF ALL THE YEARS' FUEL COSTS

SORT IN ASCENDING ORDER OF ANNUAL COST INCLUDING CAPABILITY & GENERATION ADJUSTMENTS

A&C DEPT A J MUSTO 11/10/77

| CASE NO. | ANNUAL SYSTEM COSTS |                     |                 | INVESTMENT COSTS | PERFORMANCE AT DESIGN CONDITIONS |                      |                            |                       |                     |                  |                | PERFORMANCE AT PEAK LOAD CONDITION |                        |                      |
|----------|---------------------|---------------------|-----------------|------------------|----------------------------------|----------------------|----------------------------|-----------------------|---------------------|------------------|----------------|------------------------------------|------------------------|----------------------|
|          | WITHOUT ADJUSTMNTS  | INCLUDES ADJUSTMNTS | INITIAL + ESCAL | TOTAL            | TG CAPABIL. (MW)                 | AVG BACK PRESS IN HG | TOTAL SURFACE AREA (SQ FT) | TEMP RISE ACROSS COND | TOTAL FLOW 1000 GPM | TUBE VELOC (FPS) | TUBE LGTH (FT) | TUBE DIAM (IN)                     | UNIT NET CAPABIL. (MW) | AVG BACK PRESS IN HG |
| 1        | 13930               | 21305               | 37168           | 57632            | 616.46                           | 3.47                 | 423000                     | 20.0                  | 448.4               | 6.25             | 43             | 0.875                              | 574.23                 | 4.09                 |

|  |          |                                       |                                    |       |
|--|----------|---------------------------------------|------------------------------------|-------|
| SPECIFICATIONS FOR CASE NO. 1 FAN ASSISTED ND COOLING TOWER SYSTEM |          |                                       | A&C DEPT A J MUSTO 11/10/77 PAGE 7 |       |
| CW INLET DESIGN TEMPERATURE (F)                                    | 88.00    | PERFORMANCE AT DESIGN CONDITIONS:     | NO. OF COOLING TOWERS-CT           | 2     |
| CONDENSER TEMPERATURE RISE (F)                                     | 19.96    | TG CAPABILITY (MW)                    | NO. OF CELLS PER CT                | 24    |
| TUBE DIAMETER (INCHES)/GAUGE                                       | 0.875/22 | AVG CONDENSER PRESSURE (IN.HGA)       | 616.46                             | 3.47  |
| TOTAL TUBE LENGTH (FT/SHELL)                                       | 42.50    | PERFORMANCE AT MAX SUMMER TEMPERATURE | CT DESIGN APPROACH TEMP (F)        | 14.00 |
| NO. OF: TUBES PER SHELL/SHELLS                                     | 14562/3  | TG CAPABILITY (MW)                    | 604.14                             | 2789  |
| NO. OF: TUBE PASSES/PRESS ZONES                                    | 1/1      | AVG CONDENSER PRESSURE (IN.HGA)       | 4.09                               | 8622  |
| TOTAL SURFACE AREA (SQ FT)   | 423000   | AVG SEASONAL COND PRESS (IN.HGA)      | 1.81 2.22 3.00                     | 3000  |
| CIRCULATING WATER FLOW (GPM)                                       | 448400   | ESTIMATED INITIAL INVESTMENT COST     |                                    | 79.00 |
| TUBE VEL. AT ABOVE CW FLOW (FPS)                                   | 6.25     | TODAY'S MATERIAL COST                 |                                    | 10.50 |
|  |          | TODAY'S INSTALLATION COST             |                                    | 4     |
|  |          | ESCALATION 1000\$                     |                                    | 1000  |

| ACCOUNT CODE | INITIAL INVESTMENT COST ITEMS  | TODAY'S MATERIAL COST UNIT TOTAL 1000\$ | TODAY'S INSTALLATION COST UNIT TOTAL 1000\$ | ESCALATION 1000\$ MATERIAL | INSTALLATION |
|--------------|--|---|---|----------------------------|--------------|
| 1.11         | MAJOR SITE DEVELOPMENT   | -----                                   | 4080  | -----                      | 1600         |
| 2.1          | LOCAL IMPROVEMENT TO SITE-CLEARING   | -----                                   |   | 0\$/ACPE                   | 0            |
| 2.5          | LOCAL GRADING  | -----                                   |   | 2.50\$/CU YD               | 26           |
| 3.42         | PILING   | 1.45\$/SQ FT                            | 121   | 1.00\$/SQ FT               | 83           |
| 3.2          | INTAKE STRUCTURE   | 4.10\$/CU FT                            | 498   | 10.75\$/CU FT              | 1306         |
| 3.2          | CIRCULATING WATER CONDUIT: MAIN BRANCHES   | 365\$/LIN FT                            | 584   | 244.00\$/LIN FT            | 390          |
| 3.32         | DISCHARGE STRUCTURE  | 71.67\$/LIN FT                          | 172   | 67.60\$/LIN FT             | 162          |
| 3.41         | COOLING TOWER BASTN  | 0.00\$/CU FT                            | 0   | 0.00\$/CU FT               | 0            |
| 3.44         | COOLING TOWER SUPERSTRUCTURE   | 0.80\$/SQ FT                            | 67  | 8.20\$/SQ FT               | 684          |
| 4.1          | TG BUILDING (DIFFERENTIAL)   | 2699949\$/EACH                          | 5400  | 2209049\$/EACH             | 4418         |
| 4.18         | TG PREDESTAL (DIFFERENTIAL)  | 0.00\$/CU FT                            | 0   | 0.00\$/CU FT               | 0            |
| 7.1          | TG & ACCESSORIES (DIFFERENTIAL)  | 0\$/FT HT                               | 0   | 0\$/FT HT                  | 0            |
| 10.211       | CONDENSER SHELL  | 0.00\$/KVA                              | 0   | 0.00\$/KVA                 | 0            |
| 10.213       | CONDENSER TUBE (TITAN)   | 0\$/EACH                                | 0   | 0\$/EACH                   | 0            |
| 10.221       | CIRCULATING WATER PUMP   | 0.0000\$/FT                             | 0   | 0.0000\$/FT                | 0            |
| 15.3         | CIRCULATING WATER PUMP MOTOR   | 292320\$/EACH                           | 1169  | 292320\$/EACH              | 117          |
| 14.1         | INSTRUMENTATION & CONTROL  | 206375\$/EACH                           | 826   | 8255\$/EACH                | 33           |
| 15.11        | START-UP & STANDBY TRANSFORMER (DIFFERENTIAL)                                    | 1484.62\$/EACH                          | 77  | 1015.36\$/EACH             | 53           |
| 15.12        | UNIT AUXILIARY TRANSFORMER (DIFFERENTIAL)  | 0\$/MVA                                 | 0   | 0\$/MVA                    | 0            |
| 15.21        | CIRCULATING WATER SWITCHGEAR   | 6700\$/MVA                              | 65  | 1200\$/MVA                 | 12           |
| 15.6         | WIRING FOR CIRCULATING WATER SYSTEM  | 43000\$/PUMP                            | 172   | 18000\$/PUMP               | 72           |
| 15.1         | UNIT MAIN POWER TRANSFORMER (DIFFERENTIAL)                                       | 48445\$/MVA                             | 614   | 143727\$/MVA               | 1822         |
| 15.23        | FAN MOTOR POWER CENTER + REQ'D SWGR & FEEDER                                     | 0\$/MVA                                 | 0   | 0\$/MVA                    | 0            |
|              |  | 166000\$/CENTER                         | 830   | 37000\$/CENTER             | 185          |
|              | TOTAL  |   | 14675                                       |                            | 10964        |
|              | TOTAL DIRECT ESCALATED COST: MATERIAL PLUS 0.00% SALES/USE TAX PLUS INSTALLATION |   |   |                            | 37168        |
|              | INDIRECT CONSTRUCTION COST INCLUDING PROFESSIONAL SERVICES                       |   |   |                            | 5598         |
|              | CONTINGENCY (14.00% OF DIRECT PLUS INDIRECT COST)                                |   |   |                            | 5987         |
|              | UTILITY'S EXPENSES, INTEREST DURING CONSTRUCTION, & LAND                         |   |   |                            | 8679         |
|              | TOTAL ESTIMATED INVESTMENT COST 1000\$   |   |   |                            | 57632        |

| UNIT NET CAPABILITY W/SF/S/P (MW) | DIFFERENTIAL UNIT NET CAPABILITY (MW) | UNIT NET ANNUAL GENERATION (MWH/YR) | DIFFERENTIAL UNIT NET GENERATION (MWH/YR) | WATER CONSUMPTION (MILLION GALLONS/YR) | TOTAL ANNUAL UNIT FUEL COST (AT 0.6500\$/MILLION BTU) (1000\$) | TOTAL COMPARABLE INVESTMENT COST INCLUDING CAPABILITY ADJUSTMENT (1000\$) | CW SYSTEM FUEL COST (BASE VALUE) | ANNUAL FIXED CHARGES (AT RATE 0.2225) | WATER COST (AT 0.00\$/MILLION GALLONS + CHEMICALS) | MAINTENANCE (1.20% OF TOTAL INV + 2000\$/FAN) | SUBTOTAL ANNUAL COST | NET PRODUCTION COST | ADJUSTMENT FOR DIFFERENTIAL CAPABILITY | ADJUSTMENT FOR DIFFERENTIAL NET ANNUAL GENERATION | TOTAL COMPARABLE ANNUAL COST INCLUDING ADJUSTMENTS FOR EQUALIZED CAPABILITY & NET ANNUAL GENERATION | COMPARABLE NET PRODUCTION COST INCL. ADJUSTMENTS |
|-----------------------------------|---------------------------------------|-------------------------------------|---|--|--|---|----------------------------------|---------------------------------------|--|---|----------------------|---------------------|--|---|---|--|
| 621.3                             | 614.7                                 | 596.1                               | 574.2                                     |  |  |   | 163                              | 12823                                 | 156  | 788   | 13930                |                     |  |   |   |  |
|                                   |                                       | 45.77                               |   | 6242                                   | 23981  | 62624   |                                  |                                       |  |   |                      |                     | 1111                                   | 6265  | 21305   | 6.019  |



Exhibit 202

OYSTER CREEK FAN ASSISTED  
NATURAL DRAFT TOWER IMPACTS

TABLE 2

PREDICTED MAXIMUM PEAK SHORT-TERM NEAR  
GROUND AIRBORNE CONCENTRATION (UG/M<sup>3</sup>) OF SALT RESULTING  
FROM OPERATION OF TWO FAN ASSISTED NATURAL DRAFT  
COOLING TOWERS AT THE OYSTER CREEK SITE

| <u>Month</u> | <u>Hours of Persistence</u> | <u>Direction<sup>(a)</sup></u> | <u>Distance (miles)</u> | <u>Near Ground Airborne Concentration (ug/m<sup>3</sup>)</u> |
|--------------|-----------------------------|--------------------------------|-------------------------|--|
| January      | 10                          | W                              | 0.16                    | 13.6   |
| February     | 5                           | SW                             | 0.16                    | 8.8  |
| March        | 5                           | E                              | 0.16                    | 12.2   |
| April        | 5                           | NNW                            | 0.16                    | 8.0  |
| May          | 7                           | WSW                            | 0.16                    | 13.6   |
| June         | 12                          | ENE                            | 0.16                    | 4.2  |
| July         | 5                           | NW                             | 2.5                     | 4.4  |
| August       | 7                           | N                              | 2.5                     | 3.2  |
| September    | 5                           | ENE                            | 0.16                    | 4.0  |
| October      | 5                           | ESE                            | 0.16                    | 6.0  |
| November     | 7                           | WSW                            | 0.16                    | 11.2   |
| December     | 6                           | SE                             | 0.16                    | 10.6   |

(a) Indicates direction where salt is deposited - winds come from opposite direction

Source: Pickard, Lowe and Garrick, Inc.,  
October 1977.

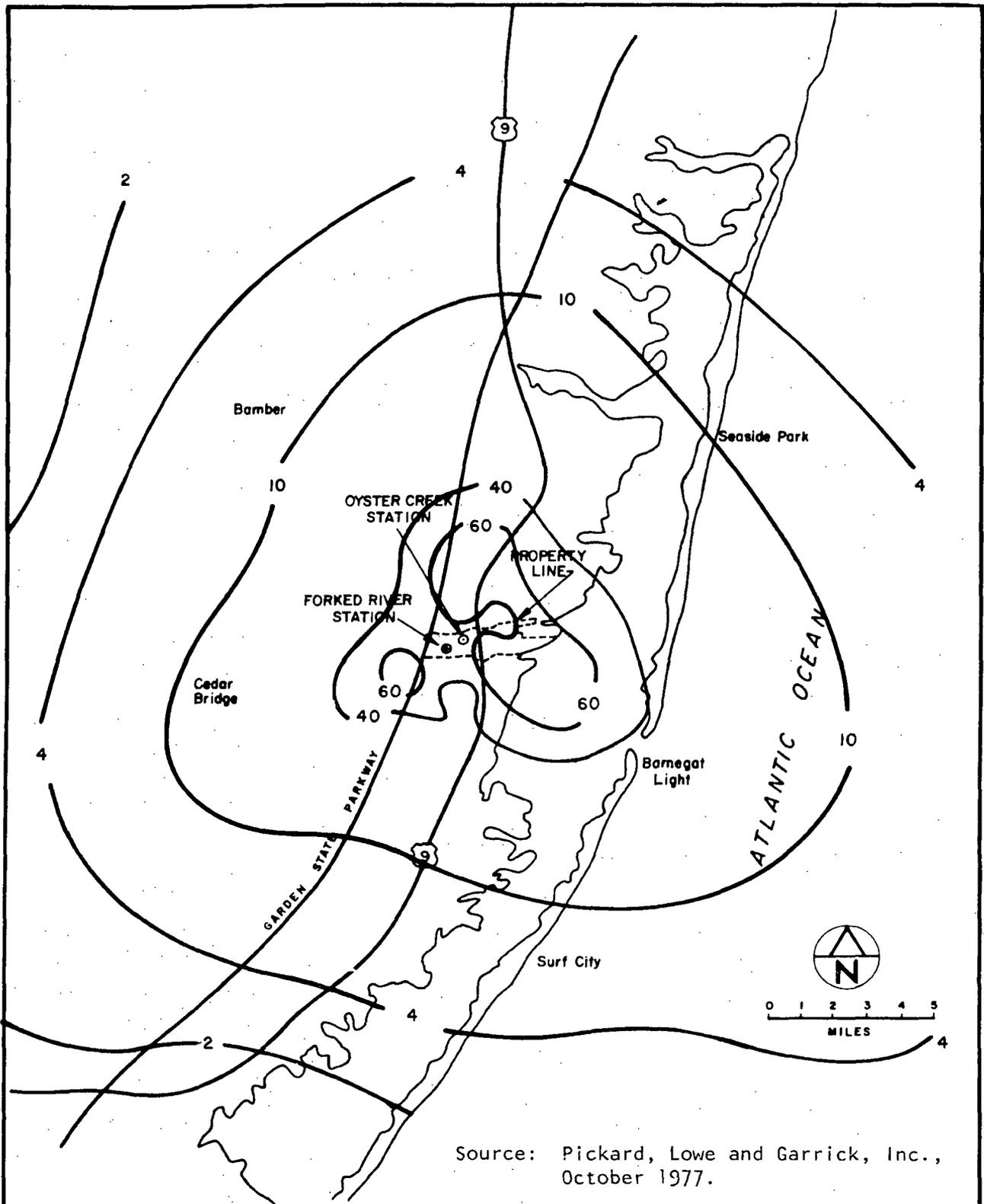
Exhibit 202  
OYSTER CREEK FAN ASSISTED  
NATURAL DRAFT TOWER IMPACTS  
TABLE 3

PREDICTED MAXIMUM PEAK SHORT-TERM NEAR GROUND AIRBORNE  
CONCENTRATION ( $\mu\text{g}/\text{m}^3$ ) OF SALT RESULTING FROM OPERATION OF TWO  
FAN ASSISTED NATURAL DRAFT TOWERS AT THE OYSTER CREEK SITE  
AND ONE NATURAL DRAFT TOWER AT THE FORKED RIVER SITE

| <u>Month</u> | <u>Hours of Persistence</u> | <u>Direction<sup>(a)</sup></u> | <u>Distance (miles)</u> | <u>Near Ground Airborne Concentration (<math>\mu\text{g}/\text{m}^3</math>)</u> |
|--------------|-----------------------------|--------------------------------|-------------------------|---|
| January      | 10                          | W                              | 0.16                    | 13.6  |
| February     | 5                           | SW                             | 0.16                    | 8.8   |
| March        | 5                           | E                              | 0.16                    | 12.2  |
| April        | 5                           | NNW                            | 0.16                    | 8.0   |
| May          | 7                           | WSW                            | 0.16                    | 13.6  |
| June         | 12                          | ENE                            | 0.16                    | 4.7   |
| July         | 5                           | NW                             | 2.5                     | 4.8   |
| August       | 7                           | N                              | 2.5                     | 4.0   |
| September    | 5                           | ENE                            | 0.16                    | 4.4   |
| October      | 5                           | ESE                            | 0.16                    | 6.0   |
| November     | 7                           | WSW                            | 0.16, 0.75              | 11.2  |
| December     | 6                           | SE                             | 0.16                    | 10.6  |

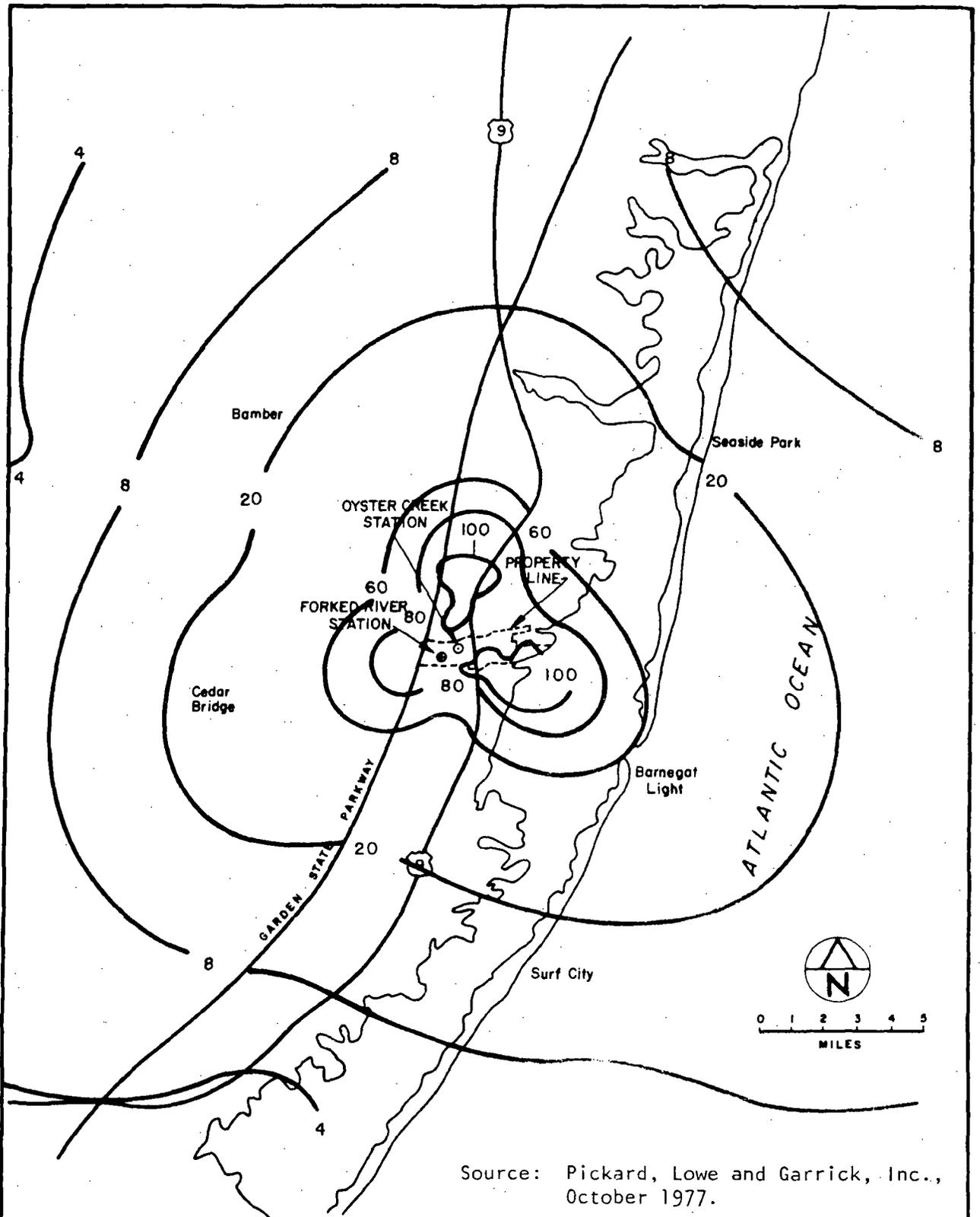
(a) Indicates direction where salt is deposited - winds come from opposite direction

Source: Pickard, Lowe and Garrick, Inc.,  
 October 1977.



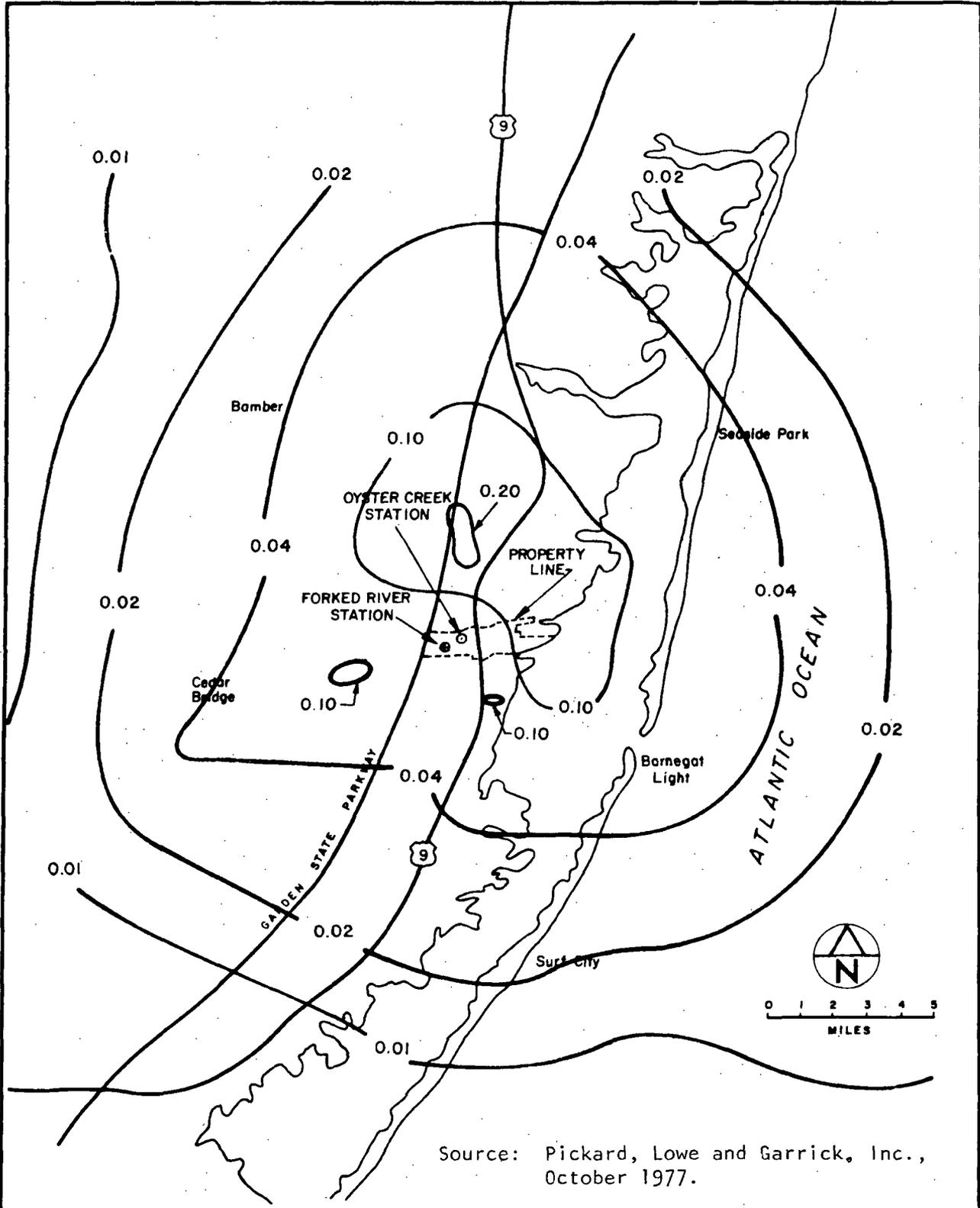
Source: Pickard, Lowe and Garrick, Inc.,  
October 1977.

|  |  |                       |
|--|--|-----------------------|
| <p><b>JERSEY CENTRAL<br/>POWER &amp; LIGHT COMPANY</b></p> | <p><b>ANNUAL AVERAGE SALT DEPOSITION RATE<br/>(<math>\text{Kg/Km}^2</math> - Month) FROM TWO FAN ASSISTED<br/>TOWERS AT THE OYSTER CREEK<br/>SITE (0 - 15 MILES)</b></p> | <p><b>EXHIBIT</b></p> |
| <p><b>EBASCO SERVICES INCORPORATED</b><br/>New York</p>    |  | <p><b>203</b></p>     |



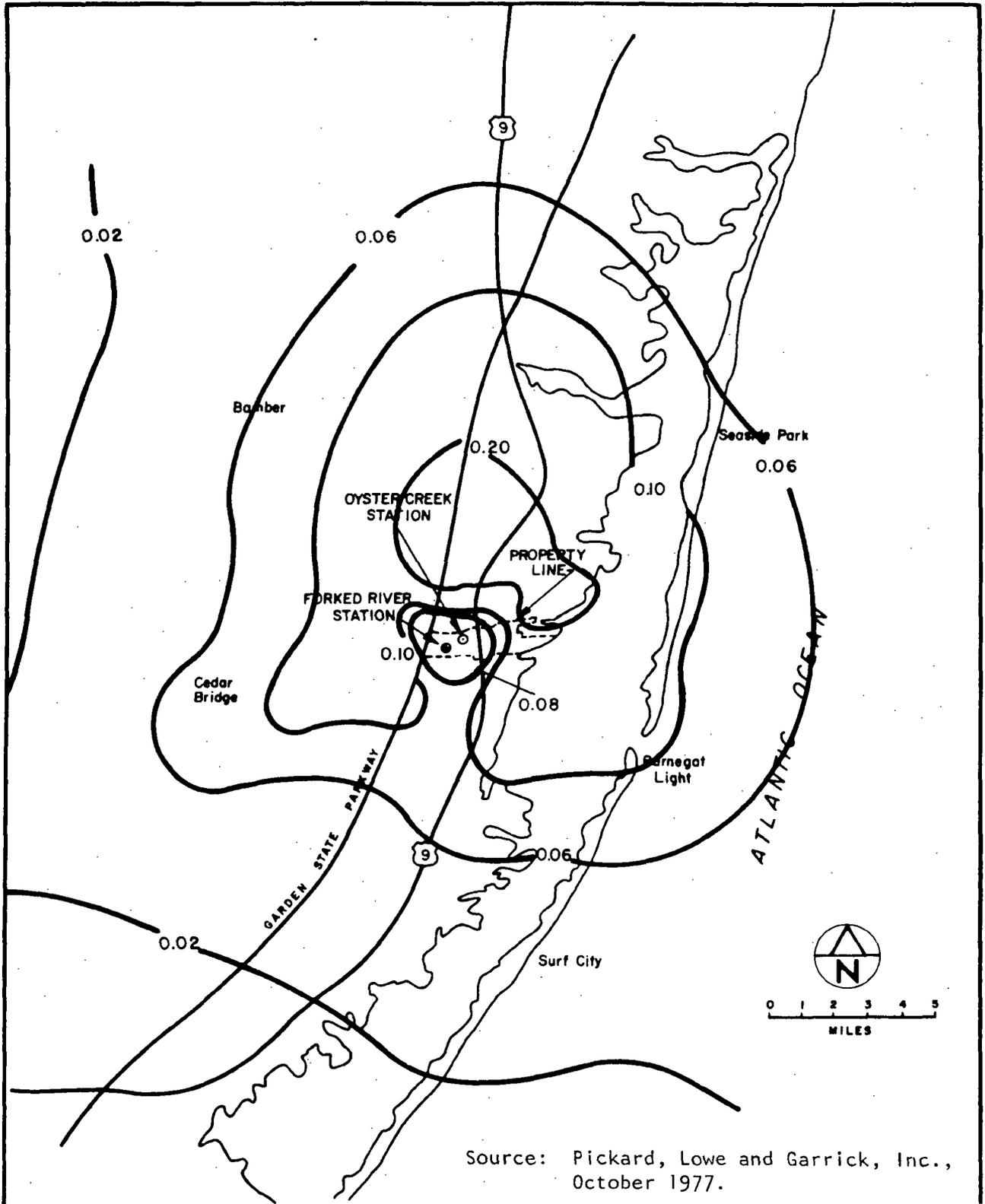
Source: Pickard, Lowe and Garrick, Inc.,  
October 1977.

|   |   |                |
|---|---|----------------|
| <p>JERSEY CENTRAL<br/>POWER &amp; LIGHT COMPANY</p> | <p>ANNUAL AVERAGE SALT DEPOSITION<br/>RATE (kg/km<sup>2</sup>-month) FROM TWO FAN<br/>ASSISTED TOWERS AT OYSTER CREEK<br/>AND ONE NATURAL DRAFT TOWER AT<br/>FORKED RIVER (0-15 MILES).</p> | <p>EXHIBIT</p> |
| <p>EBASCO SERVICES INCORPORATED<br/>New York</p>    |   | <p>204</p>     |



Source: Pickard, Lowe and Garrick, Inc.,  
October 1977.

|   |   |                |
|---|---|----------------|
| <p>JERSEY CENTRAL<br/>POWER &amp; LIGHT COMPANY</p> | <p>AVERAGE SUMMER AIRBORNE SALT<br/>CONCENTRATIONS (<math>\mu\text{g}/\text{m}^3</math>) FROM TWO<br/>FAN ASSISTED TOWERS AT THE OYSTER CREEK<br/>SITE (0 - 15 MILES)</p> | <p>EXHIBIT</p> |
| <p>EBASCO SERVICES INCORPORATED<br/>New York</p>    |   | <p>205</p>     |



Source: Pickard, Lowe and Garrick, Inc.,  
October 1977.

|   |   |                        |
|---|---|------------------------|
| <p>JERSEY CENTRAL<br/>POWER &amp; LIGHT COMPANY</p> | <p>AVERAGE SUMMER AIRBORNE SALT<br/>CONCENTRATIONS (ug/m<sup>3</sup>) FROM TWO<br/>FAN ASSISTED TOWERS AT OYSTER<br/>CREEK AND ONE NATURAL DRAFT<br/>TOWER AT FORKED RIVER (0-15 MILES)</p> | <p>EXHIBIT<br/>206</p> |
| <p>EBASCO SERVICES INCORPORATED<br/>New York</p>    |   |                        |

DISCHARGE PARAMETERS UNDER AVERAGE CONDITIONSFAN-ASSISTED TOWERS

| <u>Month</u> | <u>Oyster Creek NGS<br/>Discharge Flow<br/>GPM</u> | <u>Forked River NGS<br/>Discharge Flow<br/>GPM</u> | <u>Required*<br/>Dilution Flow<br/>GPM</u> | <u>Combined Flow<br/>to Oyster Creek<br/>GPM</u> | <u>Combined<br/>Temperature Rise<br/>in Oyster Creek<br/>Deg F</u> |
|--------------|--|--|--|--|--|
| January      | 16,000   | 26,400   | 520,000                                    | 562,400  | 2.6  |
| February     | 16,000   | 26,200   | 520,000                                    | 562,200  | 2.2  |
| March        | 15,800   | 25,600   | 260,000                                    | 301,400  | 3.4  |
| April        | 15,200   | 25,000   | 260,000                                    | 300,200  | 2.4  |
| May          | 14,800   | 24,600   | 260,000                                    | 299,400  | 1.6  |
| June         | 14,500   | 24,100   | 260,000                                    | 298,600  | 1.2  |
| July         | 14,300   | 23,800   | 260,000                                    | 298,100  | 1.1  |
| August       | 14,300   | 23,800   | 260,000                                    | 298,100  | 1.2  |
| September    | 14,500   | 24,200   | 260,000                                    | 298,700  | 1.7  |
| October      | 14,900   | 24,700   | 260,000                                    | 299,600  | 2.4  |
| November     | 15,400   | 25,100   | 260,000                                    | 300,500  | 3.5  |
| December     | 16,000   | 26,200   | 520,000                                    | 562,200  | 2.2  |

\* Required to Meet Thermal Criteria in  
Oyster Creek for Temperature Rise

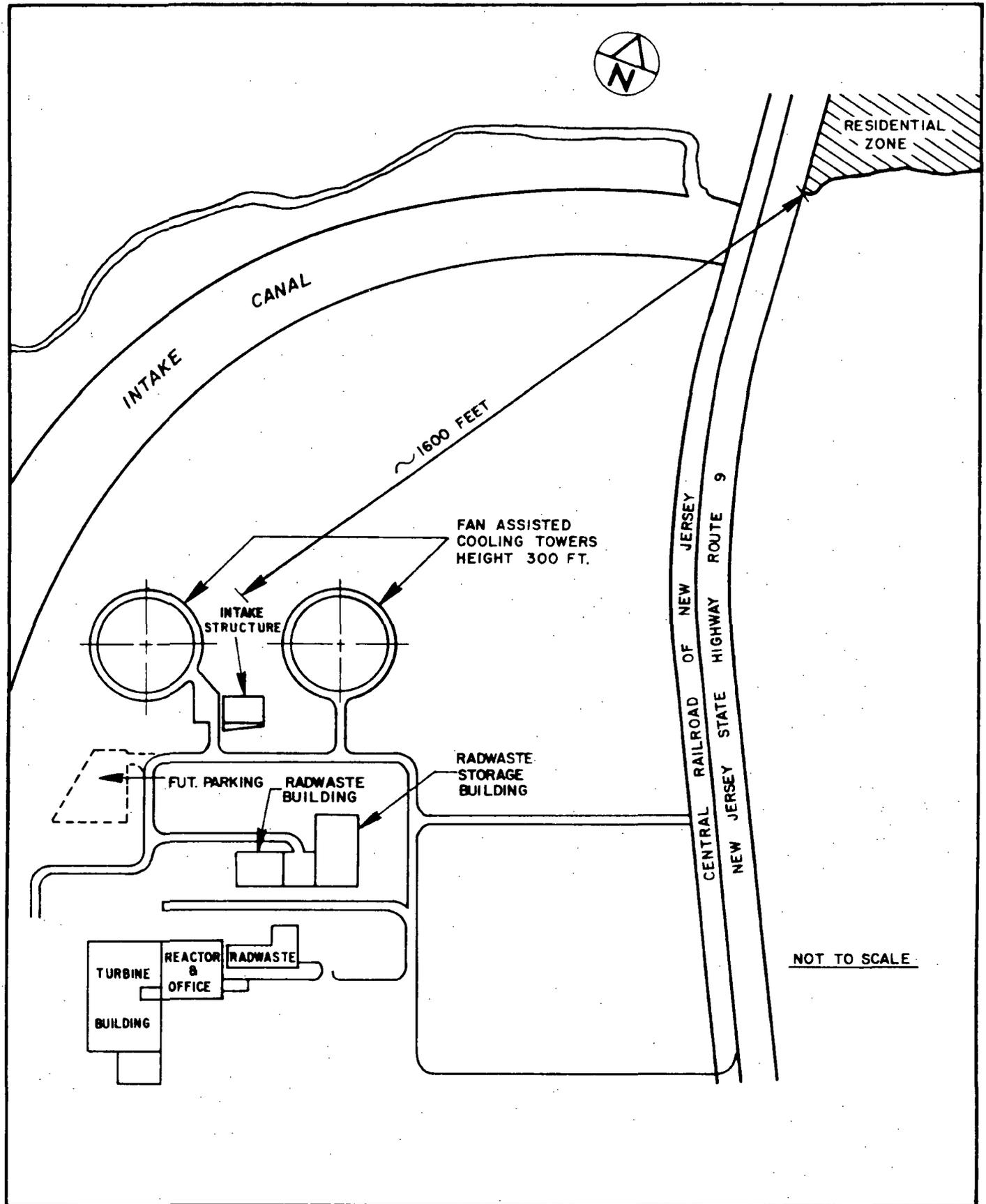
Exhibit 208

DISCHARGE PARAMETERS UNDER EXTEME CONDITIONS

FAN-ASSISTED TOWERS

| <u>Month</u> | <u>Oyster Creek NGS<br/>Discharge Flow<br/>GPM</u> | <u>Forked River NGS<br/>Discharge Flow<br/>GPM</u> | <u>Required*<br/>Dilution Flow<br/>GPM</u> | <u>Combined Flow<br/>to Oyster Creek<br/>GPM</u> | <u>Combined<br/>Temperature Rise<br/>in Oyster Creek<br/>Deg F</u> |
|--------------|--|--|--|--|--|
| January      | 14,700   | 24,400   | 520,000                                    | 559,100  | 3.5  |
| February     | 14,500   | 24,300   | 520,000                                    | 558,800  | 3.3  |
| March        | 14,500   | 24,200   | 520,000                                    | 558,700  | 2.7  |
| April        | 14,300   | 23,800   | 520,000                                    | 558,100  | 2.2  |
| May          | 14,000   | 23,100   | 260,000                                    | 297,100  | 3.3  |
| June         | 13,400   | 22,100   | 520,000                                    | 555,500  | 1.5  |
| July         | 13,400   | 22,100   | 520,000                                    | 555,500  | 1.3  |
| August       | 13,400   | 22,100   | 520,000                                    | 555,500  | 1.3  |
| September    | 13,500   | 22,300   | 260,000                                    | 295,800  | 3.3  |
| October      | 14,200   | 23,500   | 260,000                                    | 297,700  | 4.0  |
| November     | 14,300   | 23,800   | 520,000                                    | 558,100  | 2.8  |
| December     | 14,600   | 24,400   | 520,000                                    | 559,000  | 3.2  |

\* Required to Meet Thermal Criteria in  
Oyster Creek for Temperature Rise



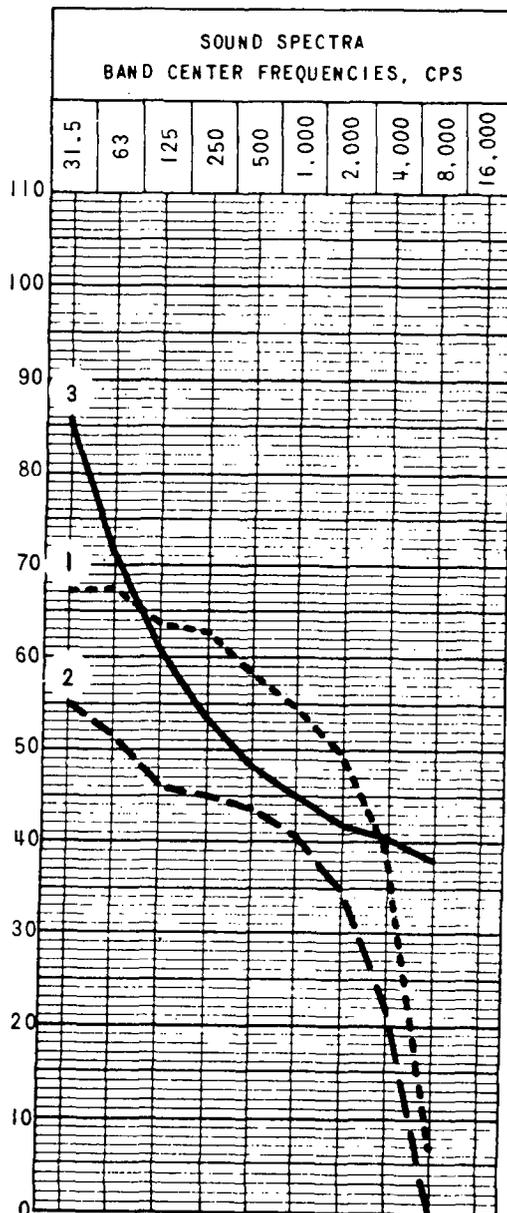
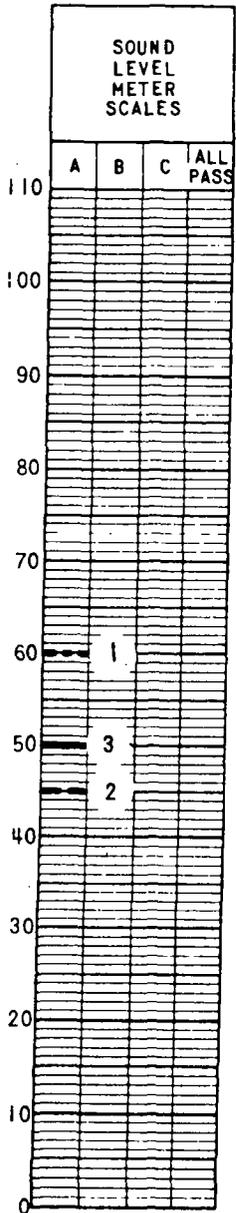
JERSEY CENTRAL  
POWER & LIGHT COMPANY

EBASCO SERVICES INCORPORATED  
New York

LOCATION OF  
FAN ASSISTED COOLING TOWERS  
WITH RESPECT TO NEAREST RESIDENTIAL ZONE

EXHIBIT  
209

SOUND PRESSURE LEVEL - DECIBELS (db - Re 0.0002 Microbars)

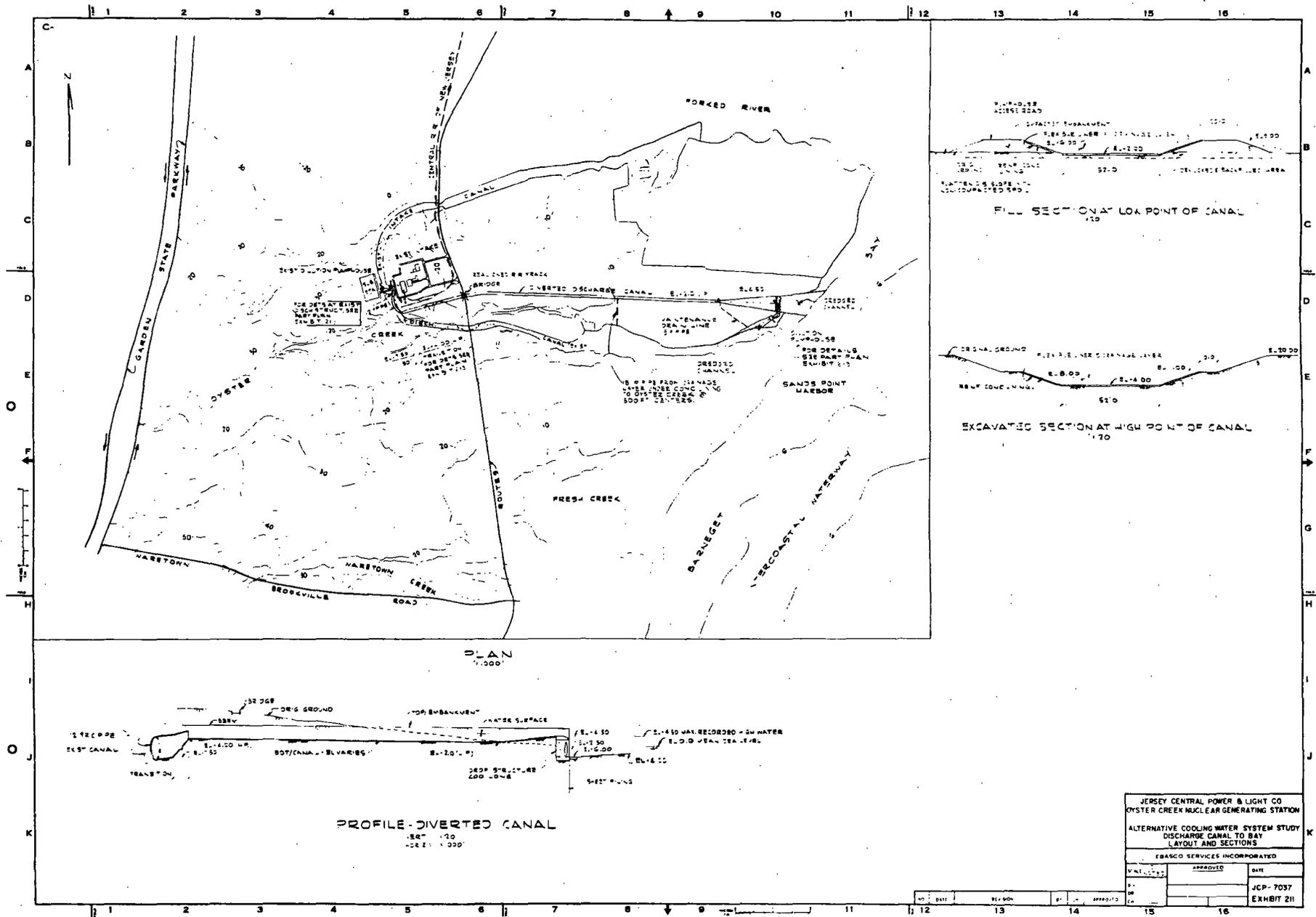


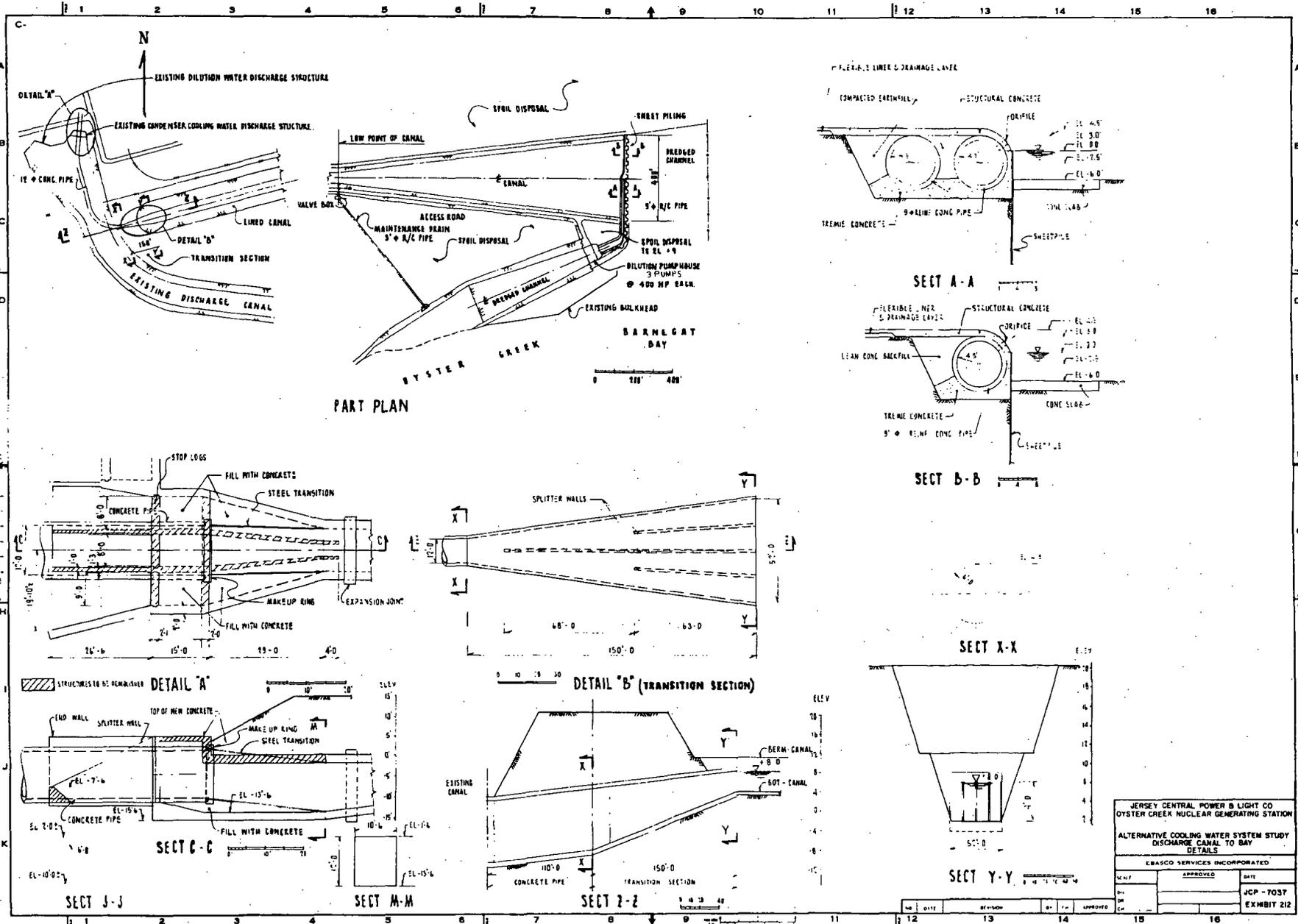
1. UNATTENUATED SPL AT A DISTANCE OF ABOUT 1800 FT FROM TWO TOWERS.
2. ATTENUATED SPL AT A DISTANCE OF ABOUT 1800 FT FROM TWO TOWERS.
3. NEW JERSEY NIGHTTIME CRITERION.

JERSEY CENTRAL  
POWER & LIGHT COMPANY  
EBASCO SERVICES INCORPORATED  
New York

NOISE DATA FOR  
FAN-ASSISTED NATURAL  
DRAFT COOLING TOWERS

EXHIBIT  
210





PART PLAN

SECT A-A

SECT B-B

SECT X-X

SECT Y-Y

SECT J-J

SECT M-M

SECT Z-Z

|   |          |      |             |
|---|----------|------|-------------|
| JERSEY CENTRAL POWER & LIGHT CO<br>OYSTER CREEK NUCLEAR GENERATING STATION  |          |      |             |
| ALTERNATIVE COOLING WATER SYSTEM STUDY<br>DISCHARGE CANAL TO BAY<br>DETAILS |          |      |             |
| Ebasco Services Incorporated  |          |      |             |
| NO. 17  | APPROVED | DATE | JCP - 7037  |
| BY  | DATE     | DATE | EXHIBIT 212 |
| CH  | DATE     | DATE | DATE        |

(ALTERNATE COOLING WATER SUPPLY)

CANAL SECTION:

- STRIP & STOCKPILE TOPSOIL
- DEMUCK MARSH
- REFILL & COMPACT DEMUCK AREA
- EXCAVATION IN OPEN CUT
- COMPACTED FILL IN EMBANKMENTS
- DISPOSAL SURPLUS EXCAVATION
- FLEXIBLE LINER INCLUDING DRAINAGE LAYER
- CONCRETE LINER
- CONSTRUCT ACCESS ROAD TO PUMPHOUSE
- CONSTRUCT T-WAY BRIDGE
- RELOCATE RAILROAD TRACK
- RELOCATE EXISTING FENCES
- SUPPLY & INSTALL 3" Ø S.C. PIPE
- 1" OUTLET VALVE BOX 3' Ø DIP
- VALVE FOR 3" Ø PIPE
- SPREAD TOPSOIL

DROP STRUCTURE AT BAY:

- EDGE EXCAVATION
- SUPPLY & INSTALL SHEEPILING
- SUPPLY & INSTALL 9" I.D. R.C. PIPE
- TREMIE CONCRETE UNDER PIPE
- TREMIE CONCRETE IN SLAB
- STRUCTURAL CONCRETE
- CONCRETE BACKFILL AROUND PIPES
- SUPPLY & INSTALL BOAT GUARD

PUMPHOUSE AT BAY:

- DREDGE EXCAVATION
- EXCAVATION PUMPHOUSE STRUCTURE
- PUMPHOUSE STRUCTURE
- SUPPLY & INSTALL PUMPS, MOTORS, & ACCESS
- SUPPLY & INSTALL TRASHRACK, & SCREENS
- SUPPLY & INSTALL BOAT GUARD
- POWER SUPPLY & CONTROL CABLE

TRANSITION & DISCHARGE STRUCTURE:

- EXCAVATION & BACKFILL
- STRUCTURE
- STRUCTURAL CONCRETE

PIPELINE:

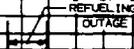
- EXCAVATION
- SUPPLY & INSTALL 12" Ø R.C. PIPE
- TREMIE CONCRETE UNDER PIPE
- BACKFILL
- REMOVE & REPLACE EXISTING SLOPE MATERIAL

CONNECT PIPE TO EXISTING OUTLET:

- EXCAVATION
- INSTALLATION STOPLOGS
- CONCRETE DEMOLITION STAGE 1
- SUPPLY & INSTALL STEEL TRANSITION
- EMBED LINER CONCRETE
- REMOVE STOPLOGS
- CONCRETE DEMOLITION STAGE 2
- MAKE JOINT-PIPELINE TO TRANSITION
- EMBED JOINT IN TREMIE CONCRETE
- BACKFILL
- REPAIR EXISTING ROAD

MODIFY EXISTING PUMPHOUSES:

- DILUTION WATER PUMPHOUSE (no work req'd)
- COOLING WATER PUMPHOUSE



EBASCO SERVICES INCORPORATED

DIV. CIVIL ENGR. GA.

APPROVED

SCALE: NTS ON

DATE

JERSEY CENTRAL POWER & LIGHT  
 OYSTER CREEK NUCLEAR GEN. STATION  
 ALTERNATIVE COOLING WATER SYS. STUDY  
 DISCHARGE CANAL TO BAY  
 CONSTRUCTION SCHEDULE

JCP - 7037  
 EXHIBIT 213

EXHIBIT 214

DISCHARGE PARAMETERS UNDER AVERAGE CONDITIONS

CANAL-TO-BAY SYSTEM

| <u>Month</u> | <u>Oyster Creek NGS<br/>Discharge Flow<br/>Into Canal<br/>GPM</u> | <u>Forked River NGS<br/>Discharge Flow<br/>Into Oyster Creek<br/>GPM</u> | <u>Required*<br/>Dilution Flow<br/>Into Oyster Creek<br/>GPM</u> | <u>Combined Flow<br/>To Barnegat Bay<br/>From Canal &amp;<br/>Oyster Creek<br/>GPM</u> | <u>Combined Initial<br/>Temperature Rise<br/>To Barnegat Bay<br/>From Canal<br/>Deg F</u> |
|--------------|---|--|--|--|---|
| January      | 460,000   | 26,400   | 520,000  | 1,006,400  | 9.8   |
| February     | 460,000   | 26,200   | 520,000  | 1,006,200  | 9.7   |
| March        | 460,000   | 25,600   | 520,000  | 1,005,600  | 9.6   |
| April        | 460,000   | 25,000   | 520,000  | 1,005,000  | 9.4   |
| May          | 460,000   | 24,600   | 520,000  | 1,004,600  | 9.2   |
| June         | 460,000   | 24,100   | 520,000  | 1,004,100  | 9.2   |
| July         | 460,000   | 23,800   | 520,000  | 1,003,800  | 9.2   |
| August       | 460,000   | 23,800   | 520,000  | 1,003,800  | 9.2   |
| September    | 460,000   | 24,200   | 520,000  | 1,004,200  | 9.3   |
| October      | 460,000   | 24,700   | 520,000  | 1,004,700  | 9.4   |
| November     | 460,000   | 25,100   | 520,000  | 1,005,100  | 9.6   |
| December     | 460,000   | 26,200   | 520,000  | 1,006,200  | 9.7   |

\* System Requires 520,000 GPM at All Times

## EXHIBIT 215

DISCHARGE PARAMETERS UNDER EXTREME CONDITIONSCANAL-TO-BAY SYSTEM

| <u>Month</u> | <u>Oyster Creek NGS<br/>Discharge Flow<br/>Into Canal<br/>GPM</u> | <u>Forked River NGS<br/>Discharge Flow<br/>Into Oyster Creek<br/>GPM</u> | <u>Required*<br/>Dilution Flow<br/>Into Oyster Creek<br/>GPM</u> | <u>Combined Flow<br/>To Barnegat Bay<br/>From Canal &amp;<br/>Oyster Creek<br/>GPM</u> | <u>Combined Initial<br/>Temperature Rise<br/>To Barnegat Bay<br/>From Canal<br/>Deg F</u> |
|--------------|---|--|--|--|---|
| January      | 460,000   | 24,400   | 520,000  | 1,004,400  | 10.2  |
| February     | 460,000   | 24,300   | 520,000  | 1,004,300  | 10.1  |
| March        | 460,000   | 24,200   | 520,000  | 1,004,200  | 9.9   |
| April        | 460,000   | 23,800   | 520,000  | 1,003,800  | 9.7   |
| May          | 460,000   | 23,100   | 520,000  | 1,003,100  | 9.6   |
| June         | 460,000   | 22,100   | 520,000  | 1,002,100  | 9.5   |
| July         | 460,000   | 22,100   | 520,000  | 1,002,100  | 9.4   |
| August       | 460,000   | 22,100   | 520,000  | 1,002,100  | 9.4   |
| September    | 460,000   | 22,300   | 520,000  | 1,002,300  | 9.6   |
| October      | 460,000   | 23,500   | 520,000  | 1,003,500  | 9.7   |
| November     | 460,000   | 23,800   | 520,000  | 1,003,800  | 9.9   |
| December     | 460,000   | 24,400   | 520,000  | 1,004,400  | 10.1  |

\* System Requires 520,000 GPM at All Times

EXHIBIT 216

CANAL-TO-BAY ALTERNATIVE

TEMPERATURE RISE IN OYSTER CREEK FROM

FORKED RIVER NUCLEAR GENERATING STATION DISCHARGE AND TWO DILUTION PUMP FLOW

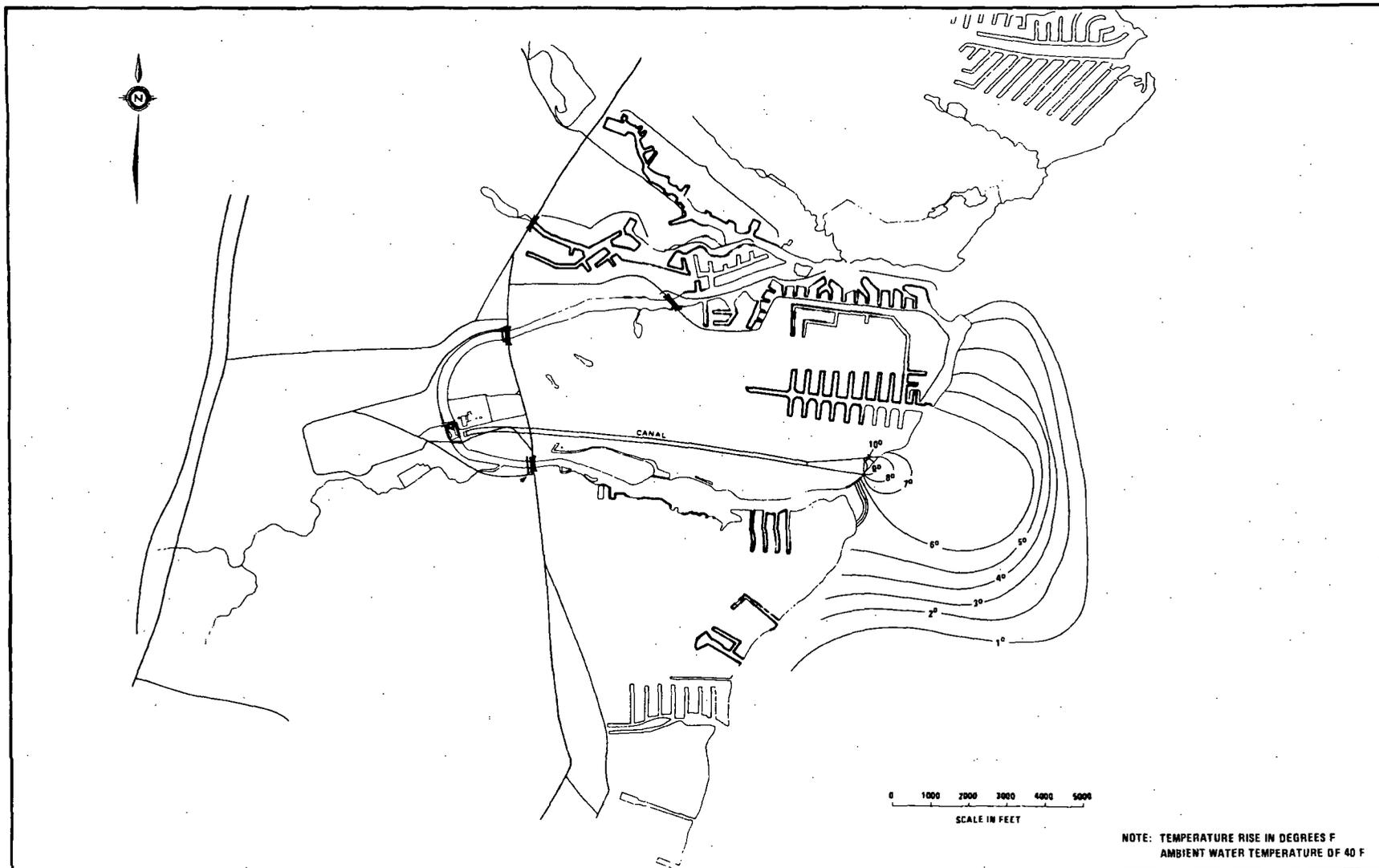
| <u>Month</u> | <u>Extreme Conditions</u> | <u>Average Conditions</u> |
|--------------|---------------------------|---------------------------|
| January      | 2.4                       | 1.8                       |
| February     | 2.2                       | 1.5                       |
| March        | 1.9                       | 1.3                       |
| April        | 1.5                       | 0.9                       |
| May          | 1.2                       | 0.7                       |
| June         | 1.1                       | 0.5                       |
| July         | 0.9                       | 0.5                       |
| August       | 1.0                       | 0.5                       |
| September    | 1.2                       | 0.7                       |
| October      | 1.5                       | 1.0                       |
| November     | 1.9                       | 1.3                       |
| December     | 2.2                       | 1.5                       |

## EXHIBIT 217

SUMMARY OF THERMAL MEASUREMENTS FOR EXISTING STATIONDURING SUMMER CONDITIONS

| <u>Survey Date</u> | <u>Wind Condition</u> | <u>Tidal Current*</u> | <u>Percent Surface<br/>Within 1.5 Deg F</u> | <u>Percent Cross-<br/>Section Within<br/>1.5 Deg F</u> |
|--------------------|-----------------------|-----------------------|---|--|
| 8/5/74             | 1-4 knots SE          | Ebb                   | 42%   | 24%  |
| 7/11/75            | Light W-SW            | Ebb                   | 43%   | 25%  |
| 6/11/76            | 2-5 knots SW          | Ebb                   | 31%   | 20%  |
| 7/13/76            | 10-30 knots NW        | Ebb                   | 24%   | 27%  |
| 8/24/76            | 1-3 knots SE          | Slack or Flood        | 18%   | 25%  |
| Allowable          | ----                  | ----                  | 67%   | 25%  |

\* Predicted at Barnegat Inlet

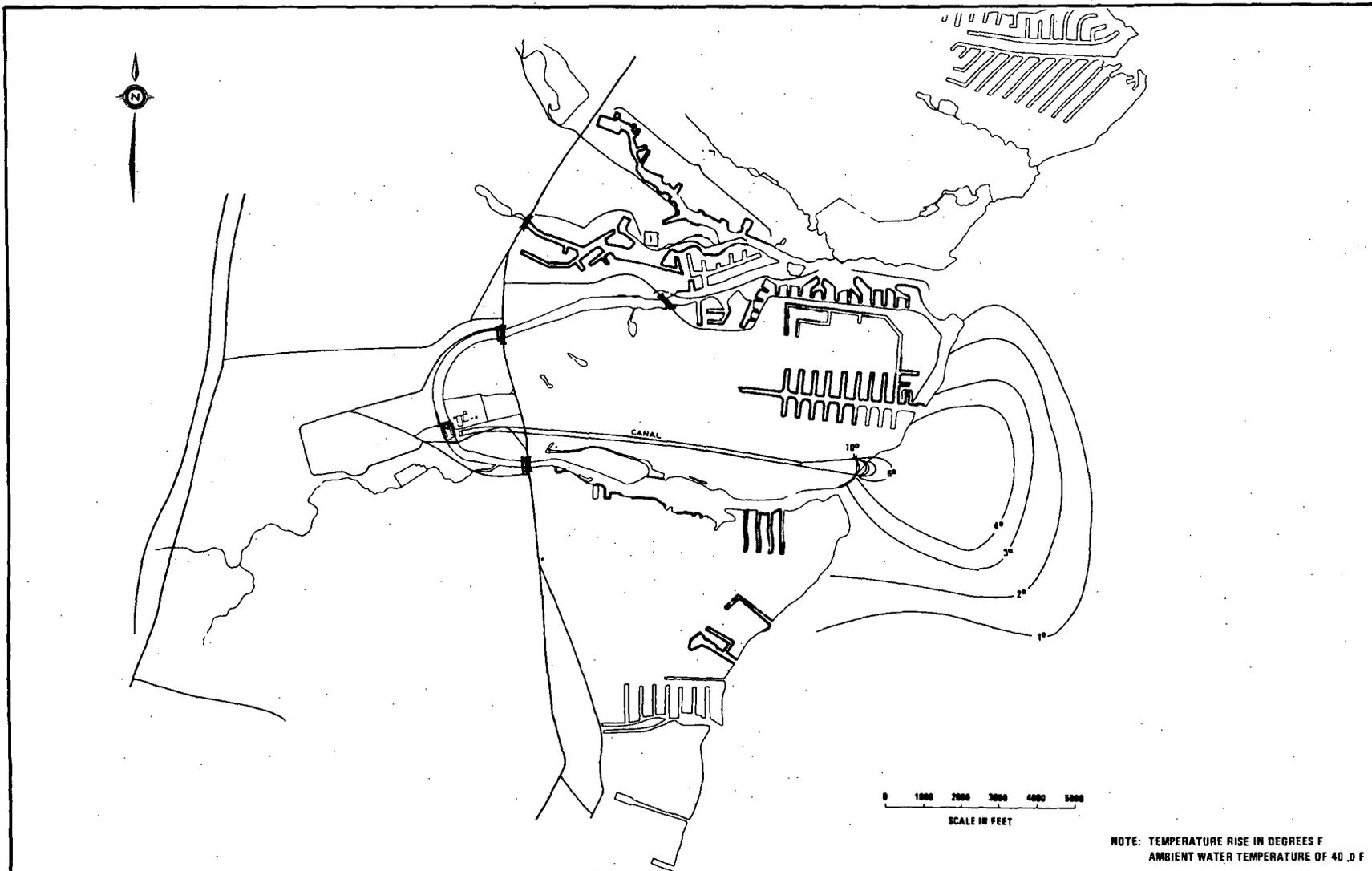


NOTE: TEMPERATURE RISE IN DEGREES F  
 AMBIENT WATER TEMPERATURE OF 40 F

JERSEY CENTRAL POWER  
 AND LIGHT COMPANY  
 EBASCO SERVICES INCORPORATED  
 New York

PREDICTED CANAL TO BAY SYSTEM TEMPERATURE DISTRIBUTION FOR THE COMBINED FORKED RIVER AND OYSTER CREEK STATIONS' DISCHARGES  
 TEMPERATURES AT SURFACE AND 2.5 FOOT DEPTH  
 TWO DILUTION PUMP OPERATION UNDER JANUARY CONDITIONS

EXHIBIT  
 218



NOTE: TEMPERATURE RISE IN DEGREES F  
 AMBIENT WATER TEMPERATURE OF 40.0 F

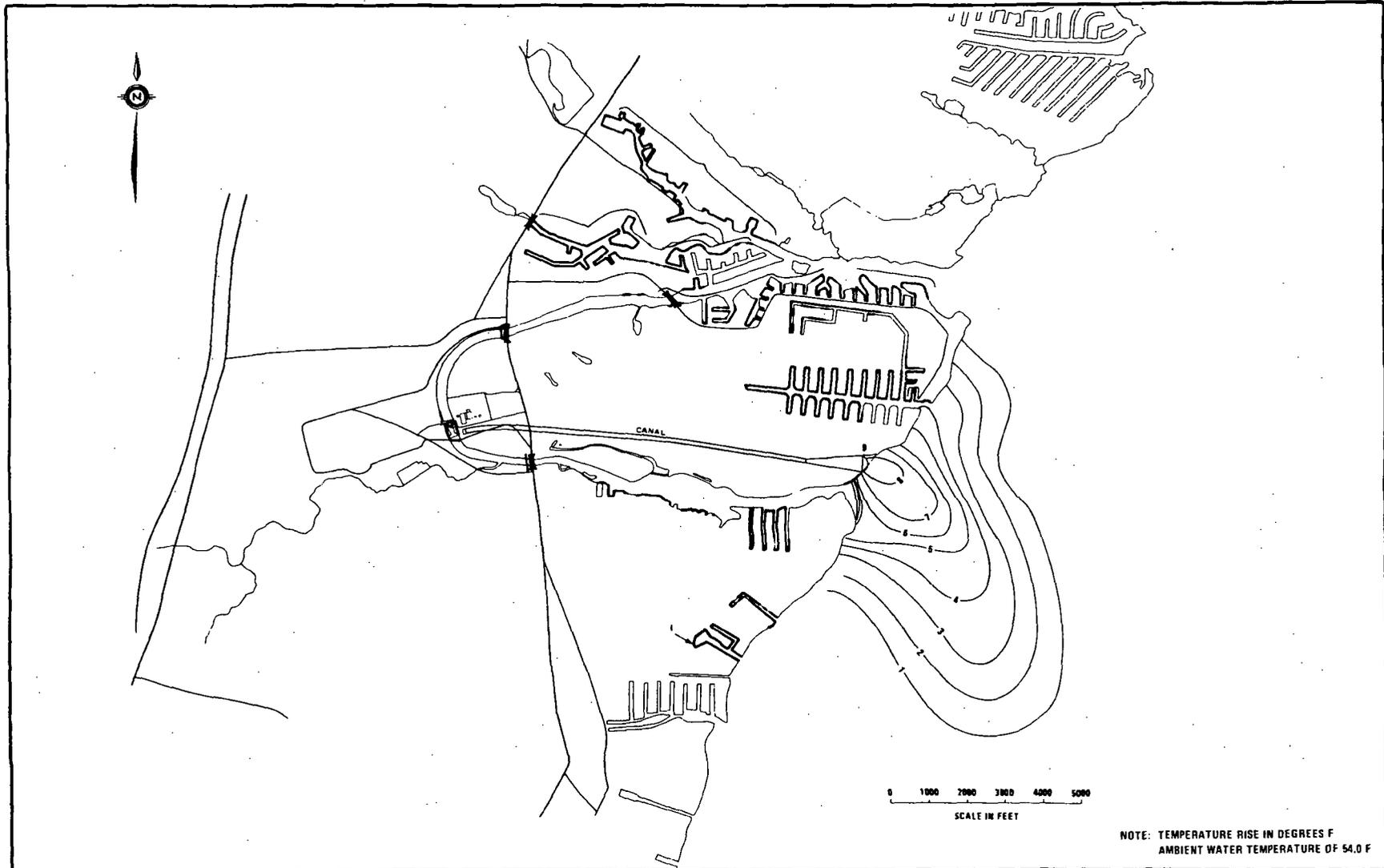
JERSEY CENTRAL POWER  
 AND LIGHT COMPANY

EBASCO SERVICES INCORPORATED  
 New York

PREDICTED CANAL TO BAY SYSTEM TEMPERATURE DISTRIBUTION FOR THE COMBINED FORKED RIVER AND OYSTER CREEK STATIONS' DISCHARGES  
 TEMPERATURES AT 5.0 FT DEPTH  
 TWO DILUTION PUMP OPERATION UNDER JANUARY CONDITIONS

EXHIBIT

219



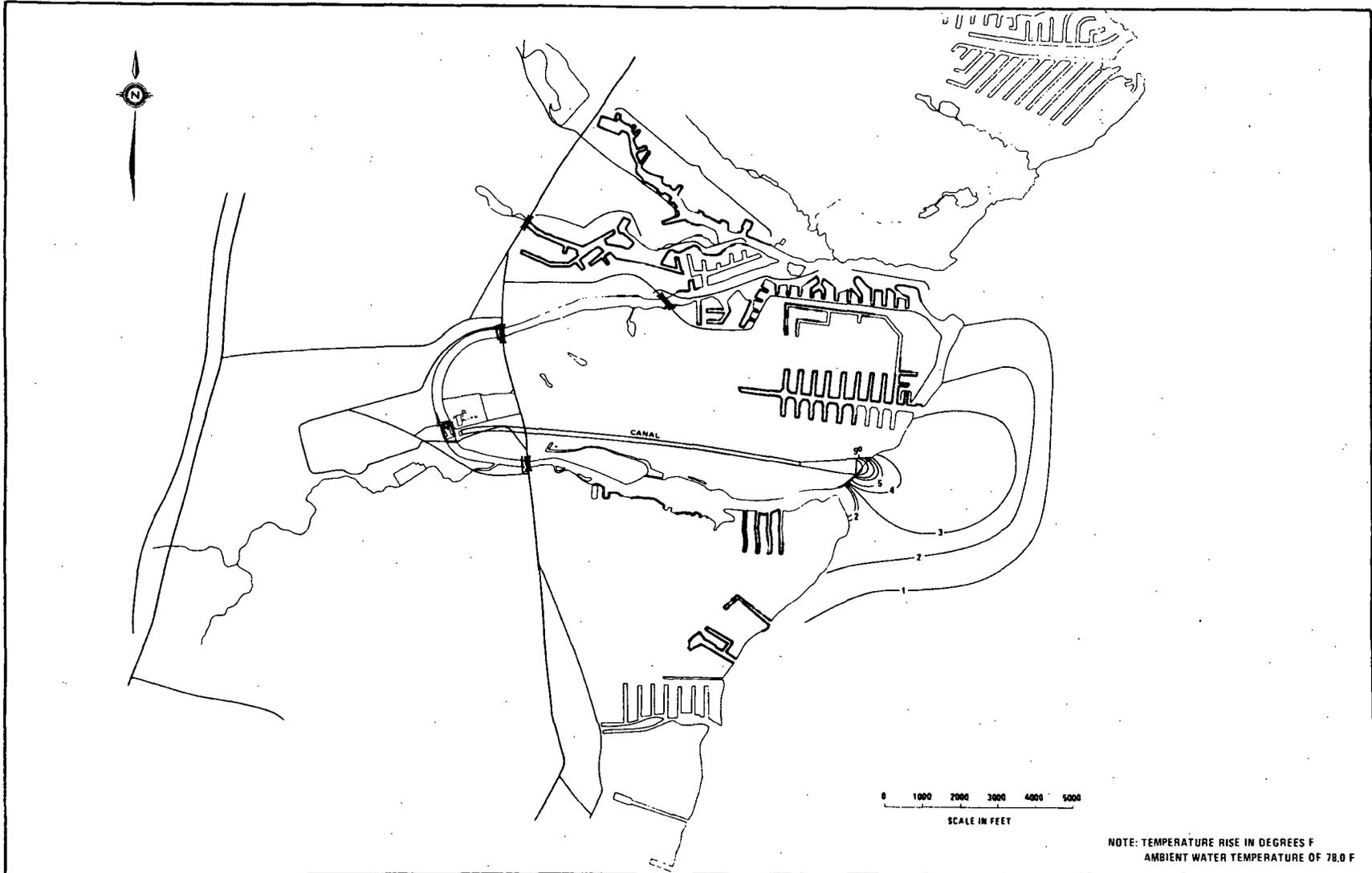
NOTE: TEMPERATURE RISE IN DEGREES F  
 AMBIENT WATER TEMPERATURE OF 54.0 F

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 New York

PREDICTED CANAL TO BAY SYSTEM TEMPERATURES DISTRIBUTION FOR THE COMBINED FORKED RIVER AND OYSTER CREEK STATIONS' DISCHARGES  
 TEMPERATURES AT SURFACE, 2.5 AND 5.0 FT DEPTH  
 TWO DILUTION PUMP OPERATION UNDER APRIL CONDITIONS

EXHIBIT  
 220



NOTE: TEMPERATURE RISE IN DEGREES F  
 AMBIENT WATER TEMPERATURE OF 78.0 F

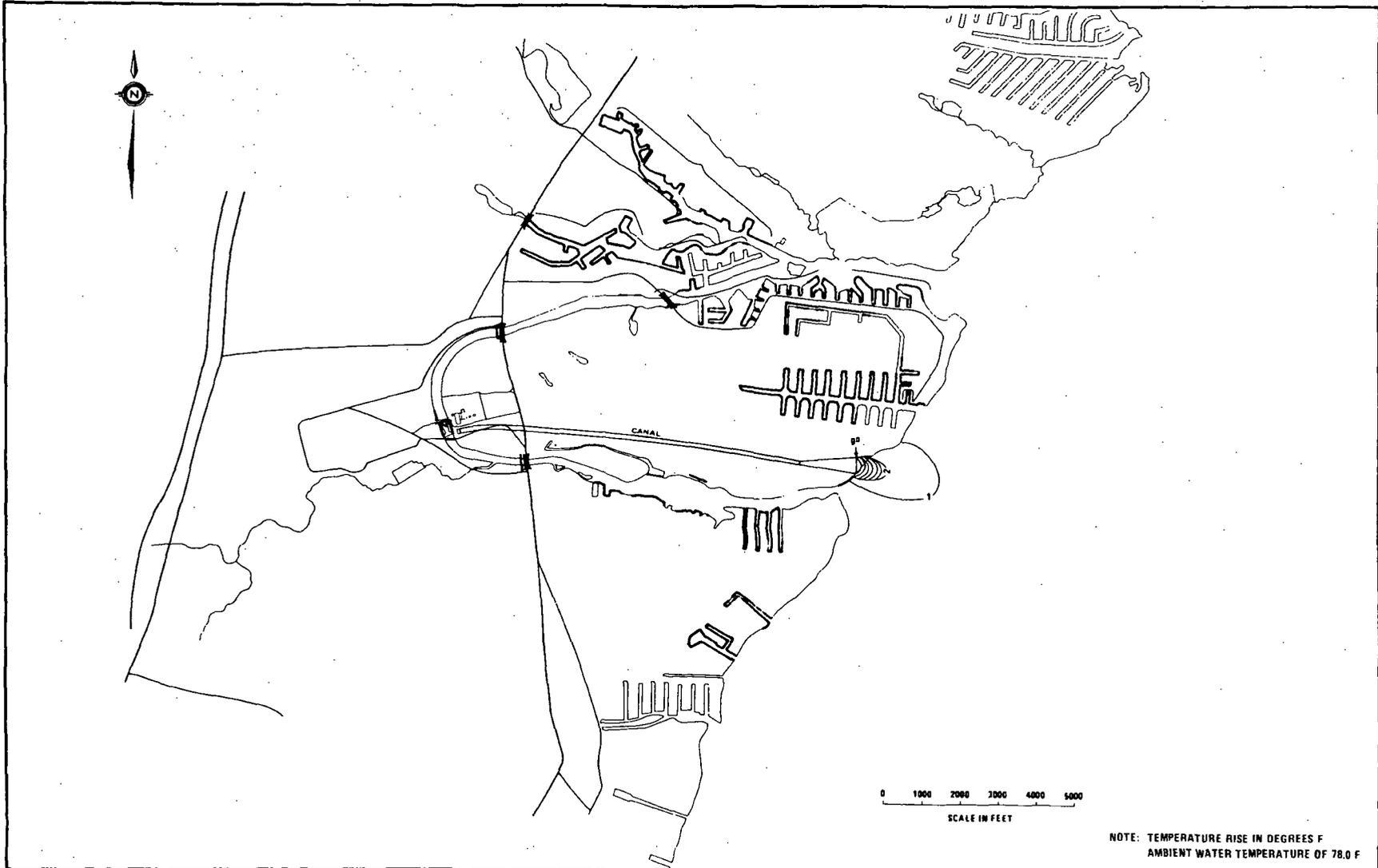
JERSEY CENTRAL POWER  
 AND LIGHT COMPANY

EBASCO SERVICES INCORPORATED  
 New York

PREDICTED CANAL TO BAY SYSTEM TEMPERATURE DISTRIBUTION FOR THE COMBINED FORKED RIVER AND OYSTER CREEK STATIONS' DISCHARGES  
 TEMPERATURES AT THE SURFACE  
 TWO DILUTION PUMP OPERATION UNDER JULY CONDITIONS

EXHIBIT

221



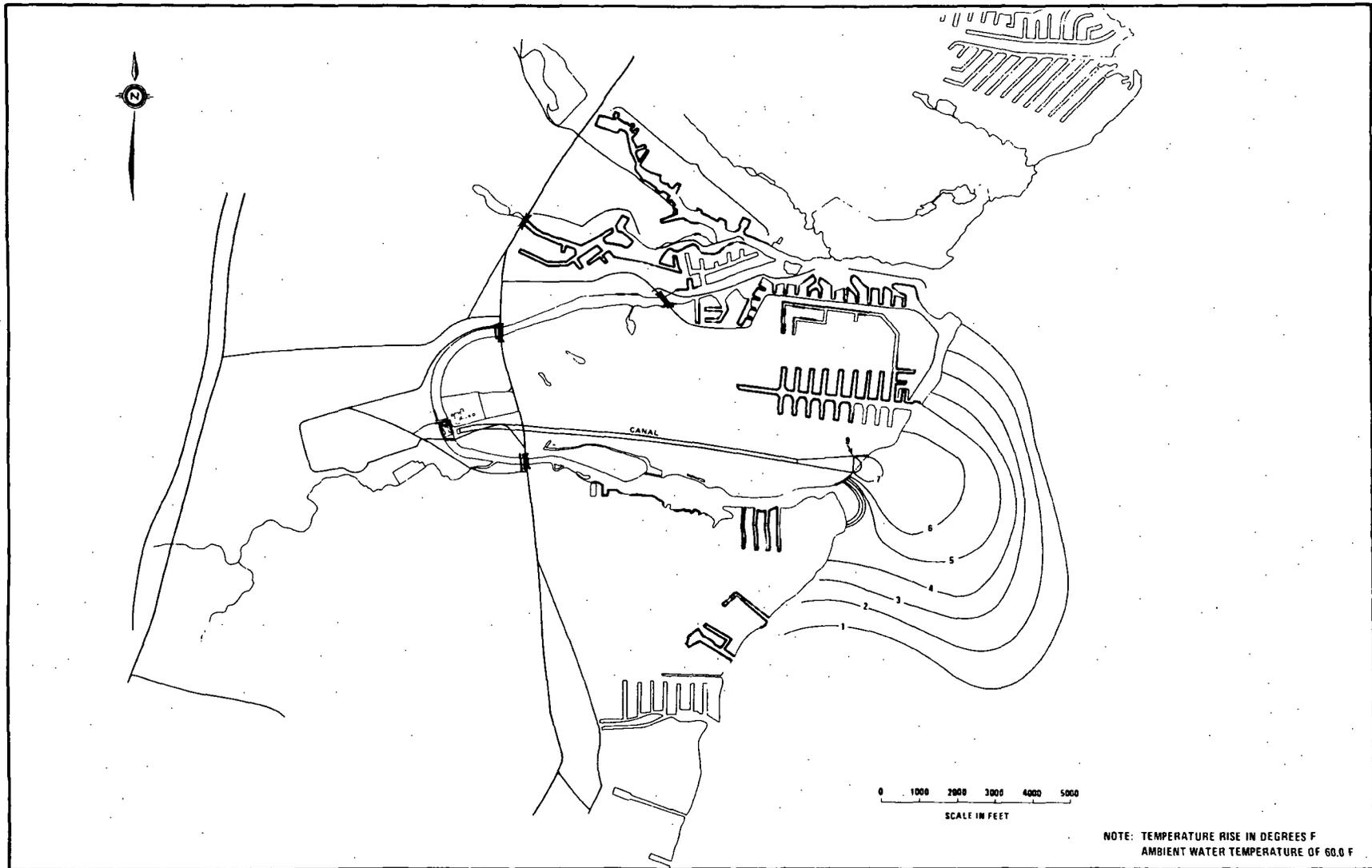
JERSEY CENTRAL POWER  
AND LIGHT COMPANY

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EBASCO SERVICES INCORPORATED  
New York

PREDICTED CANAL TO BAY SYSTEM TEMPERATURE DISTRIBUTION FOR THE COMBINED FORKED RIVER AND OYSTER CREEK STATIONS' DISCHARGES  
TEMPERATURES AT 5.0 FT DEPTH  
TWO DILUTION PUMP OPERATION UNDER JULY CONDITIONS

E X H I B I T  
222



NOTE: TEMPERATURE RISE IN DEGREES F  
 AMBIENT WATER TEMPERATURE OF 60.0 F

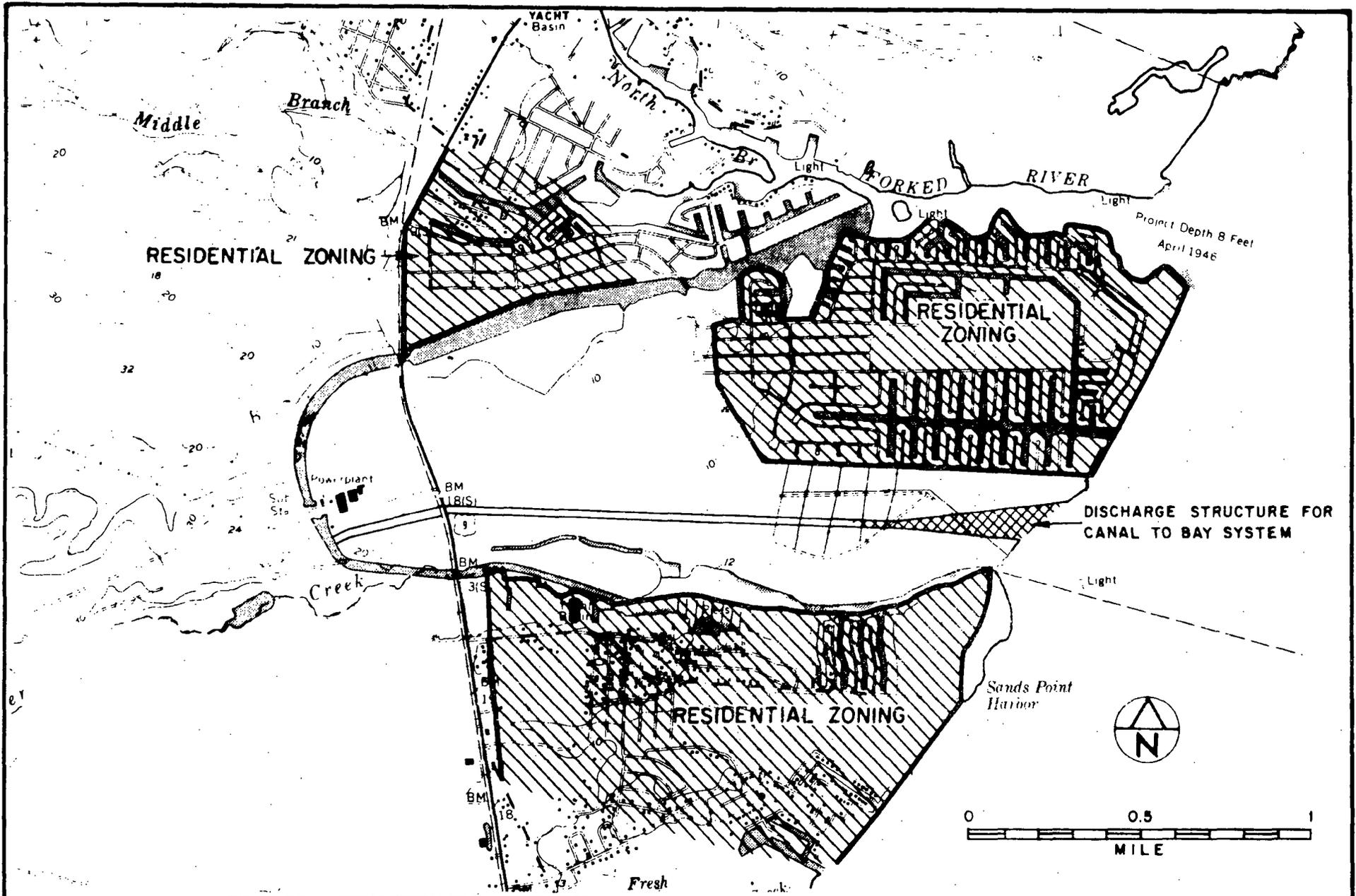
JERSEY CENTRAL POWER  
 AND LIGHT COMPANY

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EBASCO SERVICES INCORPORATED  
 New York

PREDICTED CANAL TO BAY SYSTEM TEMPERATURE DISTRIBUTION FOR THE COMBINED FORKED RIVER AND OYSTER CREEK STATIONS' DISCHARGES  
 TEMPERATURES AT SURFACE, 2.5 AND 5.0 FT DEPTH  
 TWO DILUTION PUMP OPERATION UNDER OCTOBER CONDITIONS

EXHIBIT  
 223

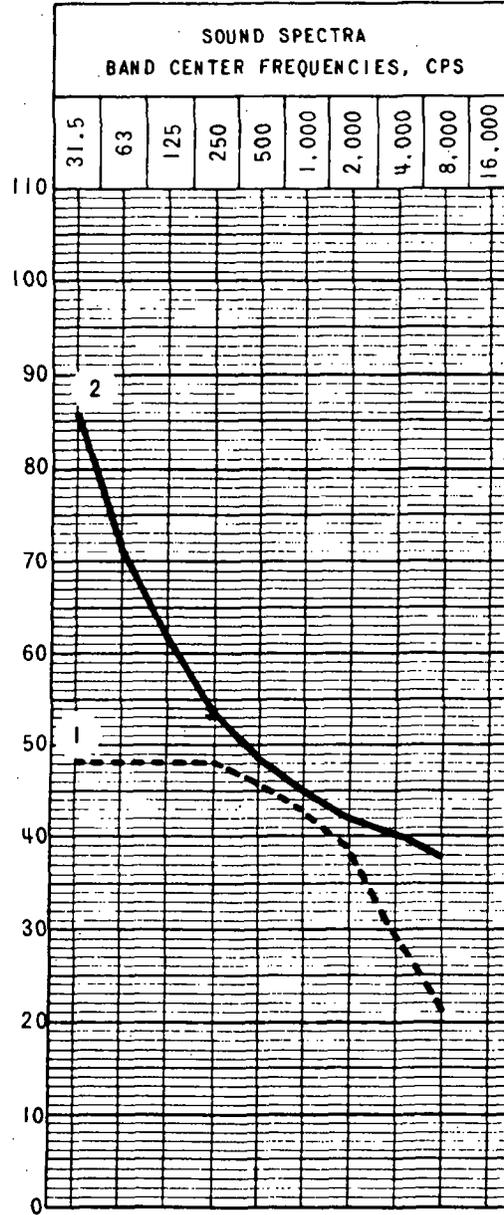
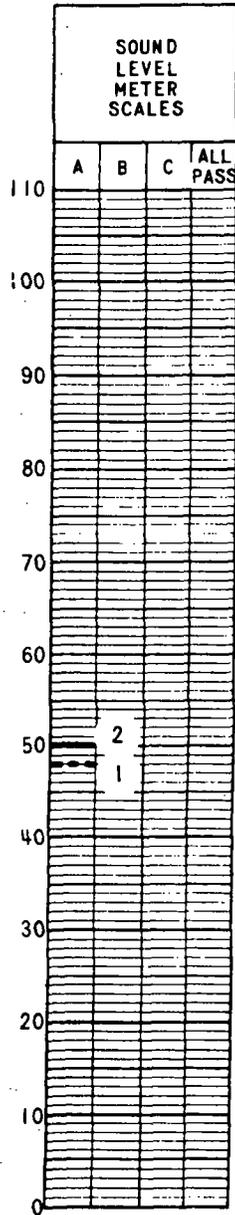


JERSEY CENTRAL POWER  
AND LIGHT COMPANY  
EBASCO SERVICES INCORPORATED  
New York

LOCATION OF CANAL-TO-BAY ALTERNATIVE  
WITH RESPECT TO NEAREST RESIDENTIAL AREAS

EXHIBIT  
224

SOUND PRESSURE LEVEL - DECIBELS (db - Re 0.0002 Microbars)



1. SPL AT A DISTANCE OF ABOUT 600 FT FROM THE DROP STRUCTURE
2. NEW JERSEY NIGHTTIME CRITERION

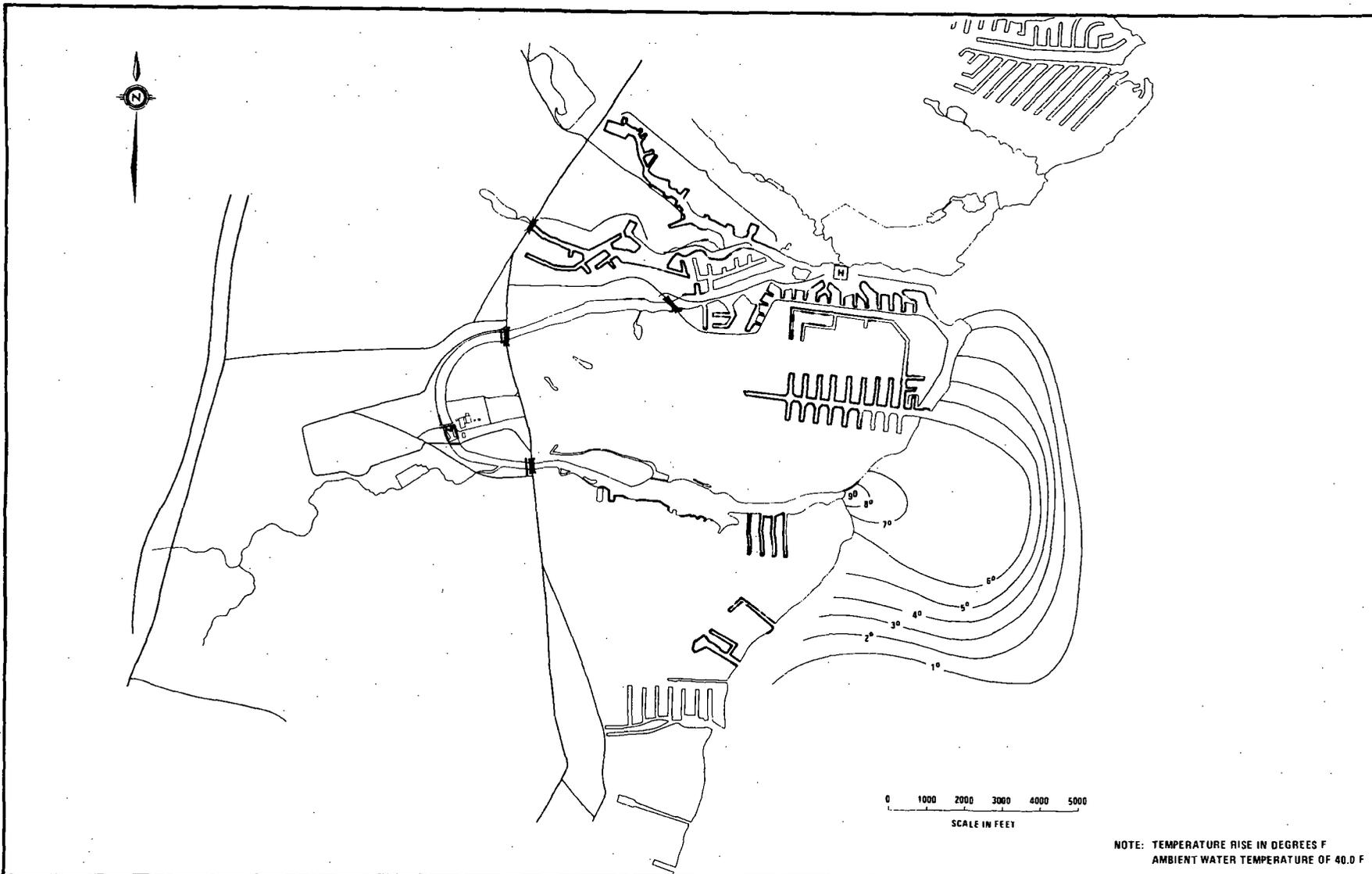
JERSEY CENTRAL  
POWER & LIGHT COMPANY

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EBASCO SERVICES INCORPORATED  
New York

ROUND DROP STRUCTURE  
NOISE DATA

EXHIBIT  
225



NOTE: TEMPERATURE RISE IN DEGREES F  
 AMBIENT WATER TEMPERATURE OF 40.0 F

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---

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 New York

EXISTING OYSTER CREEK NGS COOLING SYSTEM  
 THERMAL SURVEY DATA OF 1/8/75  
 TEMPERATURES AT SURFACE AND 2.5 FT DEPTH

EXHIBIT  
 226

## Exhibit 227

PLANT NET CAPABILITY, ANNUAL HEAT RATE AND ANNUAL GENERATION  
FOR THE PREFERRED COOLING WATER SYSTEMS

| Type of<br>Cooling Water<br>System    | Plant Net Capability<br>at Average<br>Summer Conditions |              | Plant Net Annual<br>Average Heat Rate |              |      | Net<br>Annual Generation |              |
|---------------------------------------|---|--------------|---------------------------------------|--------------|------|--------------------------|--------------|
|                                       | MW  | Differential | Btu/kWh                               | Differential |      | MWh/yr                   | Differential |
|                                       |   | MW           |                                       | Btu/kWh      | %    |                          | MWh/yr       |
| Existing Once-Through                 | 620.2   | Base         | 10,423                                | Base         | Base | 3,539,729                | Base         |
| Discharge Canal-to-Bay                | 618.1   | 2.1          | 10,472                                | 49           | 0.47 | 3,523,109                | 16,620       |
| Natural Draft Cooling Tower           | 599.1   | 21.1         | 10,710                                | 287          | 2.75 | 3,444,835                | 94,894       |
| Fan-Assisted Cooling Towers           | 597.1   | 23.1         | 10,778                                | 355          | 3.40 | 3,423,282                | 116,447      |
| Round Mechanical Draft Cooling Towers | 600.0   | 20.2         | 10,778                                | 355          | 3.40 | 3,423,209                | 116,520      |

<sup>1</sup>Includes additional dilution pumps at mouth of Oyster Creek

CHEMICAL EFFLUENT LIMITATIONS<sup>1</sup> FOR STEAM ELECTRIC GENERATING SOURCESBPCTA - TO BE MET BY ALL EXISTING UNITS BY JULY 1, 1977

| Effluent Source <sup>3</sup> | pH      | TSS<br>(mg/l) | Oil &<br>Grease<br>(mg/l) | Total<br>Copper<br>(mg/l) | Total<br>Iron<br>(mg/l) | Free<br>Available <sup>2</sup>  |     | Zinc<br>(mg/l) | Chromium<br>(mg/l) | Phos-<br>phorus<br>(mg/l) | Other<br>Corrosion<br>Inhibi-<br>ting<br>Materials<br>(mg/l) |
|------------------------------|---------|---------------|---------------------------|---------------------------|-------------------------|---------------------------------|-----|----------------|--------------------|---------------------------|--|
|                              |         |               |                           |                           |                         | Chlorine <sup>2</sup><br>(mg/l) |     |                |                    |                           |  |
| Once-Through Cooling Water   | -       | -             | -                         | -                         | -                       | 0.2                             | 0.5 | -              | -                  | -                         | -  |
| Cooling System Blowdown      | 6.0-9.0 | -             | -                         | -                         | -                       | 0.2                             | 0.5 | -              | -                  | -                         | -  |

BATEA - TO BE MET BY ALL EXISTING UNITS BY JULY 1, 1983

|                            |         |   |   |   |   |     |     |     |     |     |     |     |     |   |
|----------------------------|---------|---|---|---|---|-----|-----|-----|-----|-----|-----|-----|-----|---|
| Once-Through Cooling Water | -       | - | - | - | - | 0.2 | 0.5 | -   | -   | -   | -   | -   |     |   |
| Cooling System Blowdown    | 6.0-9.0 | - | - | - | - | 0.2 | 0.5 | 1.0 | 1.0 | 0.2 | 0.2 | 5.0 | 5.0 | Limit to<br>be estab-<br>lished on<br>a case by<br>case basis |

<sup>1</sup> The (daily) quantity of pollutants discharged shall not exceed the quantity determined by multiplying the (daily average) flow times the concentration listed in this table.

<sup>2</sup> Neither free available chlorine nor total residual chlorine may be discharged from any unit for more than two hours in any one day and not more than one unit in any plant may discharge free available or total residual chlorine at any one time unless the utility can demonstrate to the regional administrator or state, if the state has NPDES permit issuing authority, that the units in a particular location cannot operate at or below this level of chlorination.

<sup>3</sup> Low volume wastes, ash transport water, metal cleaning and boiler blowdown are not included here.

1. Class FW-3 Definition:

Fresh surface water suitable for the maintenance, migration and propagation of the natural and established biota; and for primary contact recreation; industrial and agricultural water supply and any other reasonable uses.

2. Class FW-3 Criteria:

i. Floating, Suspended, Colloidal and Settleable Solids; Oil, Grease, Color and Turbidity

- (1) None noticeable in the water or deposited along the shore or on the aquatic substrata in quantities detrimental to the natural biota. None which would render the waters unsuitable for the designated uses.
- (2) Maximum 30-day average of 20 Jackson Turbidity Units (JTU), a maximum of 110 JTU at any time, unless exceeded due to natural conditions.

ii. Toxic or Deleterious Substances, Including but not Limited to Mineral Acids, Caustic Alkali, Cyanides, Heavy Metals, Carbon Dioxide, Ammonia or Ammonium Compounds, Chlorine, Phenols, Pesticides, etc.

None, either alone or in combination with other substances, in such concentrations as to affect humans or be detrimental to the natural aquatic biota, produce undesirable aquatic life, or which would render the water unsuitable for designated uses.

iii. Taste and Odor Producing Substances

None offensive to humans or which would produce offensive tastes and/or odors in biota used for human consumption. None which would render the waters unsuitable for the designated uses.

iv. pH

Between 6.5 and 8.5. Natural conditions outside this range shall prevail.

v. Dissolved Oxygen

- (1) Nontrout Waters - 24-hour average not less than 5.0 mg/l. Not less than 4.0 mg/l at any time.

vi. Temperature

(1) Nontrout Waters -

- (a) General - No thermal alterations which would cause temperatures to deviate more than 5 degrees F (2.8 degrees C) any time from ambient stream temperatures. No heat may be added which would cause temperatures to exceed 82 degrees F (27.8 degrees C) for small mouth bass or yellow perch waters or 86 degrees F (30 degrees C) for other nontrout waters.  
Temperatures shall be measured outside of designated heat dissipation areas.
- (b) Heat Dissipation Areas - The limitations specified above may be exceeded in designated heat dissipation areas by special permission on a case-by-case basis.
- (c) Heat Dissipation Area Determinations - The determination of heat dissipation areas shall take into consideration the extent and nature of the receiving waters so as to meet the intent and purpose of the criteria and standards including provision for the passage of free-swimming and drifting organisms so that negligible or no effects are produced on their populations. As a guideline, heat dissipation areas shall be limited to no more than 1/4 of the cross-sectional area and/or volume of flow of the stream, leaving 3/4 free as a zone of passage including a minimum of 1/3 surface measured from shore to shore at any flow.
- (d) Adjacent Heat Dissipation Areas - Where waste discharges would result in heat dissipation areas in such close proximity to each other as to impair protected uses, additional limitations may be prescribed to avoid such impairment.
- (e) Rate of Temperature Change - The rate of temperature change in designated heat dissipation areas shall not cause mortality of fish.

vii. Radioactivity

Current U S Public Health Service Drinking Water Standards shall apply.

viii. Bacterial Quality

Fecal coliform levels shall not exceed a geometric average of 200/100 ml.

ix. Total Dissolved Solids

Not to exceed 133 percent of background. Notwithstanding this criterion, the Department, after notice and opportunity for hearing, may authorize increases exceeding this limit provided the discharger responsible for such increases can demonstrate to the satisfaction of the Department that such increases will not significantly affect the growth and propagation of indigenous aquatic biota or other designated uses.

Any authorization by the Department of such increases shall be conditioned upon utilization of the maximum practicable control technology.

EXCERPTS FROM STATE OF NEW JERSEY SURFACE WATER QUALITY CRITERIA CLASS TW-1 WATERS

1. Class TW-1 Definition:

- i. Tidal waters approved as sources of public water supply. These waters shall be suitable for public potable water supply after such treatment as shall be required by law or regulation.
- ii. These waters shall be suitable for shellfish harvesting where permitted.
- iii. These waters shall also be suitable for the maintenance, migration and propagation of the natural and established biota; and for primary contact recreation; industrial and agricultural water supply and any other reasonable uses.

2. Class TW-1 Criteria:

- i. Floating, Suspended, Colloidal and Settleable Solids; Oil, Grease, Color and Turbidity.
  - (1) Same as Class FW-3 Waters.
  - (2) Maximum 30-day average of 25 Jackson Turbidity Units (JTU), a maximum of 130 JTU at any time, unless exceeded due to natural conditions.
- ii. Toxic or Deleterious Substances, Including but not Limited to Mineral Acids, Caustic Alkali, Cyanides, Heavy Metals, Carbon Dioxide, Ammonia or Ammonium Compounds, Chlorine, Phenols, Pesticides, etc.  
Same as Class FW-3 Waters.  
In addition, where tidal waters are approved as sources of public water supply, none which would cause standards for drinking water to be exceeded after appropriate treatment.
- iii. Taste and Odor Producing Substances  
Same as Class FW-3 Waters.
- iv. pH  
Same as Class FW-3 Waters.
- v. Dissolved Oxygen
  - (1) Nontrout Waters -  
Same as Class FW-3 Waters.
- vi. Temperature
  - (1) Nontrout Waters -
    - (a) General - Shall not be raised above ambient by more than 4 degrees F (2.2 degrees C) during September through May, nor more than 1.5 degrees F (0.8 degrees C) during June through August; nor shall temperatures exceed 82 degrees F (27.8 degrees C) in yellow perch or 85 degrees F (29.4 degrees C) in other nontrout waters.  
Temperatures shall be measured outside of designated heat dissipation areas.
    - (b-e) Same as Class FW-3 Waters.
- vii. Radioactivity  
Same as Class FW-3 Waters.
- viii. Bacterial Quality
  - (1) Approved Shellfish Harvesting Waters - Where harvesting of shellfish is permitted, requirements established by the National Shellfish Sanitation Program as set forth in its current manual of operations shall apply.
  - (2) All Other Waters - Fecal coliform levels shall not exceed a geometric average of 200/100 ml.
- ix. Same as Class FW-3 Waters.

EXCERPTS FROM STATE OF NEW JERSEY SURFACE WATER QUALITY CRITERIA CLASS CW-1 WATERS

1. Class CW-1 Definition:

- i. The waters of the Atlantic Ocean within 1,500 feet from mean low tide shoreline or to a bottom depth of 15 feet below the mean low tide elevation, whichever is more distant from the mean low tide shoreline.
- ii. These waters shall be suitable for shellfish harvesting where permitted.
- iii. These waters shall be suitable for primary contact recreation; the maintenance, migration and propagation of the natural and established biota and any other reasonable uses.

2. Class CW-1 Criteria:

- i. Floating, Suspended, Colloidal and Settleable Solids; Oil, Grease, Color and Turbidity.
  - (1) Same as Class FW-3 Waters.
  - (2) Turbidity shall not exceed 10 Jackson Turbidity Units (JTU).
- ii. Toxic or Deleterious Substances, Including but not Limited to Mineral Acids, Caustic Alkali, Cyanides, Heavy Metals, Carbon Dioxide, Ammonia or Ammonium Compounds, Chlorine, Phenols, Pesticides, etc.  
Same as Class FW-3 Waters.
- iii. Taste and Odor Producing Substances  
Same as Class FW-3 Waters.
- iv. pH  
Natural pH conditions shall prevail.
- v. Dissolved Oxygen  
Not less than 5.0 mg/l from other than natural conditions.
- vi. Temperature
  - (1) General - No heat may be added directly to these waters.  
As a result of any heat which may be added elsewhere, the temperature shall not be raised above ambient by more than 4 degrees F (2.2 degrees C) during September through May, nor more than 1.5 degrees F (0.8 degrees C) during June through August, nor shall temperatures exceed 80 degrees F (26.7 degrees C).
- vii. Radioactivity  
Same as Class FW-3 Waters.
- viii. Bacterial Quality
  - (1) Same as Class TW-1 Waters.
  - (2) All Other Waters - Fecal coliform levels shall not exceed a geometric average of 50/100 ml.
- ix. Total Dissolved Solids  
Same as Class FW-3 Waters. In addition, total dissolved solids are not to exceed 500 mg/l for waters approved as sources of public water supply.

EXCERPTS FROM STATE OF NEW JERSEY SURFACE WATER QUALITY CRITERIA CLASS CW-2 WATERS

---

1. Class CW-2 Definition:

- i. Atlantic Ocean waters beyond those established under CW-1 to the three mile limit.
- ii. Same as Class CW-1 waters.
- iii. Same as Class CW-1 waters.

2. Class CW-2 Criteria:

i.-v. Same as Class CW-1 waters.

vi. Temperature

- (1) General - No heat may be added which would cause temperatures to be raised above ambient by more than 4 degrees F (2.2 degrees C) during September through May, nor more than 1.5 degrees F (0.8 degrees C) during June through August, nor shall temperatures exceed 80 degrees F (26.7 degrees C). Temperatures shall be measured outside of designated heat dissipation areas.
- (2) Heat Dissipation Areas - Same as Class TW-1 waters.
- (3) Heat Dissipation Area Determinations - The determination of designated heat dissipation areas shall take into special consideration the extent and nature of such waters so as to meet the intent and purpose of the criteria and standards including provision for the passage of free-swimming and drifting organisms so that negligible or no effects are produced on their populations.
- (4) Adjacent Heat Dissipation Areas - Same as TW-1 waters.
- (5) Rate of Temperature Change - Same as TW-1 waters.

vii. Radioactivity

Same as CW-1 waters.

viii. Bacterial Quality

- (1) Approved Shellfish Harvesting Waters - Same as TW-1 waters.
- (2) All Other Waters - Same as TW-1 waters.

Exhibit B-3

NEW JERSEY REGULATIONS ON AIR POLLUTION  
FROM MANUFACTURING PROCESSES

Maximum Allowable Emission Rate for Particles

| <u>1</u>  | <u>2</u>   | <u>3</u>                                       | <u>4</u>  |
|---|--|--|---|
| Potential<br>Emission<br>Rate From<br>Source<br>Operation<br>(lbs/hr) | Allowable<br>Emission Rate<br>(based on 99%<br>Collection<br>Efficiency)<br>(lbs/hr) | Source Gas<br>Emitted<br>from Source<br>(SCFM) | Allowable<br>Emission<br>Rate (based<br>on 0.02 gr/SCF)<br>(lbs/hr) |
| 50 or<br>less   | 0.5  | 3,000 or<br>less                               | 0.5   |
| 100   | 1.0  | 6,000  | 1.0   |
| 1,000   | 10.0   | 35,000   | 6.0   |
| 2,000   | 20.0   | 70,000   | 12.0  |
| 3,000 or<br>greater   | 30.0   | 140,000  | 24.0  |
|   |  | 175,000 or<br>greater                          | 30.0  |

**APPENDIX E2**

APPENDIX E2

ALTERNATIVE DISCHARGE/COOLING  
SYSTEMS FOR FORKED RIVER NUCLEAR  
GENERATING STATION - UNIT #1

APPENDIX E2  
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E2 ALTERNATIVE DISCHARGE/COOLING SYSTEMS FOR FORKED RIVER NUCLEAR STATION-  
UNIT #1

E2.1 History and Description of Alternatives

During the early planning and development stage of the Forked River Nuclear Station, Unit #1, from 1968 through 1970, a "once-through" condenser cooling system was contemplated. The "once-through" cooling system would have drawn water into the plant from Barnegat Bay, via the existing Oyster Creek Nuclear Station intake canal, and discharged the condenser and plant services cooling water directly to the Atlantic Ocean, off shore, through a six-mile long concrete outfall. A study of this alternative revealed that the long concrete pipe into the ocean and its associated discharge structure would be not only technically difficult to construct, but also extraordinarily expensive. In 1971 the Ocean Discharge System was regarded as economically prohibitive and a three-year search by Burns and Roe, Inc., was initiated to determine the most practical cooling system alternative from the standpoint of the following constraints:

- (1) Investment and Operating Cost
- (2) Practical Constructibility
- (3) Environmental Impact

The following additional alternatives were considered in this study (Reference 1):

- (A) Once-through Salt Water Cooling Lake
- (B) Recirculated Cooling Lake with Well Field Makeup
- (C) Recirculated Cooling Lake with Toms River Water Makeup
- (D) Recirculated Cooling Lake with Sewage Plant Effluent Makeup
- (E) Recirculated Cooling Lake with Salt Water Makeup
- (F) Recirculated Spray Pond with Salt Water Makeup
- (G) Recirculated Spray Pond with Sewage Plant Effluent Makeup
- (H) Once-through Spray Pond for OCNS and FR-1 in Series
- (I) Once-through Spray Pond for OCNS and FR-1 in Parallel
- (J) Cooling Towers with Well Field Makeup
- (K) Cooling Towers with Toms River Water Makeup
- (L) Cooling Towers with Sewage Plant Effluent Makeup
- (M) Cooling Towers with Salt Water Makeup
- (N) Cooling Towers with Desalination Plant to provide Non-Saline Makeup

This study concluded that a natural draft cooling tower with salt water makeup was the most economical system.

Studies were continued through 1972 to 1974 to evaluate the practicality and environmental acceptability of a closed-cycle cooling tower system for the Forked River Nuclear Station Unit #1. Detailed studies of the effects of a salt water, hyperbolic, natural draft cooling tower were evaluated in 1974 (Reference 2) with respect to:

- Ambient Levels of Salt in the Forked River Environs,
- Salt Water Drift from a Hyperbolic Tower, and its Impact on the Surroundings,
- Plume Rise and Visibility,
- Ground Level Fogging,
- Ground Level Icing,
- Blowdown Effects on Thermal and Chemical Releases to the Public Waterway.

This study concluded that a salt water natural draft tower was environmentally acceptable, and the preferred cooling system alternative at that date. The Final Environmental Statement and the construction permits issued by the then U.S. Atomic Energy Commission reflected a cooling system incorporating a natural draft cooling tower.

During 1977, Ebasco Services, Inc., performed an alternative cooling system study for Oyster Creek Nuclear Station including an evaluation of sixteen alternatives (Reference 3). These alternatives differed somewhat from those considered earlier for Forked River Unit #1, primarily due to substantial technical progress made recently in cooling tower engineering.

The 1977 information for Oyster Creek Nuclear Station has been used to provide a common base for comparing the relative economics, engineering practicality and environmental impact of these and additional alternatives.

Therefore, the following alternatives are also considered:

- (O) Mechanical Draft Round Cooling Tower
- (P) Fan Assisted Natural Draft Cooling Tower

## E2.2 Economic Comparison of Alternatives

The cooling system alternatives described in Section E2.1 were evaluated on the basis of total comparative annual system costs. Using this method the most cost-effective system over the life of the plant can be selected.

In addition to these seventeen alternatives, two others were considered which are add-on features to a natural draft cooling tower to reduce the heat released from its blowdown to the Oyster Creek discharge canal. They are:

- (Q) Natural Draft Cooling Tower with Small Blowdown Helper Tower
- (R) Natural Draft Cooling Tower with Blowdown Pipe to Barnegat Bay

The total comparative annual system costs were determined (References 2 and 3) from the following levelized expenses:

- a) annual ownership expense (annual fixed charges on initial investment cost)
- b) operating expense (annual energy cost for circulating water system pump and fan motors and cost for chemical water treatment)
- c) maintenance expense (cooling water system equipment and structures)
- d) annual cost adjustments for differential plant net output and net annual generation (to equalize unit performance with various cooling water systems)

The results of these analyses (normalized to the cost of the canal intake/ocean discharge alternative) which are based on the work performed for the Oyster Creek Alternative Cooling Study and in the 1971 Forked River Alternative Cooling Study are presented in Exhibit E2-1.

This Exhibit demonstrates that the Natural Draft Tower with Salt Water makeup is the most economically preferable System, closely followed by the Mechanical Draft Round Cooling Tower System, Fan-Assisted Natural Draft Cooling Tower System, Natural Draft Tower with Small Helper Tower System and the Mechanical Draft Rectangular Cooling Tower System.

### E2.3 Engineering Evaluation of Alternatives

Technical problems or limitations relating to the construction, operation and/or maintenance of the cooling system are major factors in the evaluation process. The problems and limitations of the cooling systems considered are discussed below.

All of the recirculating cooling systems require a makeup which amounts to a small percentage of the circulating water flow. A fresh water system would require a smaller amount of makeup than a salt water system. However, a study of the water resources in the area (both ground and surface water) revealed that a fresh water supply of the required amount is not available. Therefore the cooling system selected should be able to operate reliably on salt water which is abundant in the area. This consideration is most critical in mechanical type systems such as mechanical draft towers and spray systems due to the additional maintenance required resulting from the corrosive effects of saltwater, and favors the use of a natural draft tower.

Rectangular mechanical draft towers are typically low in profile, usually not exceeding 70 feet in height. Due to this low profile, the saturated air discharge tends to produce low level fogging and icing of near-by structures during adverse meteorological conditions. In addition, recirculation of moist air from the tower effluent can occur due to the small separation distance of the tower stack and the air intake louvers. Recirculation of warm moist air can seriously affect the tower's performance and also requires that towers be separated by at least one tower length.

Mechanical draft towers have some advantage over other systems such as flexibility of operation, i.e. turning off some fans during periods of low wet bulb temperature and low loads. The ability to shut off individual cells also enhances maintainability of the system by not requiring a complete shutdown. The fans are also reversible which aids de-icing during winter startup or extreme cold conditions.

Round mechanical draft towers have essentially the same advantages and minimize some of the problems associated with rectangular towers. For instance, the clustered formation of tower fans tends to produce a larger more buoyant plume. This condition results in a reduction in ground level fog, icing of nearby structures and potential recirculation. The round tower performance is not affected by wind direction, thus providing more flexibility in location at the site.

Natural draft towers have the distinct advantage over mechanical (induced draft) types of having no moving parts. This permits the tower to operate dependably with a minimum of maintenance, even in a saltwater environment. A natural draft tower is not as flexible as a mechanical draft tower in terms of operation, but it does perform better than mechanical draft towers during winter conditions. Current designs require the tower height to exceed 400 feet (to assure adequate draft) which results in a typically large visible water vapor plume.

Additional advantages of a natural draft tower include the lack of low level fogging and icing on nearby structures due to the height of exhaust. Salt deposition, although extending for a further distance is less concentrated at ground level than a mechanical system and would have negligible effect on nearby structures.

The fan-assisted natural draft tower is a hybrid tower, combining aspects of the mechanical draft and natural draft designs. The fans are located around the base of the shell and are generally provided with a two-speed motor for some flexibility of operation. The inherent advantages and disadvantages of this type of system fall between the natural and mechanical draft as tower height is decreased. The reliability is better than a mechanical draft tower since the fans only contact ambient air and are not exposed to the salt in the tower drift.

Cooling lakes with either salt water or fresh water makeup would require a surface area of as much as one and one-half acres per megawatt of generation capacity, or several square miles of lake surface. The availability and cost of land to provide adequate cooling, and uncertainties concerning maintenance of large vinyl lined lakes to prevent seepage losses and intrusion of ground water, proved the cooling lake option impractical. Operating costs of a cooling lake are generally lower than those of the other self-heat dissipating systems. However, the disadvantages of this system far outweigh the advantages.

Spray ponds require less land area than cooling lakes because their aerial sprays dissipate heat to the atmosphere more effectively. A large number of independent floating modules each with a 75 hp pump and motor assembly and four spray heads take their suction from the warmer floating layer near

the surface of the pond. Water would be sprayed into the air at a height of about 20 feet in many large sized droplets measuring from about 1/4 to about 1/2 inch in diameter. This design minimizes drift resulting from smaller size droplets so that the area of effective drift can be maintained within a 300 yard exclusion area even under strong wind conditions. A spray pond for Forked River Nuclear Station, Unit #1, would be sized for a 23 °F approach, with vinyl lining covered with about one foot of sandy soil for in-place retention and protection. If salt water were used, a second vinyl liner would be laid on top of the sand cover for positive protection against salt water intrusion of ground water. Fogging, icing and drift effects on nearby structures are typically more severe than that expected from cooling towers.

The Atlantic ocean discharge alternative would consist of a pipeline about seven miles long. This alternative is not only expensive but also would require massive dewatering during construction. The length of pipeline is such that an additional pumphouse might be required to transport cooling water from the plant to the ocean. Control of fouling by marine growths would be extremely difficult and costly to control. This alternative is not judged to be practical.

The natural draft tower with discharge to Barnegat Bay would require the construction of an approximate three-mile-long, large-diameter concrete pipeline to accommodate the required flow, and a lift station on the east side of Route U.S. #9. This alternative would also require a concrete drop structure on the West Shore of Barnegat Bay. A conceptual layout of this system is presented in Exhibit E2-2. Since a portion of construction would be performed below the water level some dewatering would be necessary. The engineering and construction difficulties for this alternative, however, are not judged to be as severe as in the ocean discharge alternative.

The natural draft tower with a small rectangular helper tower to cool blowdown would not be expected to present any difficulty in construction or maintenance. However, reliability during winter operation could decrease due to icing potential of the small tower during severe weather. A conceptual layout of this alternative is presented in Exhibit E2-3.

#### E2.4 Environmental Assessment of Alternatives

The nineteen cooling system alternatives for Forked River Nuclear Station Unit #1, as described above, were assessed with respect to the following environmental effects:

- Atmospheric
- Hydrothermal
- Water Resources
- Noise
- Visual/Esthetic

- Aquatic Ecological
- Terrestrial Ecological
- Radiological
- Materials

#### Atmospheric Effects

The primary atmospheric effects associated with cooling system operation are:

Elevated Visible Water Vapor Plumes

Ground Level Fogging and Icing

Salt Deposition and Drift

Convective Instability, Cloud Growth and Precipitation Augmentation

A summary of the atmosphere-related impacts associated with the alternative cooling systems are presented in Exhibit E2-4. The information presented in this exhibit is summarized from Reference 3. A comparison of atmospheric effects for cooling towers reveals that the natural draft tower has a significant elevated visible plume approximately 825 hrs/year which extends more than 3000 feet. However, the next best alternative, the round mechanical draft tower has similar characteristics. The natural draft tower, as well as the fan assisted natural draft, has insignificant ground level fogging, salt deposition and drift compared to the round which has a moderate effect. This shows that the natural draft is the preferable tower system based on atmospheric effects.

Spray ponds and cooling lakes have more local effects than the natural draft tower, however, they have a negligible elevated plume and an insignificant effect on convective instability, cloud growth and precipitation augmentation.

The ocean discharge system and the piped blowdown from a cooling tower have no atmospheric effects. A small helper cooling tower for the main cooling tower blowdown line would have only minimal atmospheric effects because of its small size and rather remote location.

#### Hydrothermal Effects

All of the closed-cycle alternatives considered would dissipate the entire plant waste heat. However, the temperature to which the circulating water is cooled is dependent on atmospheric conditions, primarily wet bulb temperature. Since the intake water source does not respond to atmospheric conditions as rapidly as a cooling tower, a temperature differential results between the blowdown and receiving water (receiving water temperature and intake water temperature are assumed equal for Forked River Station). This temperature differential varies, on the average, from about 2°F during summer to 18°F during winter (assuming a natural draft

tower similar to that evaluated for Oyster Creek Station). The discharge water flow from closed cycle systems is very small compared to the circulating water flow. Therefore, the expected increase in the Oyster Creek discharge canal heat load would be a small percentage increase over the OCNGS heat load during worst conditions.

The discharge temperature characteristics of the alternate cooling systems were not evaluated for the Forked River Station. They have been evaluated for the Oyster Creek Station (Reference 3) and are considered representative of the values expected at Forked River. Utilizing the evaporation rates determined for the Oyster Creek Station alternatives (modified by the ratio of the generating capacities of each station) a blowdown flow for each alternative was determined based on a constant makeup pumping rate of 43,200 gpm. A summary of the combined temperature effects due to the Forked River Station and the Oyster Creek Station is presented in Exhibit E2-5 for all the alternatives considered.

By comparing the results in this exhibit the following generalizations can be made.

- 1) A natural draft tower with a helper tower at FRNGS would slightly improve the temperature effects of OCNGS alone.
- 2) The natural draft tower with discharge to the Oyster Creek discharge canal has a small temperature effect. The exhibit shows that even this alternative could improve water temperature some of the time.
- 3) There is no significant hydrothermal benefit using the natural draft tower with bay discharge.
- 4) The hydrothermal characteristics of the cooling lake and spray pond alternatives are very similar to the natural draft tower alternatives.
- 5) The fan assisted natural draft tower and round mechanical draft tower alternatives are not as desirable as the other alternatives during winter. Performance of these alternatives is comparable to the others during summer operation.
- 6) The once-through ocean discharge alternative has no effect on the Oyster Creek discharge canal temperature. However, the thermal release in the Atlantic Ocean from this alternative would probably require an allowance for a heat dissipation area.

Based on this hydrothermal analysis, the natural draft tower with a helper cooling tower is the preferred system, closely followed by the natural draft tower with canal discharge, cooling lakes and spray ponds.

#### Water Resources Effects

The alternatives were evaluated on the basis of water availability and relative impact on water quality. The water requirements for each of the

typical salt water systems is approximately 36,000 gpm\* for the cooling tower and spray pond alternatives, 41,000 gpm\* for the cooling lake and 570,000 gpm for the ocean discharge system. A fresh water system would require less makeup since the concentration of dissolved solids is not as critical.

The freshwater availability in the plant area was investigated previously (References 1 and 4) with the following conclusions:

- 1) small fresh water streams in the immediate area could not supply the amount of water required by even a closed cycle cooling system without constructing several impoundments;
- 2) fresh water availability in Toms River (the largest fresh water stream in the area) would be adequate even though a major portion (approximately 60 percent) of the low flow would be required while the quantity available from Forked River would be inadequate;
- 3) the ground water aquifers in the area could be developed to supply the required flow, even though this would require a 20 square mile well field utilizing 37 wells, but it is unlikely that such a large flow ground water diversion would be allowed by the State of New Jersey.

Considering the vast abundance of saline water in the plant area and the environmental and economic disadvantages of the other water source alternatives, a saltwater cooling system is preferred.

The effect on water quality from a saltwater system is primarily the increase in salinity in the surrounding water bodies due to solids concentration in the cooling tower blowdown. The closed-cycle alternatives are expected to increase salinity in the lower reach of Forked River and Oyster Creek by a small percentage. The increase in bay salinity is expected to be negligible.

\*Includes evaporation and sufficient blowdown (non-consumptive use) to maintain 1.5 cycles of solids concentration in system.

#### Noise Effects

The noise effects of all the alternative cooling systems are expected to be minimal due to the remote location of the Forked River Station with respect to residences. It is expected that the unattenuated sound levels produced by any of the systems would meet New Jersey's A-weighted and octave band noise limitations well within the site boundaries.

#### Visual/Esthetic Effects

Direct visual and esthetic impacts are those resulting from the intrusion of that system into the landscape and the effects of visible plumes, fogging, misting, etc. Indirect impacts result from the removal of vegetative cover

for the purpose of installing the system and possible subsequent losses of vegetative cover from salt-deposition. For the evaluation of alternative cooling systems a qualitative assessment of the above impacts are presented.

The natural draft tower, being hyperbolic in profile, would present a curvilinear shape to the observer. Its principal disadvantages are its large size (about 500 feet in height) and the elevated visible plume which would extend several miles during certain infrequent combinations of meteorological conditions (Reference 2).

The fan-assisted tower (about 300 feet in height) while still a dominant visual feature, would probably have a similar, though lesser, impact compared to the natural draft tower.

The cooling tower alternative expected to produce the least visual esthetic effect is the round mechanical draft cooling tower because of its curvilinear shape, low profile and moderate ground level fogging potential.

Cooling lakes may produce the least visual/esthetic effect of any alternative. However, the huge expanse of water would not be unique to the area. Further, the loss of vegetative cover required for its construction could detract from any of the system's esthetic advantages.

Spray ponds may provide a unique view to the observer, however, the visual effect of fogging and significant local salt deposition (which may preclude the use of tree screening) would probably detract from any of the systems esthetic advantages.

The ocean discharge would have the least visual impact of all alternatives since the only facility visible would be a relatively small concrete pump-house located on the West Shore of Barnegat Bay. However, the disruption of Island Beach State Park during the construction of the pipeline would be undesirable.

A summary of the relative visual/esthetic impact of each alternative is provided in Exhibit E2-6 (Reference 3).

#### Aquatic Ecological Effects

The cooling system alternatives were analyzed with respect to the following aquatic ecological effects:

- a) Average Summer and Winter Temperature Differences
- b) Cold Shock
- c) Wood Borers
- d) Impingement
- e) Entrainment
- f) Water Quality

These effects were considered for the fauna and flora in the intake canal, at the intake structure, in the Nuclear Services Cooling Water System, at the discharge, and in Oyster Creek and Barnegat Bay.

(a) Average Summer and Winter Temperature Differences

A natural draft tower operating with the FRNGS will increase the temperature of the discharge canal during average winter conditions by only 0.3°F if OCNGS is operating with its existing cooling system; and, by only 1.8°F if OCNGS also had a natural draft tower, assuming only one dilution pump running (the worst practical case). This can be seen by comparing the data in Exhibit E2-5 for a natural draft tower with canal discharge versus a natural draft tower with bay discharge. A 0.3°F temperature increase is insignificant to the local marine biota. Moreover, the detection of such a temperature increase would be masked by local ambient temperature variations. (See Exhibit E2-7 for a tabular illustration of the aquatic ecological effects of the various cooling system alternatives.)

Summer temperature extremes will be more critical than temperature variations in the winter. Many species will be living near their upper lethal temperature limit during summer in the discharge canal. Thus, small increases in temperature in the summer could lead to fish avoidance of canal waters for some species. Comparison of the same two cases for summer shows a 0.4°F incremental decrease in average summer temperature expected for a natural draft tower at FRNGS and the existing cooling system at OCNGS, and a 0.2°F increase if OCNGS also used a natural draft tower. Most species found in the canal during the winter are resident fishes or cold water forms. Slight increases in the water temperature in winter will have no detrimental impact on these species. It could potentially cause some increased attraction and concentration of organisms in the heated effluent near the plant.

The round mechanical draft, fan-assisted natural draft, fresh and salt water spray ponds, and fresh and salt water cooling lakes would have an impact similar to the natural draft tower.

If a small helper tower or a blowdown pipe to Barnegat Bay were used in conjunction with a natural draft tower at FRNGS, there would be only a negligible temperature change in the discharge canal, and a negligible ecological effect.

If a once-through cooling system were discharged directly to the Atlantic Ocean there would not be noteworthy thermal impact near the point of ocean discharge, because a diffuser mechanism or a deep-water jet mixer would be used.

(b) Cold Shock

Since the total heat added to the receiving water by any of the closed cycle systems would be minimal under the worst conditions, the threat of cold shock would be minimal.

A once-through ocean discharge might attract fish occasionally during winter, but the cold shock impact would not be very great because the ocean currents will diffuse the warmer water fairly rapidly in such a manner that large schools of fish are not expected to accumulate in the heat dissipation zone during winter months.

(c) Wood Borers

Wood borer (or shipworm) effects will be negligible because of the tenuous temperature changes caused by any of the closed cycle systems. Once-through ocean discharge would not release heat to a natural habitat area for wood borers.

(d) Impingement

The relatively low intake velocities (approximately 0.5 ft./sec.) associated with the intake structure should help to keep impingement relatively low. The use of Ristroph screens should assure that most fish (i.e., over 80 to 90% for most species) should survive impingement and be returned to the discharge canal. Survival of most species impinged should be over 90% except for a few sensitive species such as the bay anchovy (82% survival at the Surry Plant) and weakfish (59% survival) (Reference 5).

Closed cycle systems require only reduced flows at the intake structure, which is a significant advantage over once-through systems as far as impingement losses are concerned.

(e) Entrainment

The reduced flow through the Forked River Nuclear Generating Station due to its use of a cooling tower will mean that fewer organisms are entrained than with the once-through system. However, all organisms entrained are expected to be lost. Therefore, for some species such as the hard clam larvae and blue crab megalops, which have relatively high survival through the Oyster Creek Nuclear Generating Station, the loss may actually be greater at Forked River. However, even the combined losses through the two stations are not predicted to have a significant detrimental effect on the local populations in the Bay.

(f) Water Quality

Evaporative closed cycle cooling systems will concentrate the natural salts in sea water at FRNGS so that their blowdown will have a salinity of approximately 4.5% (sodium chloride) as compared to about 3.0% in the intake water. However, the volume of blowdown flow is only a small percentage of the flow induced by OCNGS dilution pumps through the canal system. The overall increase in salinity about 60m downstream of the discharge will be only 0.26 to 0.53 ppt (Reference 6), and the maximum salinity in the canal should not exceed about 27 ppt. Such small increases in salinity will not have any detrimental effect on local aquatic populations.

Fresh water spray ponds and cooling lakes, as well as a once-through ocean discharge system, are alternatives with negligible effect on water quality.

#### Terrestrial Ecological Effects

The terrestrial ecological effects of the FRNGS alternate cooling systems were evaluated (Reference 2) for their environmental impacts in the following categories.

- a) Land requirements
- b) Salt emissions
- c) Vapor emissions
- d) Impact on waters
- e) Structural impacts

When reviewed in this perspective the environmental effects of the cooling systems on the natural terrestrial fauna and flora of the surrounding area can be compared for their relative benefits and adverse effects. See Exhibit E2-8.

#### (a) Land Requirements

The natural draft, round mechanical draft, fan assisted natural draft, and the small helper tower for blowdown in conjunction with a natural draft tower would each involve the use of somewhere between ten and twenty acres of land for their construction and operation. The land involved in each of these cases has been cleared and leveled some years ago, and even though much of it has been undisturbed for several years before construction of the FRNGS, only sparse and scattered clumps of pine-barren grasses grew in the very sandy soil, and negligible numbers of animals were to be found in, or on, this pine-barren type of land. The land to be used is therefore not of significant habitat value in its present condition. The portion of the FRNGS land not occupied by structures, pavements, etc. will be revegetated.

The cooling tower blowdown pipe (in conjunction with a natural draft tower) from the tower basin to Barnegat Bay will occupy about 25 to 30 acres during construction, but only about half this much during operation due to the buried nature of the blowdown pipe. The natural draft tower will be built and operated on land of very slight habitat value for most fauna and flora. The blowdown pipe would cross the OCNGS land on the periphery of its facilities, pass under Route U.S. #9 and cross about 9,000 feet of previous pasture land supporting spotty patches of pine-barren grasses and scrub growth at elevations slightly above maximum high-tide levels, this land provides a marginal terrestrial habitat for wildlife. Further to the east is a wetlands area which has significant habitat value. After construction of the blowdown pipe and its discharge structure at the shore of Barnegat Bay this land would be restored.

A once-through pipe to an Atlantic Ocean discharge point would also cross the OCNGS site and pass under Route U.S. #9 and the same (above described) area of previous pasture land, as well as Barnegat Bay and Island Beach State Park, requiring the temporary construction use of about 50 acres. Island Beach State Park traditionally has supported only the growth of the more salt tolerant terrestrial organisms due to its proximity to ocean waves and winds. Restoration of the dunes and indigenous vegetation disrupted by pipeline construction will be difficult at best because of the sensitive nature of dune habitats and barrier beach vegetation. Disruption of native fauna on this island would be minimal. Changes in terrestrial habitats by construction of an ocean discharge pipe on the mainland, from FRNGS to Barnegat Bay, would be similar to that for a cooling tower blowdown pipe as described above.

A fresh water or salt water spray pond would occupy approximately 700 acres of land presently supporting pine-barren grasses, scrub vegetation and clumps of scrub trees (principally pine-barren cedars and pines), causing a loss of indigenous fauna as well as flora, and replacing it with a water body. Even with spray modules in operation, such a water body might serve as a temporary resting area for water fowl, but not as a significant habitat for aquatic life, principally because of the retardation of plant growth by their warm, hypersaline waters and the plastic liners in the bottom of the pond.

A fresh or salt water cooling lake would occupy about twice the land area as a spray pond and would have a proportionately similar environmental impact, considering that 1400 acres would be occupied instead of only 700 acres.

#### (b) Drift Effects

The ambient levels of salt in the air and deposited on the ground and various structures in the environs of the FRNGS are significant due to the proximity to the ocean, the bay and the salt water canals (Reference 3). Consequently, the average deposition of salt in areas frequently downwind of a tall natural draft cooling tower would represent less than a ten percent increase above ambient salt levels. However, it is possible that a moderate adverse effect on leaves and needles of vegetative growth might occur in the most frequently affected downwind areas, such as several thousand feet to the southeast of the natural draft tower (Reference 3).

Fan assisted natural draft towers would not be as tall as a natural draft tower and thereby are anticipated to deliver a more concentrated dose of drift fallout in those areas where land surface deposition would most frequently occur. Foliar saline injury to the vegetation east of the towers may cause some, although localized, permanent damage (Reference 3).

Round mechanical draft towers which emit drift droplets at lower elevations above ground level would probably cause vegetation damage on the JCP&L property closer to the towers, but the total amount of salt deposition should be less than that which could cause soil toxicity, primarily

due to leaching of the salt deposited into the sandy soil. The leached salt should not, however, create a salty intrusion into the ground water to any greater extent than that presently occurring from nearby saltwater bodies, and domestic ground water supplies should not be affected (Reference 3).

A natural draft tower with small mechanical draft helper tower for blow-down will have a small additional localized effect. A natural draft tower with a blowdown pipe directly to the bay, will have approximately the same effect as a natural draft tower alone.

A saltwater spray pond may cause a localized injurious affect on vegetation in the most frequent downwind areas from the spray modules.

Fresh water spray ponds, and saltwater or fresh water cooling lakes, as well as direct ocean discharge would probably have no adverse impact due to salt emissions or deposition.

(c) Vapor Emissions

All cooling system alternatives would have only slight or minimal, if any, adverse effects due to vapor emissions (Reference 3).

(d) Terrestrial Ecological Effects on Fresh Water Bodies

As shown in Exhibit E2-8 only slight to negligible, if any, adverse affects would result from increased salinity to fresh water bodies, or due to construction activities, from any of the cooling system alternatives herein considered.

(e) Structural Impacts

Tall hyperbolic cooling towers could provide a hazard to migrating birds due to their width, because some individuals in a migrating flock do not have adequate opportunity to avoid collision with such towers (Reference 3). This is a particular concern for smaller shore birds and song birds which prefer nighttime migration. These nocturnal migrating birds fly at low altitude below the clouds in adverse weather and are attracted to the concentrations of light along the shoreline. The use of red lights as aircraft navigational avoidance warnings are preferable on tall cooling towers to protect these migrating birds as compared to high intensity lights (Reference 3). Both types of lighting are acceptable to the Federal Aviation Administration.

A natural draft tower at FRNGS could be a moderate hazard to nocturnal bird migration in bad weather, even with the use of selective lighting, while fan assisted natural draft towers of lower height would be somewhat less, and round mechanical draft towers would have a negligible effect on birds (Reference 3).

Spray ponds and cooling lakes, with fresh or salt water, by contrast, would provide temporary resting, but probably not feeding or breeding areas for water fowl.

A system which includes a small helper tower or blowdown pipe to bay would have the same effect as a natural draft tower alone.

The once-through ocean discharge system, with only a low level pumphouse above the surface should have no effect on terrestrial ecology.

#### Radiological Effects

The 1977 Ebasco report (Reference 3) addressed the effects of stack gas and tower plume interaction. The results of this study (which are substantiated by NRC staff testimony at a recent environmental hearing) can be summarized as follows:

"... the results of this study indicate that the potential interaction between stack gases and cooling tower drift should have no effect on the choice of a cooling tower design. Furthermore, it is judged that any such interaction will make a negligibly small contribution to the overall radiological impact of a nuclear facility."

#### Effects on Materials

A detailed analysis of cooling tower saltwater drift effects on metal structures and residential home sidings was performed for OCNGS by National Economic Research Associates, Inc. (NERA) (Reference 7), for the natural draft, fan-assisted natural draft and round mechanical draft tower alternatives. Using this detailed analysis as a basis for estimating, the same three alternatives were evaluated for FRNGS, but this has not been extended to the other FRNGS cooling system alternatives.

Considering the increase in incremental costs for maintenance and repair to metal structures and home sidings as compared to the comparable condition in the absence of a saltwater cooling tower at FRNGS, corrosive effects were considered on three categories of metals and two categories of home sidings. The metal categories were:

- a) Highly corrosive
  - carbon steel
  - wrought iron
  
- b) Mildly corrosive
  - low alloy steel
  - copper based alloys
  - aluminum based alloys
  - magnesium
  - zinc

- c) Highly resistant
  - stainless steel
  - nickel-based alloys
  - titanium
  - noble metals
  - lead
  - cadmium
  - tin

The housing siding categories were:

- a) Dimensionally unstable
  - wood
  - asbestos
- b) Dimensionally stable
  - brick
  - stone
  - aluminum

Considering that the closest structures beyond the JCP&L property lines that might be affected are at least 6,000 feet away from these cooling tower locations, the effect of cooling tower saltwater drift would have no more than a slight to moderate incremental influence in increasing the rate of corrosion of metals or weathering of painted surfaces. Most all of the possibly affected structures in the local area are in the immediate proximity to Barnegat Bay and are therefore naturally influenced by salt spray drift from the ocean and the bay.

The round mechanical draft and fan-assisted natural draft tower alternatives would release drift with their plumes at lower altitudes than the natural draft tower and might have a moderate effect in the immediate area. The natural draft tower effect, with its plume dispersed over a wider area, is expected to have no more than a slight effect on structures in comparison with the ambient levels of salt naturally dispersed by winds from ocean and bay spray drift.

#### E2-5 Optimum Choice of the Cooling System

When considered from the standpoint of each of the important factors, namely:

- a) Atmospheric effects
- b) Hydrothermal effects
- c) Water resources effects
- d) Noise effects

- e) Visual and esthetic effects
- f) Aquatic and terrestrial ecological effects
- g) Radiological effects
- h) Materials effects
- i) Engineering and construction practicality,  
and
- j) Investment and operating costs

a natural Draft Cooling Tower has the most beneficial characteristic and least adverse impacts of the above considered alternatives, and is also preferred from the standpoints of economics, engineering and constructability.

## APPENDIX E2

### REFERENCES

1. Alternate Cooling Systems Study for Forked River Unit #1, Jersey Central Power and Light Co., May 1971, Burns and Roe, Inc.
2. The Forked River Program, A Case Study in Salt water Cooling, J.C. DeVine, Jr., February, 1974, GPU Service Corporation.
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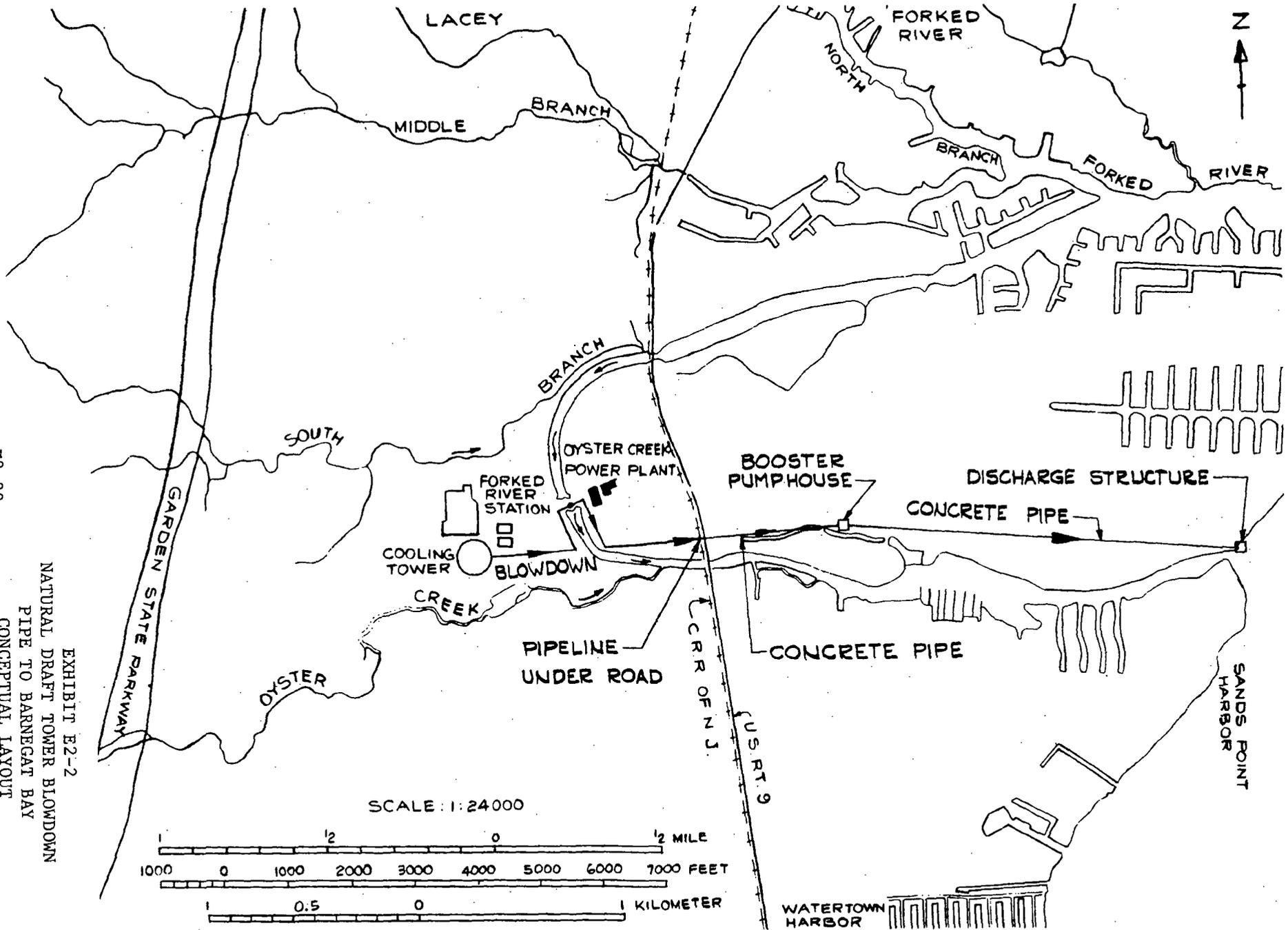
EXHIBIT E2-1

COMPARATIVE SUMMARY OF TOTAL ANNUAL COOLING SYSTEM COSTS

| <u>ALTERNATIVE</u>  | <u>NORMALIZED COSTS RELATIVE TO<br/>CANAL INTAKE/OCEAN DISCHARGE<br/>COST</u> |
|---|---|
| Natural Draft Tower with Salt Water Makeup                | 0.70  |
| Mechanical Draft Round Cooling Tower                      | 0.72  |
| Fan Assist Natural Draft Cooling Tower                    | 0.74  |
| Natural Draft Tower with Small Helper Tower               | 0.74  |
| Mechanical Draft Rectangular Cooling Tower                | 0.75  |
| Spray Pond with Salt Water Makeup                         | 0.77  |
| Natural Draft Tower with Blowdown Pipe to Bay             | 0.77  |
| Natural Draft Tower with Toms River Makeup                | 0.79  |
| Natural Draft Tower with Sewerage Effluent Makeup         | 0.79  |
| Once-Through Spray Pond FR-1, OCGS in Parallel            | 0.87  |
| Recirculating Spray Pond with Sewerage Effluent<br>Makeup | 0.88  |
| Canal Intake with Ocean Discharge                         | 1.00 (Base)   |
| Large Cooling Lake with Sewerage Effluent Makeup          | 1.16  |
| Natural Draft Tower with Well Field Makeup                | 1.20  |
| Large Cooling Lake with Toms River Makeup                 | 1.23  |
| Once-Through Spray Pond FR-1, OCGS in Series              | 1.25  |
| Large Cooling Lake with Salt Water Makeup                 | 1.49  |
| Large Cooling Lake with Well Field Makeup                 | 1.61  |
| Once-Through Salt Water Cooling Lake                      | 1.68  |
| Natural Draft Tower with Desalination<br>Plant Makeup     | 1.94  |

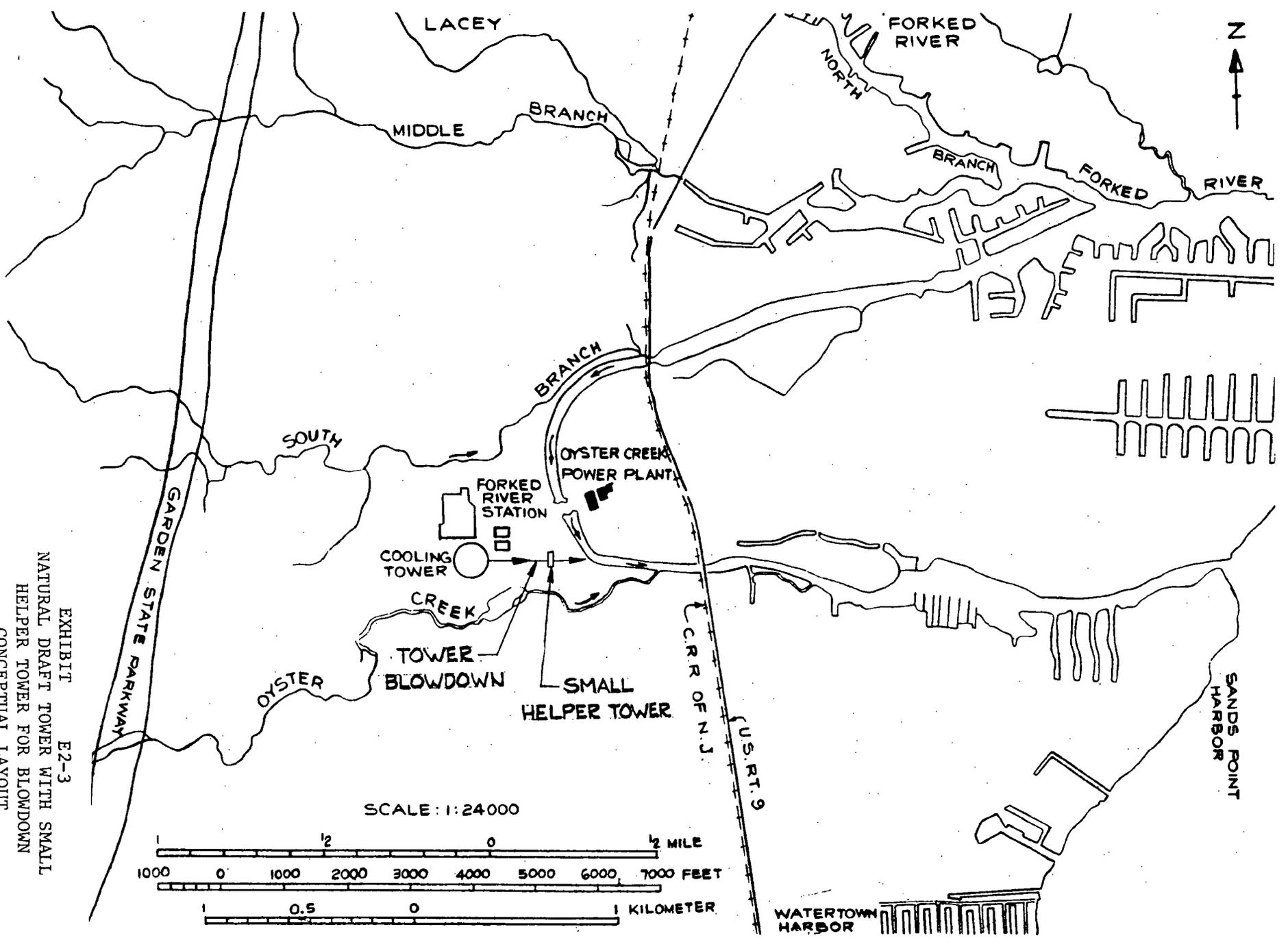
E2-22

EXHIBIT E2-2  
NATURAL DRAFT TOWER BLOWDOWN  
PIPE TO BARNEGAT BAY  
CONCEPTUAL LAYOUT



E2-23

EXHIBIT E2-3  
NATURAL DRAFT TOWER WITH SMALL  
HELPER TOWER FOR BLOWDOWN  
CONCEPTUAL LAYOUT



SCALE: 1:24000

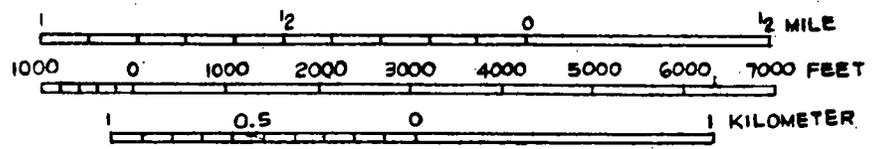


EXHIBIT E2-4

RELATIVE ATMOSPHERIC EFFECTS OF ALTERNATIVE COOLING WATER SYSTEMS FOR FORKED RIVER NGS

| <u>System</u>              | <u>Elevated Plumes</u> |  | <u>Ground Level Fogging</u> |                             | <u>Salt Deposition-Drift</u> |  | <u>Convective Instability</u>                             |
|----------------------------|------------------------|--|-----------------------------|-----------------------------|------------------------------|--|---|
|                            | <u>Impact</u>          | <u>Comment</u>                                     | <u>Impact</u>               | <u>Comment</u>              | <u>Impact</u>                | <u>Comment</u>   | <u>Cloud Growth and Precipitation Augmentation Impact</u> |
| <u>Cooling Towers</u>      |                        |  |                             |                             |                              |  |   |
| Natural Draft              | High                   | Less than 825 hrs/yr extending more than 1,000 yds | Low                         | -                           | Low                          | Max annual deposition rates estimated less than 89 kg/km per month | Moderate  |
| Round                      | High                   | Frequency similar to natural draft tower           | Low to Moderate             | Depends on wind speed       | Moderate to Low              | Depends on wind speed  | Moderate  |
| Fan Assisted Natural Draft | High                   | Frequency similar to natural draft tower           | Low to Moderate             | Depends on tower height     | Low to Moderate              | Depends on tower height  | Moderate  |
| <u>Cooling Lake</u>        | None                   | -  | Moderate                    | Fogging may extend 1/2 mile | None                         | -  | Low   |
| <u>Spray Pond</u>          | None                   | -  | Moderate                    | Fogging may extend 1/2 mile | High                         | Drift may extend 2,000 ft. or more from canal                      | Low   |
| <u>Ocean Discharge</u>     | None                   | -  | None                        | -                           | None                         | -  | None  |

Evaluations are based on comparison to other cooling systems.

E2-24

EXHIBIT E2-5

COMBINED TEMPERATURE EFFECTS\* IN OYSTER CREEK FROM FORKED RIVER STATION AND OYSTER CREEK STATION FOR ALTERNATIVE COOLING SYSTEMS

|   | Forked River Station Discharge Flow (gpm) |         | Forked River Station Discharge Temp. °F |        | Oyster Creek Temperature Rise, °F<br>OCNGS Utilizing Existing System<br># Dilution Pumps Operating |        |        |        |        |        | Oyster Creek Temperature Rise, °F<br>OCNGS Utilizing Natural Draft Tower<br># Dilution Pumps Operating |        |        |        |        |        |
|---|---|---------|---|--------|--|--------|--------|--------|--------|--------|--|--------|--------|--------|--------|--------|
|   | Winter                                    | Summer  | Winter                                  | Summer | 0  |        | 1      |        | 2      |        | 0  |        | 1      |        | 2      |        |
|   |   |         |   |        | Winter   | Summer | Winter | Summer | Winter | Summer | Winter   | Summer | Winter | Summer | Winter | Summer |
| Natural Draft Twr. With Canal Discharge     | 34,300                                    | 31,300  | 55.2                                    | 81.0   | 18.9   | 17.9   | 12.3   | 11.6   | 9.1    | 8.6    | 17.7   | 2.2    | 2.9    | 0.3    | 1.6    | 0.2    |
| Natural Draft Twr. With Bay Discharge       | 34,300                                    | 31,300  | 55.2                                    | 81.0   | 19.0**   | 19.0** | 12.0** | 12.0** | 8.8**  | 8.8**  | 17.7**   | 2.2**  | 1.1**  | 0.1**  | 0.6**  | 0.1**  |
| Natural Draft Twr. with Helper Cooling Twr. | 34,300                                    | 31,300  | 39.0                                    | 69.0   | 17.8   | 17.1   | 11.6   | 11.1   | 8.6    | 8.2    | 6.9  | -5.8   | 1.0    | -0.8   | 0.6    | -0.5   |
| Fan Assisted Natural Draft Twr.             | 34,300                                    | 31,300  | 64.5                                    | 82.5   | 19.6   | 18.0   | 12.7   | 11.7   | 9.4    | 8.7    | 23.9   | 3.2    | 4.0    | 0.5    | 2.2    | 0.3    |
| Round Mechanical Draft Tower                | 34,300                                    | 31,300  | 60.0                                    | 78.0   | 19.3   | 17.7   | 12.6   | 11.5   | 9.3    | 8.5    | 21.6   | 0.2    | 3.6    | 0.0    | 1.9    | 0.0    |
| Cooling Lake                                | 39,300                                    | 29,700  | 47.8                                    | 80.6   | 18.3   | 17.9   | 12.0   | 11.6   | 8.9    | 8.6    | 12.6   | 1.9    | 2.2    | 0.3    | 1.2    | 0.2    |
| Spray Pond                                  | 34,300                                    | 30,700  | 49.0                                    | 77.2   | 18.5   | 17.7   | 12.0   | 11.5   | 8.9    | 8.5    | 13.6   | -0.3   | 2.2    | 0.0    | 1.2    | 0.0    |
| Canal Intake/Ocean Discharge                | 570,000                                   | 570,000 | 63.1                                    | 104.4  | 19.0   | 19.0   | 12.0   | 12.0   | 8.8    | 8.8    | 17.7   | 2.2    | 1.1    | 0.1    | 0.6    | 0.1    |

\*Assuming complete and rapid mixing of flows, negligible in flow from Oyster Creek  
 \*\*Temperature increases for this alternative are those expected from the operation of Oyster Creek Station alone.

E2-25

## EXHIBIT E2-6

SUMMARY OF VISUAL/ESTHETIC IMPACTS

| <u>Cooling System</u>      | <u>Permanent<br/>Loss of<br/>Vegetative<br/>Cover</u> | <u>Profile<br/>Impact</u> | <u>Visible<br/>Plume</u> | <u>Ground<br/>Fog</u> | <u>Combined<br/>Impact</u> |
|----------------------------|---|---------------------------|--------------------------|-----------------------|----------------------------|
| Natural Draft<br>Towers    | None  | High                      | High                     | None                  | High                       |
| Round Mechanical<br>Towers | None  | Moderate                  | Moderate                 | Low                   | Moderate                   |
| Fan-Assisted<br>Towers     | None  | High                      | High                     | Low                   | High                       |
| Spray Canal<br>System      | Moderate  | Low                       | Low                      | Moderate              | Moderate                   |
| Cooling Ponds              | High  | Low                       | None                     | Moderate              | Moderate                   |
| Ocean Discharge            | None  | Low                       | None                     | None                  | Low                        |

EXHIBIT E2-7

Aquatic Ecology Effects of Alternate Cooling Systems

| Cooling System                  | Summer/Winter Temperature Differential                           | Cold Shock | Wood Borer | Impingement                  | Entrainment                                       | Water Quality   |
|---------------------------------|--|------------|------------|------------------------------|---|---|
| Natural Draft                   | <u>Tenuous</u><br>Slight Thermal Increase Above OCNGS O/T System | Minimal    | Negligible | Highest in Spring and Summer | No Significant Detrimental Bay Pop. Effect Likely | Slight Salinity Increase<br>pH and D.O. Change Negligible |
| Round Mechanical Draft          | <u>Tenuous</u><br>As Natural Draft                               | Minimal    | Negligible | Highest in Spring and Summer | No Significant Detrimental Effect Likely          | Same as Natural Draft                                     |
| Fan-Assist Fan Draft            | <u>Tenuous</u><br>As Natural Draft                               | Minimal    | Negligible | Highest in Spring and Summer | No Significant Detrim Effect Likely               | Same as Natural Draft                                     |
| Helper Tower for Tower Blowdown | Negligible   | Minimal    | Negligible | Highest in Spring and Summer | No Significant Detrimental Effect Likely          | Slight Salinity Increase in Discharge Canal               |
| Blowdown Pipe to Barnegat Bay   | Negligible   | Slight     | Negligible | Highest in Spring and Summer | No Significant Detrimental Effect Likely          | Slight Salinity Increase at Bay Discharge                 |

E2-27

EXHIBIT E2-7 (Cont'd)

Aquatic Ecology Effects of Alternate Cooling Systems

| Cooling System             | Temperature Extremes Hi/Lo                   | Cold Shock | Wood Borer | Impingement                  | Entrainment                                       | Water Quality            |
|----------------------------|--|------------|------------|------------------------------|---|--------------------------|
| Salt-Water Spray Ponds     | Same as Natural Draft                        | Minimal    | Negligible | Highest in Spring and Summer | No Significant Detrimental Bay Pop E.L            | Slight Salinity Increase |
| Fresh-Water Spray Ponds    | Same as Natural Draft                        | Minimal    | Negligible | Highest in Spring and Summer | No Significant Detrimental Bay Pop. Effect Likely | Negligible               |
| Salt-water Cooling Lake    | Same as Natural Draft                        | Minimal    | Negligible | Highest in Spring and Summer | No Significant DetrimentalBP Effect Likely        | Slight Salinity Increase |
| Fresh-Water Lake           | Same as Natural Draft                        | Minimal    | Negligible | Highest in Spring and Summer | No Significant DetrimentalBP Effect Likely        | Negligible               |
| O/T Pipe to Atlantic Ocean | Thermal Effect Near Point of Ocean Discharge | Slight     | None       | Substantial                  | Substantial                                       | Negligible Ocean Effect  |

EXHIBIT E2-8

Terrestrial Ecology Effects of Alternate Cooling Systems

| Cooling System                  | Land Requirement   | Salt Emissions  | Vapor Emissions           | Impact on Water                          | Structural Impacts                          |
|---------------------------------|--|---|---------------------------|--|---|
| Natural Draft                   | About 12 Acres of cleared land without significant habitat value | Deposition less than 10% above ambient<br>Foliar Injury Impact Moderate and Mainly to Southeast | Minimal Biological Effect | Fresh Water Salinity Increase Negligible | Moderate Hazard to Nocturnal Bird Migration |
| Round Mechanical Draft          | About 16 Acres of cleared land without significant habitat value | Injurious to nearby vegetation, but deposition should not cause soil toxicity                   | Minimal Biological Effect | Slight                                   | Negligible                                  |
| Fan-Assist Natural Draft        | About 16 Acres of cleared land without significant habitat value | Threshold salt conc. maximum east of site, and might cause lasting Foliar Injury                | Minimal Biological Effect | Negligible                               | Slight Hazard to Nocturnal Bird Migration   |
| Helper Tower for Tower Blowdown | About 17 Acres of cleared land without significant habitat value | Same as Natural Draft   | Same as Natural Draft     | Same as Natural Draft                    | Same as Natural Draft                       |

E2-29

EXHIBIT E2-8 (Cont'd)

Terrestrial Ecology Effects of Alternate Cooling Systems

| Cooling System                | Land Requirement   | Salt Emissions                 | Vapor Emissions       | Impact on Water                                   | Structural Impacts  |
|-------------------------------|--|--------------------------------|-----------------------|---|---|
| Blowdown Pipe to Barnegat Bay | 26 Acres Construction, with 16 Acres permanent, mostly of marginal habitat value | Same as Natural Draft          | Same as Natural Draft | Same as Natural Draft                             | Same as Natural Draft                                       |
| Salt-Water Spray Ponds        | About 700 Acres of partially grassy land with some Pine & Cedar woods            | Injurious to nearby vegetation | Slight                | Depends on Proximity to non-saline surface waters | Waterfowl Resting Area                                      |
| Fresh-Water Spray Ponds       | Same as Salt Water Spray Ponds   | None                           | Slight                | None  | Waterfowl Resting Area                                      |
| Salt-Water Cooling Lake       | About 1400 Acres partially forested with White Cedar and Pine                    | Negligible                     | Negligible            | Depends on Proximity to non-saline surface waters | Temporary Resting Area, but not feeding Area, for Waterfowl |

E2-30

EXHIBIT E2-8 (Cont'd)

Terrestrial Ecology Effects of Alternate Cooling Systems

| Cooling System             | Land Requirement                                     | Salt Emissions | Vapor Emissions | Impact on Water   | Structural Impacts     |
|----------------------------|--|----------------|-----------------|---|------------------------|
| Fresh-Water Cooling Lake   | Same as Salt Water Cooling Lake                      | None           | Negligible      | None  | Waterfowl Resting Area |
| O/T Pipe to Atlantic Ocean | About 50 Acres of Sensitive Habitat on Barrier Beach | None           | None            | Four Linear Miles of Construction thru Barnegat Bay and the Ocean | Negligible             |

E2-31

## **Appendix F**

APPENDIX F1

AN EVALUATION OF THE ECONOMIC BENEFITS  
AND COSTS OF ALTERNATIVE COOLING SYSTEMS  
AT THE OYSTER CREEK NUCLEAR GENERATING STATION

Prepared by

Dr. Thomas K. Fitzgerald  
National Economic Research Associates, Inc.

November 28, 1977

APPENDIX F1

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## I. INTRODUCTION

This study investigates the economic benefits and costs deriving from the installation and operation of four alternative cooling systems at Jersey Central Power & Light (JCP&L) Company's Oyster Creek Nuclear Generating Station (OCNGS). The alternative systems analyzed were the four chosen, by Ebasco (1977a), as preferred for the OCNGS. The four include three closed-cycle systems operating with: (1) two fan-assisted natural draft towers; (2) two round mechanical draft towers; and, (3) one natural draft tower. The fourth system involves a modification of the existing discharge structure by means of a canal-to-bay discharge system. The economic analysis of these alternatives is composed of two parts: the first part examines the capital, operating and maintenance costs of each alternative system; and the second part involves an evaluation, in monetary terms, of the environmental effects produced by the operation of each system.

A major element of costs of each alternative system involves the cash outlays required for installation and operation. These include the capital costs of the system and the replacement of lost capacity due to generation required for operation and for plant deratings resulting from increased turbine back pressure, maintenance costs, water costs, and the fuel costs associated with operation of the circulating water system and with the losses in net capability from increases in turbine back pressure.

Once-through systems, because of their large intake water requirements and their discharge of similar volumes of heated water, often produce adverse environmental impacts through their effects on aquatic populations. Large aquatic specimens are impinged on intake screens, whereas various minute organisms are entrained in the intake water and carried over the condensers: in each case, substantial mortalities may occur. The discharge of thermal effluent into local water bodies may result in changes in the water quality and ecological balance of those systems. At the OCNGS, an additional problem of fish kills due to cold shock has occurred occasionally during plant shutdowns in the winter.

The closed-cycle cooling systems analyzed require considerably less intake water, and their blowdown discharge does not result in substantial increases in the temperatures in the receiving water body. Because of reductions in the volume of intake water, impingement mortalities are reduced. Fewer organisms are entrained because of the smaller volume of intake water and, although mortalities in the closed cycle reach 100 percent of the entrained biomass, net reductions in entrainment mortalities are expected to occur. The reductions in the volume of thermal discharge from cooling tower blowdowns minimize impacts on ecological balance; and exposures to cold shock are decreased. These reductions in plant-related mortalities of aquatic species constitute the major source of benefits from installation of the closed-cycle systems.

The canal-to-bay discharge structure involves no changes from the existing system in terms of intake structure and relocates the point of discharge to Barnegat Bay rather than Oyster Creek. No changes in entrainment and impingement losses, therefore, are expected; and the problem of cold shock, while eliminated from Oyster Creek, is expected to be shifted to the lagoon system between Oyster Creek and Forked River. The net effect of this shift in the cold-shock impact area has not been estimated but is expected to be insignificant. Overall, therefore, the canal-to-bay discharge structure is assumed to generate no quantifiable environmental benefits.

The benefits to the aquatic environment are not the only side of the social benefit-cost ledger affected. Operation of the cooling towers produces a number of adverse environmental effects. These effects include: the production of ground-level fogging and, in sub-freezing weather, surface-icing conditions which may, depending on the cooling system alternative, create hazards for local road traffic; the emission, in the case of the OCNGS, which uses saltwater for cooling, of sea-salt particles which deposit on materials and vegetation in the vicinity of the plant; and increases in background noise levels, particularly at night.

Of these adverse environmental effects, only noise problems are involved in the case of the canal-to-bay system; and these problems appear to be capable of attenuation through technical means. Consequently, with no additional environmental benefits or costs, only the capital and operating costs of this system are considered further in this study.

The study is divided into two main parts. The first part reports estimates of capital and operating costs of each system, briefly outlines the methods for evaluating the environmental effects noted above and presents the resulting estimates obtained. In the second part, the methodologies employed for estimating the values of the environmental effects are described in greater detail.

## II. THE BENEFITS AND COSTS OF ALTERNATIVE COOLING SYSTEMS

All estimates of benefits and costs arising during this period have been estimated in the current dollars of years in which they are expected to occur and expressed in terms of levelized annual values. Levelized values are the constant annual values of benefits and costs which have the same present values as the actual benefit/cost streams projected for the period of operation. The levelized annual values have been calculated assuming: (1) a discount rate of 11.22 percent; (2) a fixed charge rate of 22.25 percent; and (3) a period of operation from 1984 through 2004.

For selected environmental effects, a range of estimates was calculated based on high and low environmental impact assumptions and/or high and low economic value parameters. Best, most likely and worst case estimates were developed using values in these ranges. Estimated benefits combine the upper limits of the environmental impacts and economic values in the best case and the lower limits of each range in the worst case. Conversely, estimated costs combine the lower limits of the environmental impacts and economic values in the best case and the upper limits of each range in the worst case. For benefits and costs, the most likely case generally reflects an average of the best and worst case estimates.

### A. Capital, Operating and Maintenance Costs

The costs of installing and operating the four alternative cooling systems have been estimated by Ebasco Services Incorporated (Ebasco, 1977a). Estimates for each system, by major cost components, are presented in Table 1. The aggregate levelized annual costs of installation and operation are lowest for the canal-to-bay discharge modification--\$9.13 million. Following this system is the natural draft tower at a levelized annual cost of \$20.37 million. This system is only slightly less costly than the round mechanical draft towers--\$20.81 million--and the fan-assisted natural draft towers--\$21.30 million.

### B. Environmental Effects of the Closed-Cycle Alternatives

#### 1. Aquatic Benefits<sup>1</sup>

---

<sup>1</sup>No attempts were made to evaluate the incremental effects of the alternative cooling systems on bank fishing in Oyster Creek. The New Jersey Department of Environmental Protection (1974) in a 1971-72 survey of recreational activity in the Upper Barnegat System provides findings which suggest approximately 6,000 man-days of bank fishing at Oyster Creek with the existing system in operation. Each of the alternative cooling systems is likely to reduce the level of activity in Oyster Creek, but the magnitudes of the reductions and the extent to which relocation to nearby banks would be feasible have not been quantified; and the overall net impact is therefore indeterminate.

The installation of a closed-cycle cooling system with cooling tower(s) at the OCNGS is expected to reduce the mortality levels of various aquatic species that have been observed at the plant site. These reductions in mortality levels have value to society primarily as a result of their effect on commercial and recreational fisheries.

Reductions in mortalities from three aspects of cooling system operation--entrainment, impingement and cold-shock--were analyzed. Each of the closed-cycle alternatives is expected to result in similar reductions in mortalities of aquatic species.<sup>2</sup> Estimated reductions were expressed in terms of gains in species population weight for all species with recognized commercial and/or recreational value.<sup>3</sup> These gains were evaluated using values per unit of weight, by species, derived from weighted averages of commercial values, based on landings values, and recreational values based on estimates of the recreational value of a day of salt-water angling and average recreational catches. Adjustments were made in these values to account for the relationship between harvests and stocks and, in the case of recreational fishing, for the relationship between effort and stocks. Estimates of the economic benefits from these gains in species stocks are presented in Table 2.

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<sup>2</sup>In the case of one species, the Blue Crab, entrainment mortalities are expected to be greater with the cooling towers. Although entrainment is reduced with these systems, there is 100 percent mortality of the entrained biomass. By contrast, negligible mortalities of the large number of entrained Blue Crab organisms have been observed with the existing system.

<sup>3</sup>Two exceptions were made: Tautog and Hard Clams. In the case of Tautog, it was not possible to translate reduced entrainment mortalities into adult weights. This species is commercially harvested but total 1976 landings in New Jersey were less than 22 tons. Similarly, in the case of Hard Clams, a total lack of reliable data on the natural mortality rates of the egg and larval stages made determination of adult equivalent weight gains from reduced entrainment losses impossible. The Hard Clam represents a highly important species in the commercial fishery of the Bay; and JCP&L intends to conduct a study of the age-structure and density of the Hard-Clam population in different regions of the Bay during the summer of 1978; in order to determine the frequency and intensity of recruitment in past years and the effects of entrainment at the OCNGS on the Bay population.

The levelized annual benefits from reductions in entrainment mortalities are approximately \$1.7 thousand; reductions in impingement mortalities yield benefits ranging from \$3.6 thousand in the best case to \$1.8 thousand in the worst case with a most likely value of \$2.7 thousand; and reductions in cold-shock mortalities result in benefits ranging from \$14.2 thousand in the best case to \$0.4 thousand in the worst case with a most likely value of \$7.3 thousand. The aggregate annual benefit resulting from the switch to any of the three closed-cycle alternatives at the OCNGS ranges downward from \$19.5 to \$3.9 thousand with a most likely estimate of \$11.7 thousand.

The effects of operation of the alternative closed-cycle cooling systems on aquatic populations stand as the primary benefit to society from this prospective change in cooling systems. The costs of certain undesirable side effects resulting from operation of these alternative systems must be weighed against these benefits.

## 2. The Costs of Fogging and Icing

Operation of the fan-assisted natural draft towers and the round mechanical draft towers is expected to produce increases above natural levels in hours of ground-level fogging and icing. The natural draft tower is not expected to have any measurable impact on natural atmospheric conditions. These increased incidents of foggy weather and icing impose costs on society primarily through their effects on ground transportation. The hazards created by these adverse weather conditions have been examined in the case of vehicular traffic on Route 9, which passes within the boundaries of the fog/ice impact area.

Estimates have been made of the effect of incremental hours of fogging and icing on expected numbers of accidents, fatalities, injuries and property-damage-only (PDO) accidents. Various social costs of these effects, comprising values of lost lives, lost production, hospital and medical costs, administrative costs, vehicle damages and values of time in accident-induced traffic delays, have been estimated. In addition, the effects of these adverse driving conditions on increases in travel time due to reduced speeds have been evaluated. Estimates are presented in Table 2.

The levelized costs of accident-related effects of fog and ice and induced traffic delays are estimated to range from \$0.2 to \$0.3 thousand in the best and worst cases, respectively, with a most likely value of \$0.2 thousand for the fan-assisted natural draft towers, and are less than \$50 in all cases for the round mechanical draft towers. No costs were associated with the natural draft towers.

### 3. Salt Deposition and the Costs of Material Damages<sup>4</sup>

Because saltwater is used in the OCNGS cooling system, operation of all of the closed-cycle alternatives will result in emissions of sea salt from the towers. Estimates have been made of the increments to natural salt deposition rates in a 30 by 30 mile square impact area around the site for each of the alternative closed-cycle cooling systems. These estimates were converted into population-weighted average deposition rates applying to the entire impact area.

Relative physical damages from corrosive effects of increased rates of salt deposition were estimated for metal systems and residential home sidings. These estimates of relative corrosion rates were compared with the difference in relative corrosion rates, attributable to air pollution, observed between polluted and non-polluted atmospheres. Increases in social costs arising from increased frequency of maintenance and repair, which have been estimated for materials in polluted environments, were scaled by the ratio of relative corrosion rate differentials in the impact area and in polluted atmospheres. These incremental maintenance cost estimates were applied to estimates of material and housing stocks in the impact area. The stock estimates were developed from population projections in the area and assumptions about the per capita distribution of stocks. Estimates of damages to metal systems and residential home sidings are presented in Table 2.

The levelized annual social costs of damages to metal systems are \$23.2 thousand for the natural draft tower, \$36.6 thousand for the fan-assisted natural draft towers, and \$38.1 thousand for the round mechanical draft towers. The levelized annual costs arising from the increased maintenance requirements for home sidings range from \$18.4 thousand in the best case to \$82.8 thousand in the worst case with a most likely estimate of \$50.6 thousand for the natural draft tower. In the case of the fan-assisted natural towers, these costs range from \$29.2 thousand in the best case to \$131.8 thousand in the worst case with a most likely estimate of \$80.5 thousand. For the round mechanical draft towers, the range is from \$30.5 thousand in the best case to \$137.8

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<sup>4</sup>No estimates have been made of potential damages to vegetation. Ebasco's examination of the impacts of salt deposition from the tower alternatives generally indicate little likelihood of foliar injury to species native to Island Beach State Park. Long-term damage thresholds are approached, however, on the Western shore of Barnegat Bay in the case of the fan-assisted natural draft towers. These conclusions appear to hold for species that are not native to the State Park; but, particularly with ornamentals, some caution is advised, due to the lack of extensive scientific inquiry on the problem (Ebasco, 1977a). Without more conclusive estimates of potential damages, attempts to analyze effects of tower operation on vegetation appeared unwarranted.

thousand in the worst case with a most likely estimate of \$84.2 thousand. Overall, salt deposition damages are estimated to range from \$41.6 to \$106.0 thousand for the natural draft towers, \$65.8 to \$168.4 thousand for the fan-assisted natural draft towers, and \$68.6 to \$175.9 thousand for the round mechanical draft towers.

#### 4. Noise Impacts

Operation of the three closed-cycle cooling alternatives results in increased noise levels which exceed New Jersey nighttime residential noise standards. In order to overcome this problem, JCP&L would have to extend its property lines sufficiently to encompass all areas not commercially or industrially zoned, where the noise standards would be exceeded.

Estimates of the cost of meeting the noise regulations<sup>5</sup> were based, therefore, on the costs of acquiring all property in the areas, not currently designated as either commercial or industrial, where noise levels exceed the standards, and on the costs of relocating all households now residing in these areas. Acquisition costs were based on recent sales prices and assessed values of property in these areas; and relocation costs were based on estimates of moving expenses and the number of residential homes purchased. Estimates of these costs are presented in Table 2.

The levelized annual costs of property acquisition are estimated at \$1.1 million for the fan-assisted natural draft and round mechanical draft towers, which have essentially the same noise impact areas; and these costs are estimated at \$66.4 thousand for the natural draft tower. Relocation costs are nominal by comparison, ranging from \$16.2 to \$22.4 thousand for the fan-assisted natural draft and round mechanical draft towers and from \$1.6 to \$2.2 thousand for the natural draft tower. The aggregate costs imposed by noise are estimated at roughly \$1.15 million for the fan-assisted natural draft and round mechanical natural draft towers and \$68.3 thousand for the natural draft tower.

#### C. A summary of the Benefit-Cost Estimates

An aggregate measure of the economic attractiveness of each system can be obtained by summing the estimates of capital, operating, and environmental costs and subtracting the total from the estimated aquatic benefits (Table 3). These differences provide a basis for ranking the alternative systems in terms of economic attractiveness.

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<sup>5</sup>The estimates provided are social costs only in the sense of measuring the costs of meeting socially motivated, but politically determined, legislation. A true measure of social costs would inquire into the amounts that residents would require as compensation for bearing the noise annoyance. Thus, for example, it might be that few, if any, would be bothered by the projected noise levels of the systems; but, some (or many) local residents might be annoyed by noise levels below the standards. Neither of these possibilities was investigated here.

For each alternative cooling system, the major components of costs are the capital and operating costs. Among the environmental costs, only those incurred in dealing with the noise problems of the fan-assisted natural draft and round mechanical draft towers add significantly to the capital and operating costs. The damages imposed by salt drift, although sufficient by themselves to outweigh the benefits of the closed-cycle alternatives, are a minor component of the total costs of these systems. Damages from fogging and icing, because of the few hours induced and the limited impact zone, are inconsequential.

The economic benefits produced by the three closed-cycle alternatives are minor by contrast to either the environmental or the capital and operating costs of these systems. These benefits derive primarily from the reductions in cold-shock mortalities of Atlantic Menhaden and entrainment mortalities of Summer Flounder and Weakfish.

The canal-to-bay discharge structure emerges as the least costly alternative by a substantial margin. The levelized annual capital and operating costs are \$9.1 million; and the system has no measurable incremental environmental benefits or costs over the existing system.

The natural draft tower ranks second, using the least cost criterion, and is slightly less costly than the other tower alternatives. The levelized annual capital and operating costs are \$20.4 million. Operation of this system produces, on balance, an adverse environmental impact of approximately \$0.1 million, which increases its net social cost to \$20.5 million or about twice the net cost of the canal-to-bay discharge modification.

The round mechanical draft and fan-assisted natural draft towers are roughly equivalent in costs, but somewhat more expensive than the natural draft tower. Levelized annual capital and operating costs are \$20.8 and \$21.3 million, respectively. The net social costs of each system are further increased by environmental costs of approximately \$1.3 million for a total levelized annual net social cost of \$22.1 million for the round mechanical draft towers and \$22.6 million for the fan-assisted natural draft towers.

#### D. The Distribution of Benefits and Costs

The benefits and costs associated with the installation and operation of each alternative cooling system will be unevenly distributed among members of society. Capital and operating costs of each system along with the costs of acquiring property and relocating families to deal with noise problems will be borne by JCP&L's customers. The incidence of other environmental costs is less easily traced. Costs associated with sea-salt emissions from the cooling tower alternatives will be incurred by industry, commerce and residential homeowners in the salt deposition impact areas. The minimal impacts of fogging and icing can conceivably affect any future user of the impacted roadway, but are more likely to affect those residents in the vicinity of the plant.

The minor aquatic benefits produced by the towers will accrue primarily to commercial and recreational fishermen in Barnegat Bay but could extend to fishermen in other waters. Commercial fishermen affected would presumably be predominantly state residents. In the case of recreational fishermen, however, a National Marine Fisheries Service survey (1976) undertaken in 1973-74 estimated that only 53.9 percent of the participants in marine recreational fishing were New Jersey residents. Since estimated recreational benefits constitute from 13.7 to 15.4 percent of the total aquatic benefits, this suggests that roughly 7 percent of these total benefits accrue to out-of-state residents.

The capital and operating costs of the four alternatives and the costs of dealing with the associated noise effects, which will require cash outlays by JCP&L, can be expressed in terms of their impact on JCP&L's residential customers. The direct costs (increases in electric bills) were estimated by multiplying levelized costs by the proportion of sales to residential customers to total sales projected by JCP&L for 1984 (.413); indirect costs (increases in prices of goods and services produced and sold locally) were obtained in the same manner using the proportion of JCP&L's projected 1984 sales to commercial customers, street lighting and public authorities to total sales (.276).<sup>6</sup> In all, this calculation suggests that 68.9 percent of the levelized annual costs are passed on to JCP&L's residential customers. An estimate of the annual direct and indirect costs per residential customer was obtained by dividing the sum of these cost estimates by the projected number of residential customers (918,300) in 1995, the median year of the time interval used in levelizing costs.

The total annual effect on JCP&L's residential customers of these capital and operating costs and land acquisition costs would be an estimated increase in their budgets of \$6.85 with the canal-to-bay discharge structure, \$15.33 with the natural draft tower, \$16.46 with the round mechanical draft towers, and \$16.83 with the fan-assisted natural draft towers.

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<sup>6</sup>This estimate assumes that the costs to these purchasers will be passed on to residential consumers in the form of higher prices and possibly taxes. By contrast, the costs to large industrial consumers, while passed forward to consumers of final products, are assumed to affect consumer costs on a regional or national basis and are not therefore limited to JCP&L's residential customers.

### III. METHODOLOGIES FOR EVALUATING THE ENVIRONMENTAL BENEFITS AND COSTS OF THE ALTERNATIVE CLOSED-CYCLE COOLING SYSTEMS

#### A. Evaluation of Effects on Commercial and Recreational Fishing

The operation of any of the proposed alternative closed-cycle cooling systems is expected to reduce mortalities of aquatic populations from entrainment, impingement and cold-shock; these reductions represent a potential source of economic benefit to society. Increased aquatic populations might increase commercial fish catches in the general area and enhance the quality of recreational fishing in Barnegat Bay or the Middle Atlantic area. Evaluation of these benefits required two stages of analysis: first, estimation of the reductions in mortalities of aquatic populations from the operation of the alternative cooling systems and the expression of these reductions in terms of the increase in weight of juvenile and adult stocks; and second, estimation of the commercial and recreational values per pound to be assigned to the increased weight of juvenile and adult stocks.

1. Changes in Mortalities of Aquatic Populations Estimates of reductions in the mortalities of aquatic populations were developed by Ebasco (1977a). The estimates of aquatic benefits were focused only on those species for which records indicated either commercial and/or recreational harvests in the Middle Atlantic fishery. This list of species was further delineated in the case of entrainment effects by the ability to convert reductions in egg and larval mortalities into gains in juvenile and adult stocks (see footnote 3). Other species that are entrained or impinged at the OCNGS, but are not harvested recreationally or commercially, were assumed to have no direct economic value. Many of these species occupy lower positions in the food chain, and while increases in their populations could indirectly increase social benefits through beneficial effects on the populations of species higher in the food chain, the state of the art is not sufficiently developed to quantify such ramifications. A list of the species analyzed appears in Tables 4 and 5.

The estimates of reduced mortalities were translated into weight gains by species. In the case of entrained eggs and larvae, estimates of minimum and maximum survival rates to the juvenile and adult stages from each lower stage, supplied by Ebasco (1977b), were used to project the number of juveniles and adults that might normally be expected to develop from the number of eggs and larvae rescued from entrainment mortality. Estimates of average juvenile and adult weights, developed through consultations with Ebasco and Ichthyological Associates, Inc. (IA) and from the use of life-history data and length-weight regression equations (IA, 1977a) were used to convert numbers of juveniles and adults

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7 Projections of adult-equivalent gains only were made for Atlantic Menhaden and Blue Crabs because these species are harvested primarily at this stage. The other species are harvested at the juvenile stages as well, mainly by recreational fishermen, and projections were made, therefore, of gains in both their adult and juvenile stocks.

into weight gains by species. The ranges of estimated reductions in mortalities from cold-shock were transformed into estimates of weight gains using the appropriate length weight regression equations reported by IA (1977a) and average lengths of cold-shock mortalities reported by Ebasco (1977a). Reductions in impingement mortalities were transformed into gains in weight of species stocks using the sample numbers and average weights of species impinged on the OCNGS traveling screens during the period from March 1976 through February 1977 (IA, 1977a,b).

Estimated annual weight gains from reduced entrainment, impingement and cold-shock mortalities are presented, for each of the species analyzed, in Table 4.

## 2. Commercial Values of Aquatic Species

Values of each species commercially harvested were obtained by dividing the total value of commercial landings by the weight of commercial landings in New Jersey, Maryland, Virginia and North Carolinas reported in 1976 (U.S. National Marine Fisheries Service, 1977). In the case of Blue Crabs, however, only 1976 New Jersey data was used because of the non-migratory nature of the Barnegat Bay population. These values reflect ex-vessel prices on a per-pound basis. They are the prices received by fishermen and exclude mark-ups that are added as the catch proceeds from the dock through various productive and distributive stages to retail markets. On the assumption that changes in aquatic populations do not increase harvests by an amount sufficient to affect commercial prices, gains accrue, not to consumers, but to the factors of production able to increase output at no extra cost. To the extent that fishermen are able to increase their harvests without additional effort, the increased output valued at the price that the fisherman receives accurately measures the net social benefit of increases in aquatic populations.

Commercial values were inflated at a constant annual rate of 5.0 percent beyond 1976. This rate corresponds to the assumed rate of general inflation used elsewhere in the analysis.

## 3. Recreational Values of Aquatic Species

Assigning recreational values to aquatic species is more complicated than the assignment of commercial values. This reflects two factors: (a) there is no comprehensive market for recreational fishing and, hence, no market value established for this activity; and, (b) the value of recreational fishing, while sensitive to the stock of fish, depends upon a number of other factors as well.

The first step in assigning recreational values involves estimating the value to a recreational fisherman of a day of salt water fishing. To do this, a demand curve for salt water fishing relating the number of days of salt water fishing to the cost of this activity must be estimated. The nature of this demand curve and its role in estimating the value of recreational fishing is illustrated in Figure (1).

Line "D" describes a hypothetical relationship between the cost of recreational fishing and the number of days fished. In this figure, when the cost of fishing is \$6.00, the average person does not fish at all; when the price falls to \$5.00, the amount of fishing rises to one day. At a cost of \$1.00, the average person fishes five days. From this demand curve, a value of a day of recreational fishing can be inferred. Since at \$6.00 per

day, the average person does not fish at all, but at \$5.00 per day he fishes one day, the first day must be worth between \$5.00 and \$6.00. By similar reasoning, the second day is worth between \$4.00 and \$5.00. Consider a person living in an area where fishing costs \$2.00 per day: he would fish four days and the total value to him of those days would be \$16.00, or \$4.00 per day. However, since each of these days costs \$2.00, the net value to the fisherman of this experience is \$2.00 per day. This net value is referred to as consumer's surplus and measures the amount the fisherman would be willing to pay to avoid being deprived of the opportunity to engage in recreational fishing.

It is important to note that the value of the fishing experience to the fisherman is calculated net of his costs. Clearly, the value of the experience to the fisherman is partly reflected by the expenditures he makes; but if deprived of this experience, those expenditures would be applied elsewhere and, therefore, would not be lost when the individual ceases to engage in fishing.

An estimate of consumer's surplus per day of salt water fishing was developed based on data from the 1970 National Survey of Fishing and Hunting (U.S. Fish and Wildlife Service, 1972). This survey provides data on the expenditures per day for salt water fishing and the total days fished by people living in nine regions of the country. These data (Table 6) were used to estimate the following demand relationship between salt water fishing days per capita in each region and per diem expenditures for this activity:

$$\ln \frac{\text{Fishing Days}}{\text{Population}} = 1.655 - \frac{.259 \text{ Expenditures}}{(.129) \text{ Day}} \quad (1)$$

$$R^2 = .365 \text{ (Standard error shown in parenthesis.)}$$

This fitted demand schedule is graphed in Figure (2). The basic form of the equation has the property that, regardless of cost, consumer's surplus per visitor day is equal to the reciprocal of the coefficient of the expenditures-per-day variable, or \$3.85, in 1970 dollars. This value was inflated at the actual rate of increase in the Consumer Price Index to 1976; and, beyond 1976, it was inflated at the rate of increase in the general price level of 5 percent per annum assumed throughout this analysis.

This estimated value of a day of salt water fishing was used to estimate the recreational value per pound of salt water fish harvest. Initially, this was done using the highly conservative assumption that the full value of the fishing experience is assignable to the fish caught. The 1970 Salt Water Angling Survey (U.S. National Marine Fisheries Service, 1973b) contains data on the number of fisherman reporting that they fished for particular species and the pounds of each species caught in the Middle Atlantic region. The U.S. Fish and Wildlife Service (1973) reports an estimate of 12.2 days of fishing per salt water recreational fisherman in the Atlantic, from which it is possible to estimate the total number of days of fishing effort in the Middle Atlantic. Dividing total days among species in proportion to the number of fishermen who fished for each species produced an estimate, by species, of the number of pounds harvested

per day of fishing effort. From this information and the estimated value per day of salt water fishing, a value per pound was derived using the formula:

$$\frac{\text{Value}}{\text{Pounds}} = \frac{\text{Value}}{\text{Day}} \cdot \frac{\text{Pounds}}{\text{Day}} \quad (2)$$

This approach seems overly conservative, since there is substantial evidence indicating that the value of the fishing experience does not increase in proportion to the increases in the expected harvest. A study of Lake fishing (Perl, 1975) found that a 100-percent increase in fishing stock produced only a 50-percent increase in fishing effort and in the total value of the fishing experience. Consequently, as a more reasonable estimate, the values per pound, produced by Equation (2), were halved.

#### 4. Combining Recreational and Commercial Values

The U.S. National Marine Fisheries Service (1973a) provides the total recreational catch, and the U.S. National Marine Fisheries Service (1970) provides the commercial catch for the Middle Atlantic region in 1970. For recreational fishing, the Middle Atlantic includes the coastal area from New Jersey to Cape Hatteras. For commercial fishing, all landings in New Jersey, Delaware, Maryland, Virginia and one-half of North Carolina were combined. Based on the data for each species, recreational and commercial proportions of the total recreational and commercial catch were determined. A weighted average of commercial and recreational values was obtained for each species using these proportions as weights. These proportions and the weighted averages of commercial and recreational values, in 1975 dollars, are presented in Table 5 as the high estimates. Implicitly, these high estimates value each additional pound of stock as if it were harvested.

It must be noted that not all of the increased fish stock is harvested either by recreational or commercial fishermen. While the ratio of stock to harvest is likely to vary from species to species, an overall ratio of 0.5 is more likely to overestimate than to underestimate this proportion. Consequently, by assigning the value of the increased harvest to the increased stock, as a lower limit, increases in stock were valued at only one-half of the average commercial and recreational values per pound, or at one-half the high estimates of values per pound. These low estimates are also presented in Table 5.

Estimates of the annual benefits from the alternative cooling systems were obtained by applying these high and low values to the increases in stock weights resulting from reduced entrainment, impingement and cold-shock mortalities.

#### B. The Evaluation of Cost From Fogging and Icing

Ground level fogging and icing occur as a result of operation of the fan-assisted natural draft and the round mechanical draft towers. Estimates of the additional hours of fogging and icing, by direction and distance from the towers, are presented in Table 7.

Analysis of these effects and the costs imposed on society was limited to the impacts on vehicular traffic on Route 9 in the vicinity of the plant. This road represents the only thoroughfare within the boundaries

of the fog area which is characterized by heavy traffic volume, high speeds and continuous movement of vehicles. Residential side roads would also be impacted, but because of the light volume, low speed and erratic movement of their traffic, it has been assumed that no adverse consequences would result. (See Figure 3 for a depiction of the impact area.)

Distances on Route 9 within the different sectors impacted by fog and ice were measured using a map meter; estimated distances appear in Table 7. The social costs from the effects of fogging and icing on transportation arise through (1) changes in the number and/or severity of automobile accidents, and (2) loss of time from delays caused by reductions in vehicular speeds. The measurement of these costs involves two stages: first, estimation of the incremental effect of additional hours of fogging and icing on the number of accidents, fatalities and injuries and on the amount of time spent in travel; and, second, conversion of accident magnitudes into costs based on the values of such items as lost market production, hospital and medical costs and vehicle damages, and of increased trip durations into dollar values of lost time.

#### 1. The Effect of Fog and Ice on Accidents, Accident Severity and Travel Time

Estimates of the effects of fogging and icing on accidents and their severity were based on evidence regarding differences in accident rates and accident severity between foggy and non-foggy weather conditions and between icy and non-icy road conditions. The limited number of studies examining the effects of fog on accident rates suggest that fog has little or no effect on these rates (Kochmond and Perchonok, 1969; Organization For Economic Cooperation and Development (OECD), 1976). An Australian study of metropolitan roadways (Foldvary and Ashton, 1962), however, found a reduction (although not highly significant) in accident rates of approximately 7 percent on foggy days as compared to non-foggy days; and a study in Great Britain (Moore and Cooper, 1972) found that foggy weather conditions resulted in an approximate increase of 50 percent in accident rates.

These findings were utilized to generate low, most likely and high impact estimates of the effect of fog on accidents. Available historical accident and vehicle mile data for the segment of Route 9 passing through Lacey Township (New Jersey Department of Transportation, 1973) were used to calculate an average accident rate for all driving conditions. Separate estimates of fog and non-fog accidents rates were calculated then by assuming that the overall accident rate was a weighted average of the two weather specific rates where the weights were based on Ebasco's (1977a) assumption of 138 hours of natural fog in the area. Thus,

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8 This finding actually relates to personal injury accidents which are presumed to include fatality accidents (Moore and Cooper, 1972, p. 10). Its application to the overall accident rate, therefore, suggests a similar increase in fog accident rates where only property damage is involved.

$$\text{Accident Rate} = \frac{138}{8760} \times (\text{accident rate, fog}) + \frac{8622}{8760} \times (\text{accident rate, non-fog}) \quad (3)$$

Solutions for the unknown weather-specific accident rates were obtained by substituting into Equation (3) ratios of fog to non-fog accident rates of .92 in the low impact case, 1.00 in the most likely impact case and 1.50 in the high impact case.

Evidence from the literature on the effects of icy road conditions on accident rates in non-existent. Hence, as a conservative estimate, it was assumed that no differences in accident rates exist between icy and non-icy surfaces.

The various estimated accident rates were applied to projected vehicle miles traveled on the impacted road sections during the increased hours of fogging and icing to obtain estimates of the number of accidents that could be expected to occur under foggy, non-foggy, icy and non-icy conditions. In estimating annual accidents over the entire period, vehicle miles traveled in the impacted road sections were allowed to grow at a rate of 4 percent annually.<sup>10</sup> At the same time, all accident rates were assumed to decline at an annual rate of .4 percent based on estimated trends in state-wide accident rates between 1965 and 1975 (New Jersey Department of Transportation, various years). Projections for 1984 of all accident rates used in the study are presented in Table 8.

Estimates of the number of accidents in each weather and road condition were converted into numbers of fatalities, non-fatal injuries and property-damage-only (PDO) accidents. Effects of fogging and icing on accident severity were based on statewide accident statistics which differentiate accidents by severity, road and weather conditions (New Jersey Department of Transportation, various years). These data utilize three mutually exclusive accident categories: fatality, injury and PDO accidents. Each category is defined according to the most serious event recorded in the accident.

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9 The Foldvary-Ashton (1962) estimate of lower accident rates in fog has been increased from 7 to 8 percent. This estimate corresponds with the midpoint of the range reported in Butler (1976) and that used by Con Edison (1977).

10 This estimate for the impacted section of Route 9 was obtained in a telephone conversation with Mr. Arthur Carl of the New Jersey Department of Transportation, Transportation Systems and Planning.

These data were used to estimate the proportions of total accidents in fog and non-fog, and ice and non-ice which involved fatalities, injuries and PDO accidents. The estimated proportions are presented in Table 8. In the case of injuries, which can occur in either fatality or injury accidents, the proportion of total accidents that were either fatality or injury accidents was estimated for each weather/road condition.

By applying the relevant proportion to the estimated number of accidents in each weather/road condition, total accidents were distributed into severity categories. The number of accidents in each fatality and fatality and injury category were then converted into estimates of fatalities and injuries, using, respectively, the average number of fatalities per fatality accident and injuries per fatality and injury accidents obtained from the historical accident record for the Lacey Township section of Route 9.

Estimates of the loss of time due to delays resulting from reductions in speed associated with fogging and icing conditions were based on estimates of reductions in speeds under these adverse driving conditions obtained from the literature, average speeds on the impacted section of Route 9 and average vehicle occupancy rates.

The impact of fog on traffic patterns and vehicular speeds has received some attention in the literature. Studies in California indicate reductions in speeds during foggy conditions of 5 to 6 miles per hour (Theobald, 1969) and 5 to 8 miles per hour (Kochmond and Perchonok, 1969); and in New York, reductions of approximately 5 miles per hour (Perchonok, 1969). Similar evidence regarding the impact of ice on vehicular speeds is scant. OECD (1976) posits some unspecified reduction based on indirect evidence concerning reduced severity of accidents in snow and on icy roads. Con Edison (1977) has posited a speed reduction of 33 percent from speeds in normal conditions based on casual observation.

The speed limit on the impacted sections of Route 9 is 45 miles per hour. Average vehicle speeds on roadways, allowing for periods of congestion, range from 5 to 8 miles per hour below the speed limit.<sup>11</sup> An average speed on Route 9 of 38.5 miles per hour, therefore, was assumed to apply in non-fog and non-ice situations. From the studies noted above, fog was assumed to lead to a 6 mile-per-hour reduction in this average, or to an average speed of 32.5 miles per hour. Icy surface conditions were assumed to reduce speeds by 12.5 miles per hour, or to produce average speeds of 26 miles per hour; this lower speed represents a reduction of approximately 33 percent in average speeds following the assumption in the Con Edison (1977) study.

The amount of time lost per vehicle was estimated by taking the difference between the time required to travel through the impacted section of roadway at the reduced speed and the time required at normal speeds. Multiplying this estimate by the number of vehicles projected to pass through each impacted section during the increased hours of adverse conditions yields an

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<sup>11</sup> Conversation with Thomas Keenan of the New Jersey Department of Transportation, Bureau of Traffic Engineering.

estimate of the aggregate loss of time in vehicle hours. Vehicle hours lost were then expressed in terms of passenger hours lost using vehicle occupancy rates. To accomplish this, vehicle hours were divided between passenger vehicles and trucks assuming 80 percent automobiles and 20 percent trucks<sup>12</sup> and vehicle occupancy rates of 1.5 persons per automobile and 1.0 persons per truck.<sup>13</sup>

## 2. Cost Estimates Used in Evaluating Accident Effects and Delays from Reduced Speed

The previous section described the means for estimating the effects of changes in weather and road surface conditions on accident fatalities and injuries, PDO accidents and delays caused by speed reductions. This section outlines the methods for translating these effects into dollar estimates of social costs.

In assessing the social costs of automobile accidents, estimates were made of the costs per fatality and costs per injury and, with PDO accidents, of the costs per-accident rather than per-vehicle. These average cost values were applied to the estimated numbers of fatalities, injuries and PDO accidents occurring in each weather/road condition to obtain estimates of economic damages for each condition; and total economic damages were calculated as the difference between damages that occur during the adverse driving condition, and those that would have occurred otherwise.

Average costs, in each case, were generated for the following different categories:

| <u>Fatalities</u>              | <u>Injuries</u>                |
|--------------------------------|--------------------------------|
| Valuation of Life              | Market and Home Production     |
| Community Production           | Community Production           |
| Hospital Costs                 | Hospital and Rehabilitation    |
| Physician, Coroner,            | Costs                          |
| Medical Examiner Costs         | Physician Costs                |
| Emergency Transport Costs      | Emergency Transport Costs      |
| Losses to Others               | Losses to Others               |
| Legal Costs                    | Legal Costs                    |
| Court Costs                    | Court Costs                    |
| Insurance Administration Costs | Insurance Administration Costs |
| Accident Investigation Costs   | Accident Investigation Costs   |
| Vehicle Delay Costs            | Vehicle Damage Costs           |
| Traffic Delay Costs            | Traffic Delay Costs            |

<sup>12</sup> Based on correspondence with Mr. Joseph Kanda, New Jersey Department of Transportation, Bureau of Data Resources.

<sup>13</sup> The Tri-State Regional Planning Commission (1970) estimated vehicle occupancy rates for all-purpose trips at 1.42. Federal national estimates have ranged from 1.3 to 1.9, depending upon the purpose of the trip. Truck passenger estimates were assumed.

Property Damage Only Accidents

Legal Costs

Court Costs

Insurance Administration Costs

Accident Investigation Costs

Vehicle Damage Costs

Traffic Delay Costs

The values, in 1975 dollars, assumed for each of these categories are presented in Table 9; assumed rates of inflation in each category are presented in Table 10.

These cost categories and estimates were derived primarily from a study by the United States Department of Transportation (USDOT, 1976). Detailed descriptions of the methodologies employed in developing each of the estimates are provided in this source.

Several changes were made in the USDOT estimates. The USDOT chose to evaluate loss of life in terms of, inter alia, the losses in market and home production, and the costs of premature funeral expenses of these costs were replaced with a single value designed to reflect the compensation that a group<sup>14</sup> of individuals must be paid to assume increased risks of mortality.

The value used was based on an empirical analysis of the role of risk in wage determination in 37 occupations, characterized by above-average mortality risks, undertaken by Rosen and Thaler (1973). Using multiple regression analysis, these authors found a statistically significant, positive relationship between risk of mortality and wages. In a linear version of their relationship, they found that each increase of .001 in the risk of mortality increased wages (in 1967 dollars) by \$5.20 per week, or \$260 per year. This finding suggests that 1000 individuals would require \$260,000 per year in compensation for the statistical expectation of one additional mortality in their group. For purposes of this study, this estimate was adjusted for differences in life-expectancy among the potentially affected population and expressed in current dollars.

Minor changes were made in the USDOT estimates of market, home and community production losses from injuries and community production losses from fatalities. These changes comprised updating earnings data adjustments to allow for variations in life and work-life expectancy, and use of the 11.22 percent discount rate employed in the rest of the study.

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<sup>14</sup> The basis for this argument is presented in Schelling (1968) and Mishan (1971). Mishan's argument emphasizes the compatibility of this approach with cost-benefit principles. In keeping with the scope of Mishan's analysis, it is important to emphasize that this approach does not provide a comprehensive measure of the social value in that other members of society must be compensated for an increase in the risk of mortality to another individual.

The final change involved USDOT estimates of the costs of accident-induced delays. The USDOT estimates were based on rush-hour time delays from minor accidents on the Gulf Freeway in Houston, Texas as reported by Pittmann and Loutzenheiser (1972). Their estimates were called downward to reflect the average traffic volumes and highway width of the impacted sections of Route 9 using estimates reported by them on the effects of lane blockage on roadway capacity and Gulf Freeway rush-hour traffic flows. This estimate was applied to PDO accidents. Fatality and injury accidents were assumed to be more calamitous than minor accidents and, therefore, arbitrarily to involve twice the delay time of PDO accidents. These per-accident estimates were then expressed on a per-fatality and per-injury basis, using the estimates of average fatalities per fatality accident and average injuries per injury and fatality accident observed for the impacted section of Route 9. Losses of time were converted into costs using values of travel time described below.

Valuation of the social costs incurred in delays from tower-induced fogging and icing involved placing values on lost passenger time. Separate estimates of time values were derived for automobile and truck passengers and multiplied by the estimates of time lost for each of these respective groups to obtain the total social costs of delays from speed reductions caused by each tower system.

A considerable amount of literature exists on the subject of valuation of passenger time (see, e.g., Watson, 1974). A number of studies suggest that the value of commuter time lies between 20 and 60 percent of commuter wage rates. In this analysis, individual passengers between the ages of 15 and 64 were assumed to value their time at 40 percent of the wage rate, while all other passengers valued their time at 20 percent of the wage rate. The wage rate used was the hourly average wages of production or non-supervisory workers in manufacturing in the Atlantic City Area (Bureau of Labor Statistics, 1977). A weighted average of the time values for the two categories of passengers was calculated using the age-distribution of fatalities and injuries, between 1970 and 1975 (New Jersey Department of Transportation, various years), to determine the proportions of passengers in each age group.

Truckers were assumed to be working on the job and to value their time at 100 percent of their wage rate. Estimates of truck drivers' hourly wage rates were based on the average estimates for truck drivers in the metropolitan Northeast (Bureau of Labor Statistics, 1976).

### C. The Economic Effects of Salt Drift

The emission of sea salts from cooling towers designed to cool salt water poses a threat to physical materials in the area primarily from corrosive processes initiated by the deposition of salt on exposed surfaces. Assessment of the monetary value of damages imposed on physical materials requires three stages of analysis: first, measurement of additions to background rates of salt deposition resulting from tower operation; second, estimation of the incremental physical damages to

receptor materials in the area attributable to the increases in deposition rates; and third, translation of physical damages into economic damages.

#### 1. Measurement of Salt Deposition Rates

Pickard, Lowe and Garrick, Inc. have developed estimates of increases, above background rates, in salt deposition from operation of each of the three alternative cooling towers. These estimates describe incremental annual average salt deposition rates, in a 30 by 30 mile square impact area surrounding the OCNGS site, in terms of isopleth configurations (see Figures 4 through 9). Each isopleth represents a locus of points of equal average annual deposition rates.

The results of the Pickard, Lowe and Garrick, Inc. analysis were used to estimate a population-weighted average of the increase in salt deposition rates which could be applied to the entire impact area. To develop this estimate, it was assumed that the area between two adjacent isopleths would be exposed to annual incremental deposition rates equivalent to the average of the two isopleth values. This assumption establishes a correspondence between annual deposition rates and area. By further assuming that the population of each township was evenly distributed geographically, the portion of area in a township falling between any two isopleths was translated into an estimate of population exposed to the corresponding average deposition rate. The resulting distributions of the entire population in the impact area by levels of exposure to the salt deposition rates generated by the different tower alternatives are presented in Table II; the averages of the salt deposition rates, weighted by populations exposed at the different rates, are also presented there. In developing the materials-damage estimates for each tower alternative, it was assumed that all of the receptor stock in the impact zone was exposed to the corresponding average deposition rate.

#### 2. Measurement of Physical Damage

The corrosive effects of marine atmospheric salts on metals have been extensively examined at various sites using exposed metal panels (Ambler and Bain, 1955; American Society for Testing and Materials, 1968; Copson, 1952 and 1960; Fink and Boyd, 1970; and Guttman and Sereda, 1968). A variety of metals has been tested and rates of corrosion at coastal and inland sites related to salt deposition, ambient concentrations of other air pollutants, other atmospheric factors and surface conditions. This literature was reviewed to delimit the materials to be analyzed.

The corrosive effects of marine environments on a wide range of metals are summarized by Fink and Boyd (1970). These authors found such metals as carbon steel and wrought iron to be highly<sup>15</sup> corrosive, low alloy steels, aluminum and aluminum-based alloys, copper and copper-based

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15 Aluminum alloys, while exhibiting high corrosion in the initial year of exposure, tend to corrode at much lower rates after the first year. Moreover, the resistivity of aluminum to corrosion can be enhanced through anodizing or painting (Fink and Boyd, 1970, p.58).

alloys, magnesium and zinc to be mildly corrosive and stainless steels, nickel and nickel-based alloys, titanium, noble metals, lead, cadmium and tin to be highly resistant to corrosion in marine environments.

Of the metals subject to corrosion in marine environments, damage functions, i.e., relationships between corrosion rates and deposition rates, have been estimated for steel, zinc and copper (Guttman and Sereda, 1968). These estimates suggest that atmospheric salts, per se, influenced corrosion rates for steel and zinc, and by their interaction with atmospheric and surface variables, affected corrosion rates for all three metals.<sup>16</sup>

Other metals do not appear to have been subjected to the same degree of analysis in the literature. Since these other metals, with the exception of aluminum, which is not highly corrosive in marine environment and can be treated for protection, are not as extensively used, the analysis of materials damage focused on steel, zinc and copper. The existence of damage functions for these three metals was useful in identifying their importance in an analysis of corrosion. The need to transform estimates of physical damages into economic values, however, limited the usefulness of predictions of corrosion rates based on these functions. In order to utilize these predictions in making the necessary transformations, monetary values would have to be placed on the loss of material thickness caused by corrosion. No satisfactory methodology has been developed for performing this evaluation.<sup>17</sup>

A more fruitful approach for analysis of steel and zinc corrosion can be developed with estimates of the relative rates of corrosion of these metals in different atmospheric environments (American Society for Testing and Materials, 1968; and U.S. Public Health Service, 1969). Such estimates have been made in marine environments, as well as in areas of industrial pollution and in rural areas. Estimates in these last two areas are particularly significant because more satisfactory estimates have been made of the economic costs of corrosion due to air pollution.

In order to implement these cost estimates, physical damages from salt deposition were expressed in terms of relative corrosion rates by assuming linear relationships between the relative corrosion rates observed

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16 Several test regressions were run, as part of the current study, on a portion of the data utilized by Guttman and Sereda, and indicated that, in general, measures of atmospheric salt were statistically significant explanatory factors of the corrosion rates in steel and zinc. Similar findings in the case of copper were less pronounced in these test analyses.

17 Salmon (1970) has estimated the value of the damages to a variety of metals from air pollution by effectively estimating value in terms of physical losses in metal thickness. His effort attempts to "indicate susceptibility to economic loss" and does not relate these losses to actual losses in the economic usefulness and, hence, economic value of the affected metals (p. 9).

at sites on Kure Beach, North Carolina and estimates of salt deposition at those sites. These relationships were used to estimate changes in relative corrosion rates with respect to changes in salt deposition rates. Multiplying these estimates by the average increment to salt deposition attributed to each cooling tower alternative established changes in relative corrosion rates for steel and zinc caused by tower operation. More formally,

$$\Delta RCR_{ij} = B_j \Delta S_i$$

where,

$$B_j = \frac{\Delta RCR_{KBj}}{\Delta S_{KB}} \quad [4]$$

$\Delta RCR_{jj}$  = change in relative corrosion rate of the metal associated with the operation of cooling tower alternative i,

$\Delta S_j$  = estimated average change in salt deposition rates in the impact zone resulting from operation of cooling tower alternative i,

$\Delta S_{KB}$  = the difference in rates of salt deposition at the Kure Beach, North Carolina, 80-foot and 800-foot sites, and

$\Delta RCR_{KBj}$  = the difference in relative corrosion rates of the jth metal at the Kure Beach, North Carolina, 80-foot and 800-foot sites.

Physical damages to steel and zinc, therefore, were measured in relative, rather than absolute, terms. Damages to copper, as discussed below, were not measured explicitly, but have been included in terms of an adjustment to the measure of economic damages to steel and zinc.

### 3. The Monetary Evaluation of Physical Damages

Evaluation of relative corrosion damages induced by salt deposition was based on the cost estimates for damages from air pollution (particularly concentrations of sulfur dioxide). Having developed estimates of the relative physical damages caused by cooling tower operation, these were compared in magnitude to the differences in relative corrosion rates between State College, Pennsylvania and New York City, which were chosen to reflect, respectively, unpolluted and polluted ambient air conditions. The ratio of these two estimates of differences in relative corrosion rates was used to scale downward the estimates of incremental corrosion costs between polluted and unpolluted atmospheres. In formal terms,

$$\Delta C_{ij} = \frac{\Delta RCR_{ij}}{\Delta RCR_j} \times \Delta C_j \quad [5]$$

where,  $\Delta C_{jj}$  = the incremental cost of increased corrosion to the jth metal associated with the operation of cooling tower alternative i,

$\Delta RCR_{ij}$  = the change in relative corrosion rate of the jth metal associated with the operation of cooling tower alternative i,

$\Delta RCR_j$  = change in relative corrosion rate of the  $j$ th metal between polluted environment (New York City) and unpolluted environment (State College, Pennsylvania), and

$\Delta C_j$  = estimated incremental cost to metal  $j$  between polluted and unpolluted atmospheres

#### 4. The Incremental Costs of Physical Damages in Polluted Atmospheres

Where continued exposure to pollution causes physical damage, a reduction in the physical life of the material is to be expected. Viewing individual materials as system components, the relationships between economic and physical damage will be determined by the relative importance of the material as a component of the system. If the material is a minor component of the system, its physical life has little effect on the useful, or economic, life of the system: it can be replaced, maintained, or scrapped when the system is scrapped. On the other hand, where the material is a major component of the system, the economic life of the system may depend on the physical life of the component; a decision to maintain or scrap the component can apply also to the system.

To the extent that pollution measurably affects the physical life of certain materials, the economic damage will depend on the effect of physical damage on the frequency of maintenance or replacement of these materials; this effect is conditioned by the relative importance of materials as system components. In addition to these costs of material damage, costs can be incurred indirectly as a result of preventive measures, research and development, and material substitutions, undertaken to mitigate or eliminate physical damage.

The method for evaluating damages to metal surfaces in polluted environments follows that developed by Fink, et al. (1971). These authors, using the component/systems framework, focus on exposed metal surfaces as the primary system components. Susceptible metal-surface system components are found to originate in the manufacturing sector and are deployed in exposed systems in the construction sector. Several screening stages were employed to reduce system component categories originating in the manufacturing sector to a group that was of value, exposed and sensitive to corrosion. A list of these systems that were analyzed in this study appears in Table 12.

Fink, et al. (1971), on the basis of Internal Revenue Service Guidelines, define a useful and depreciable lifetime for each of these systems. These system lifetimes are utilized first to estimate the total stock in use of each system in 1970 by summing estimates of annual shipments over a period (to 1970) equal to system life. Units of stock in use were then converted into areas exposed to air pollution using literature on manufacturer's design. The stocks in use of each system were then distributed between polluted and nonpolluted (rural) regions on the basis of observations, estimations and knowledgeable judgements.

Estimates of system lifetimes coupled with information on the timing and magnitude of maintenance costs formed the basis for estimates of

the total cost of maintaining a system during its life. A stream of maintenance costs in polluted and nonpolluted environments was determined for each system for a period of 21 years using information developed by Fink, et al., on rates of corrosion in the two environments.<sup>18</sup> The streams of future maintenance costs in each environment were discounted to present value (in 1984) at a rate of 11.22 percent, and the differences in present values for each system were then expressed as levelized annual values to provide a measure of the average annual incremental maintenance costs of a system in a polluted versus an unpolluted environment.<sup>19 & 20</sup> These incremental cost estimates were assumed to result from differential ambient concentrations and corresponding relative corrosion rates in State College, Pennsylvania and New York City.

Estimates of the average annual incremental maintenance costs, by metal system, associated with each cooling tower alternative were then obtained using equation [5]. (Examples of these cost estimates, measured in 1975 dollars, are presented in Table 12.) These average annual incremental maintenance costs were applied to estimates of the projected 1984 stocks of exposed areas of steel and galvanized systems in the impact area to obtain estimates of the aggregate incremental costs in 1984 for each alternative cooling tower. Estimates for successive years in the incremental cost stream were obtained by allowing this 1984 aggregate cost to increase at the projected rate of growth in the stocks of exposed areas.

The estimates of the stocks of exposed areas were derived from the 1970 national estimates of system stocks developed by Fink, et al. by assuming that the national stocks were distributed roughly according to the geographical distribution of population. Where Fink, et al. provided an estimate of the rurally-allocated proportion of a national stock, this proportion was adjusted by the ratio of the population residing in the impact area (which is considered rural) to the total population in 1970; in all other instances, national stocks were adjusted by the ratio of impact-

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18 The maintenance cost estimates developed by Fink, et al., were inflated to 1976 dollars using the actual per annum rate of increase in painters' wages of 8.20 percent, and thereafter at 7.5 percent.

19 These estimates correspond to new systems in the year of present value. All systems are not new as of that year, however, and new systems will be installed after that year. Because of this, the levelized annual values used can be expected to differ slightly from estimates of weighted values based on the age distribution of older systems and re-estimates for future new systems.

20 This approach extends the suggestion of Møller and Wyzga (1975), who demonstrate that the method employed by Fink, et al., for estimating average annual incremental maintenance costs--dividing differences in total maintenance expenditures in the two environments by system lifetime--unnecessarily exaggerates the desired cost estimate.

area population to total U.S. population in 1970. The impact-area stock estimates were assumed to grow from 1970 through the period of the analysis at an annual rate of 2 percent, reflecting the rate of growth in real Net National Product between 1970 and 1976. (Estimates of the exposed stocks in the impact area in 1975 presented in Table 12.)

As noted above, the corrosion rates of copper and copper alloys have been found to be positively influenced by salt deposition rates. Copper and its alloys, however, develop a protective patina in marine atmospheres that acts to inhibit corrosive processes. The resulting film can raise problems in the case of electrical systems utilizing copper components. Gillette (1974) has estimated that the damages to electrical devices from sulfur dioxide in 1968 amounted to approximately 5 percent of total materials-damages from sulfur dioxide. Corrosion damages to copper (as a component of electrical devices) from salt deposition were similarly estimated at 5 percent of the estimated damages to steel and zinc materials.

This procedure places an upper limit on losses, since the damages to electrical devices from air pollution involve damages of metals that are not as susceptible to atmospheric salt as they are to sulfur dioxide.

#### 5. Damages to Housing

The effect of salt deposition on the painted surfaces of homes represents a potentially costly aspect of cooling tower operation. This particular aspect of salt deposition, however, does not appear to have been the subject of any thorough analysis. Gronwald and Mears (1971) suggest in the absence of reliable quantitative information, that "the corrosion of bare metals should be considered as a limiting case [of the life of paint films as a function of salt deposition rates]." Since their concern with the effect of salt deposition on paint coatings is limited mainly to paint coatings of metal surfaces, the application of the suggestion to an investigation of paint coatings on wood and asbestos shingling is somewhat conjectural. This is particularly so in the case of wood shingles where their findings suggest that bare wood surfaces, unlike bare metal surfaces, are not greatly affected by salt deposition. Nevertheless, without specific information on the corrosive effects of salt deposition on paint coated wood and asbestos surfaces, the relative corrosion rates of zinc and steel as low and high estimates, respectively, were used to determine relative physical damages to the paint surfaces of the housing stock in the impact area.

Following the methodology outlined above for damages to metals, estimates of the service life of exterior wall paintings in unpolluted and polluted environments were obtained from the literature. On the basis of work done by Spence and Haynie (1972), Waddell (1974) reports an expected service life of six years in an unpolluted environment and three years in a polluted environment. These estimates of the timing of maintenance were combined with estimates of the current costs of house paintings obtained in a limited survey of house painters in Burlington County, New Jersey, which, depending largely upon the size of the house, indicated costs ranging from \$450 to \$1,000. Levelized annual values of the present values of the differences in maintenance costs of a new unit in polluted and unpolluted atmospheres over a 21-year period were then calculated in the manner described above for metal damages. These estimates were then scaled by the same procedure as outlined in Equations [4] and [5].

A further difficulty in completing these damage estimates arises in measuring the housing stock in the impact area. Moreover, not only the number, but also, as indicated above in developing cost estimates, the size-distribution of the stock is important. An additional factor involves the type of siding used in the structure. Brick siding is likely to be less susceptible to corrosive attack from salt than aluminum siding, which, in turn, is not as susceptible as wood siding.

A survey of tax assessors in the area indicated that the approximate proportion of wood frame houses in the population was .95. Examination of property records in the vicinity of the plant in Lacey Township indicated that a large proportion of the homes had asbestos siding. No effort was made to determine a distribution of wood frame units by types of sidings. Implicitly, therefore, it was assumed that the effect of corrosion was essentially similar for all types of sidings used on wood frame houses. The stock was further delimited by considering only one- and two-unit structures, on the assumption that larger structures would be more predominately brick or stone.

An estimate of the 1975 housing stock in the impact area was derived by taking the number of units in either one- or two-unit structures in 1970 in Ocean and Burlington counties (Bureau of the Census, 1972), expressed on a per capita basis, and applying it to the 1975 estimate of population, by county, in the impact area. These stocks were then allowed to grow over the period of analysis at the projected rates of growth in the county populations. Average annual incremental maintenance cost estimates associated with salt deposition from the tower alternatives were applied to the estimated stocks in 1984 to obtain an aggregate cost estimate in that year. Successive years in the cost stream were obtained by allowing this aggregate to increase at the projected rates of growth in the housing stock.

#### D. Evaluation of Noise Impacts

The increased background noise levels occurring with operation of the three closed-cycle cooling system alternatives exceed New Jersey noise standards at the Company property line for all property not zoned for industrial or commercial use. In order to resolve this problem, the only apparent option would be to extend Company property lines to a sufficient degree to bring noise levels at the perimeter below the standards.

The distances from the tower sites required to bring noise levels below the relevant standards were estimated as 2,500 feet for the natural draft tower and 5,000 feet for both the fan-assisted natural draft and round mechanical natural draft towers (Ebasco, 1977a). Noise buffer zones, using these distances as radii, were drawn around the tower sites (Figures 10-11); and inventories of all property lots in each zone were compiled from Township Tax Maps.

The lots in each zone were divided into groups of commercial, industrial, residential and undeveloped properties. Lots designated as commercial or industrial were not valued since existing noise standards for such properties are not violated by the tower alternatives. All other lots were divided

into two groups: lots with current assessed values of less than \$60,000 and lots with current assessed values greater than \$60,000. Market values for the lower-valued lots were estimated using the results of a multi-variate regression analysis relating recent (since 1972) sales values of lots in the area (obtained from Lacey and Ocean Township tax assessors' offices) to current assessed values, year of sale, and a dichotomous variable indicating location, by township. The estimated equation derived from a sample of 75 lots was:

$$\ln MV = -0.5799 + 0.0286 T - 0.7907 Z + 0.8611 \ln AV [6]$$

(0.3610) (1.4041) (6.8419) (18.5725)

where values in parentheses represent absolute t-values, and,  $R^2$  (adjusted) = 0.9437,

$\ln MV$  = natural log of recorded market sales values,  
 $T$  = year of sale,  
 $Z$  = 0 if property is in Lacey Township, and  
 = 1 if property is in Ocean Township; and,  
 $\ln AV$  = natural log of assessed property value.

Since there were only a few sales of large lots with assessed values in excess of \$60,000, these observations were excluded from the regression analysis on the grounds that these few outlying data points would improve the predictive power of the regression estimate in a minor way for only a few observations while distorting it for the bulk of the observations (which had assessed values of less than \$40,000). Valuation of these higher-valued lots was undertaken separately. Lots in Lacey Township were valued in 1977 dollars at 1.235 times their most recent assessed values; and lots in Ocean Township were valued at .952 times their most recent assessed values. These scale factors correspond to the respective tax assessor's estimates of the current ratio of true to assessed property values.

An estimate of the property acquisition costs in each of the noise buffer zones was obtained by cumulating the estimated market values of all lots in each zone.

Where the purchase of residential homes was required, relocation costs, including search costs and moving expenses, were estimated.<sup>21</sup> Based on a limited survey of moving companies in New Jersey, current moving costs for a move within 25 miles were estimated to range from \$325 to \$450. It was further assumed that the costs of searching for a new home by relocating families would amount to 50 percent of the moving costs. The total costs, in current dollars, of relocation for a one-family

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21 In order to avoid double counting, an adjustment was made in the estimated damages to residential home sidings from salt deposition to account for the reduction in housing stock resulting from these purchases of residential homes.

dwelling, therefore, were estimated to range from \$487.50 to \$675.00. Total relocation costs were then estimated by applying these average costs to the number of homes purchased.

Since property acquisitions would be required prior to the initial operation date, it was assumed that complete acquisition would occur in 1982. Market values estimated for lots with assessed values greater than \$60,000 were assumed to increase at a rate of 2.86 percent per annum based on the regression coefficient of the time-variable in equation [6], while the prices of the lower-valued lots were projected directly from equation [6] by setting the time variable equal to 1982. Relocation costs were assumed to increase at a 7.5 percent annual rate reflecting the increase in general wage levels used throughout the analysis.

The total estimated costs of property acquisitions were expressed in present values for 1984 by including a compounded interest charge, based on JCP&L's current interest charges during construction, of 9.3 percent per annum; these present values were then converted into levelized annual values.

**TABLES**

LEVELIZED ANNUAL CAPITAL AND OPERATING COSTS OF ALTERNATIVE COOLING SYSTEMS

|                              | <u>Canal-<br/>to-Bay<br/>Discharge</u> | <u>Natural<br/>Draft Tower</u> | <u>Fan-Assisted<br/>Natural<br/>Draft Towers</u> | <u>Round<br/>Mechanical<br/>Draft Towers</u> |
|------------------------------|--|--------------------------------|--|--|
|                              | ----- (Thousands of Dollars) -----     |                                |  |  |
|                              | (1)                                    | (2)                            | (3)  | (4)  |
| <b>Capital Costs:</b>        |  |                                |  |  |
| Circulating Water System     | 7,523                                  | 13,484                         | 12,823   | 12,463                                       |
| Replacement of Capacity Loss | 128                                    | 857                            | 1,111  | 1,017  |
| <b>Operating Costs:</b>      |  |                                |  |  |
| Fuel                         | 1,057                                  | 5,265                          | 6,428  | 6,424  |
| Maintenance                  | 338                                    | 606                            | 785  | 748  |
| Water                        | 85                                     | 156                            | 156  | 155  |
| <b>Total</b>                 | <b>9,131</b>                           | <b>20,368</b>                  | <b>21,303</b>                                    | <b>20,807</b>                                |

Note: Capital cost estimates utilize a levelized fixed charge rate of 22.25 percent. Operating cost estimates are based on present worth estimates in 1984 and a discount rate of 11.22 percent. The systems have an assumed service life of 21 years.

Source: Ebasco Service Incorporated.

SUMMARY OF THE LEVELIZED ANNUAL ENVIRONMENTAL BENEFITS AND COSTS  
FROM OPERATION OF ALTERNATIVE COOLING SYSTEMS

| Benefit/Cost Category                  | Natural Draft Tower |               |               | Fan-Assisted Natural Draft Towers |                 |                 | Round Mechanical Draft Towers |                 |                 |
|--|---------------------|---------------|---------------|-----------------------------------|-----------------|-----------------|-------------------------------|-----------------|-----------------|
|  | Best Case           | Most Likely   | Worst Case    | Best Case                         | Most Likely     | Worst Case      | Best Case                     | Most Likely     | Worst Case      |
|  |                     | Case          |               |                                   | Case            |                 |                               | Case            |                 |
| (Thousands of Dollars)                 |                     |               |               |                                   |                 |                 |                               |                 |                 |
|  | (1)                 | (2)           | (3)           | (4)                               | (5)             | (6)             | (7)                           | (8)             | (9)             |
| <b>Aquatic Benefits</b>                |                     |               |               |                                   |                 |                 |                               |                 |                 |
| Entrainment                            | 1.7                 | 1.7           | 1.7           | 1.7                               | 1.7             | 1.7             | 1.7                           | 1.7             | 1.7             |
| Impingement                            | 3.6                 | 2.7           | 1.8           | 3.6                               | 2.7             | 1.8             | 3.6                           | 2.7             | 1.8             |
| Cold Shock                             | 14.2                | 7.3           | 0.4           | 14.2                              | 7.3             | 0.4             | 14.2                          | 7.3             | 0.4             |
| <b>Total</b>                           | <b>19.5</b>         | <b>11.7</b>   | <b>3.9</b>    | <b>19.5</b>                       | <b>11.7</b>     | <b>3.9</b>      | <b>19.5</b>                   | <b>11.7</b>     | <b>3.9</b>      |
| <b>Fog/Ice Costs</b>                   |                     |               |               |                                   |                 |                 |                               |                 |                 |
| Traffic Accidents                      | 0.0                 | 0.0           | 0.0           | 0.1                               | 0.1             | 0.2             | -                             | -               | -               |
| Traffic Delays Due to Speed Reductions | 0.0                 | 0.0           | 0.0           | 0.1                               | 0.1             | 0.1             | -                             | -               | -               |
| <b>Total</b>                           | <b>0.0</b>          | <b>0.0</b>    | <b>0.0</b>    | <b>0.2</b>                        | <b>0.2</b>      | <b>0.3</b>      | <b>-</b>                      | <b>-</b>        | <b>-</b>        |
| <b>Salt Deposition Costs</b>           |                     |               |               |                                   |                 |                 |                               |                 |                 |
| Metals                                 | 23.2                | 23.2          | 23.2          | 36.6                              | 36.6            | 36.6            | 38.1                          | 38.1            | 38.1            |
| Home Sidings                           | 18.4                | 50.6          | 82.8          | 29.2                              | 80.5            | 131.8           | 30.5                          | 84.2            | 137.8           |
| <b>Total</b>                           | <b>41.6</b>         | <b>73.8</b>   | <b>106.0</b>  | <b>65.8</b>                       | <b>117.1</b>    | <b>168.4</b>    | <b>68.6</b>                   | <b>122.3</b>    | <b>175.9</b>    |
| <b>Noise Costs</b>                     |                     |               |               |                                   |                 |                 |                               |                 |                 |
| Property Acquisitions                  | 66.4                | 66.4          | 66.4          | 1,125.8                           | 1,125.8         | 1,125.8         | 1,125.8                       | 1,125.8         | 1,125.8         |
| Relocations                            | 1.6                 | 1.9           | 2.2           | 16.2                              | 19.3            | 22.4            | 16.2                          | 19.3            | 22.4            |
| <b>Total</b>                           | <b>68.0</b>         | <b>68.3</b>   | <b>68.6</b>   | <b>1,142.0</b>                    | <b>1,145.1</b>  | <b>1,148.2</b>  | <b>1,142.0</b>                | <b>1,145.1</b>  | <b>1,148.2</b>  |
| <b>Total Benefits Less Costs</b>       | <b>-90.1</b>        | <b>-130.4</b> | <b>-170.7</b> | <b>-1,188.5</b>                   | <b>-1,250.7</b> | <b>-1,313.0</b> | <b>-1,191.1</b>               | <b>-1,255.7</b> | <b>-1,320.2</b> |

Note: Based on present worth estimates in 1984, a discount rate of 11.22 percent and system service life of 21 years. Benefits combine the upper limits of the range of estimated environmental impacts and economic values in the best case and the lower limits of each range in the worst case. Costs combine the lower limits of the range of estimated environmental impacts and economic values in the best case and the upper limits of each range in the worst case. For benefits and costs, the most likely case generally reflects an average of the best and worst case estimates. - Indicates values of less than \$50. Subtotals may not add due to rounding.

Source: NERA estimates.

SUMMARY OF THE AGGREGATE LEVELIZED ANNUAL BENEFITS AND COSTS  
FROM OPERATION OF ALTERNATIVE COOLING SYSTEMS

|                                      | <u>Total Benefits</u>              | <u>Total Costs</u>   |                                  | <u>Total<br/>Benefits<br/>Less Costs</u> |
|--------------------------------------|------------------------------------|----------------------|----------------------------------|--|
|                                      | <u>Environmental</u>               | <u>Environmental</u> | <u>Capital and<br/>Operating</u> |  |
|                                      | ----- (Thousands of Dollars) ----- |                      |                                  |  |
|                                      | (1)                                | (2)                  | (3)                              | (1)-(2)-(3)<br>(4)                       |
| Canal-to-Bay Discharge               |                                    |                      |                                  |  |
| Best Case                            | 0                                  | 0                    | 9,131                            | -9,131                                   |
| Most Likely Case                     | 0                                  | 0                    | 9,131                            | -9,131                                   |
| Worst Case                           | 0                                  | 0                    | 9,131                            | -9,131                                   |
| Natural Draft Tower                  |                                    |                      |                                  |  |
| Best Case                            | 20                                 | 110                  | 20,368                           | -20,458                                  |
| Most Likely Case                     | 12                                 | 142                  | 20,368                           | -20,498                                  |
| Worst Case                           | 4                                  | 175                  | 20,368                           | -20,539                                  |
| Fan-Assisted Natural<br>Draft Towers |                                    |                      |                                  |  |
| Best Case                            | 20                                 | 1,208                | 21,303                           | -22,491                                  |
| Most Likely Case                     | 12                                 | 1,262                | 21,303                           | -22,553                                  |
| Worst Case                           | 4                                  | 1,317                | 21,303                           | -22,616                                  |
| Round Mechanical<br>Draft Towers     |                                    |                      |                                  |  |
| Best Case                            | 20                                 | 1,211                | 20,807                           | -21,998                                  |
| Most Likely Case                     | 12                                 | 1,267                | 20,807                           | -22,062                                  |
| Worst Case                           | 4                                  | 1,324                | 20,807                           | -22,127                                  |

Note: The best case combines high environmental benefit estimates with low environmental cost estimates; the worst case combines low environmental benefit estimates and high environmental cost estimates; and the most likely case represents an average of the best and worst case estimates.

Source: Cols. (1) and (2): NERA estimates.  
Col. (3): Ebasco Services Incorporated.

TABLE 4

ESTIMATED ANNUAL WEIGHT GAINS FROM REDUCTIONS IN ENTRAINMENT,  
 IMPINGEMENT AND COLD SHOCK MORTALITIES RESULTING FROM  
 REPLACEMENT OF EXISTING OCNGS COOLING SYSTEM WITH  
 CLOSED-CYCLE ALTERNATIVES, BY SELECTED SPECIES

|                   | <u>Entrainment</u>   |                | <u>Impingement</u> | <u>Cold Shock</u>   |                |
|-------------------|----------------------|----------------|--------------------|---------------------|----------------|
|                   | <u>Total Weight</u>  |                | <u>Total</u>       | <u>Total Weight</u> |                |
|                   | <u>Maximum</u>       | <u>Minimum</u> | <u>Weight</u>      | <u>Maximum</u>      | <u>Minimum</u> |
|                   | ----- (Pounds) ----- |                |                    |                     |                |
|                   | (1)                  | (2)            | (3)                | (4)                 | (5)            |
| Atlantic Menhaden | 1,211                | 604            | 261                | 228,168             | 12,442         |
| Bluefish          | 0                    | 0              | 22                 | 652                 | 26             |
| Summer Flounder   | 6,115                | 5,129          | 0                  | 0                   | 0              |
| Weakfish          | 7,135                | 2,767          | 0                  | 0                   | 0              |
| Winter Flounder   | 466                  | 409            | 0                  | 0                   | 0              |
| Blue Crab         | -11,461              | -4,299         | 5,618              | 0                   | 0              |

Note:

Entrainment weights are based on estimated survival to juvenile and adult stages of entrainment mortalities for Summer and Winter Flounder and Weakfish and on estimated survival to adult stages for Atlantic Menhaden and Blue Crab. Survival numbers in these advanced stages were converted to weights using estimates of average weights, by stage and species.

Impingement weights are based on estimated impingement mortalities and the average weights, by species, of impingement samples at the OCNGS.

Cold shock weights are based on the conversion to average weights, using length-weight regression equations, of the average lengths, by species, estimated from cold-shock samples.

Source: Ebasco Services (1977).  
 Ichthyological Associates (1977a, 1977b).  
 NERA estimates.

1970 COMMERCIAL AND RECREATIONAL CATCH AS A PERCENTAGE OF TOTAL 1970 CATCH  
AND ESTIMATED 1975 VALUES PER POUND OF STOCK, BY SELECTED SPECIES

| Species                | Percentage of Total<br>1970 Catch |              | Value per Pound <sup>1</sup> |        |              |        | Weighted Value per Pound |                       |
|------------------------|-----------------------------------|--------------|------------------------------|--------|--------------|--------|--------------------------|-----------------------|
|                        | Commercial                        | Recreational | Commercial                   |        | Recreational |        | High                     | Low                   |
|                        |                                   |              | High                         | Low    | High         | Low    |                          |                       |
|                        | (1)                               | (2)          | (3)                          | (4)    | (5)          | (6)    | (7)                      | (8)                   |
|                        |                                   |              | (Dollars per Pound)          |        |              |        |                          |                       |
|                        |                                   |              | -----                        |        |              |        |                          |                       |
|                        |                                   |              | (1)x(3)+(2)x(5) ÷ 100        |        |              |        |                          | (1)x(4)+(2)x(6) ÷ 100 |
| Atlantic Menhaden      | 100.00                            | 0.00         | 0.0229                       | 0.0114 | n.c.         | n.c.   | 0.0229                   | 0.0114                |
| Blue Fish              | 3.92                              | 96.08        | 0.0922                       | 0.0461 | 0.1271       | 0.0635 | 0.1257                   | 0.0628                |
| Summer Flounder        | 43.89                             | 56.11        | 0.3235                       | 0.1618 | 0.4452       | 0.2226 | 0.3918                   | 0.1959                |
| Weakfish               | 30.15                             | 69.85        | 0.1213                       | 0.0606 | 0.2455       | 0.1227 | 0.2081                   | 0.1040                |
| Winter Flounder        | 2.25                              | 97.75        | 0.1436                       | 0.0718 | 0.3121       | 0.1561 | 0.3083                   | 0.1542                |
| Blue Crab <sup>2</sup> | 100.00                            | 0.00         | 0.2219                       | 0.1110 | n.c.         | n.c.   | 0.2219                   | 0.1110                |

n.c. - Denotes "not calculated."

<sup>1</sup>High Commercial values for all species but Blue Crab are based on the ratio of the value of commercial landings to the weight of commercial landings in New Jersey, Maryland, Virginia and North Carolina in 1975; Blue Crab values are based on the same ratio calculated with New Jersey data only. Low commercial values are estimated at one-half the high commercial values. See text for explanation of the derivation of recreational values and further explanation.

<sup>2</sup>All harvests of Blue Crab were valued at commercial landings values and no distinction, therefore, was made between commercial and recreational harvests. The assumption of commercial catch of 100 percent used in the table reflects this valuation procedure rather than actual division of the total catch between commercial and recreational harvests.

Source: U.S. National Marine Fisheries Service, Current Fisheries Statistics, Nos. 7213, 7216, 7183 and 7184, Washington, 1977.  
U.S. National Marine Fisheries Services, 1970 Salt-Water Angling Survey, Washington, 1973.  
NERA estimates.

TABLE 6

FISHING DAYS, PER CAPITA, LOGARITHM OF DAY PER CAPITA  
AND EXPENDITURES PER DAY FOR NINE CENSUS REGIONS

|                    | <u>Fishing<br/>Days per<br/>Capita</u> | <u>Ln Fishing<br/>Days per<br/>Capita</u> | <u>Expenditures<br/>per Day</u><br>(Dollars) |
|--------------------|--|---|--|
|                    | (1)                                    | (2)                                       | (3)  |
| New England        | 0.8002                                 | -0.2229                                   | \$ 9.99                                      |
| Middle Atlantic    | 0.7648                                 | -0.2682                                   | 9.48   |
| East North Central | 0.0754                                 | -2.5849                                   | 9.71   |
| West North Central | 0.0263                                 | -3.6393                                   | 19.66  |
| South Atlantic     | 2.0859                                 | 0.7352                                    | 11.18  |
| East South Central | 0.3093                                 | -1.1735                                   | 8.80   |
| West South Central | 0.9150                                 | -0.0888                                   | 12.15  |
| Mountain           | 0.0451                                 | -3.0992                                   | 12.03  |
| Pacific            | 0.8251                                 | -0.1922                                   | 10.78  |

Source: Computer tape of responses to 1970 Survey  
of Fishing and Hunting, op. cit.

INCREMENTAL HOURS OF FOGGING AND ICING AND LENGTHS OF ROUTE 9 IMPACTED,  
BY ALTERNATIVE COOLING TOWERS AND DIRECTIONS AND DISTANCES FROM THE TOWERS

|                              | Length of<br>Route 9<br>Impacted<br>(Miles)<br>(1) | Additional Hours of Fog                    |  | Additional Hours of Ice                    |  |
|------------------------------|--|--|--|--|--|
|                              |  | Round<br>Mechanical<br>Draft Towers<br>(2) | Fan-Assisted<br>Natural<br>Draft Towers<br>(3) | Round<br>Mechanical<br>Draft Towers<br>(4) | Fan-Assisted<br>Natural<br>Draft Towers<br>(5) |
| <u>Direction from Towers</u> |  |  |  |  |  |
| 0-500 Km                     |  |  |  |  |  |
| N                            | 0.000  | 0  | 1  | 0  | 0  |
| E                            | 0.125  | 0  | 11   | 0  | 1  |
| ESE                          | 0.062  | 2  | 9  | 0  | 2  |
| SE                           | 0.000  | 0  | 7  | 0  | 4  |
| SSE                          | 0.000  | 0  | 1  | 0  | 1  |
| S                            | 0.000  | 0  | 1  | 0  | 1  |
| SSW                          | 0.000  | 0  | 2  | 0  | 2  |
| SW                           | 0.000  | 0  | 3  | 0  | 0  |
| WSW                          | 0.000  | 0  | 12   | 0  | 4  |
| 500-1,000 Km                 |  |  |  |  |  |
| ESE                          | 0.094  | 0  | 2  | 0  | 0  |
| 1,000-1,500 Km               |  |  |  |  |  |
| ESE                          | 0.000  | 0  | 1  | 0  | 0  |

Note: No significant increments to natural fogging and icing were estimated in the case of the Natural Draft Tower.

Source: Ebasco Services Incorporated and NERA estimates.

NEW JERSEY ACCIDENT AND ACCIDENT SEVERITY RATES  
FOG/NONFOG AND ICE/NONICE CONDITIONS

|                                      | Fatal<br>Accidents         | Fatal and<br>Injury<br>Accidents | Property<br>Damage Only<br>Accidents | Accident Rates per<br>Million Vehicle Miles <sup>1</sup> |                |       |
|--------------------------------------|----------------------------|----------------------------------|--------------------------------------|--|----------------|-------|
|                                      |                            |                                  |                                      | Low  | Most<br>Likely | High  |
|                                      | ----- (Per Accident) ----- |                                  |                                      |  |                |       |
|                                      | (1)                        | (2)                              | (1)-(2)<br>(3)                       | (4)  | (5)            | (6)   |
| <b>Weather Conditions:</b>           |                            |                                  |                                      |  |                |       |
| Fog                                  | 0.0096                     | 0.4271                           | 0.5729                               | 3.276  | 3.557          | 5.294 |
| Nonfog                               | 0.0058                     | 0.4387                           | 0.5613                               | 3.561  | 3.557          | 3.529 |
| Difference (Fog-Nonfog) <sup>2</sup> | 0.0038*                    | -0.0116*                         | 0.0116*                              | -0.285   | 0.000          | 1.765 |
| <b>Road Conditions:</b>              |                            |                                  |                                      |  |                |       |
| Ice                                  | 0.0015                     | 0.2831                           | 0.7169                               | n.c.   | 3.557          | n.c.  |
| Nonice                               | 0.0045                     | 0.3800                           | 0.6200                               | n.c.   | 3.557          | n.c.  |
| Difference (Ice-Nonice) <sup>2</sup> | -0.0030**                  | -0.0969*                         | 0.0969*                              | n.c.   | 0.000          | n.c.  |

n.c. - denotes "not calculated."

<sup>1</sup>Accident rates are estimated for Route 9, Lacey Township in 1984. See text for further explanation.

<sup>2</sup>\*Significant at level less than 0.001 using a two-tailed test; \*\*significant at level less than 0.01 using a two-tailed test. The difference in accident rates per million vehicle miles are mathematically determined and are not subject, therefore, to statistical tests.

Source: New Jersey, Department of Transportation, Summary of Motor Vehicle Accidents, 1965-1973, 1975. New Jersey, Department of Transportation, Accident Data, Traffic Volumes and Mileage on the State Highway System, 1965-1967, 1970-1973. NERA estimates.

COST ESTIMATES FOR ACCIDENT DAMAGES  
1975 DOLLARS

| Cost Category                       | Fatality<br>Accident<br>(1) | Injury<br>Accident<br>(2) | Property<br>Damage Only<br>Accident<br>(3) |
|-------------------------------------|-----------------------------|---------------------------|--|
| Value of Life <sup>1</sup>          | \$437,436.00                | \$ 0.00                   | \$ 0.00                                    |
| Market/Home Production <sup>1</sup> | 0.00                        | 531.44                    | 0.00                                       |
| Community Production <sup>1</sup>   | 5,675.94                    | 19.56                     | 0.00                                       |
| Losses to Others <sup>1</sup>       | 2,146.99                    | 55.51                     | 0.00                                       |
| Hospital/Rehabilitation             | 165.00                      | 153.93                    | 0.00                                       |
| Physician/Coroner/Medical Examiner  | 260.00                      | 75.95                     | 0.00                                       |
| Emergency Transport                 | 50.00                       | 18.01                     | 0.00                                       |
| Legal Costs                         | 1,955.00                    | 106.89                    | 7.00                                       |
| Court Costs                         | 235.00                      | 50.23                     | 5.00                                       |
| Insurance Administration            | 285.00                      | 74.66                     | 50.59                                      |
| Accident Investigation              | 84.48                       | 30.72                     | 10.75                                      |
| Vehicle Damage                      | 3,990.00                    | 1,669.00                  | 531.20                                     |
| Traffic Delays                      |                             |                           |  |
| Automobile                          | 67.83                       | 86.41                     | 67.83                                      |
| Trucks                              | 43.39                       | 55.27                     | 43.39                                      |
| Total                               | 452,394.63                  | 2,927.58                  | 715.76                                     |

Note: Estimates for fatality and injury accidents are expressed on a per fatality and per injury basis, respectively; property damage only estimates are expressed on a per accident basis.

<sup>1</sup> Present values based on assumed discount rate of 11.22 percent.

Source: NERA estimates and U.S. Department of Transportation, National Highway Traffic Safety Administration, 1975 Societal Costs of Motor Vehicle Accidents, Washington, D.C., 1975.

COST ESCALATION RATES FOR ACCIDENT DAMAGES

| Cost Category                      | Cost Escalation Rates<br>(Percent)<br>(1) | Basis for Escalation<br>(2)  |
|------------------------------------|---|--|
| Value of Life                      | 7.50                                      | Average annual earnings of male full-time workers <sup>1</sup>                         |
| Market/Home Production             | 6.36                                      | Average annual earnings of all workers <sup>1</sup>                                    |
| Community Production               | 6.36                                      | Average annual earnings of all workers <sup>1</sup>                                    |
| Losses to Others                   | 6.36                                      | Average annual earnings of all workers <sup>1</sup>                                    |
| Hospital Rehabilitation            | 5.95                                      | Consumer Price Index (CPI), Hospital Service Charges <sup>2</sup>                      |
| Physician/Coroner/Medical Examiner | 5.54                                      | CPI, Physician Fees <sup>2</sup>   |
| Emergency Transport                | 5.49                                      | CPI, Medical Care <sup>2</sup>   |
| Legal Costs                        | 6.67                                      | CPI, Legal Services (short form will) <sup>2</sup>                                     |
| Court Costs                        | 7.40                                      | Average state and local government, nonschool (other) wages and salaries <sup>3</sup>  |
| Insurance Administration           | 3.93                                      | CPI, Automobile Insurance Premiums <sup>2</sup>  |
| Vehicle Damage                     | 5.99                                      | CPI, Automobile Repair and Maintenance <sup>2</sup>                                    |
| Traffic Delays:                    |   |  |
| Automobile                         | 10.61                                     | Average annual earnings of all workers <sup>1, 4</sup>                                 |
| Trucks                             | 12.14                                     | Average hourly earnings of male truck drivers, Metropolitan Northeast. <sup>2, 4</sup> |

Note: All cost escalation rates based on Consumer Price Indexes were scaled downward proportionately to reflect differences in the general rate of inflation of 6.15 percent during the historical period (1967-75) and of 5 percent in the period of projection. Escalation rates based on earnings and wage data reflect similar adjustments to an assumed general rate of increase in earnings of full-time workers of 7.5 percent based on the sum of the general rate of inflation of 5 percent per annum and an historical growth in labor productivity of 2.5 percent per annum.

<sup>1</sup> U.S. Bureau of the Census, Current Population Reports, Series P-60, Nos. 60 and 105.

<sup>2</sup> U.S. Bureau of Labor Statistics, Handbook of Labor Statistics, Washington, 1976.

<sup>3</sup> U.S. Bureau of Economic Analysis, unpublished data.

<sup>4</sup> Underlying cost escalation rate scaled upward by a factor of 1.04 to reflect growth in traffic volume. This adjustment is necessary because cost estimates are based on traffic volumes in a specific year.

Source: NERA estimates.

DISTRIBUTION OF 1975 RESIDENT POPULATION  
BY EXPOSURE TO AVERAGE ANNUAL GROUND DEPOSITION RATES  
OF SALT AND ALTERNATIVE COOLING TOWERS

| Mean Annual<br>Deposition Rate<br>(Kg/Km /month) | Two Fan-<br>Assisted            |                                | Two Round                          |
|--|---------------------------------|--------------------------------|------------------------------------|
|  | Natural Draft<br>Cooling Towers | Natural Draft<br>Cooling Tower | Mechanical Draft<br>Cooling Towers |
|  | ----- (1975 Population) -----   |                                |                                    |
|  | (1)                             | (2)                            | (3)                                |
| 0-10   | 136,936                         | 162,963                        | 161,065                            |
| 10-20  | 45,624                          | 37,717                         | 25,197                             |
| 20-40  | 12,167                          | 1,157                          | 7,586                              |
| 40-60  | 5,566                           | 187                            | 1,957                              |
| 60-80  | 1,370                           | 53                             | 1,625                              |
| 80-100   | 328                             | 1                              | 883                                |
| 100-200  | 58                              | 0                              | 2,169                              |
| 200-300  | 7                               | 0                              | 936                                |
| 300-400  | 21                              | 0                              | 399                                |
| 400-500  | 0                               | 0                              | 235                                |
| 500-600  | 0                               | 0                              | 21                                 |
| 600-700  | 0                               | 0                              | 17                                 |
|  | ----- (Kg/Km /month) -----      |                                |                                    |
| Weighted Average of<br>Salt Deposition<br>Rates  | 10.95                           | 6.86                           | 11.45                              |

Note: Estimated 1975 resident population in the impact zone is 202,080. Column totals do not add to this number because of rounding procedures used in distributing population by deposition rates.  
Weighted averages calculated from frequency distributions with a larger number of deposition rate intervals.

Source: NERA estimates based on Pickard, Lowe and Garrick deposition model results and U.S. Bureau of the Census population estimates.

ESTIMATES OF INCREASED ANNUAL MAINTENANCE COSTS FOR METAL SYSTEMS, BY ALTERNATIVE COOLING TOWERS, IN 1975 DOLLARS

|  | Exposed Area<br>in Impact<br>Zone <sup>2</sup> (1975)<br>(Sq. Ft.) | Extra Annual Maintenance Costs<br>per Unit of Exposed Area <sup>1</sup> |                         |                            | Extra Annual Maintenance Costs |                         |                            |
|--|--|---|-------------------------|----------------------------|--------------------------------|-------------------------|----------------------------|
|  |  | Natural   | Fan-Assisted            | Round                      | Natural                        | Fan-Assisted            | Round                      |
|  |  | Draft Tower   | Natural<br>Draft Towers | Mechanical<br>Draft Towers | Draft Tower                    | Natural<br>Draft Towers | Mechanical<br>Draft Towers |
|  | (1)  | (2)   | (3)                     | (4)                        | (1)x(2)<br>(5)                 | (1)x(3)<br>(6)          | (1)x(4)<br>(7)             |
|  | (1975 Dollars)   |   |                         |                            |                                |                         |                            |
| <b>Steel Systems</b>                               |  |   |                         |                            |                                |                         |                            |
| <b>Tanks:</b>                                      |  |   |                         |                            |                                |                         |                            |
| Water  | 145,870  | 0.00016   | 0.00025                 | 0.00026                    | 23                             | 36                      | 38                         |
| Chemical and Industrial Storage                    | 416,078  | 0.00020   | 0.00032                 | 0.00033                    | 83                             | 133                     | 137                        |
| Steel Bridges                                      | 4,556,260  | 0.00036   | 0.00058                 | 0.00061                    | 1,640                          | 2,643                   | 2,779                      |
| Externally Mounted Power Transformers              | 319,671  | 0.00016   | 0.00025                 | 0.00026                    | 51                             | 80                      | 83                         |
| <b>Street Lighting Fixtures:</b>                   |  |   |                         |                            |                                |                         |                            |
| Exposed Heavy Gauge Steel                          | 33,926   | 0.00016   | 0.00025                 | 0.00026                    | 5                              | 8                       | 9                          |
| Exposed Light Gauge Steel                          | 358,347  | 0.00016   | 0.00025                 | 0.00026                    | 57                             | 90                      | 93                         |
| <b>Galvanized Roofing, Siding, Roof Drainage</b>   |  |   |                         |                            |                                |                         |                            |
| Industrial   | 5,535,658  | 0.00015   | 0.00024                 | 0.00025                    | 830                            | 1,329                   | 1,384                      |
| Commercial   | 3,706,915  | 0.00006   | 0.00009                 | 0.00009                    | 222                            | 334                     | 334                        |
| Residential and Other                              | 11,120,742   | 0.00006   | 0.00009                 | 0.00009                    | 667                            | 1,001                   | 1,001                      |
| Industrial Siding                                  | 521,311  | 0.00015   | 0.00024                 | 0.00025                    | 78                             | 125                     | 130                        |
| <b>Structural Steel - External Use:</b>            |  |   |                         |                            |                                |                         |                            |
| Exposed: Industrial                                | 876,646  | 0.00032   | 0.00051                 | 0.00053                    | 281                            | 447                     | 465                        |
| Exposed: Commercial                                | 588,817  | 0.00016   | 0.00025                 | 0.00026                    | 94                             | 147                     | 153                        |
| Exposed: Public Utilities                          | 389,960  | 0.00032   | 0.00051                 | 0.00053                    | 125                            | 199                     | 207                        |
| Outdoor Gratings, Fire Escape and Grillwork        | 711,678  | 0.00016   | 0.00025                 | 0.00026                    | 114                            | 178                     | 185                        |
| <b>Metal Doors:</b>                                |  |   |                         |                            |                                |                         |                            |
| Industrial   | 48,133   | 0.00032   | 0.00051                 | 0.00053                    | 15                             | 25                      | 26                         |
| Commercial   | 31,156   | 0.00016   | 0.00025                 | 0.00026                    | 5                              | 8                       | 8                          |
| Residential  |  |   |                         |                            |                                |                         |                            |
| Metal Window, Sash and Frames                      | 31,015   | 0.00032   | 0.00051                 | 0.00053                    | 10                             | 16                      | 16                         |
| Pole-Line Hardware                                 | 2,356,917  | 0.00008   | 0.00013                 | 0.00014                    | 189                            | 306                     | 330                        |
| Chain-Link Fence                                   | 6,656,531  | 0.00009   | 0.00014                 | 0.00015                    | 599                            | 932                     | 998                        |
| Posts and Fittings                                 | 970,135  | 0.00010   | 0.00016                 | 0.00017                    | 97                             | 155                     | 165                        |
| Galvanized Rope Wire                               | 2,667,072  | 0.00079   | 0.00125                 | 0.00130                    | 2,107                          | 3,334                   | 3,467                      |
| Galvanized Steel Power Line Trans Tower            | 1,213,550  | 0.00006   | 0.00009                 | 0.00009                    | 73                             | 109                     | 109                        |
| <b>Prefabricated and Portable Steel Buildings,</b> |  |   |                         |                            |                                |                         |                            |
| <b>Roofing and Siding:</b>                         |  |   |                         |                            |                                |                         |                            |
| Industrial   | 4,557,468  | 0.00015   | 0.00024                 | 0.00025                    | 684                            | 1,094                   | 1,139                      |
| Commercial   | 5,178,941  | 0.00006   | 0.00009                 | 0.00009                    | 311                            | 466                     | 466                        |
| Residential  | 1,479,698  | 0.00006   | 0.00009                 | 0.00009                    | 89                             | 133                     | 133                        |
| Electrical Contacts <sup>3</sup>                   | n.c.   | n.c.  | n.c.                    | n.c.                       | 422                            | 666                     | 693                        |
| <b>Total</b>                                       | <b>n.c.</b>  | <b>n.c.</b>   | <b>n.c.</b>             | <b>n.c.</b>                | <b>8,871</b>                   | <b>13,994</b>           | <b>14,548</b>              |

n.c. - Denotes "not calculated."

<sup>1</sup>Estimates derived from those presented by Fink, et. al. (1971). Expressed in terms of levelized annual values based on present values for 1975 calculated using an 11.22 percent discount rate.

<sup>2</sup>Based on 1970 national stock estimates from Fink, et. al. (1971). National estimates were inflated to 1975 using a 2 percent per annum growth rate to reflect the change in Real Net National Product from 1970 to 1975 and apportioned to the impact area. See text for further explanation.

<sup>3</sup>Cost estimates assumed to be 5 percent of other materials-damage costs. (See Gillette, 1974.)

Source: NERA estimates.

FI-44

TABLE 12

**FIGURES**

Figure 1

A HYPOTHETICAL DEMAND CURVE  
FOR RECREATIONAL FISHING

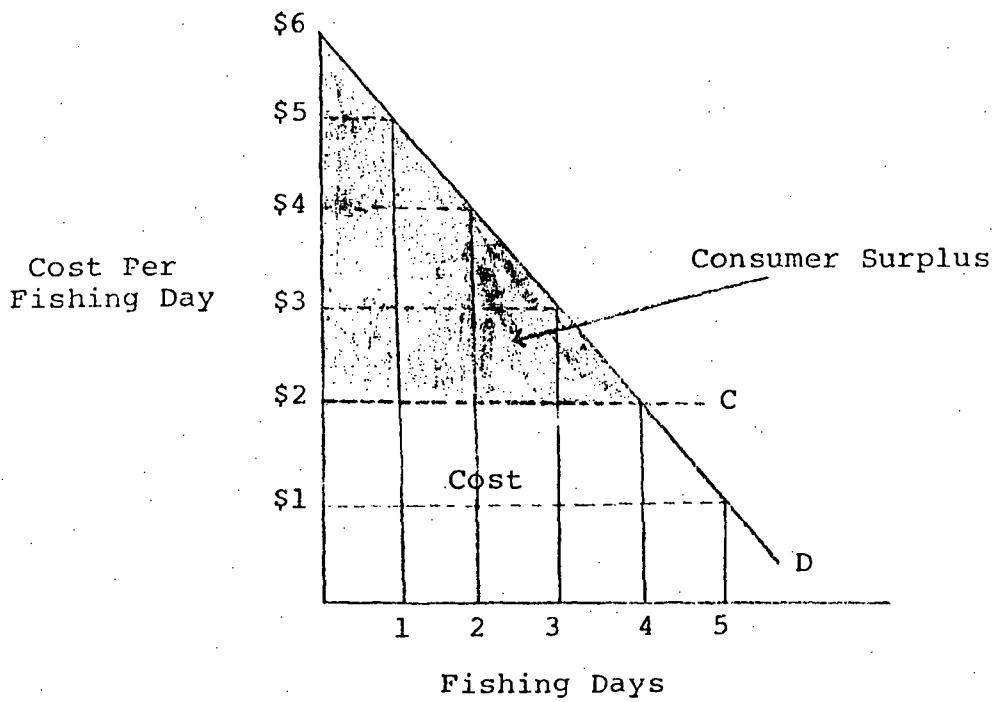
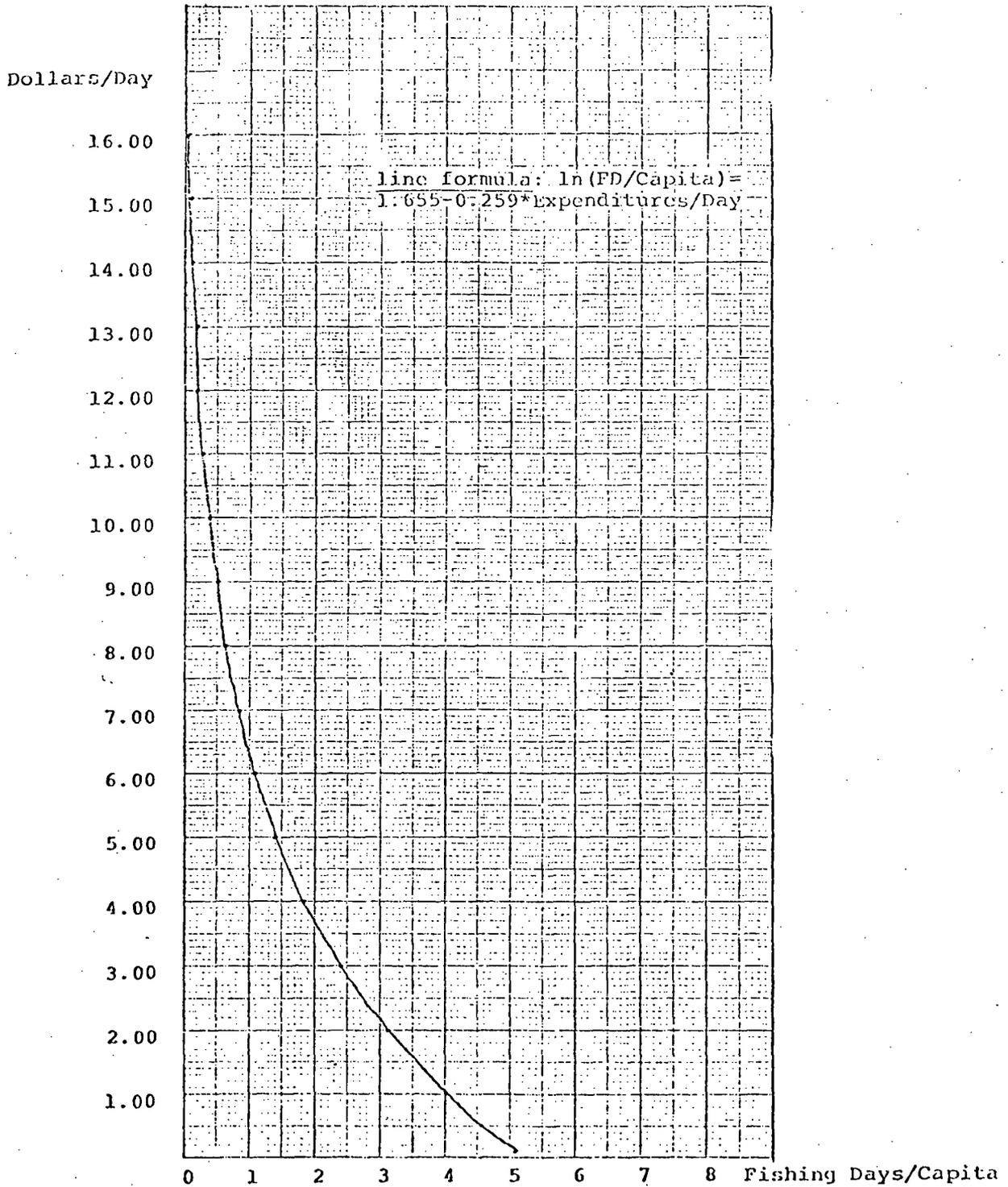


Figure 2

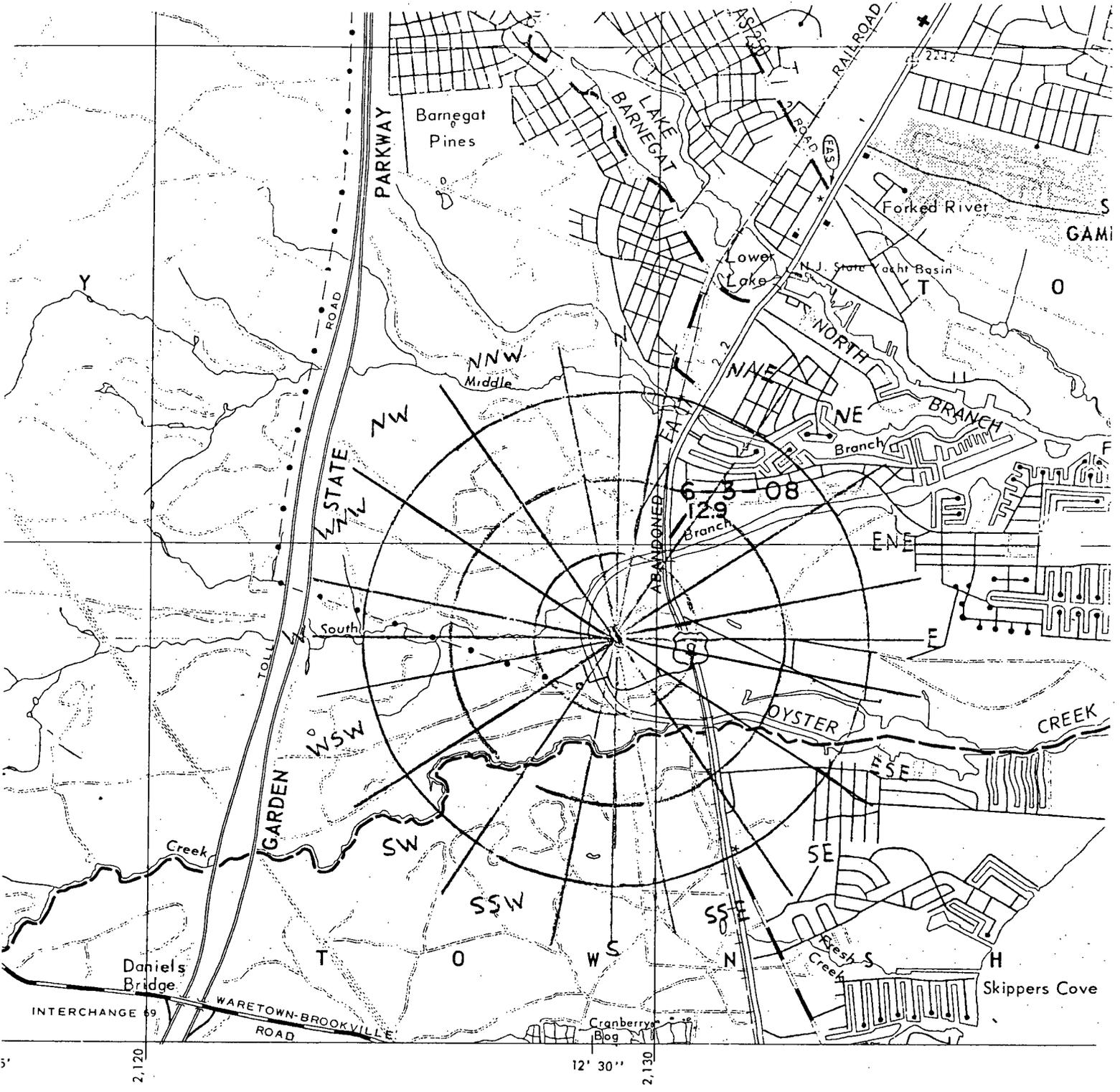
DEMAND FOR SALTWATER FISHING AS A FUNCTION  
OF COST OF FISHING PER DAY



Source: NERA Estimates.

Figure 3

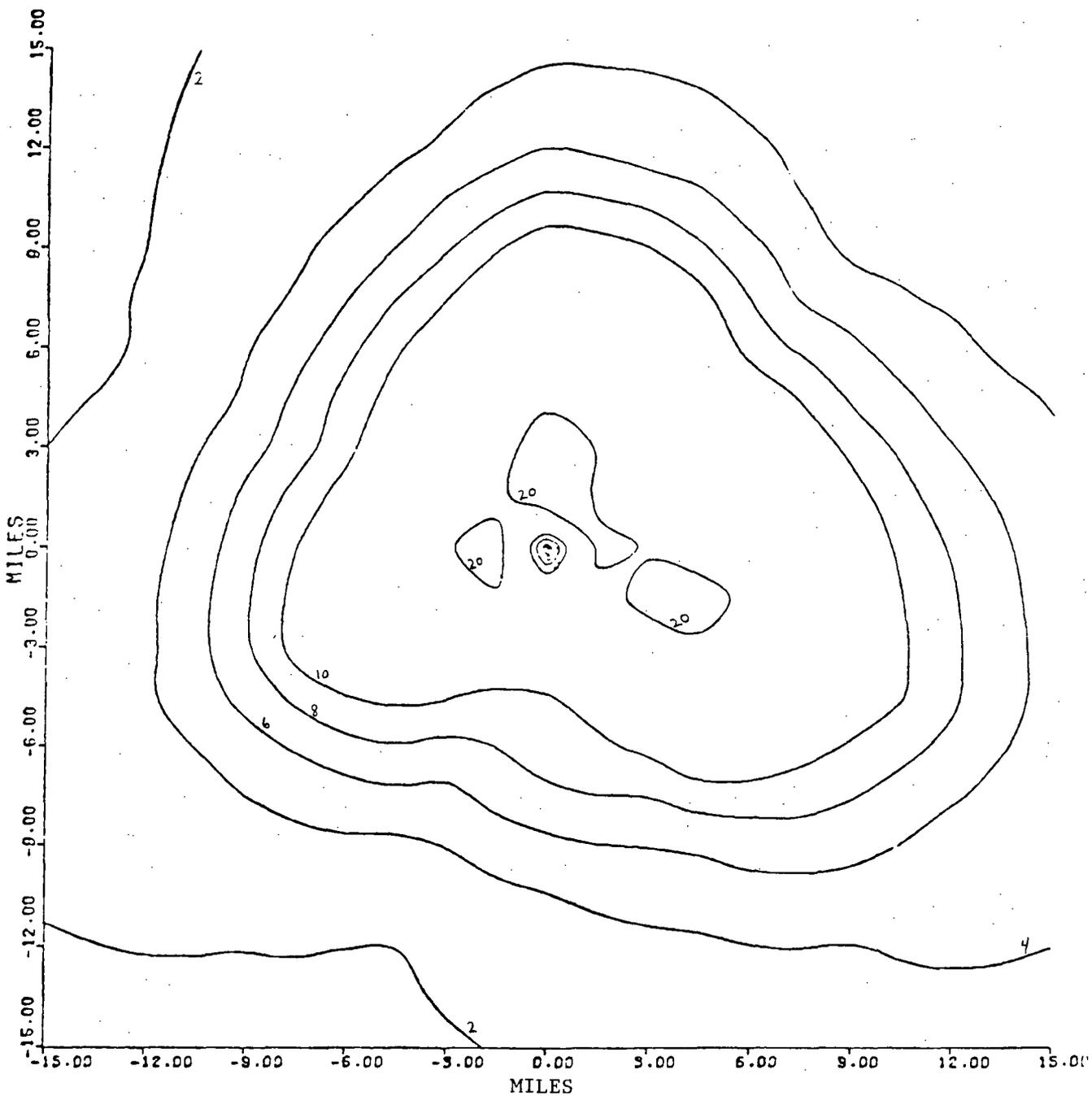
FOG AND ICE IMPACT AREAS:  
FAN-ASSISTED NATURAL DRAFT  
AND ROUND MECHANICAL DRAFT TOWERS



Note: Concentric circles with radii equal to 500, 1000 and 1500 meters.

Source: Ebasco Services, Inc. (1977).

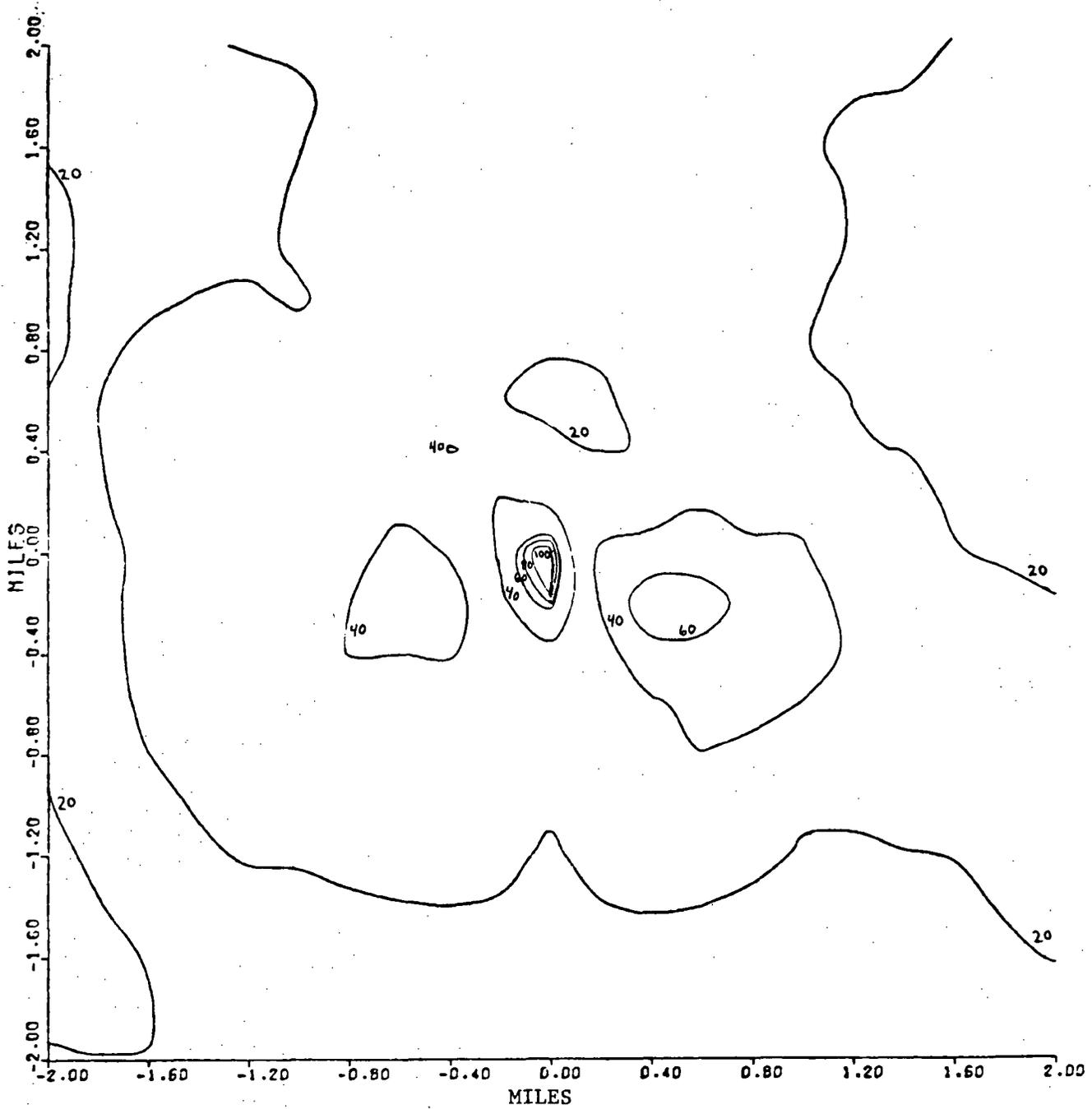
IMPACT AREA ISOPLETHS OF ANNUAL AVERAGE  
GROUND DRY DEPOSITION RATES IN KG/KM<sup>2</sup>/MONT: :  
NATURAL DRAFT TOWER  
(0-15 MILES)



Source: Pickard, Lowe and Garrick, Inc. Estimates

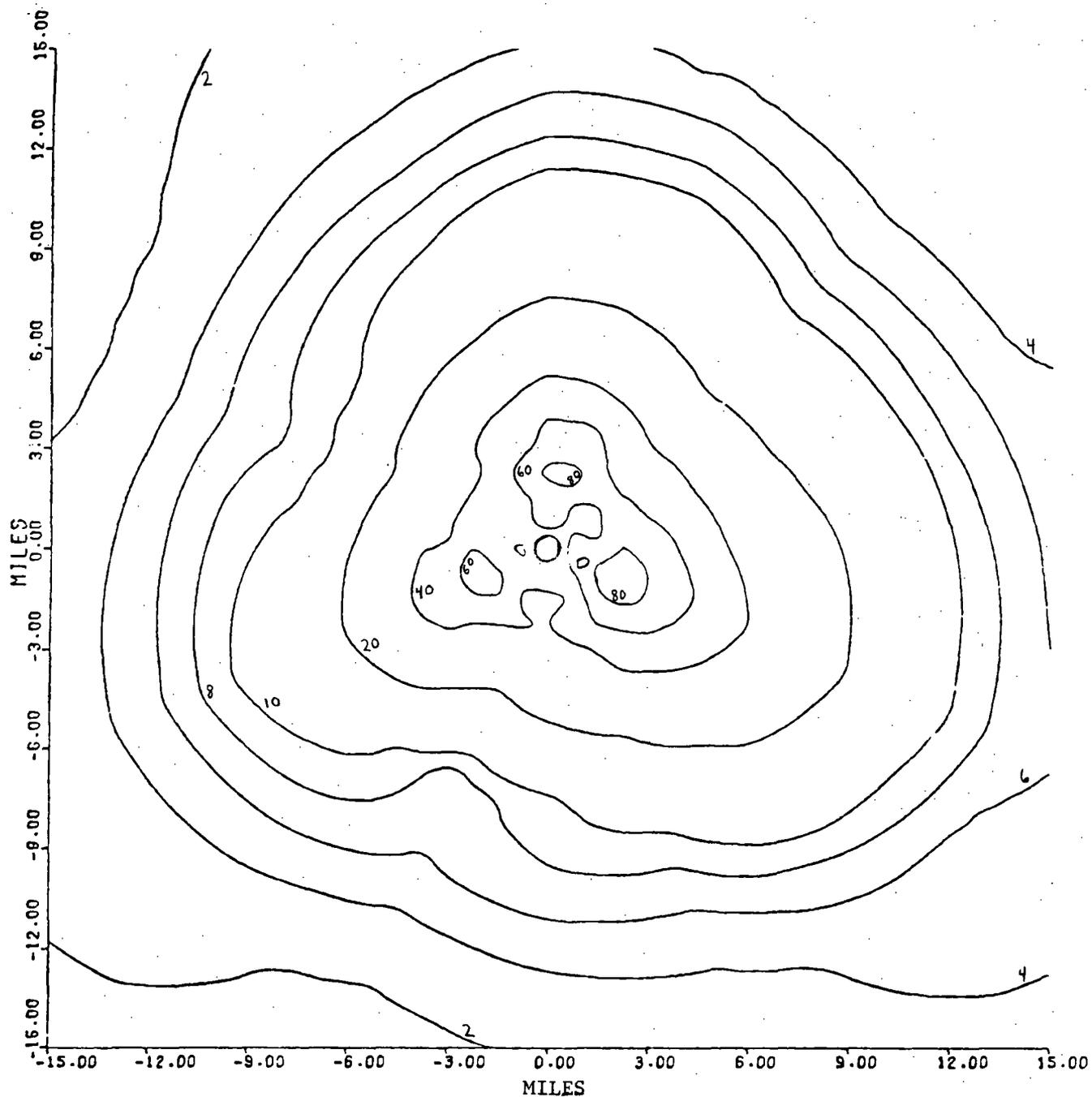
Figure 5

IMPACT AREA ISOPLETHS OF ANNUAL AVERAGE  
GROUND DRY DEPOSITION RATES IN KG/KM<sup>2</sup>/MONTH:  
NATURAL DRAFT TOWER  
(0-2 MILES)



Source: Pickard, Lowe and Garrick, Inc. Estimates

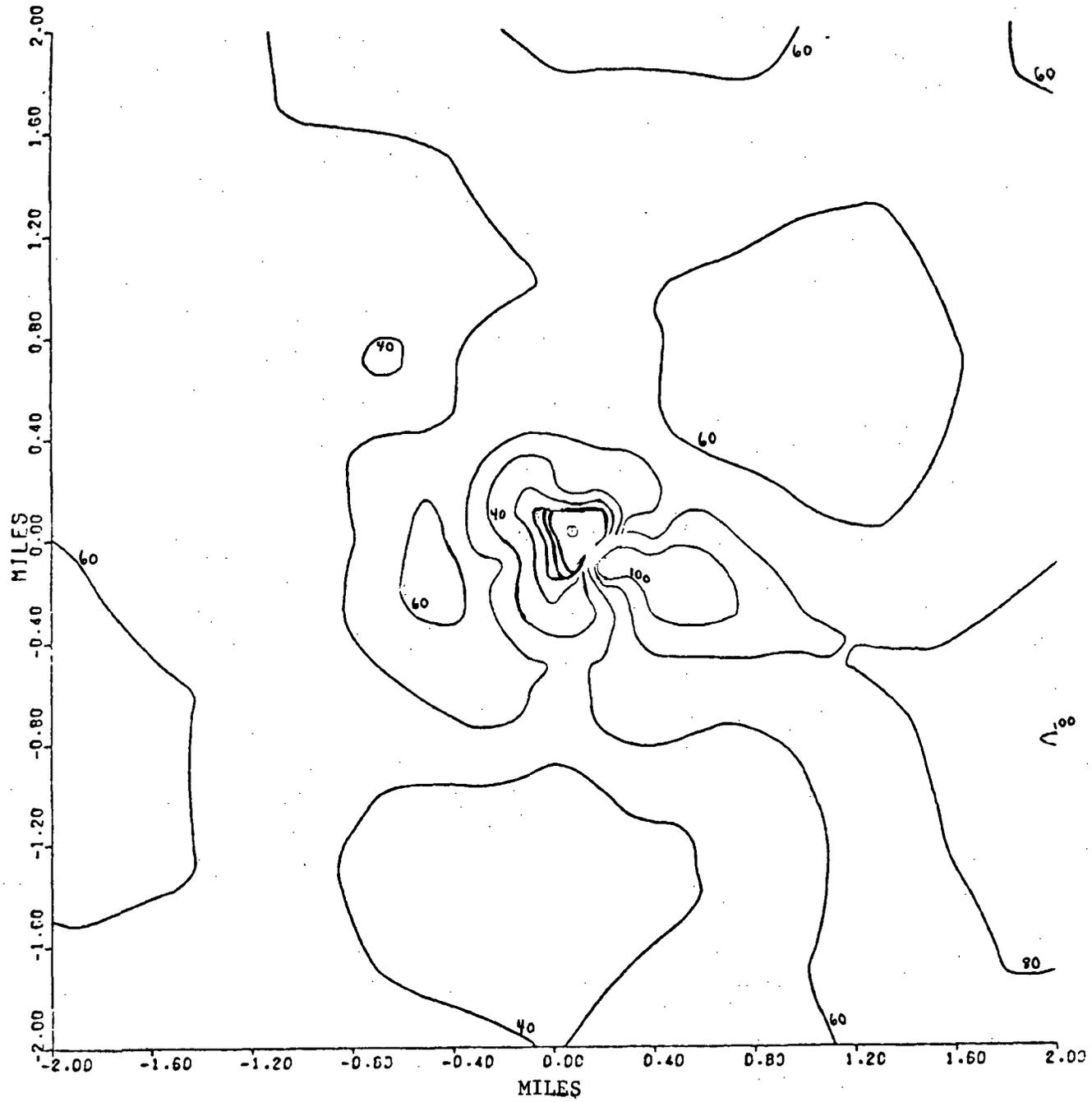
IMPACT AREA ISOPLETHS OF ANNUAL AVERAGE  
GROUND DRY DEPOSITION RATES IN KG/KM<sup>2</sup>/MONTH:  
FAN-ASSISTED NATURAL DRAFT TOWERS  
(0-15 MILES)



Source: Pickard, Lowe and Garrick, Inc. Estimates

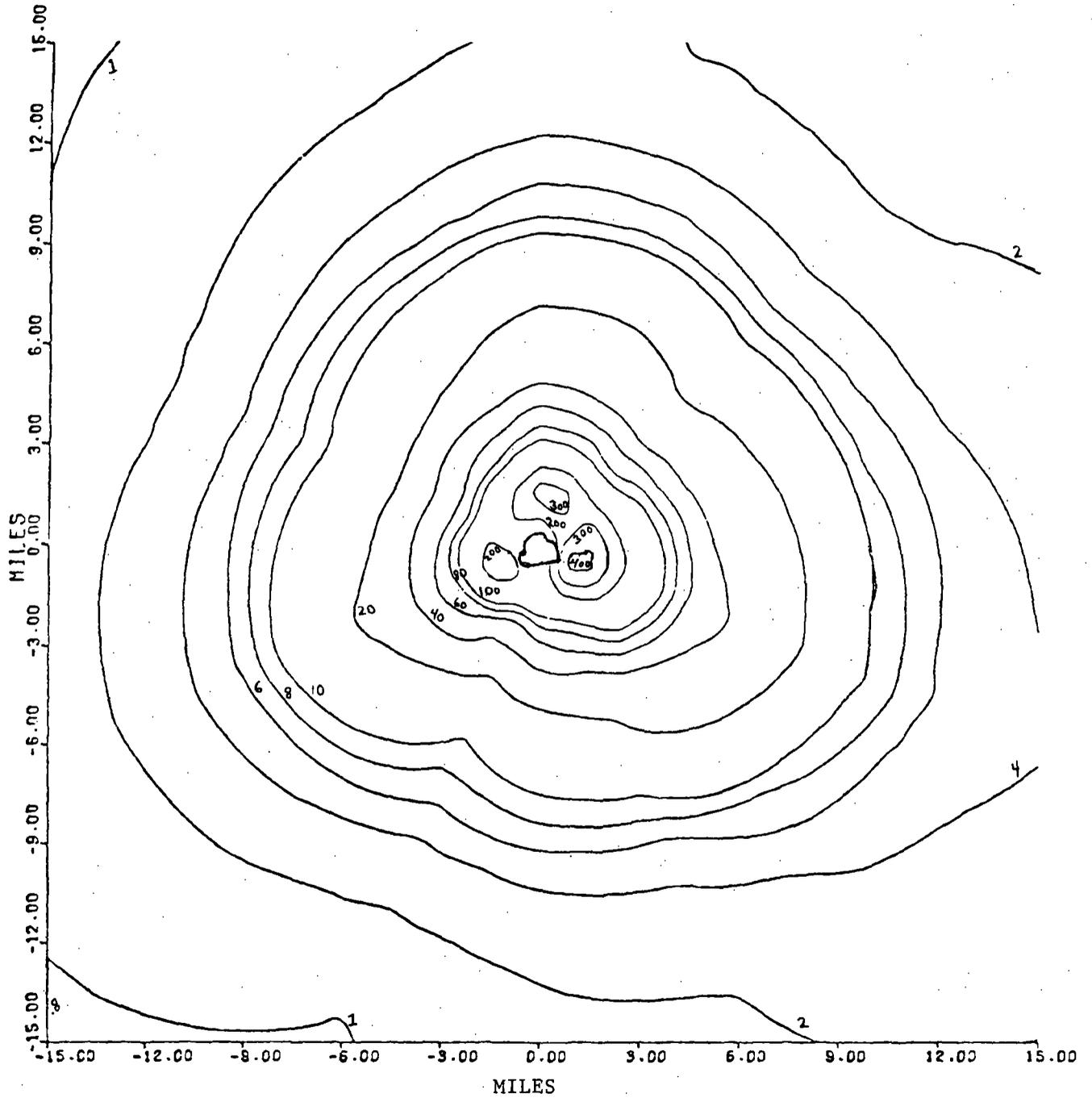
Figure 7

IMPACT AREA ISOPLETHS OF ANNUAL AVERAGE  
GROUND DRY DEPOSITION RATES IN KG/KM<sup>2</sup>/MONTH:  
FAN-ASSISTED NATURAL DRAFT TOWERS  
(0-2 MILES)



Source: Pickard, Lowe and Garrick, Inc. Estimates

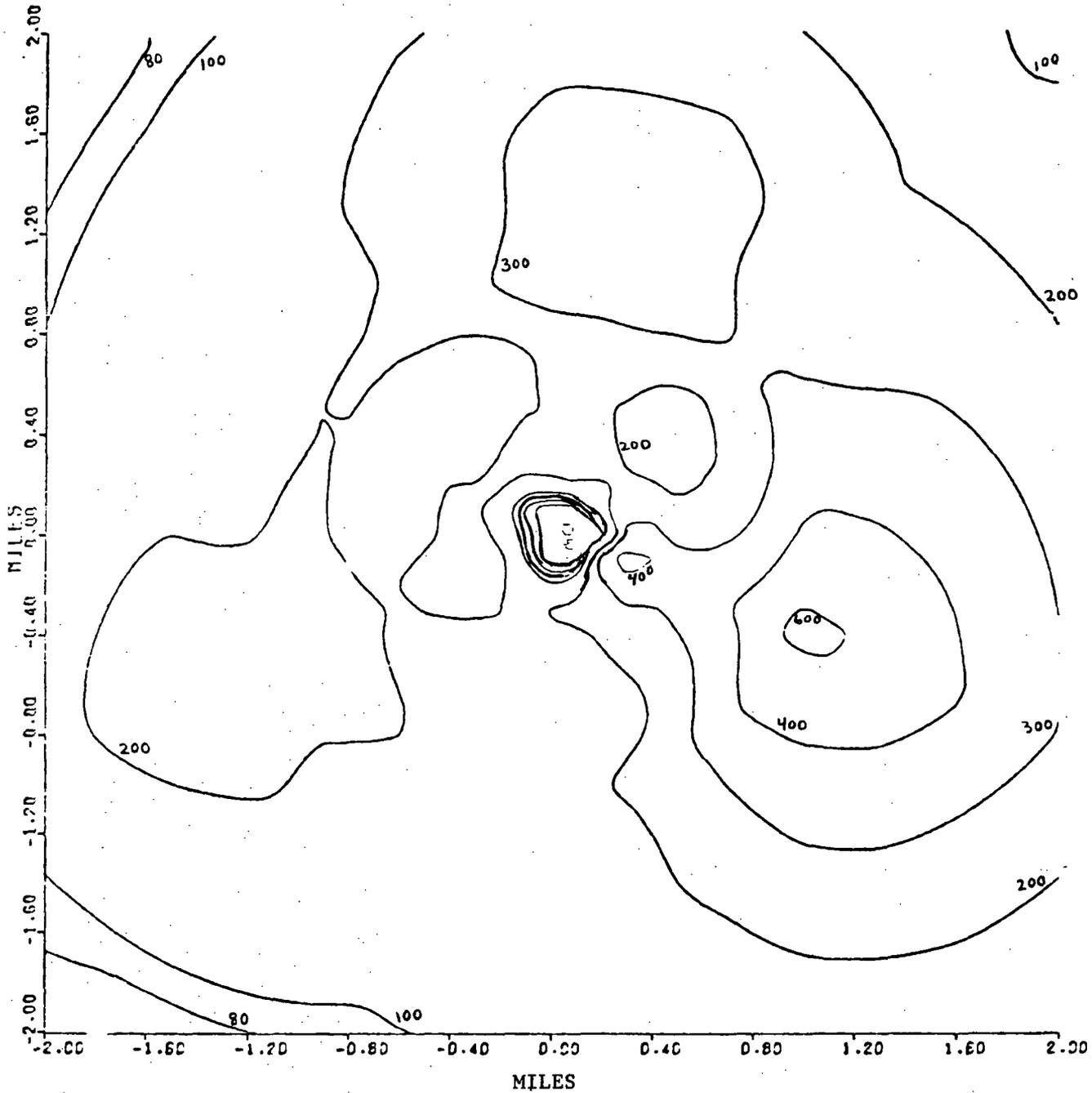
IMPACT AREA ISOPLETHS OF ANNUAL AVERAGE  
GROUND DRY DEPOSITION RATES IN KG/KM<sup>2</sup>/MONTH:  
ROUND MECHANICAL DRAFT TOWERS  
(0-15 MILES)



Source: Pickard, Lowe and Garrick, Inc. Estimates

Figure 9

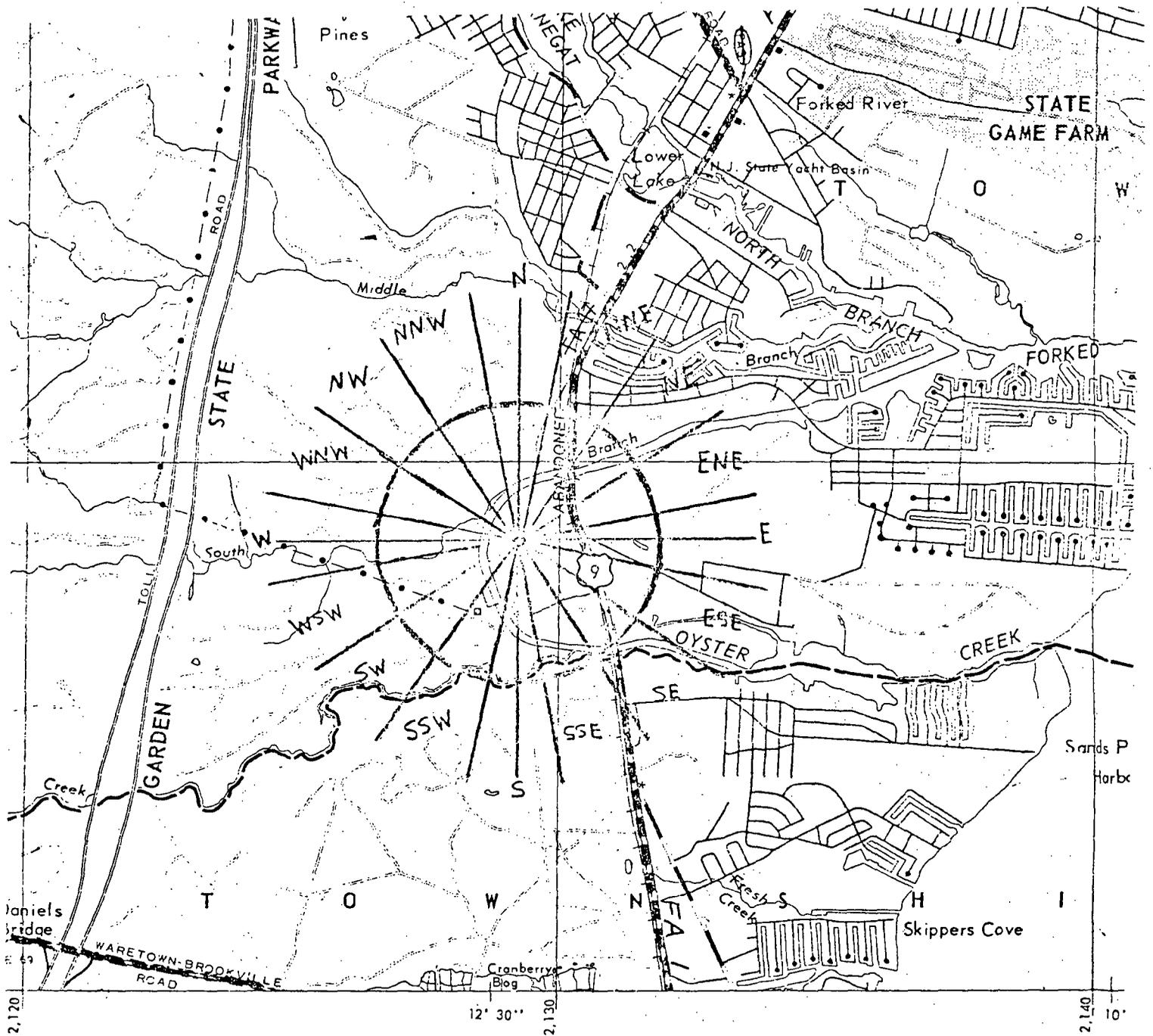
IMPACT AREA ISOPLETHS OF ANNUAL AVERAGE  
GROUND DRY DEPOSITION RATES IN KG/KM<sup>2</sup>/MONTH:  
ROUND MECHANICAL DRAFT TOWERS  
(0-2 MILES)



Source: Pickard, Lowe and Garrick, Inc. Estimates

Figure 10

NOISE IMPACT AREA:  
NATURAL DRAFT TOWER



Note: Circle with radius equal to 2500 feet and estimated dB(A) of 46 at perimeter.

Source: Ebasco Services, Inc. (1977).