Jersey Central Power & Light Company

OYSTER CREEK
NUCLEAR GENERATING STATION

ALTERNATIVE COOLING WATER SYSTEM STUDY

EXECUTIVE SUMMARY

VOLUME I

JCP&L GPU
A Member Company of the General Public Utilities System

JCP&L GPU

Jersey Central Power & Light Company
Madison Avenue at Punchbowl Road
Morristown New Jersey 07960
201 539 6111

November 30, 1977
EAJEA-743

Mr. Voss A. Moore
Assistant Director for Environmental Projects
Directorate of Licensing
Office of Regulations
United States Nuclear Regulatory Commission
Washington, DC 20555

Dear Mr. Moore:

Subject: Oyster Creek Nuclear Generating Station
Docket No. 50-219
Alternative Cooling Water System Study

In its December, 1974 Final Environmental Statement (FES) concerning the issuance of a Full Term Operating License (FTOL) for the Oyster Creek Nuclear Generating Station, the NRC (then the AEC) Staff recommended that the FTOL, when issued, should be subject to certain conditions to protect the environment. The conditions originally proposed in the FES were modified by the NRC Staff on August 15, 1975 largely due to Jersey Central Power & Light Company's (JCP&L's) actions taken since the FES was issued.

Condition 7(d) of those proposed conditions calls for a detailed cost-benefit study of alternative cooling systems by November, 1977. Although the FTOL has not been issued as of this date, we are continuing to abide by the stipulation agreed upon by the Staff in the Joint Motion to Terminate Hearing of November 14, 1975. We are, therefore, enclosing eleven (11) copies of the Alternative Cooling Water System Study prepared by Ebasco Services Incorporated and National Economic Research Associates, Inc.

This study concludes that for each alternative system analyzed, total costs exceed total benefits by a substantial margin. In view of this fact, the installation of any alternative to the once through cooling system at the Oyster Creek Nuclear Generating Station is not justified.

Very truly yours,

Ivan R. Finfrock, Jr.

Ivan R. Finfrock, Jr.
Vice President

pk

Enclosures

JERSEY CENTRAL POWER & LIGHT COMPANY

OYSTER CREEK NUCLEAR GENERATING STATION

ALTERNATIVE COOLING WATER SYSTEM STUDY

DOCKET NO. 50-219

INTRODUCTION AND SUMMARY

In its December 1974 Final Environmental Statement (FES) concerning the issuance of a Full-Term Operating License (FTOL) for the Oyster Creek Nuclear Generating Station, the NRC (then the AEC) Staff recommended that the FTOL when issued should be subject to certain conditions to protect the environment. The conditions originally proposed in the FES were modified by the NRC staff on August 15, 1975 largely due to Jersey Central Power & Light Company's (JCP&L's) actions taken since the FES was issued.

Condition 7(d) of the modified conditions states:

"The licensee will submit by November 1977 for review by the Staff a detailed reevaluation on a cost-benefit basis of alternative cooling systems taking account of the results of the monitoring program pursuant to condition (c). Such evaluation shall include, in addition to the present cooling system, systems that would not use Barnegat Bay water for once-through cooling, e.g., a closed cycle helper cycle, or ocean intake-discharge system. The staff will consider this information in arriving at a determination in conformance with the provisions of Section 511 of the Federal Water Pollution Control Act amendments of 1972 (FWPCA), and in conformance with the applicable NPDES permit issued under Section 402 of the FWPCA or any alternative effluent limitation established pursuant to Section 316 of FWPCA, concerning the acceptability of continued operation using the present cooling system."

Although the FTOL has not been issued as of this date, we are submitting this Alternative Cooling Water System Study in accordance with that condition.

The Alternative Cooling Water System Study is divided into two sections. The first section, prepared by Ebasco Services Incorporated (Ebasco), evaluates sixteen alternative cooling systems considering engineering, environmental, economic and regulatory factors. Ebasco identified four "preferred" systems, natural draft cooling tower, fan-assisted natural draft cooling towers, round mechanical draft cooling towers, and discharge canal to Barnegat Bay, of which the natural draft cooling tower is considered the optimun.

The second section of the study, prepared by National Economic Research Associates, Inc. (NERA) examines the four alternative systems Ebasco identified as "preferred" in a socio-economic analysis. The results of the NERA study indicate that the levelized annual environmental costs outweigh the environmental benefits for each of the tower alternatives ranging from a low net cost

of $130,400 for the natural draft tower to a high of $1,255,700 for the round mechanical draft tower. The discharge canal to bay system is similar to the existing system and at best would provide only marginal improvements; therefore, no incremental costs or benefits were identified.

When the levelized annual capital and operating costs are added to the net environmental costs, the discharge canal to bay is the least costly by a substantial margin. The most likely total net levelized annual costs for these systems are $9,131,000 discharge canal to bay, $20,498,000 natural draft tower, $22,062,000 round mechanical draft tower, and $22,553,000 fan-assisted natural draft tower.

The capital, operating and land acquisition costs of these alternatives would be passed on to JCP&L's customers which would amount to an estimated increase in the annual budget of an average residential customer of $6.85 canal to bay, $15.33 natural draft tower, $16.46 round mechanical draft tower and $16.83 fan-assisted natural draft tower.

In view of the fact that total costs exceed total benefits by a substantial margin for each of the alternatives, the installation of any alternative cooling system at the Oyster Creek Nuclear Generating Station is not justified.

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

VOLUME 1

EXECUTIVE SUMMARY

Ebasco Services Incorporated
Two Rector Street
New York, N Y

November 1977

ABSTRACT

Ebasco Services Incorporated evaluated sixteen alternative open-cycle and closed-cycle cooling systems for Oyster Creek Nuclear Generating Station. The evaluation considered engineering, licensing, and environmental factors. Twelve alternatives were eliminated either because: 1) they exhibited overriding environmental impacts; 2) they did not exhibit compensating advantages for important disadvantages in one or more disciplinary areas; or 3) they involved significant commercial risk. The four remaining alternatives (natural draft cooling tower, round mechanical draft cooling tower, fan-assisted natural draft cooling tower, and discharge canal to Barnegat Bay systems) were designated "preferred" alternative systems and evaluated in greater detail.

The round mechanical draft tower system was eliminated from consideration because no practical method could be identified to achieve compliance with nighttime New Jersey noise limits. The discharge canal-to-bay alternative was considered less desirable than the remaining preferred alternatives because it would provide, at best, a marginal improvement on existing environmental conditions compared to the remaining preferred alternatives. The fan-assisted natural draft tower system was judged to be less desirable than the natural draft tower system on the basis of noise mitigation and operating experience considerations. Other differences between these latter two alternatives are comparatively minor.

Based on its study of engineering, licensing, and environmental factors, Ebasco concluded that the natural draft cooling tower system is the optimum of the sixteen alternatives considered.

VOLUME 1

PREFACE

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

Volume 1 contains the Executive Summary (Chapter I) and six accompanying Exhibits.

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 the Exhibits cited in the other volumes.

I. EXECUTIVE SUMMARY

TABLE OF CONTENTS

CHAPTER I - EXECUTIVE SUMMARY

CHAPTER I

LIST OF EXHIBITS

A. BACKGROUND

The Oyster Creek Nuclear Generating Station (OCNGS), owned and operated by Jersey Central Power and Light Company (JCP&L), is a 620 MW generating station using a boiling water reactor designed and fabricated by General Electric. The station has been in commercial operation since 1969.

OCNGS is located west of Barnegat Bay between Forked River and Oyster Creek. A man-made intake canal connects OCNGS to the South Branch of Forked River; a discharge canal connects the station to Oyster Creek. A composite water supply of fresh water flowing down the three branches of Forked River and saline water drawn upstream through the mouth of Forked River from Barnegat Bay is circulated through the condensers and other station equipment and then discharged into Oyster Creek, which empties into Barnegat Bay. Additionally, water drawn from the intake canal supplies pumps which dilute heat discharged by OCNGS.

In the case of the Oyster Creek Nuclear Generating Station, pertinent environmental regulatory limits have been consistently met. However, observations since 1969 have noted both direct plant impacts (e.g., fish kills due to cold shock, entrainment and impingement) and localized changes in aquatic ecology which might be related to plant operation (e.g., increases in damage to docks and pilings from marine organisms known as "shipworms").

The United States Nuclear Regulatory Commission has requested that Jersey Central Power & Light Company conduct a program of study to determine the benefits and costs of implementing a cooling system alternative to the existing system. In this context, benefits would include any reductions in current levels of adverse environmental impacts or any favorable socio-economic impacts. Costs would include any increases in adverse environmental impacts resulting from construction or operation or an alternative cooling water system, adverse socio-economic impacts, increases in system operating costs, construction costs, or any reduction in generating capacity or reliability.

JCP&L has authorized three consultants to prepare studies and recommendations on the appropriate alternative cooling system for use at OCNGS, each from a different perspective. In September 1976, Ebasco Services, Incorporated (Ebasco) was authorized to prepare its recommendation of the "best" available alternative cooling system, should any alternative be required. This recommendation was to be based on Ebasco's evaluation of the engineering, licensing, and environmental implications of the various alternatives. However, the recommendation would not address social impacts or be based on actual assignment of dollar values to environmental impacts, both of which would normally be done in a formal cost-benefit assessment. Ebasco was requested to include in its report an estimate of comparable annual system costs (capital and operating expenses) and a description of the environmental impacts of the alternatives which would be suitable for use as part of any formal cost-benefit assessment to be conducted by others.

Separately, National Economic Research Associates, Inc, was authorized to examine the most viable alternatives as defined by Ebasco, evaluating socioeconomic impacts, and comprehensively weigh the engineering, environmental, and social costs and benefits of those most viable alternatives. Furthermore, Pickard, Lowe & Garrick, Inc., nuclear and meteorological consultant to JCP&L on the Forked River Nuclear Generating Station (which is proposed for construction adjacent to OCNGS) was assigned responsibility for preparing the required salt deposition estimates and providing those estimates to Ebasco.

This document presents the results of Ebasco's engineering, licensing and environmental assessments of cooling system alternatives and includes estimates of salt deposition for the "preferred" cooling tower systems that were prepared by Pickard, Lowe & Garrick, Inc. A recommendation is made concerning that cooling system which is optimum among the alternative cooling systems evaluated.

B. STUDY OBJECTIVES

To fulfill its assigned responsibilities, Ebasco undertook to accomplish the following tasks:

1. To characterize the engineering and environmental features of the current condenser cooling system;
2. To identify the appropriate design features of each of the alternatives considered in order to permit estimation of construction and operating costs;
3. To identify impacts of alternative systems on plant capacity, potential derating and reliability;
4. To prepare estimates of the comparable investment and annual system costs associated with each of the alternatives considered;
5. To identify the licensing merits or disadvantages of the alternatives;
6. To identify feasible mitigative measures, where necessary for licensing purposes, in order to permit estimation of whether the impacts of such measures on alternative selection would be significant (and to modify comparable annual system cost estimates if such impacts were significant);
7. To identify and, where possible, quantify the potential environmental effects and impacts associated with the alternatives;
8. To identify at an early stage of the study, using qualitative or semi-quantitative arguments, the most viable alternatives so that the study effort could be focused on producing its most detailed description for those alternatives; and,
9. To analyze those most viable alternatives, referred to throughout the report as "preferred alternatives", in sufficient depth to make a recommendation regarding the "best" alternative.

C. SCOPE

In performing its study, Ebasco relied upon published data, information supplied by JCP&L and their other consultants, and computer modeling results. Additional field studies were beyond the scope of Ebasco's assigned responsibilities.

Consultation between Ebasco and JCP&L led to the establishment of sixteen alternatives to the existing system to be considered. While some data on the existing system is included, this study does not address the option of continued reliance on the existing system. However, the effect of equipping the existing intake structure with new screening devices to mitigate fish impingement mortality was considered. The scope of this study is limited to comparative analysis of the 16 alternative systems. Classified as either "open cycle" or "closed cycle" systems, these alternatives are listed below:

Cooling Water System Alternatives

Open Cycle (Once-Through) Cooling Systems

Discharge Canal-to-Bay + Existing Condenser
Discharge Pipelines-to-Bay + Existing Condenser
Ocean Intake & Ocean Discharge Pipelines + Single Pressure Condenser
Ocean Intake & Ocean Discharge Pipelines + Multipressure Condenser
Three Mechanical Draft Helper Cooling Towers + the Existing System
Five Mechanical Draft Helper Cooling Towers + the Existing System

Closed Cycle (Circulating) Cooling Systems

500 Acre Cooling Pond

1000 Acre Cooling Pond

Spray Cooling Modules

Mechanical Draft Rectangular (Multicell) Cooling Towers

Mechanical Draft Round Cooling Towers

Natural Draft Cooling Tower

Fan-Assisted Natural Draft Cooling Towers

Salt Water Wet/Dry Mechanical Draft Cooling Towers

Fresh Water Wet/Dry Mechanical Draft Cooling Towers

Dry Cooling Towers

D. APPROACH

In order to fulfill its responsibilities, as reflected in the specific study objectives, Ebasco defined and characterized the engineering parameters of each of the 16 alternative cooling water systems under consideration to provide a basis for licensing, environmental and system cost comparisons between systems. Next, preliminary assessments of annual system costs, licensability, and environmental impacts were made for each alternative in order to seek any quantitative or qualitative bases for concluding that the given system was clearly inferior to one or more of the other alternatives and so could be eliminated from further consideration. Finally, a detailed study of the remaining "preferred" systems was made to identify a single alternative as the best of the sixteen.

1. Conceptual Design Basis for Alternatives

The designs of the alternatives were conceived under the constraint that they be able to operate in conjunction with the existing General Electric BWR Nuclear Steam Supply System, the existing General Electric TC6F-38 inch LSB 1800 rpm turbine generator (rated 640.7 MW at 1 inch Hga back pressure) and, with one exception, the existing three-shell, single pass, single pressure condenser. This constraint was adopted to avoid major backfitting costs above and beyond such costs associated with the cooling systems themselves.

Representatives of engineering and environmental disciplines interacted to develop the conceptual design features for each alternative based on prudent and reasonable engineering practice and environmental information available at the start of the study. Conceptual locations for facilities required by each alternative were chosen, and a computer model was used to assist in optimizing each given alternative from cost and engineering feasibility standpoints, subject to environmental constraints.

2. <u>Selection of Preferred Alternatives</u>

Each of the following areas were separately addressed for each of the sixteen alternatives' conceptual engineering designs:

- Cost
- Licensing
- Atmospheric Effects
- Hydrothermal Effects
- Water Availability and Suitability
- Water Quality Effects
- Noise Effects
- Visual and Esthetic Effects
- Aquatic Ecology Effects
- Terrestrial Ecology Effects
- Radiological Effects

Separate disciplinary analyses were undertaken to identify differences between alternatives which would permit the selection of the preferred alternatives through elimination of those that were clearly less desirable.

Three general elimination criteria were utilized. 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 ecological stresses. Second, systems were eliminated where adverse (not overriding) impacts and/or comparatively high costs were not compensated by sufficient environmental benefits which could justify "preferred" status. Third, systems judged to involve significant commercial risk due to potential technical problems were not selected as preferable.

The evaluation approaches used by the individual disciplines are outlined in the following paragraphs.

a. Cost Evaluation

The cost and performance data for all alternative cooling water systems

considered were defined utilizing the Ebasco computer program "Economic Selection of Steam Condensing System". This program enabled determinations to be made of both total estimated investment cost and total comparable annual system cost. Investment cost was defined to include: 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. Total comparable system cost was defined to include: fixed charges on investment cost, maintenance and water treatment costs, fuel cost for energy consumed by cooling system equipment, and adjustments for differential net plant capability and net annual generation. Comparable annual system cost was used as the basis for comparing systems.

b. Licensing Considerations

Licensing considerations involved land use, noise, air quality and water quality. Possible conflicts with applicable regulations were identified for a number of alternatives. However, in general, licensing implications were not found to be significantly differentiating among alternatives.

c. Atmospheric Effects

Elevated visible plumes, ground level fogging and icing, salt deposition and drift, and convective instability, cloud growth and precipitation augmentation were the primary atmospheric effects considered. The magnitude of these effects was estimated by use of published studies containing measured or model-predicted results for similar equipment at other sites for the alternatives of interest.

d. Hydrothermal Effects

In evaluating the hydrothermal characteristics of closed-cycle systems, it was assumed that blowdown would be controlled so that the total dissolved solids in the discharge would be limited to 1.5 times that of the intake water. Temperature rise above ambient water temperature was calculated for average seasonal conditions. These temperatures were compared to the applicable thermal criteria, which are comprised of maximum allowable temperature rises above ambient and also of maximum allowable temperatures. Both are

measured outsi a designated heat dissipation area which, as a guideline, should not include more than 1/4 of the volume or more than 2/3 of any surface cross-section of the water body of interest. Because of the similarities between systems, no distinction was made between closed-cycle alternatives on the basis of hydrothermal effects.

It was assumed that the existing dilution pumps would be available to assist in meeting thermal criteria, as necessary. Further, it was assumed that the Forked River Nuclear Generating Station would be operational and that thermal criteria must be based on the combined discharge of the two stations.

Open-cycle alternatives were evaluated in a similar manner. However, because of the complexity of Barnegat Bay hydrology, the data base available to Ebasco at this stage of the study was inadequate to provide any basis for the elimination of open-cycle alternatives using Barnegat Bay as a heat dissipation area.

e. Water Availability

Analysis of water availability for the cooling systems considered the following sources: fresh water resources within the vicinity of the plant, aquifers underlying the plant area, Barnegat Bay, and the Atlantic Ocean. Water availability was evaluated in terms of minimum required supply - given the maximum total dissolved solids concentration consistent with prudent engineering practice - and maximum available supply from the source, given competing uses for the source. Where it was determined that a water source would be inadequate, alternatives dependent upon that source were eliminated.

f. Water Quality

Impacts on water quality were evaluated through qualitative judgements about likely effects during construction and calculations of all pertinent water quality parameter concentrations during oprerationm. No differentiation was made between alternatives on the basis of operational water quality, provided applicable water quality standards could be met. Distinctions were drawn between systems on the basis of construction impacts on water quality.

g. Noise Effects

Noise levels produced by the various cooling systems were estimated using existing literature, vendors' information and in house analytical methods. Possible mitigative measures were not considered prior to selection of preferred alternatives. The analysis was based on the most stringent of the applicable New Jersey noise standards, a 50 dB(A) limit and octave band spectra limits for nighttime hours in residential areas.

h. Visual Effects

Evaluation of esthetic impacts was based on qualitative judgements of the potential for an alternative to directly intrude on the visual scene or to indirectly affect the scene through the destruction of existing vegetation.

The following criteria were employed:

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

2) Cooling systems which could be installed in such a manner that vegetative cover could be used for screening purposes would be preferred over those where no such cover would exist;

3) Cooling systems which would have a low profile would be preferred over those which would entail high, broad, or lengthy elements;

4) Structures which would be visible to a small number of potential viewers would be preferred to those which would expose a large number of potential viewers to the structure; and,

5) Systems which would locate cooling structures near existing power plant elements would be preferable.

i. Aquatic Ecology Effects

Evaluation of aquatic ecological effects primarily addressed the issues of shipworm infestation, cold shock, entrainment, and impingement.

Existing conditions relevant to shipworm infestation and the potential for cold shock were identified from the literature along with information on how these phenomena would be influenced by changes in parameters such as water temperature or salinity. Calculated changes in temperature and salinity expected to be produced by each of the alternatives were then used to make qualitative predictions of how and to what extent shipworm infestation and the potential for cold shock would be influenced by the selection of each alternative.

Published experimental data compiled at OCNGS and other relevant power plants were used along with simplified mathematical techniques to estimate the densities of organisms available for entrainment and impingement. These densities were combined with information on the mortalities of entrained or impinged organisms under an assumption about the relationship between impingement and entrainment rates and intake flow volume to produce quantitative estimates of impingement and entrainment losses.

j. Terrestrial Ecology Effects

Evaluation of terrestrial ecological effects focused on land requirements salt deposition, and potential hazards to birds. Relevant research findings reported in site-related documents and scientific literature were used to rate the type and severity of impact on a qualitative basis. In particular, the potential impacts of salt deposition on vegetation were estimated by comparing reported deposition rates at other installations to existing background (sea salt) concentrations and specific plant toxicity studies.

k. Radiological Effects

It was judged unlikely that radiological doses would have an important impact on alternative selection since past experience has indicated that applicable federal guidelines under the "as low as reasonably achievable" criterion are in most cases compatible with a wide variety of cooling systems.

Dose estimation was deferred until preferred alternatives were selected. A radiological evaluation was conducted, however, to study the interaction of cooling tower drift with stack emissions. The potential effects of such an interaction, which had not been evaluated as an exposure pathway at nuclear power plants until recently, were estimated in order to determine the significance of this phenonenon and its possible importance in preferred cooling system selection.

3. Selection of Recommended Alternative

As detailed in a later section of this Executive Summary, Ebasco's analysis resulted in the identification of four preferred alternatives: the natural draft cooling tower, the round mechanical draft cooling tower, the fan-assisted natural draft cooling tower, and the discharge canal-to-bay systems. These four systems were subsequently evaluated in greater detail by the various disciplines and these individual assessments were combined in a multidisciplinary assessment of the effects of each cooling system.

The bases for elimination of three of the preferred alternatives are discussed in Subsection I-F-2. The paragraphs below describe the methods used by the individual disciplines in evaluating the preferred alternatives.

a. Cost Evaluation

The approach used in evaluating the costs of constructing and operating the preferred alternatives were identical to that described in Subsection I-D-2. And, with one exception, the economic data and results presented for the preferred systems were identical to those given for the earlier evaluation of all alternatives. The need for certain mitigative efforts in the discharge canal-to-bay system required design changes which significantly altered system costs.

Costs for noise abatement were not included in the cost evaluations; however, these costs would not affect the conclusions of this study.

b. Licensing Considerations

The approach used in evaluating licensing implications of the preferred alternatives was identical to that described above in Subsection I-D-2.

c. Atmospheric Effects

Computer models were used to estimate the frequency and location of occurrences of elevated plumes and ground level fogging and icing. Meteorological data used in the models were taken from on-site measurements and Atlantic City, New Jersey, records.

Pickard, Lowe and Garrick, Incorporated performed the analysis of salt emissions from the cooling tower systems. Ground level salt deposition rates and near ground air concentrations of salt were calculated.

d. Hydrothermal Effects

The data base used in assessing ambient water temperatures in Forked River, Oyster Creek, and Barnegat Bay was enlarged to include OCNGS intake records through March 1977 and the results of twenty thermal surveys of the bay conducted between August 1974 and December 1976. The canal-to-bay system, as evaluated, reflected substantive revisions in design required to mitigate non-hydrothermal environmental impacts and was not identical to the canal-to-bay design originally selected as a preferred alternative.

A "potential flow" model for the Oyster Creek site available from the literature was used to predict temperature distributions in Barnegat Bay. The model was tested by comparing its predictions to the results of the thermal surveys.

e. Water Availability

Based on the results obtained during selection of the preferred alternatives, water availability was not considered further.

f. Water Quality

The approach used in evaluating water quality was identical to that described previously in Subsection I-D-2. However, the water quality evaluation of the canal-to-bay system indicated that the alternative as conceptually designed might not meet water quality criteria in portions of Oyster Creek. Accordingly, a new conceptual design was developed.

g. Noise Effects

Additional manufacturer's data was obtained to more adequately determine emitted sound levels. Mitigative measures were considered for each of the preferred alternatives since none of the preferred systems were expected to meet applicable noise standards without such measures.

h. Visual Effects

Photographs were taken of OCNGS from various visually sensitive locations surrounding the site. Using knowledge of the height of existing plant elements, artists superimposed realistic drawings of the preferred alternatives onto prints of the photographs to create pictures of how the alternatives, if constructed, would appear to the viewer.

Meteorological model results for frequencies and locations of occurence of visible plumes and fogging were used to more adequately define the esthetic impacts of those phenomena.

i. Aquatic Ecology Effects

Aquatic impacts were quantified and refined to a greater degree for the preferred systems. For example, the possible effects of alterations on the population of shipworms in Oyster Creek were reviewed and, where practicable quantified.

Monthly impingement rates at OCNGS were estimated taking into consideration results at other power stations located on estuaries along the New Jersey to Maine coast. The relationships between seasons, intake flow and impingement rates were investigated by regression analysis and comparison of time series. Entrainment and impingement losses were also estimated for each of several important species.

j. Terrestrial Ecology Effects

Meteorological model results specific to the Oyster Creek site were used to quantify effects of cooling tower-induced atmospheric phenomena on surrounding vegetation.

k. Radiological Effects

Doses to critical ("most exposed") individuals from liquid releases from the preferred alternative cooling systems were calculated using standard models recognized by the United States Nuclear Regulatory Commission.

E. RESULTS

1. Selection of Preferred Alternatives

The estimated investment costs and total comparable annual system costs are the major cost factors in the selection of a recommended cooling water system. The investment costs and the comparable annual costs for all cooling systems considered are tabulated in Exhibit 1 and plotted in Exhibits 2 and 3. The latter costs include owning and operating expenses and adjustments for equalized net plant capability and net annual generation.

Exhibit 1 reveals that the lowest annual comparable costs would occur with the discharge canal or discharge pipeline to the bay, helper cooling tower system with 3 towers, natural draft cooling tower, round mechanical draft cooling tower, and fan-assisted natural draft cooling tower systems.

The costs for these six cooling water systems are summarized in the following table, in which all costs are in millions of dollars:

	Total Estimated Investment Cost	Comparable Annual System Cost	
		Total	Differential
Existing Cooling System	-	0.5	Base
Discharge Canal to Bay	30	6.2	5.7
Discharge Pipes to Bay	52	11.4	10.9
Helper Cooling Tower (3 Towers)	49	16.6	16.1
Natural Draft Cooling Tower	61	20.4	19.9
Round Mechanical Induced Draft Cooling Towers	56	20.8	20.3
Fan-Assisted (Forced Draft) Cooling Towers	57	21.3	20.8

The canal-to-bay system would be the least costly choice. The investment cost for the pipeline-to-bay system, as opposed to the canal-to-bay system, would be higher by approximately \$22,000,000 and the comparable annual costs would be higher by \$5,200,000 per year. The other once-through cooling systems would result in even higher annual costs (Exhibit 3).

Among the closed cycle cooling water system alternatives, the natural draft, the round mechanical draft and the fan-assisted natural draft cooling tower systems would require the least investment cost and result in the least total comparable annual costs.

These three closed cycle systems would have relatively small economic differences. The variance in total investment cost between the most expensive of the three cooling tower systems and the least expensive system would be 8 percent. The variance in total comparable annual costs between the lowest cost system and the highest cost system would be less than 5 percent. In such a situation, even more consideration than usual must be paid to factors other than cost in evaluating alternatives.

b. Plant Capability and Heat Rate

The implementation of any one of the alternatives considered but the ocean intake and ocean discharge cooling water system would result in plant derating. Reduced annual generation and increased plant net heat rate would occur with all alternatives

A reduction in plant capability with use of a cooling tower system cannot be avoided due to a higher cooling water temperature and accordingly, higher unit back pressure. Increased power requirements for circulating water pumping also contribute to plant derating. The open cycle cooling water system alternatives would cause less plant derating than would the closed cycle alternatives.

Turbine generator output, plant auxiliary power requirements and plant net output for the alternative cooling water systems are plotted in Exhibit 4.

c. Licensing Considerations

New Jersey water quality criteria concerning thermal plume extent would be exceeded if the 3 tower helper cooling tower or a 5 tower helper cooling tower systems were installed. Each of the cooling systems except the ocean intake-discharge and cooling pond systems would be expected to exceed New Jersey noise criteria. Each of the systems utilizing cooling towers would not satisfy New Jersey State regulations governing particulate (salt) emission rates.

An Amendment to the particulate emission rate limitation may be available as a possible solution to the problem of meeting air quality regulations for cooling towers.

The noise estimates were based on preliminary data and did not consider the influence of possible noise control measures. Compliance with noise regulation was considered in greater detail for analysis of the preferred alternatives. Therefore, licensing problems associated with the air and noise emissions were not utilized as a basis for selecting preferred alternatives.

Evaluation of the licensing conditions for the ocean intake-discharge and cooling pond systems did not indicate explicit noncompliance with applicable permit requirements. However, the analysis did suggest that construction of either of these systems would involve a lengthy and difficult licensing process with an uncertain outcome.

d. Atmospheric Effects

Salt deposition and ground level fogging and icing were the most important atmospheric effects influencing preferred system selection.

Salt deposition rates produced by the rectangular mechanical draft cooling towers (including the helper towers) would be comparatively high, and would exceed that of the natural draft tower by approximately 6-7 times. The deposition rate for the spray canal system would also be comparatively high.

Ground level fogging and icing from the rectangular mechanical draft cooling tower, spray canal and cooling pond systems would be an important adverse environmental impact because of the proximity of these systems to nearby highways and residential areas.

e. Hydrothermal Effects

The analysis of closed-cycle alternatives showed that all of these systems would meet applicable thermal criteria in Oyster Creek with two dilution pumps, assuming that the Forked River Nuclear Generating Station was operational and assuming extreme operating conditions. One dilution pump would be sufficient during May, September and October.

If the ocean in[illegible]ge systems were equipped with a properly designed diffuser they c[illegible] thermal criteria in offshore waters.

Discharge from the 3 tower helper cooling tower system would exceed thermal criteria in Oyster Creek; the 5 tower helper system would not be able to meet thermal criteria while still providing necessary reliability during winter operation.

f. Water Availability

An analysis of the potential cooling water supply sources at the Oyster Creek site indicated that fresh water was not available in sufficient quantities to provide a reliable water source for any of the wet cooling systems. Sources evaluated, but found to be inadequate, included Toms River and the groundwater aquifers beneath the site area.

g. Water Quality Effects

The effects of construction on water quality would be highest for the ocean intake-discharge and cooling pond systems. Construction of a dredged trench across Barnegat Bay would disrupt benthic communities along this route for several years. In addition, some 300,000 cubic yards of dredge spoil would have to be disposed of. Construction of a cooling pond would necessitate the diversion of Oyster Creek and the elimination of a substantial portion of the creek's drainage area.

Changes in Oyster Creek water quality resulting from operation of the closed-cycle alternative cooling systems would be minimal (less than a 4 percent change). No measurable impact on water quality in the local ocean waters would be expected for operation of the ocean intake-discharge systems. Operation of the canal-to-bay or pipe-to-bay systems would not affect water quality in Barnegat Bay. However, the resulting decrease in flow down Oyster Creek would adversely affect water quality conditions, requiring modification of the conceptual system design (see I-E-2).

h. Noise Effects

An analysis of noise levels produced by each of the alternatives showed that only the ocean intake-discharge and cooling pond systems would be expected to meet the New Jersey nighttime limit of 50 dB(A). However, since possible noise attenuation methods were not evaluated until after the preferred alternatives were selected, noise impact was not considered a criterion for elimination from the list of preferred systems.

i. Visual Effects

The open-cycle cooling systems were considered to exhibit low visual impacts, while the cooling tower alternatives (excluding the wet/dry towers) were all rated as having relatively high visual impact. The cooling pond, spray canal, dry towers and wet/dry towers were considered to have moderate potential for visual impact.

j. Aquatic Ecology

Alternatives which effectively remove the heated discharge from Oyster Creek, or reduce the temperature rise (canal-to-bay system, ocean system, all closed-cycle systems) would reduce any potential for plant impacts on wood borer reproduction. A reduced temperature rise in Oyster Creek would also minimize the potential for cold shock losses.

The canal (pipe)-to-bay and helper cooling tower systems would exhibit entrapment/impingement and entrainment rates similar to those of the existing cooling system. The ocean intake-discharge systems could have potentially high impingement and entrainment rates. All of the closed cycle systems would reduce impingement and entrainment. Use of Ristroph bucket screens on the existing system could reduce impingement losses to within the same order of magnitude as the closed cycle alternatives.

Construction of the cooling pond system would adversely affect a large portion of the Oyster Creek watershed. Construction of the ocean intake-discharge systems would result in substantial loss of benthic habitat for a period of several years.

k. Terrestrial Ecology Effects

The cooling pond systems would exhibit the highest impact on terrestrial ecological resources because of the large area of sensitive habitat affected. Vegetation damage due to salt contamination could be a problem with the rectangular mechanical cooling towers or spray canal systems. Sensitive Island Beach habitat would be disturbed during construction of the ocean intake-discharge system.

Bird impaction would be a potential issue concerning the natural draft and fan-assisted natural draft towers. Mitigative measures would be available to minimize any losses due to impaction.

l. Radiological Effects

The potential incremental impact of wet drift-deposited radioiodines on doses to humans would be negligible compared to the doses from dry deposition of radioactive stack emissions.

2. Selection of Recommended Alternative

a. Redefinition of Discharge Canal-to-Bay Conceptual Design

At an early stage of preferred alternative evaluation it was determined that the

canal-to-bay system as originally defined might be unable to provide acceptable water quality in portions of Oyster Creek (see Section IV-F). It was judged that the best solution to this problem was to supply additional flow to the portions of Oyster Creek in which unacceptable water quality would otherwise exist.

This could be accomplished by using two of the existing dilution pumps to transfer unheated water from the intake canal to Oyster Creek. Additional dilution pumps would then be added near the mouth of Oyster Creek to return a portion of this supplemented Oyster Creek flow to the new discharge canal where it would be combined with the plant effluent before discharge to Barnegat Bay. The discharge canal-to-bay conceptual design was revised accordingly.

While this revision was not expected to invalidate the canal-to-bay alternative's selection as a preferred alternative in any way, it would affect the alternative's cost and environmental merits in comparison to the other preferred systems. Thus, all subsequent comparison of the preferred alternatives included this revised canal-to-bay design.

b. Cost Comparison

The investment costs and comparable annual costs for the preferred cooling systems were studied in greater detail and the results are shown in the following table, in which costs are expressed in millions of dollars:

	Total Estimated Investment Cost	Comparable Annual System Cost	
		Total	Differential
Existing 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 Natural Draft Cooling Towers	57	21.3	20.8

The costs for the preferred cooling tower systems are identical to those presented in Exhibits 1, 2 and 3. However, the costs for the discharge canal-to-bay system have been revised to reflect the cost of two additional dilution pumps (and associated structures) required as part of the revised canal-to-bay conceptual design.

The canal-to-bay system would have the lowest cost among the preferred systems and would be substantially less than the cooling tower systems. The cost differential among the three preferred cooling tower systems would be relatively small. Noise abatement costs were not included in the cost evaluation.

c. Plant Capability and Generation

The substitution of the canal-to-bay system for the existing cooling water system would result in an average summer plant derating of approximately 2.1 MW. The natural draft, mechanical draft and fan-assisted cooling towers would cause a plant derating of approximately 20-23 MW. Use of the canal-to-bay system instead of the existing system would also cause the loss of about 17,000 MWh of net annual generation; use of any of the preferred cooling tower alternatives would increase this loss to about 100,000 MWh per year, with the loss less severe in the case of the natural draft cooling tower than in the case of the fan-assisted and round mechanical towers. In the case of the canal-to-bay system, these estimates include additional dilution pumps and associated structures required in the revised canal-to-bay conceptual design.

d. Plant Downtime

As described in the body of this report, the required plant outage for any alternative cooling water system interconnection with the existing cooling water tunnels is estimated to be not more than six weeks and would occur during plant shutdown for refueling. Hence, there would not be additional expenses to purchase energy during system interconnection.

e. Operational Considerations

There is very limited experience with any type of salt water cooling tower. Almost all cooling towers in operation, under construction or ordered are designed for freshwater application. However, the round mechanical draft cooling tower and the fan-assisted natural draft cooling towers are a relatively recent development, while natural draft towers have been in use for decades. There are at least fifty (50) large natural draft towers in operation in the United States, whereas only one round tower is in operation (operation started in 1975) and approximately 14 are under construction. The experience with nine (9) fan-assisted cooling towers in

operation is largely confined to European power plants.

A single natural draft cooling tower (which does not have rotating parts) would be the most reliable in operation. However, it would be the least flexible in control, and its drift loss in winter conditions would exceed design value due to increased airflow and air velocity in drift eliminators. An additional problem with this cooling tower type is drift blown through the air inlet at high wind velocities.

Two round mechanical draft towers would be more flexible in operation than the natural draft cooling tower. Flexibility would be obtainable by shutting down fans or reducing their speed. Each of the cooling towers could be operated while the other is under inspection, undergoing maintenance or is in reserve at low plant load operations. Due to a constant airflow, the drift loss (0.001 percent of circulating water flow or the same as the design value for the natural draft cooling tower) would be nearly constant during the whole year. In respect to possible drift blown through the air inlet at high wind velocities, the round mechanical draft tower performance would be similar to that of a natural draft cooling tower.

Two fan-assisted natural draft cooling towers would provide the same flexibility in operation as would the round mechanical draft towers. Their drift loss through drift eliminators would be constant, the same as for the round cooling towers. However, these cooling towers would not have air inlet openings, but instead have fan inlet sleeves. Therefore, when the fans are in operation there are no drift losses through the air inlet. For a salt water system this is quite a positive feature. Another advantage of the fan-assisted cooling towers is that the forced draft fans would operate in the ambient air environment, whereas the fans in the round mechanical induced draft towers would be subject to the cooling tower salt effluent.

f. Licensing Considerations

With the exception of air and noise, no instances of regulatory noncompliance were identified for any of the preferred alternatives (since the canal-to-bay alternative design had been revised). All three preferred cooling

tower alternatives would emit particulates in excess of levels permitted by the New Jersey air emission standards. As discussed in Subsection 1-E-1, this was not used as a basis for selecting the best cooling system.

All preferred alternative systems would produce noise levels in excess of New Jersey nighttime standards. No practical method of mitigating noise levels of the round mechanical draft cooling tower could be identified. Mitigating measures for the other alternatives were identified and are discussed subsequently.

Non-engineering methods of noise mitigation for cooling towers, such as buffer zone acquisition, were judged to be readily preferable to engineering solutions, such as cooling tower modifications, when evaluated by criteria within the scope of this study. For this reason, no attempt was made to analyze specific engineering solutions for cooling towers in detail, although possible engineering solutions were identified. In the case of the canal-to-bay system, the simplest noise mitigation solution was an engineering solution.

g. Environmental Evaluations

The environmental effects associated with the preferred cooling systems are summarized in Exhibit 5 and compared in the following paragraphs.

i. Natural Draft Cooling Tower System

The primary advantages of a natural draft cooling tower system over the canal-to-bay system (or existing system) at Oyster Creek would be related to reduced thermal plume effects and lower intake water requirements. The lower mixed Oyster Creek water temperatures would reduce potential 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.

The natural draft tower alternative could be operated in compliance with all New Jersey noise regulations if the noise bufffer zone were extended approximately 1,300 feet beyond the existing site boundary in a north-northeast direction. The purchase of about 30 acres of residentially zoned land would be involved. A few residences presently exist on portions of these 30 acres.

In comparison to the environmental effects of other preferred cooling tower systems, the natural draft tower would be similar in many respects. 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 would either the round mechanical draft tower or fan-assisted tower, assuming that the fan-assisted tower was not specially modified for noise reduction.

ii. Round Mechanical Draft Cooling Tower System

Comparisons of the round mechanical draft cooling tower 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. No practical noise reduction modifications could be identified. And, it would not be practical to attempt to acquire sufficient land to meet noise criteria in view of the amounts of land and residential density involved. A buffer zone of nearly a mile would be required. The airborne salt concentration and salt deposition rate within several thousand feet of the tower would be somewhat higher than that of the natural draft or fan-assisted towers. These rates would be less than the cautionary values discussed in regard to foliar injury.

iii. 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 measures were taken to minimize noise effects, 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 measures (with their accompanying annual system costs) sound levels would be higher than with the natural draft system and the buffer zone requirement would, in fact, be more comparable to that for the round tower alternative.

Salt deposition near the shore of Barnegat Bay would also approach levels of caution regarding foliar injury to vegetation.

iv. 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. Impingement mortalities would also be similar to those 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 might be expected because the OCNGS heated discharge would be routed directly to Barnegat Bay, an area with considerably less wood habitat. The potential for shock effects would be reduced in Oyster Creek; the potential for cold shock effects in Barnegat Bay would be similar to that of the existing system.

Some modifications to the drop structure could be made allowing the system to meet noise criteria. Atmospheric, water quality, visual and terrestrial ecological effects would be similar to those of the existing system.

When compared with the closed-cycle cooling tower alternatives, the canal-to-bay system would produce a larger thermal plume. In addition, impingement and entrainment mortalities would be higher than would be expected for the cooling tower alternatives. However, the canal-to-bay system would not release salt particulates.

F. CONCLUSIONS

The cooling system selection process is presented in Exhibit 6 and discussed below.

1. Selection of Preferred Alternatives

In Subsection I-D-2, three criteria for the elimination of alternative systems from consideration as preferred alternatives were discussed. The following paragraphs identify how each of these criteria resulted in eliminating alternatives from consideration as "preferred".

a. "Overriding Environmental Impacts" Criterion

Seven systems were eliminated because they would exhibit overriding environmental effects.

i. Cooling Pond Alternatives

Both the 500 acre and 1000 acre cooling pond alternatives would produce overriding environmental impacts in terms of construction impacts on aquatic and terrestrial ecology. Environmentally sensitive land would be preempted and water quality would be adversely effected. Fogging and icing would be produced, and there would be a potential for pollution of ground water aquifers.

ii. Spray Canal Alternative

The spray canal alternative would produce overriding environmental impacts in terms of levels of salt deposition and a potential for fogging and icing in the near vicinity of the spray canal site.

iii. Rectangular Mechanical Draft Cooling Tower Alternative

The rectangular mechanical draft cooling tower alternative would also produce overriding environmental impacts in terms of levels of salt deposition and a potential for fogging and icing in the near vicinity of the site.

iv. Helper Tower Alternatives

Because either helper tower alternative would be required to handle a large portion of the station's heat load much of the year, the impacts of these alternatives would be similar to those of a rectangular mechanical draft cooling tower alternative. Therefore, these alternatives would also produce overriding environmental impacts in terms of salt deposition, fogging and icing. In addition, there would be difficulty in designing any helper tower system which could simultaneously meet discharge hydrothermal criteria and provide reliable operation during all expected meteorological conditions.

v. Salt Water Wet/Dry Cooling Tower Alternative

When operating primarily in the wet mode, the salt water wet/dry mechanical draft cooling tower would exhibit overriding environmental impacts similar to those of the rectangular mechanical draft cooling tower. It would be possible to reduce these impacts to an acceptable level by operating the wet/dry tower primarily in a dry mode. However, if this were done, the same reasoning used to eliminate the dry cooling tower alternative, discussed subsequently in this subsection (Subsection 1-F-1), would apply, and the salt water wet/dry cooling tower system would still not be a preferred alternative.

b. "No Compensating Advantage" Criterion

Three alternatives were eliminated because they would involve significant adverse cost or environmental impacts which, while not overriding by themselves, would not be offset by other cost or environmental advantages which could justify selection as preferred systems.

i. Ocean Intake and Discharge Alternatives

Both ocean intake and discharge alternatives (single pressure and multipressure condensers) would be inferior to most of the other alternatives from the point of view of cost. Their potential disruptive effects on Barnegat Bay and Island Beach State Park during a five-year construction period could be significant. The engineering difficulties involved in construction of these alternatives would also be relatively large and the results of the licensing process unpredictable. Those areas in which the use of either of these alternatives would offer identifiable advantages over most of the other systems, notably noise and visual effects, were not judged to provide adequate compensation for the above disadvantages, and the ocean alternatives were, therefore, dropped from further consideration.

ii. Discharge Pipe-to-Bay Alternative

The discharge pipe-to-bay system would produce environmental impacts which would be similar to those of the canal-to-bay alternative, yet would be significantly more costly to construct and operate. Consequently, the pipe-to-bay alternative would be inferior to the canal-to-bay alternative and was eliminated from consideration.

c. "Significant Commercial Risk" Criterion

Two alternatives were eliminated because they were judged to involve significant risk of unanticipated technical or economic factors that could make them

infeasible at a later time.

i. Fresh Water Wet/Dry Cooling Tower Alternative

Sufficient supplies of fresh water to operate a wet/dry tower in a wet mode would not be available in the vicinity of OCNGS. This problem could be circumvented by operating the towers in such a way that the bulk of the heat dissipation duty was borne by the dry cycle. However, as was the case with the salt water wet/dry tower, the reasoning used to eliminate the dry tower alternative (discussed in the succeeding paragraph) would them apply.

ii. Dry Cooling Tower Alternative

A dry cooling tower for use at the OCNGS would need to be much larger than any existing dry tower. Unanticipated technical problems can not be ruled out in such a "scaling-up" of design which could introduce significant uncertainty in the timing or cost of achieving commercial generation of this alternative. Thus, the dry cooling tower alternative (or wet/dry towers operating primarily in a dry mode) was not preferred.

2. Selection of Recommended Alternative

The bases for eliminating from consideration three of the four preferred alternatives are discussed in the following paragraphs.

a. Round Mechanical Draft Cooling Tower Alternative

No practical method of operating a round mechanical draft cooling tower in compliance with the New Jersey nighttime noise criteria could be identified. Therefore, this alternative was not recommended.

b. Discharge Canal-to-Bay Alternative

Use of the discharge canal-to-bay alternative would produce little environmental benefit over the existing system, particularly when the additional construction impacts and the additional stress due to the dilution pumps near the mouth of Oyster Creek are considered. Since the ultimate goal of the program of study undertaken by JCP&L is to identify any cost effective methods of improving the environment (particularly the aquatic environment) in the vicinity of OCNGS, Ebasco could not recommend, as the result of its portion of this program, any alternative which would provide so little improvement in the aquatic environment.

c. Fan-Assisted Natural Draft Cooling Tower Alternative

Within the scope of its study, Ebasco identified no strong reason why fan-assisted towers would not be a viable option at OCNGS. However, Ebasco judged

the fan-assisted natural draft tower to be less desirable than the natural draft tower and did not recommend the fan-assisted tower for that reason.

In reaching this conclusion, Ebasco was influenced primarily by noise mitigation and operating experience considerations. There would be only minor difference in impacts between the two tower types in most environmental disciplines.

It would be impractical to meet applicable noise criteria for the fan-assisted tower alternative without making significant modifications to the tower design and thereby increasing costs. Experience in fan-assisted tower noise control is extremely limited (none in U.S.). Therefore, such modifications seem unwarranted as long as the 30 acre buffer zone extension needed to bring a natural draft tower into compliance could be expected to be obtainable. Additional studies should be undertaken to determine the best engineering solution to noise mitigation for either the natural draft or fan-assisted natural draft tower, if a 30 acre buffer zone extension is found to be unacceptable (for example, due to socio-economic impacts). However, at this time Ebasco believes the fan-assisted tower to be the less desirable alternative in terms of noise mitigation.

There are several suppliers of large natural draft cooling towers in the United States, but only one manufacturer offers the fan-assisted tower. There is considerable operating experience with natural draft towers in the U.S.; however, fan-assisted towers are a relatively recent development, and there is no operating experience in this country.

G. RECOMMENDATION

Based on the foregoing results and conclusions, Ebasco recommends that:

1. A natural draft cooling tower be considered as the optimum from among the alternative cooling water systems studied; and

2. The four preferred cooling systems be incorporated in the comparative cost benefit analysis to be undertaken by National Economic Research Associates for JCP&L.

EXHIBIT 1

TOTAL COMPARABLE ANNUAL SYSTEM COSTS

	Total Comparable Annual Costs Including Adjustments in Million Dollars	Differential Comparable Annual Cost in 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 Cold Water Temperature 50° F	16.6	16.1
Natural Draft Cooling Tower (CT)	20.4	19.9
Mechanical Draft Round CT	20.8	20.3
Fan-Assisted CT	21.3	20.8
Mechanical Draft Rectangular CT	21.7	21.2
Helper CT with Minimum Cold Water Temperature 43.8° F	22.8	22.3
Spray Cooling Module Canal	21.8	21.3
500 Acre Cooling Pond	28.7	28.2
Wet/Dry Salt Water CT	33.0	32.5
Ocean Intake & Discharge with Coated Steel Pipelines & Multipressure Condenser	37.4	36.9
Wet/Dry Fresh Water CT	40.3	39.8
1,000 Acre Cooling Pond	41.0	40.5
Dry Cooling Tower	44.5	44.0
Ocean Intake & Discharge with Concrete Pipelines and the Existing Condenser	102.7	102.2

EXHIBIT 2

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

TOTAL ESTIMATED INVESTMENT COST

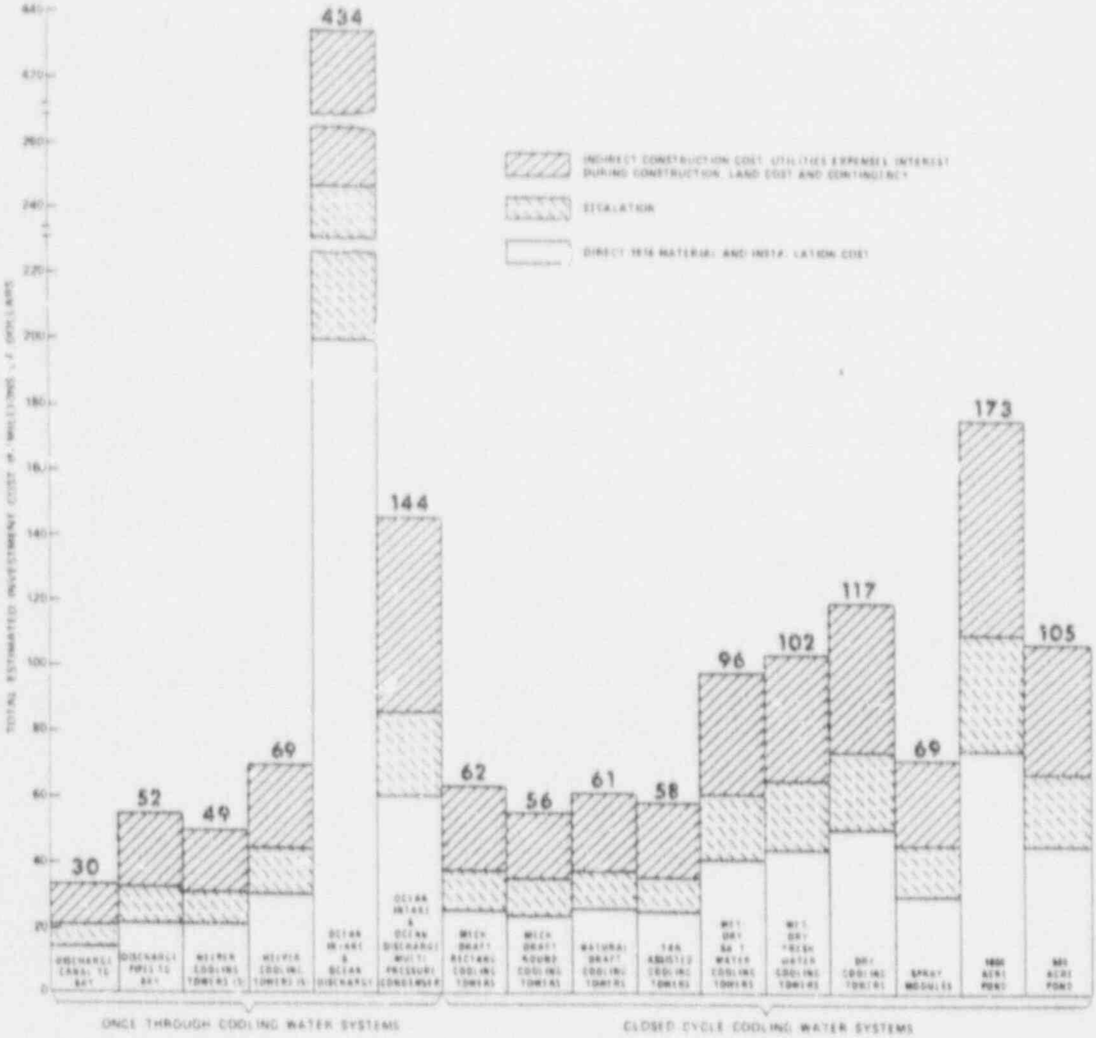
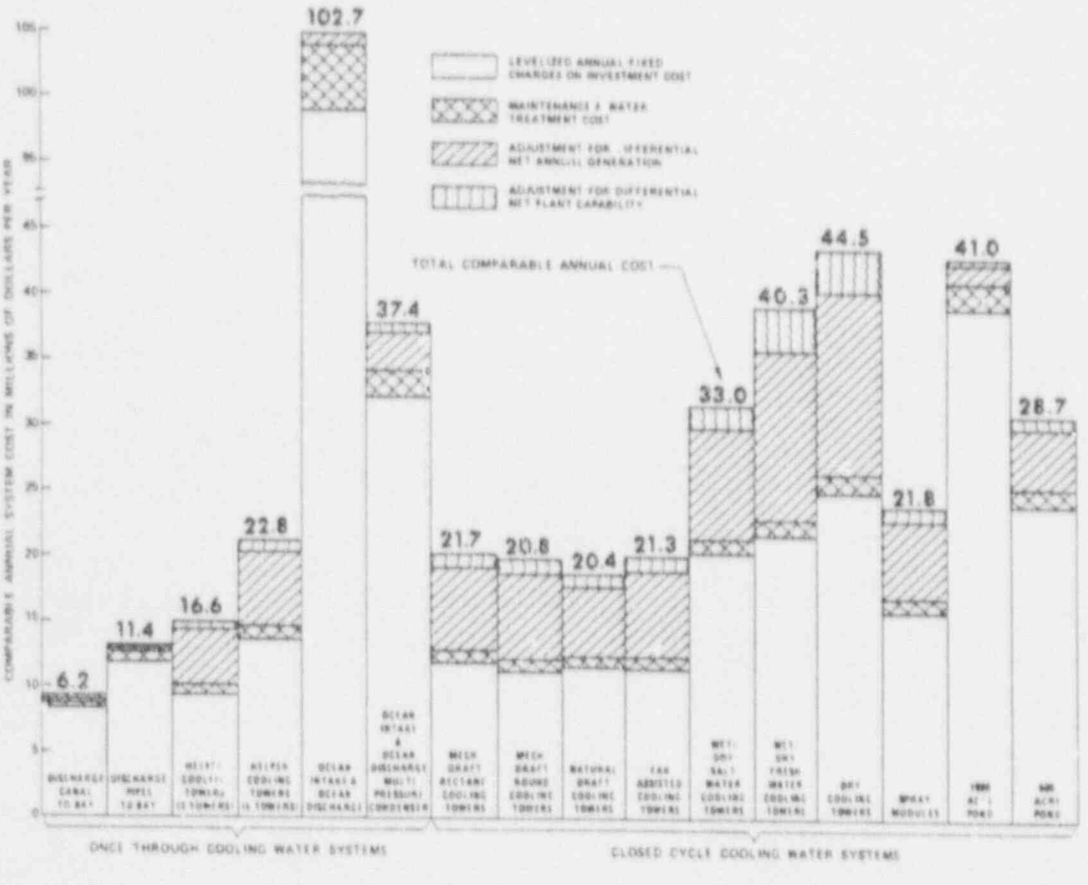


EXHIBIT 3

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

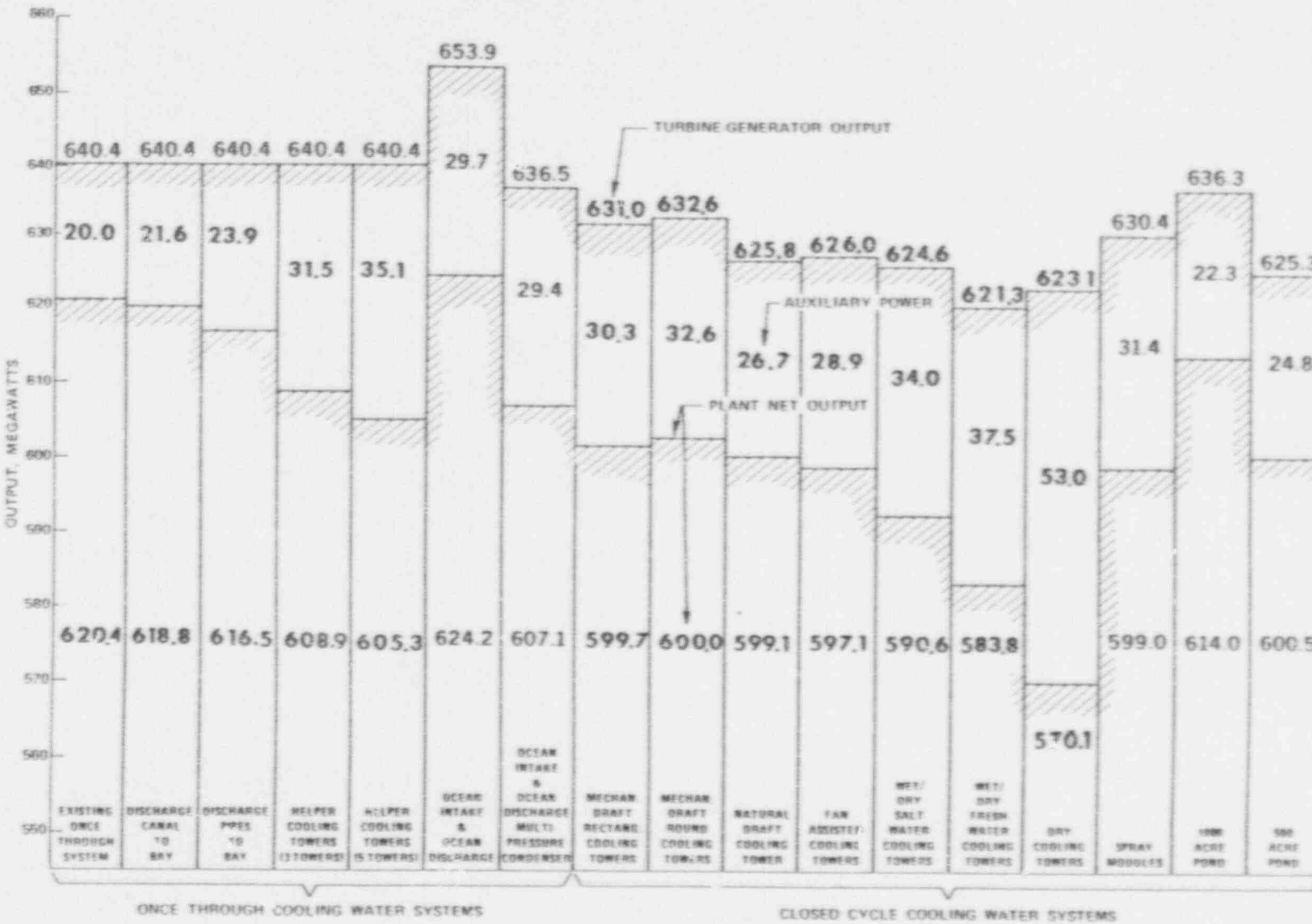


EXHIBIT 4

EXHIBIT 5

COMPARATIVE ANALYSIS OF ENVIRONMENTAL AND REGULATORY ASPECTS FOR PREFERRED COOLING SYSTEMS

Environmental Factors	Units	Natural Draft Cooling Tower	Fan-Assisted Natural Draft Cooling Tower	Round Mechanical Cooling Tower	Canal-To-Bay System	Existing System	Existing System with Ristroph Bucket Screens
1. Atmospheric Effects							
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^3	.06	0.20	0.80	0	0	0
1.4 Salt Deposition (max annual)	Kg/Km-month	80	110	511	0	0	0
2. Air Quality							
2.1 Particulate Emission Rate	% of Standard	353	336	336	0	0	0
3. Water Quality							
3.1 Construction Effects	Qualitative	Low	Low	Low	Moderate	NA(4)	NA
3.2 Operation Effects	% Change	+3	+3	+3	Low	NA	Low
4. Thermal Discharge Characteristics							
4.1 Heat Dissipation (Annual Ave)	Btu/Hr x 10^6	202	208	178	4460	4460	4460
4.2 Area of 1.5° F (Summer Max)	Acres	0	0	0	~2300	~2300	~2300
5. Noise							
5.1 Noise Level at Property Line (Without Mitigative Measures)	dB(A) above NJ Criterion (50 dB(A))	6	11.5	10	13	ND	ND
6. Visual/Esthetic Effects							
6.1 Height of Structure	Ft	540	300	70	11	NA	MA
6.2 Elevated Visible Plume	See Section 1.1						
6.3 Ground Level Fogging	See Section 1.2						
7. Land Use							
7.1 Total Area Required	Acres	~10	~10	~10	~25	NA	0
8. Terrestrial Ecology							
8.1 Sensitive Habitat Required	Acres	Low	Low	Low	15	NA	0
8.2 Potential for Salt Effects on Vegetation	Qualitative	Low	Low	Moderate	NA	NA	0
8.3 Potential for Bird Collisions	Qualitative	Moderate	Low	Low	NA	NA	0

EXHIBIT 5

COMPARATIVE ANALYSIS OF ENVIRONMENTAL AND REGULATORY ASPECTS FOR PREFERRED COOLING SYSTEMS

Environmental Factors	Units	Natural Draft Cooling Tower	Fan-Assisted Natural Draft Cooling Tower	Round Mechanical Cooling Tower	Canal-To-Bay System	Existing System	Existing System with Ristroph Bucket Screens
9. Aquatic Ecology							
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 (3)
9.4 Wood Borer Population-Potential Change in Oyster Creek	Qualitative	Reduction (2)	Reduction	Reduction	Reduction	Base	NC
9.6 Cold Shock Potential - Oyster Creek	Qualitative	Reduction	Reduction	Reduction	Reduction	Base	NC
10. Radiological Effects							
10.1 Dose to Highest Organ (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 4

SUMMARY OF PREFERRED AND RECOMMENDED SYSTEM SELECTION PROCESS

	Differential Comparable Annual Cost (million dollars)	Differential Plant Net Output[1] (MW)	Elimination Rationale Alternative Systems[2]	Elimination Rationale for Preferred 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/ Icing, Salt Deposition	
Natural Draft Cooling Tower (CT)	20.2	-21.3	Preferred	Recommended
Round Mechanical Draft CT	20.6	-20.4	Preferred	Exceeding of Noise Criteria
Fan-Assisted Natural Draft CT	21.2	-23.3	Preferred	Lack of Operating Experience and Noise Control Experience
Rectangular Mechanical Draft CT	21.6	-20.7	OEI-Fogging/ Icing, Salt Deposition	
Helper CT with Minimum 43.8° F Cold Water Temperature	22.8	-15.1	OEI-Fogging/ Icing, Salt Deposition	
Spray Cooling Module Canal	22.8	-21.4	OEI-Fogging/ Icing, Salt Deposition	
500 Acre Cooling Pond	30.3	-19.9	OEI-Fogging/ Icing, Terrestrial and Aquatic Ecology	
Wet/Dry Salt Water CT	33.0	-29.8	OEI-Salt Deposition	
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/ Icing, Terrestrial and 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

n/e/r/a

NATIONAL ECONOMIC RESEARCH ASSOCIATES, INC.
NEW YORK / WASHINGTON / PHILADELPHIA / LOS ANGELES / BOSTON

AN EVALUATION OF THE ECONOMIC BENEFITS AND COSTS OF ALTERNATIVE COOLING SYSTEMS AT THE OYSTER CREEK NUCLEAR GENERATING STATION

EXECUTIVE SUMMARY

Prepared by

Dr. Thomas K. Fitzgerald
National Economic Research Associates, Inc.

November 28, 1977

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 as preferred for the OCNGS. These 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 analyzed involves a modification of the existing discharge structure by means of a canal-to-bay discharge system.

The economic analysis 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. All estimates of benefits and costs have been expressed in terms of levelized annual values. These estimates establish a stream of constant annual 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.

This summary comprises four parts: first, the aggregate benefit/cost differentials of each system are briefly summarized; next, estimates of the costs of installing and operating each of the alternative systems are reported; then, the methods for evaluating each of the environmental effects are briefly described and the monetary estimates obtained for each system are presented; and finally the distributional impacts of each system are briefly described in terms of their costs, both direct and indirect, to residential consumers.

II. AGGREGATE COSTS AND BENEFITS

An aggregate measure of the economic attractiveness of each system can be obtained by summing the estimates of capital and operating costs and environmental costs and subtracting the total from the estimated environmental benefits (Table 1). These differences provide a basis for ranking the alternative systems in terms of economic attractiveness. Environmental benefits are relatively minor in all three tower systems and non-existent for the canal-to-bay discharge structure. Moreover, the adverse environmental effects produced by each of the cooling tower systems impose costs which outweigh these benefits. Finally, these net differences in benefits and costs are completely overshadowed by the substantial capital and operating costs of each system.

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 system. 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.

III. CAPITAL, OPERATING AND MAINTENANCE COSTS

The costs of installing and operating the four alternative cooling systems have been estimated by Ebasco

Services Incorporated (Ebasco). They are defined to include a levelized capital cost; annual maintenance costs; annual operating costs comprising the fuel costs of operating the circulating water system and of the adjustment for losses in net capability associated with increases in turbine back pressure; annual water costs; and the annual capital cost of the loss in capacity due to generation required for operation and plant deratings resulting from increased turbine back pressure. The estimates for each system are presented in Table 2.

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.

IV. ENVIRONMENTAL EFFECTS

Four types of environmental effects associated with the operation of each alternative cooling system were evaluated:

(1) reductions in damage to aquatic populations;

(2) increases in ground-level fogging and icing;

(3) corrosion induced by salt deposition; and

(4) increases in background noise levels.

For each effect, the physical impact resulting from the substitution of an alternative cooling system for the existing once-through system was estimated and subsequently evaluated in monetary terms.

A range of estimates was calculated for selected effects describing, from the standpoint of net environmental benefits, best, most likely and worst cases. Estimated benefits combine the upper limits of the ranges of estimated environmental impacts and/or economic values in the best case and the lower limits of these ranges in the worst case. Conversely, estimated costs combine the lower limits of the ranges of estimated environmental impacts and/or economic values in the best case and the upper limits of these ranges in the worst case. For benefits and costs, the most likely case generally reflects an average of the best and worst case estimates. Results are presented in Table 3.

Some measurable environmental effects were associated with each of the alternative closed-cycle systems. In the case of the canal-to-bay discharge modification, however, the level of impact was judged to be essentially no different from that of the existing system for each environmental effect considered. Consequently, this part of the analysis dealt only with the closed-cycle systems.

A. Aquatic Benefits

Measurement of aquatic benefits focused on reductions in the levels of mortality of selected species resulting from operation of the three closed-cycle alternatives.

Three sources of mortality were considered: entrainment, impingement and cold shock.

Due to reductions in intake water volume, installation and operation of a closed-cycle cooling system is expected to impinge and entrain fewer organisms and thereby reduce species mortality levels from these sources. Furthermore, reductions in thermal discharges from the plant are expected to minimize exposures to cold shock. Since the volume of intake water and the resulting reductions in water temperatures in the receiving water bodies are virtually equivalent for each system, the estimated beneficial effects from reduced species mortalities were assumed equal for all of the closed-cycle alternatives.

Estimates of the annual reductions in species mortalities were developed by Ebasco. Where possible, these reductions were translated into annual weight gains in species stocks for all species with recognized commercial and/or recreational values. These stock gains were evaluated using weighted averages of commercial and recreational values per pound. Commercial values were based on estimates of ex-vessel prices. Recreational values were derived from the ratio of an estimate of the consumers' surplus per recreation day of saltwater fishing to an estimate of the per diem weight of recreational harvests.

Depending upon assumptions made regarding the relationship of changes in stock to changes in harvest and,

in the case of recreational fishing, the relationship between stock and fishing effort, the range of weight gains in species [illegible] resulting from operation of the closed-cycle systems was estimated to produce annual levelized benefits ranging from [illegible] to $19.5 thousand with a most likely estimate of $11.7 thousand. The reduction in cold shock losses (primarily Menhaden) provides the major contribution to these estimates with annual levelized values ranging from $0.4 to $14.2 thousand. The benefits from reduced impingement losses are considerably less ranging from $1.8 to $3.6 thousand; and, the gains from reduced entrainment losses, at $1.7 thousand, are only slightly less important. In the aggregate, the most important species are the Atlantic Menhaden and Summer Flounder. Their importance in the total stems from the estimated gains in weight of their stocks and for Summer Flounder its relative economic value.

B. Ground Level Fogging and Icing

Operation of the fan-assisted natural draft towers and the round mechanical draft towers was estimated to increase, above natural levels, the hours of ground level fogging and icing; the natural draft tower was not expected to have any measurable incremental impact on natural atmospheric conditions. These effects were analyzed in terms of their impact on vehicular traffic on Route 9 which passes within the boundaries of the fog/ice impact area.

Estimates of incremental hours of fogging and icing, developed by Ebasco, were converted into estimates of changes in the number of accidents and the amount of time lost in delays due to speed reductions. Changes in the number of fatalities, injuries, and damaged vehicles associated with changes in the number of accidents were estimated on the basis of observations on the effects of these adverse driving conditions on accident rates and severity. These accident effects were evaluated using estimates of values of lives lost, lost production, hospital and medical costs, administrative costs, vehicle damages and values of time in accident-induced traffic delays. Estimates of reduced speed in these adverse driving conditions were translated into increases in passenger hours spent in transit and evaluated applying values of travel time.

Due to the minimal increase in periods of natural fogging and icing and the limited stretch of roadway affected, the overall estimated social cost arising from these adverse weather phenomena was negligible. Levelized annual values of both accident costs and driving delays ranged from $0.2 to $0.3 thousand with a most likely value of $0.2 thousand in the case of the fan-assisted natural draft towers and were essentially nil in the case of the round mechanical draft towers. No social cost was estimated for the natural draft tower.

C. Materials Damages From Salt Deposits

The use of saltwater in each of the alternative closed-cycle cooling systems produces sea-salt emissions which deposit on material surfaces and vegetation causing economic damages. No distinct quantifiable impact on vegetation was identified so the analysis focused exclusively on the damages to material surfaces.

Estimates of incremental salt deposition rates in a 30 mile by 30 mile square impact area around the OCNGS site were made by Pickard, Lowe and Garrick, Inc. for each of the closed-cycle alternatives. These estimates were used to construct, for each alternative, a population-weighted average deposition rate applicable to the entire impact area. These average deposition rates were then compared to differences in relative corrosion rates of steel and zinc associated with differential rates of salt deposition in experimental metal tests at Kure Beach, North Carolina in order to convert the estimated increments in salt deposition into changes in the rates of relative corrosion in the impact area. Estimates of the average annual increases in maintenance costs of steel and zinc metal systems were obtained by scaling maintenance cost estimates obtained from air pollution studies by the ratios of the estimated changes in the rates of relative corrosion from salt deposition to the changes in the rates of relative corrosion between polluted and unpolluted atmospheres. These average annual

maintenance costs were applied to estimates of the stock of exposed steel and zinc surfaces in the impact area to obtain the estimates of economic damage. Damages to copper metals used in electrical components were estimated as a proportion of total damages to steel and zinc.

In a similar fashion, estimates of the average annual costs of maintenance of residential home sidings based on increased frequency of repainting due to salt deposition were developed. These costs were applied to projections of the stock of housing units to obtain aggregate damage estimates.

The aggregate levelized annual cost of damages to materials from salt drift in the case of the natural draft tower ranges from $41.6 to $106.0 thousand with a most likely estimate of $73.8 thousand. For the fan-assisted natural draft towers, these costs range from $65.8 to $168.4 thousand with a most likely estimate of $117.1 thousand. Operation of the round mechanical draft towers produces costs ranging from $68.6 to $175.9 thousand and a most likely estimate of $122.3 thousand.

The costs associated with the natural draft tower are composed of an estimated $23.2 thousand from damages to metal systems and costs of damages to home sidings ranging from $18.4 to $82.8 thousand. In the case of the fan-assisted natural draft towers, the costs include $36.6 thousand for metal damages and a range from $29.2 to $131.8

thousand for damages to home sidings. For the round mechanical draft towers, costs include $38.1 thousand for metal damages and a range from $30.5 to $137.8 thousand for damages to hom sidings.

D. Evaluation of Increases in Noise Levels

Operation of each of the closed-cycle alternatives is projected to increase nighttime noise levels beyond company property lines to levels in excess of New Jersey noise standards for properties not zoned for commercial or industrial use. Feasible methods of noise attenuation have not been demonstrated and the only option for resolving the problem involves extending property lines sufficiently to bring the augmented background noise levels at the perimeter below the standards.

The boundaries of the noise buffer zones were established by Ebasco. An inventory of all properties in these zones, not designated as commercial or industrial, was compiled and the market value of each lot was projected for an assumed purchase year of 1982. These projections were developed from two sources: (a) a statistical regression analysis of the relationship between recent market values and assessed values, and (b) market to assessed value ratios assumed by Lacey and Ocean Township tax assessors. From these projected market values, a cumulative estimate of property acquisition costs of all lots in the inventory was obtained.

Since property acquisition also would involve the acquisition of residential dwellings, relocation costs, including moving expenses and the costs of searching for new residences, were estimated and applied to the number of dwellings affected.

The levelized costs of property acquisition were $66.4 thousand in the case of the natural draft tower and $1.1 million for the fan-assisted natural draft towers and round mechanical draft towers which have the same noise impact zones. The levelized costs of relocation ranged from $1.6 to $2.2 thousand with a most likely estimate of $1.9 thousand for the natural draft tower; and ranged from $16.2 to $22.4 thousand with a most likely estimate of $19.3 thousand for both the fan-assisted natural draft and round mechanical towers. The aggregate levelized costs of dealing with the noise problem were roughly $68 thousand for the natural draft tower and $1.1 million for the fan-assisted natural draft and round mechanical draft towers.

V. 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, only slightly more than 50 percent of the participants in marine recreational fishing were New Jersey residents according to a National Marine Fisheries Service survey undertaken in 1973-1974. Since approximately 15 percent of the total aquatic benefits arise from recreational values, it can be inferred that roughly 7 percent of these benefits acrrue to out-of-state residents.

Estimates were made for each system of the impact on JCP&L's residential customers of capital and operating costs and costs of dealing with noise effects. The direct costs (increases in electric bills) were estimated by multiplying levelized costs by the ratio of projected 1984 sales to residential customers to total sales; indirect costs (increases in prices of goods and services produced and sold

locally) were obtained in the same manner using instead the ratio of projected 1984 sales to commercial customers, street lighting and public authorities to total sales. An estimate of the annual direct and indirect costs per residential customer was obtained by dividing the sum of these cost estimates by the number of residential customers in 1995.

For those costs which can be passed to JCP&L's customers, capital and operating and land acquisition costs, the total annual effect on JCP&L's residential customers 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.

TABLES

TABLE 1

SUMMARY OF THE AGGREGATE LEVELIZED ANNUAL BENEFITS AND COSTS
FROM OPERATION OF ALTERNATIVE COOLING SYSTEMS

	Total Benefits	Total Costs		Total
			Capital and	Benefits
	Environmental	Environmental	Operating	Less Costs
	(Thousands of Dollars)			
				(1)-(2)-(3)
	(1)	(2)	(3)	(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	-20,4[illegible]8
Worst Case	4	175	20,368	-20,539
Fan-Assisted Natural 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 Draft Towers				
Best Case	20	1,211	20,807	[illegible]998
Most Likely Case	12	1,[illegible]7	20,807	[illegible]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 2

LEVELIZED ANNUAL CAPITAL AND OPERATING COSTS OF ALTERNATIVE COOLING SYSTEMS

	Canal-to-Bay Discharge	Natural Draft Tower	Fan-Assisted Natural Draft Towers	Round Mechanical Draft Towers
	(Thousands of Dollars)			
	(1)	(2)	(3)	(4)
Capital Costs:				
Circulating Water System	7,523	13,484	12,823	12,463
Replacement of Capacity Loss	128	857	1,111	1,017
Operating Costs:				
Fuel	1,057	5,265	6,428	6,424
Maintenance	338	606	785	748
Water	85	156	156	155
Total	9,131	20,368	21,303	20,807

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 Case	Worst Case	Best Case	Most Likely Case	Worst Case	Best Case	Most Likely Case	Worst Case
	(Thousands of Dollars)								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Aquatic Benefits									
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
Total	19.5	11.7	3.9	19.5	11.7	3.9	19.5	11.7	3.9
Fog/Ice Costs									
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	-	-	-
Total	0.0	0.0	0.0	0.2	0.2	0.3	-	-	-
Salt Deposition Costs									
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
Total	41.6	73.8	106.0	65.8	117.1	168.4	68.6	122.3	175.9
Noise Costs									
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
Total	68.0	68.3	68.6	1,142.0	1,145.1	1,148.2	1,142.0	1,145.1	1,148.2
Total Benefits Less Costs	-90.1	-130.4	-170.7	-1,188.5	-1,250.7	-1,313.0	-1,191.1	-1,255.7	-1,320.2

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.

TABLE 3

Jersey Central Power & Light Company

OYSTER CREEK
NUCLEAR GENERATING STATION

ALTERNATIVE COOLING WATER SYSTEM STUDY

VOLUME II

JCP&L GPU

A Member Company of the General Public Utilities System

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

VOLUME 2

STUDY TEXT

Ebasco Services Incorporated
Two Rector Street
New York, N Y

November 1977

VOLUME 2

PREFACE

The Alternative Cooling Water System Study prepared by Eh[illegible] Incorporated consists of three separately bound volumes.

Volume 2 contains Chapter II (Description of the Exis[illegible]), Chapter III (Discussion of Alternative Cooling Water Systems[illegible] Dis-cussion of Preferred Cooling Water Systems). This volume [illegible] methodology, analysis and results of the study in detail.

Volume 1 contains an Executive Summary (Chapter I) of the [illegible] Water System Study.

Volume 3 contains all Exhibits cited within Volume 2.

II. DESCRIPTION OF THE EXISTING COOLING WATER SYSTEM

TABLE OF CONTENTS

CHAPTER II - DESCRIPTION OF THE EXISTING COOLING WATER SYSTEM

CHAPTER II

LIST OF EXHIBITS

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 (FRNGS), 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.(1, 2) 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.[2] 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

TABLE OF CONTENTS

CHAPTER III - DISCUSSION OF ALTERNATIVE COOLING WATER SYSTEMS

CHAPTER III

LIST OF EXHIBITS

CHAPTER III

Cont'd

LIST OF EXHIBITS

CHAPTER III

Cont'd

LIST OF EXHIBITS

Cont'd

LIST OF EXHIBITS

No of Exhibits

CHAPTER III

Cont'd

LIST OF EXHIBITS

Cont'd

LIST OF EXHIBITS

CHAPTER III

Cont'd

LIST OF EXHIBITS

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:

Plant Loading Data

		Duration Hr/Yr
(i)	Plant Operation	
	Load 100%	3200
	85%	2300
	50%	1158
	Total Operation	6658
(ii)	Refueling and Overhaul 42 Days	1008
(iii)	Forced Outages 45.6 Days	1094
	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 Thermal Output	Turbine-Generator Performance		
		Output (Gross)		Heat Rate
	MWt	MWe	%	Btu/kWh
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:

Turbine Generator Output, MW:	657.4	540.2	320.0
Condenser Duty 10^6 Btu/hr:	4210	3532	2275

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:

	No. of Days in Operation	Percent of Total Annual Generation
Summer (June + July + August + September)	112	43
Spring and Fall (March + April + May + 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:

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

4. <u>Intake Water Temperature and Quality in Existing Canal and Atlantic Ocean</u>

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:

	Existing Canal	Ocean Intake
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) 1,000 lb/day (winter)

5. <u>Site Conditions</u>

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:

	Approach ^{o}F (to T_{wb} = 74° F)
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 .. 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 discha[illegible]iteria. The most stringent criterion would be the 4° F temperature rise [illegible] 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):

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

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

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° 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).

*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

Cooling Tower Minimum Discharge Water Temperature at Winter Conditions °F	43.8	50.0
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:

<u>Mechanical Draft Rectangular Cooling Tower System</u>

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	4.44×10^9
Approach to T_{wb} = .° F, °F	12
Cooling Range, °F	19.73
Circulating Water Flow, gpm	462 000
CW Temperature Leaving Cooling Tower (Entering Condenser), °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 fa 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:

<u>Round Mechanical Draft Cooling Tower System</u>

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	4.44×10^6
Approach to $T_{wb} = 74^{\circ}$ F, $^{\circ}$F	10
Cooling Range, $^{\circ}$F	21.1
Circulating Water Flow, gpm	426 200
CW Temperature Leaving Cooling Tower (Entering Condenser), $^{\circ}$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 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	4.44×10^6
Approach to $T_{wb} = 74^\circ$ F, $^\circ$F	14
Cooling Range, $^\circ$F	21.2
Circulating Water Flow, gpm	433 300
CW Temperature Leaving Cooling Tower (Entering Condenser), $^\circ$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:

<u>Fan Assisted Cooling Tower System</u>

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	4.44×10^9
Approach to T_{wb} = 74° F, °F	14
Cooling Range, °F	20.0
Circulating Water Flow, gpm	458,400
CW Temperature Leaving Cooling Tower (Entering Condenser), °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 Oyster 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 makeup 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	4.44×10^9
Approach to T_{wb} = 74° F, °F	16
Cooling Range, °F	19.8
Circulating Water Flow, gpm	462 200
CW Temperature Leaving Cooling Tower (Entering Condenser), °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 OCNGS; 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 1.2×10^9 gal/yr as opposed to 5×10^9 gal/yr and 6.4×10^9 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	4.4×10^6
Approach to T_{wb} = 74° F, °F	18
Cooling Range °F	19
Circulating Water Flow, gpm	469 200
CW Temperature Leaving Cooling Tower (Entering Condenser), °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:

<u>Dry Mechanical Draft Rectangular Cooling Tower System</u>

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	4.55×10^9
Approach to T_{db} = 89° F, °F	16
Cooling Range, °F	17.7
Circulating Water Flow	502 300
CW Temperature Leaving Cooling Tower (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 smal. 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 he 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 rational 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 (^{o}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, interst 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 weekday 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 ¢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 ¢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 \$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 $\$25/10^6$ 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:

Area	Cost per Acre
Adjacent to Garden State 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 ($1,000)	Installation ($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 Condenser)))	Section 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 (lin ft)	Installation ($/lin ft)
One CW Pipe in a Trench				
Pipe Diam (in.):	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				
Pipe Diam (in.):	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

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

viii. Supplementary Auxiliary Transformer Cost

Base - 20 MVA	- Material	$ 600,000
	- Installation	$ 120,000
Differential - ± MVA	- Material	$6,700/MVA
	- Installation	$1,200/MVA

ix. Power Wiring

High Voltage Cable to CW System Switchgear	- Material	11	$/MVA/ft
	- Installation	22	$/MVA/ft
High Voltage Cable from Switchgear 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 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

x. Control Wiring

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

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

xii. CW System Switchgear

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

xiii. Cooling Tower Fan Motor Power Center

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

xiv. Spray Modules

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

xv. Dry Cooling Tower

Approach to Tdb = 89° F, °F	Cooling Range, °F	Total Estimated Cost $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 to Twb = 74° F °F	Cooling Range °F	Total Estimated Cost $1,000,000			
		Mechanical Draft		Natural Draft	Fan-Assisted
		Rectangular	Round		
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 to Twb = 74° F °F	Cooling Range °F	Total Estimated Cost $1,000,000 Salt Water Cooling Tower	Fresh Water 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 Estimated Cost $1,000,000
3 Towers (for minimum cold water temperature, 50° F - 26 cells	9.1
5 Towers (for minimum cold water temperature, 43.8° F - 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 diamater 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, Material & Installation, 1976	Direct Cost, Material & Installation, Escalation	Indirect, Contingency, IDC, Utilities Expenses, Land Cost	Total Estimated 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	13.3	24.4	69
Spray Cooling Module Canal	23.7	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 (Δ kW) and net annual generation (Δ 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° 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:

Permit	Applicable State Regulation
CAFRA*	NJSA 13:19-1 et seq.
Wetlands	NJSA 13:9A-1 et seq.
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 areas designated as environmentally sensitive[(1)], and would include white

* 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°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.

---

*"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 30×10^6 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 that 20 minutes per day from an 1,800 MW plant utilizing natural draft towers in Switzerland.[2] Elevated plumes are considered a significant effect in natural draft and round tower operation. Studies of the Forked River NGS proposed natural draft tower[3] 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 [4] 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°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.(5) According to Carson,(6) 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 roundmechanical 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.(7)

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.(6) 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^2/month(8). Deposition from a similar natural draft tower at OCNGS 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 65,000 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.[6] A study of a 400-module spray module system by Hoffman[9]

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.[10] 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.[11] 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[12], Carson indicated that the effects of sensible heat are more important than moisture in increasing atmospheric buoyancy and resultant instability.[13] 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.[14] 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

REFERENCES

1. Ovard, J C, "Fogging and Cooling Tower Configuration", Fluor Technical Note No. 16.

2. Junod, A, et al, "Meteorological Influences of Atmospheric Cooling Systems as Projected in Switzerland", Symposium Proceedings, Cooling Tower Environment - 1974, March, 1974.

3. De Vine, J C, "The Forked River Program - A Case Study in Salt Water Cooling", GPU Service Corp, February, 1974.

4. Hanna, S E, "Meteorological Effects of the Mechanical Draft Cooling Towers of the Oak Ridge Gaseous Diffusion Plant", Symposium Proceedings, Cooling Tower Environment - 1974, March, 1974.

5. Hosler, C L, "Wet Cooling Tower Plume Behavior", paper presented at the AIChE Cooling Tower Symposium, Houston, Texas, March, 1971.

6. Carson, J E, Atmos... ic Impacts of Evaporative Cooling Systems, Argonne National Laboratory, October, 1976.

7. Rubin, A M, and Klanian, P S, "Visible Plume Abatement with the Wet/Dry Cooling Tower", Power Engineering, March, 1975.

8. Pickard, Lowe, and Garrick, Inc, Personal Communication, August 29, 1977.

9. Hoffman, D P , "Spray Cooling Fights Fog Best, says Detroit Edison" Electric Light and Power, E/G Edition, October, 1973.

10. Ceramic Cooling Tower Company, "Measured and Predicted Salt Deposition Rates - Closed Cycle Water Cooling Duty".

11. Carson, J E, "Meteorological Consequences of Thermal Discharges from Nuclear Power Plants - Research Needs", Symposium Proceedings, Cooling Tower Environment - 1974, March, 1974.

12. Huff, F A, "Potential Augmentation of Precipitation from Cooling Tower Effluents", Bulletin of the American Meteorological Society, July,1972.

13. Carson, J E, Personal Communication, January 31, 1977.

14. Vogel, J and Huff, F A, "Fog Effects Resulting from Power Plant Cooling Lakes", Journal of Applied Meteorology, Volume 14, August, 1975.

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)	1.30×10^8	4.24×10^8	2.50×10^8

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

Season	Temperature
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.[3] 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.[5] The discharge temperatures for the spray cooling systems were derived from manufacturer's thermal performance curves, and verified by analytical analyses.[6] 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

*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°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[3] and a single temperature profile obtained by remote (airborne) sensing without ground confirmation on July 13, 1973[4]. 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°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[7] 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-feet 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.

2. Burns and Roe, Inc, "Alternate Cooling Systems Study for Forked River No. 1", May, 1971.

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).

7. Koh, R C, and Fan, L N, "Mathematical Models for the Prediction of Temperature Distributions Resulting from the Discharge of Heated Water", FWQA R and D Report 16130 DWO, October, 1970.

8. Jirka, G H, Abraham, G, and Harleman, D R F, "An Assessment of Techniques for Hydrothermal Prediction", Ralph M Parsons Lab Report No. 203, July, 1975.

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.(1)

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 78.

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(1).

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,(1) 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 overlie 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 . ay 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[1] which falls on the surface areas (See Exhibit 82) of the . mations. For some specific aquifers, "leakage" from overlying formations may contribute to the volume of water in storage. About 40 percent of all pr. ipitation infiltrates the highly permeable sandy surface which is chara. .ristic of the regi n. The actual percentage varies during the year due to changing evapotranspiration rates and seasonal climatic conditions.

Based on information supplied by the USGS[1] and test borings conducted for Jersey Central Power and Light,[2] 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 aquife. 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.[3] This system contains the largest amount of groundwater in storage in the Coastal Plains in Ocean County.[1] It is currently underdeveloped with approximately 5 MGD (7,200 gpm) being withdrawn as of 1962.[1] 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[1,4] (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.[1,2] 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.[1,5] 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 vegatative 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.[1,2] 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.[1] 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,[6] 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.[1] 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 1.8×10^9 square feet and the volume at 8.3×10^9 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 7½ 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"(10) 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,[11] 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).[12] 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 Year (gpd/sq mi)	Dry Year (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:(1)

> "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.(10) 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 streamflow.(1) 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.

3. Jablonski, L, Groundwater Resources of Monmouth County, New Jersey, State of New Jersey, Dept of Conservation and Economic Development, and the U S Geological Survey, Special Report #23, 1968.

4. Gill, H E, Groundwater Resources of Cape May County, N J - Salt Water Invasion of Principal Aquifers, State of New Jersey, Dept of Conservation and Economic Development, and the U S Geological Survey, Special Report #18, 1962.

5. Dufor, C N, and Becker, E, "Public Water Supplies of the 100 Largest Cities in the United States", Geological Survey Water Supply Paper #1812, 1962.

6. Department of Geology, State of New Jersey, Bulletin Number 74, State of New Jersey, 1976.

7. U S Environmental Protection Agency, STOrage and RETrieval of Water Quality Data System.

8. Von Arx, W S, An Introduction to Physical Oceanography, Addison-Wesley Publishing Company, Don Mills, Ontario, 1962.

9. Neumann, G and Pierson, W J, Principles of Physical Oceanography, Prentice-Hall, Inc, Englewood Cliffs, N J, 1966.

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

11. Smith, B L, Forked River Unit 1, Fresh Water for Cooling Purposes, Jersey Central Power & Light Co, 1971.

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

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[1] 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.(3) 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

1. U S Environmental Protection Agency, "Discharge of Dredged or Fill Material", Federal Register, Vol 40, No. 173, September 5, 1975.

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

3. Roffman, A, et al, The State of the Art of Saltwater Cooling Towers for Steam Electric Generating Plants, Westinghouse Electric Corporation, Environmental Systems Department (for the U S Atomic Energy Commission), Pittsburgh, Pennsylvania, 1973.

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

1. Carlson, J P, and Teplizky, A, "Estimating and Impact of Environmental Noise from Natural Draft Cooling Towers", Noise Control Engineering, July-August, 1974.

2. Dyer, I, and Miller, L, "Cooling Tower Noise", Noise Control, May, 1959, pp 180-183.

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 foregound 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 saltwater or freshwater wet/dry cooling tower units between the station and the intak anal. 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:

Pond Size	Road Designation	Distance from Pond
1000 acres	Garden State Parkway	500-700' ±
1000 acres	Route 532	350-1500' maximum
1000 acres	Route 9	1000' ±
500 acres	Garden State Parkway	2100' at closest point
500 acres	Route 532	400-1500' maximum
500 acres	Route 9	1000' ±

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 mode 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 [illegible] visual impact[illegible] [illegible]ile 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° C (23° 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° to 7° C (3.6° to 12.6° 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 (Taredo 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 (ΔT), change in salinity (ΔS), 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

i. 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.(1) 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.(2) 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.(3) 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).(3)

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 launce. 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 high 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.(7) Western Bay waters from north of Oyster Creek to Waretown Creek have produced larger sport catches in winter than neighboring areas.(7, 8) 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.(9) 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.(4, 5) 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.

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

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

Phytoplankton density and productivity were found to be greatest in western Bay waters near river and creek mouths.(10) 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 [4, 5].

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[11]. Holoplankters have been the most numerous zooplankters offshore of Little Egg Inlet[11]. 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[4, 5].

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[10]. 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 densitites of these organisms have been recorded during warm seasons, late spring through early fall[12].

Recently, microplankton densities in the Bay have been higher off Oyster Creek and Forked River than other western Bay areas.[8] 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, zoae, polychaete (worm) larvae and

mysids.[7, 8] 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[9]. 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)[4]. 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.

Barnegat Bay supports abundant floral and faunal growth. Algal growth in central Barnegat Bay is seasonal.[13] 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.[13] The prominant 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 [14]. 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 [14].

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. [16] Barnacles, especially Balanus eburneus, are also common foulers [4, 5]. Barnacles themselves provide substrate suitable for further encrustration 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 [4, 5]. Fouling organisms such as mussels, oysters, barnacles, hydroids and shipworms also occur throughout Barnegat Bay.

Richards and Bellmore [17] 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 [18] 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) [19], and optimum temperatures for larvae are from 68° F - 86° F (20° C to 30° C) [20]. 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 [19].

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% [20]. 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% [17]. 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) [17]. L. tripunctatum are also tolerant of creosote, [17] 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 ΔT system and a low flow, high ΔT 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, saltwater 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[7] and March - April, 1976[8]. 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" mo... s.

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.[7] 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. Thes[illegible] tality rates may have an upward bias due to handling of the test organisms. [illegible] 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[7]. 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

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

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 capt[illegible]ed 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 3.8×10^6 ft^3. Then,

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

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

Densities were finally expressed on a metric basis (fish/100 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 m^3 were determined in a disaggregate fashion for the appropriate stations. Sample volumes (4700 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 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[21] 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. <u>Results - Comparison of Alternatives</u>

a. Overview

i. 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 (ΔT and ΔS) 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 x 75% x (22,000 gpm/460,000 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[22] 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) ΔT's associated with closed cycle alternatives are such that dilution pump operation would still be required, particularly in winter;

3) ΔS'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[23]. The model used to assess similarities among alternative cooling systems and dilution pump combinations involved a general coefficient of similarity described by Gower[24]. 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 ^{o}F in November, shipworm reproduction activity can be extended. This has been documented by gonadal studies[25]. 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[27] 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).

i. 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"[26] 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, ΔT'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(7). 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 103)

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

i. Wood Borers

Since the heated effluent would be contained in the canal, the amount of borer habitat exposed to high ΔT'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 ΔT of 4.7° F. Operation with no dilution would cause a 9.8° F mixed ΔT in winter.

i. Wood Borers

In terms of temperature reduction, the helper tower system is attractive. In spring, summer and fall, the ΔT's in Oyster Creek would probably be insignificant (roughly 3° F in spring and fall). Accentuated reproduction of shipworms is not expected at those ΔT'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.

---

*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, ΔT's are predicted to be about 4° F lower. With two dilution pumps, and FRNGS operating, ΔT'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.

i. 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 ΔT of 20° F and a multi-pressure design with a flow rate of 177,400 gpm, resulting in a ΔT 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 ΔT) 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-I

REFERENCES

1. Ichthyological Associates, Inc, Ecological Considerations for Ocean ... Off New ... for Proposed Nuclear Generating Stations, 1972.

2. ... sey C ntral Power and Light Company, Environmental Report, Oyster Creek Nuclear Generating Station, 1969.

3. ... Jersey Department of Environmental Protection, Division of Fish, Game and Shellfish, Bureau of Fisheries, Nacote Creek Research Station, Studies of the Upper Barnegat System, Misc Report ..., 1973.

4. Ichthyological Associates, Inc, Ecological Studies in the Bays and Other Waterways near Little Egg Inlet and in the Ocean in the Vicinity of the Proposed Site for the Atlantic Generating Station, New Jersey, 1974.

5. Ichthyological Associates, Inc, Ecological Studies in the Bays and Other Waterways near Little Egg Inlet and in the Ocean in the Vicinity of the Proposed Site for the Atlantic Generating Station, New Jersey, 1975.

6. Murowski, W S, "Results of Tagging Experiments of Summer Flounder (Paralichthys dentatus) Conducted in New Jersey Waters from 1960 to 1967", New Jersey Department of Environmental Protection, Nacote Creek Research Station, Misc Report 5M, 1967.

7. Ichthyological Associates, Inc, Progress Reports of Ecological Studies for the Oyster Creek Generating Station, September - December, 1975, 1975.

8. Ichthyological Associates, Inc, Progress Reports of Ecological Studies for the Oyster Creek Generating Station, January - April, 1976, 1976.

9. U S Department of the Interior, Draft Environmental Statement for Outer Continental Shelf Oil and Gas Lease Sale No. 40, 1976

10. Mountford, K, Composition and Periodicity of Phytoplankton and Zooplankton from Barnegat Bay, New Jersey, Ph.D. Dissertation, Rutgers University, 1971.

11. U S Nuclear Regulatory Commission, Revised Draft Environmental Statement, Atlantic Generating Station, Units 1 and 2, 1976.

12. Sandine, P H, "Zooplankton of Barnegat Bay: The Effect of the Oyster Creek Nuclear Power Plant", M.S. Thesis, Rutgers University, 1973.

13. Vouglitois, J J, The Benthic Flora and Fauna of Barnegat Bay Before and After the Onset of Thermal Addition, Jersey Central Power and Light Company, 1976.

14. Moul, E T, Loveland, R E, Taylor, J E, Phillips, F X, and Mountford, K, Barnegat Bay Thermal Addition - Progress Report No. 3, Rutgers University, 1968.

15. Butterfield, W S "A Study of the Benthic Invertebrates in Lagoon Systems in the Salt Marshes of New Jersey", M.S. Thesis, Rutgers University, 1973.

16. Well, W and Grey, I E, "The Seasonal Occurrence of Mytilus edulis on the Carolina Coast as a Result of Transport Around Cape Hatteras", Biological Bulletin 119:550-559, 1960.

17. Richards, B R, and Belmore, C I, "Evaluation of the Extent and Effect of the Marine Woodborer Population in Oyster Creek Upon the Overall Barnegat Bay Marine Woodborer Populations", Battelle-Columbus William F Clapp Laboratories, Duxbury, Massachusetts, Report 14609, 1975.

18. Turner, R D, Survey and Illustrated Catalog of the Teredinidae (Mollusca: Bivalvia), Harvard University, 1966.

19. Turner, R D, "Report on Marine Borers (Teredinidae) in Oyster Creek, Waretown, New Jersey", Harvard University, 1973.

20. Trussell, P C, "Teredine Borers", Sea Frontiers - Magazine of the International Ocean Foundation 13 4 :235-243, 1967.

21. Marcy, B C, Jr, "Entrainment of Organisms at Power Plants, With Emphasis on Fishes - An Overview", Fisheries and Energy Production: A Symposium, S Saila, Editor, 1975.

22. Horst, T J, "The Assessment of Impact Due to Entrainment of Ichthyoplankton", Fisheries and Energy Production: A Symposium, S Saila, Editor, 1975.

23. Haritgan, J A, Clustering, Control Data Corporation Institute for Advanced Technology (Unpublished), 1972.

24. Gower, J C, "A General Similarity Coefficient and Some of Its Properties", Biometrics 27:857-874, 1971.

25. Richards, B R, Rehm, A E, Bellmore, C I, and Hillman, R E, "Woodborer Study Associated with the Oyster Creek Generating Station", Battelle Laboratories Annual Report 14729, 1976.

26. National Academy of Sciences/National Academy of Engineering, Water Quality Criteria, 1972, EPA R3.73.033, March, 1973.

27. Bliss, C I, "Calculation of the Time-Mortality Curve", Annals of Applied Biology 24:815-825, 1937.

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,(1) 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.(2) 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.[3] 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.[4] 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 (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 o 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 ug/m^3 ten miles inland and 500 to 1,000 ug/m^3 near the ocean shore.[9] In the same study, average annual concentrations of airborne salt were predicted to be 0.9 ug/m^3 at ten miles inland to 72 ug/m^3 at the ocean shore. The study also estimated that long-term average deposition rates of natural sea salt ranged from 300 $kg/km^2/mo$ ten miles inland to 3,500 $kg/km^2/mo$

at the ocean shore. Long-term average deposition in the vicinity of the Oyster Creek Site was estimated to be between 300-600 $kg/km^2/mo$. [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^3. Short-term (several hours) exposure at 100 ug/m^3 would produce foliar injury, while short-term airborne salt concentrations below 60 ug/m^3 would not.[1] At levels above 10 ug/m^3, 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 kg/km^2/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 kg/km^2/mo.[(2)] 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).[(11)]

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.[(12)] 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.[(13)] Many bird species are nocturnal migrants, including shorebirds, rails, flycatchers, orioles and most sparrows, warblers, vireos and thrushes.[(14)] 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

REFERENCES

1. Boyce Thompson Institute, "Effects of Aerosol Drift Produced by a Cooling Tower at the Indian Point Generating Station on Native and Cultivated Flora in the Area", August 31, 1974 (unpublished).

2. Jersey Central Power and Light Company, Environmental Report, Construction Permit Stage, Forked River Nuclear Generating Station, Unit No. 1, 1972.

3. Carson, J E, "Atmospheric Impacts of Evaporative Cooling tems", Division of Environmental Impact Studies, Argonne National La. ratory, ANL/ES-53, 1976.

4. U S Nuclear Regulatory Commission, Draft Environmental Impact Statement for Selection of the Preferred Closed-Cycle Cooling System at Indian Point, Unit 2, NUREG-0038, 1976.

5. Roffman, A, et al, The State of the Art of Saltwater Cooling Towers for Steam Electric Generating Plants , prepared for U S Atomic Energy Commission, 1973.

6. Moser, B C, and Swain, R L, "Potential Effects of Salt Drift on Vegetation", prepared for Jersey Central Power and Light Company, 1971.

7. Holmes, F W, "Salt Injury to Trees", Phytopathology 51: 712-718, 1961.

8. Devine, J C, Jr, he Forked River Program: A Case Study of Salt Water Cooling", Symposium Proceedings, Cooling Towe. Environment - 1974, March, 1974.

9. U S Atomic Energy Commission, Final Environmental Statement, Oyster Creek Generating Station, Operating License Stage, 1974.

10. Toth, S J, "Potential Effects of Salt Spray Deposition on Soils and Surface Water", prepared for Jersey Central Power and Light Company.

11. Brisbin, I L, Jr, "Abundance and Diversity of Waterfowl Inhabiting Heated and Unheated Portions of a Reactor Cooling Reservoir", U S Atomic Energy Commission Symposium, CONF-730505.

12. Bull, J, Birds of the New York Area, Harper and Row, New York, New York.

13. U S Atomic Energy Commission, Final Environmental Statement Related to the Proposed Bellefonte Nuclear Plant, Units 1 and 2, 1974.

14. Lincoln, F C, The Migration of North American Birds, U S Department of Agriculture, Circular No. 363, 1935.

15. Overing, R, "The 1935 Fall Migration at the Washington Monument", Wilson Bulletin, 48: 222-224, 1936.

16. Rybak, E J, Jackson, W B, and Vessey, S H, "Impact of Cooling Towers on Bird Migration", Proceedings of the Sixth Bird Control Seminar, Bowling Green State University, Bowling Green, Ohio, 1973.

17. Federal Aviation Administration, "Obstruction Marking and Lighting", AC 70/74 60-1E, 1976.

18. Bull, J, Ornithologist, American Museum of Natural History, Personal Communication, 1977.

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., rainout 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[1] 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 [2, 3] 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[3] 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[4], 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, Λ. 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]:

$$\Lambda = \int_{0}^{\infty} FEA \, dD$$

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[5] 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(6) has shown that under wet conditions the physical halflife 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 $1 \times 10^{-6} m^{-1}$ for both types of cooling towers, as compared to a dry deposition rate of $2.4 \times 10^{-5} m^{-1}$. 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(7).

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

REFERENCES

1. U S Nuclear Regulatory Commission, Reactor Safety Study: An Assessment of Accident Risks in U S Commercial Nuclear Power Plants, Appendix VI, "Calculation of Reactor Accident Consequences", WASH-1400 (NUREG-75/014) October, 1975.

2. Gifford, F A, Jr, "An Outline of Theories of Diffusion in the Lower Layers of the Atmosphere", Meteorology and Atomic Energy - 1968, D H Slade, Editor, USAEC TID-24910, 1968.

3. Markee, E H, Jr, "A Parametric Study of Gaseous Plume Depletion by Ground Surface Adsorption", Proceedings of USAEC Meteorological Information Meeting, C A Mawson, Editor, AECL-2787, 1967.

4. U S Nuclear Regulatory Commission, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors", Regulatory Guide 1.111, 1976.

5. Engelmann, R J, "The Calculation of Precipitation Scavenging", Meteorology and Atomic Energy - 1968, D H Slade, Editor, USAEC, TID-24910, 1968.

6. Weiss, B H, et al, "Detailed Measurement of I-131 in Air, Vegetation and Milk around Three Operating Reactor Sites", NUREG-75/021, U S Nuclear Regulatory Commission, March, 1975.

7. Andrews, L, Markee, E H, Jr, and Osloond, J, "Testimony of NRC Staff Related to Interaction between the Gaseous Releases of Radioactivity and Cooling Tower Plumes", in the matter of Three Mile Island Nuclear Plant, Un[illegible] before the U S Nuclear Regulatory Commission Atomic Safety and Licen[illegible]g Board, 1977.

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° 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.

1

IMAGE EVALUATION TEST TARGET (MT-3)

150mm

6"

1

IMAGE EVALUATION TEST TARGET (MT-3)

150mm

6"

IV. DISCUSSION OF PREFERRED COOLING WATER SYSTEMS

TABLE OF CONTENTS

CHAPTER IV - DISCUSSION OF PREFERRED COOLING WATER SYSTEMS

CHAPTER IV

LIST OF EXHIBITS

Cont'd

LIST OF EXHIBITS

CHAPTER IV

Cont'd

LIST OF EXHIBITS

Cont'd

LIST OF EXHIBITS

Cont'd

LIST OF EXHIBITS

CHAPTER IV

Cont'd

LIST OF EXHIBITS

Cont'd

LIST OF EXHIBITS

Cont'd

LIST OF EXHIBITS

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° F or less.

The rise of the tower vapor effluent was calculated by Briggs' plume rise equation[1] as modified by Hanna.[2] For each hour, stability conditions were determined (neutral, able, 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.[3] 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[4] 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.[5] 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[6] for calculating saturation vapor pressure and also by assuming that the plume behaved according to a linear psychometric mixing process. The temperature at the source of the plume (at exit of cooling tower) was calculated by a heat-and-mass balance method[7] 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[8]

The meteorological data base used for the salt analysis consisted of hourly measurements of wind direction, wind speed and vertical temperature

difference, 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(8)

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(8)

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^{-5} (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^2/month) and the near ground air concentration of such salt (e.g., as g/m^3) 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.

c. Ice Formation Due to Drift (8)

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^{o}) 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° 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.(9) 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[10] 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:

$$T - E = (T_o - E)e^{-(k + \lambda)t/D}$$

where,

T is the temperature of heated water,

E is the ambient temperature of water,

T_o is the initial temperature of heated water,

k is the atmospheric heat transfer coefficient,

λ is the entrainment coefficient,

t is the travel time, and

D is the depth of water.

The entrainment coefficient (λ) has been estimated from dye experiments to be 0.4 ft/hr.[9] 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.[12] 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.[13, 14] 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 preceeding 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 spect. (see Appendix B).

The noise levels produced by the preferred cooling tower systems were estimated using existing literature[15,16,17] 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 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 [illegible] crudely understood. Because of this, the basic approach used in evalua[illegible]g 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 description 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 change 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[22] 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.[22] 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 OCNGS 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 specis (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 human to control them.[23] The teredo is protandrous.[24] 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 ΔT's are kept below 3 ^{o}C, fish delaying migration to remain in the station's thermal plume would experience 12 ^{o}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 ($12^{o} - 3^{o} = 9^{o}C$) 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 X 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 OCNGS 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 perferred 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-co

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 kg/km^2 (or 65,800 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[29] noted that "Because of the low annual rate of salt deposition by such salt drifts (13,175 - 26,355 kg sea salt/km^2, or 1100-2200 kg/km^2/month), soil salinity would usually be a minor factor compared to foliar salt deposition". For this analysis, the annual deposition rate of 65,880 kg/km^2 (5490 kg/km^2/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, Cl^- has been identified as the likely toxic agent in incidences of sea salt injury(33) and, together with Na^+, has been the subject of recent investigations of cooling tower salt deposition effects on plants.(31,32,34) 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(33). 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 ug/m^3 near the surf to 14 ug/m^3 at the leaward side of the island. Moser estimates that the average monthly concentration for the "island in general" was about 40 ug/m^3. During the same study it was observed that short-term (several hours) exposure to 100 ug/m^3 produced foliar injury, while short-term airborne sea salt concentrations below 60 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 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 s e. 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 kg/km^2/year, or 1100 kg/km^2/month).[28] 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.[32] 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 kg NaCl/km^2/month or 1766 kg Cl^-/km^2/month, and would be approximately comparable to a monthly sea salt (or cooling tower) deposition rate of 3200 kg/km^2 (assuming 55 percent as the contribution by weight of Cl^- to salt derived from sea water or cooling tower plume). Soybeans evidenced injury on less than 5 percent of trifoliate 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 ug/m^3.[35] 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 ug/m^3, while the 3 week and 5 week old plants evidenced no decrease.

In investigations conducted in the Boyce Thompson Laboratories,[36] pinto beans evidenced foliar lesions following one hour exposure to a deposition rate of 0.35 ug Cl^-/cm^2/minute. With the same assumptions as above, this is equivalent to a deposition of 387 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 89 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).[37,38] 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] LGL 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[42]; Metropolitan Edison's Three Mile Island facility[43]; the stack at the Nanticoke Plant[44]; 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 NCS 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.[45]

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

REFERENCES

1. Briggs, G A, Plume Rise, AEC Critical Review Series, TID-25075, NTIS, Springfield, Virginia, November, 1969.

2. Hanna, S R, "Rise and Condensation of Large Cooling Tower Plumes", Journal of Applied Meteorology 2:793-799, August, 1972.

3. Reisman, J I, "A Study of Cooling Tower Recirculation", Presented at 93rd Annual Meeting, American Society of Mechanical Engineers, November 26-30, 1972.

4. Turner, D B, Workbook of Atmospheric Dispersion Estimates, Environmental Protection Agency, Research Triangle Park, North Carolina, 1970.

5. Baker, K G, "Water Cooling Tower Plumes", Chemical and Engineering Process, January, 1967.

6. Tetens, O, Zeitschrife Fur Geophysik, Vol. II, 1930.

7. Leung, P, and Moore, R E, Water Consumption For Steam Power Plant Cooling Towers - A Heat and Mass Balance Method, Bechtel Corp., November, 1970.

8. Laskowski, S M, "Comparison of Environmental Effects Due to Operation of Either Natural Draft, Fan-Assisted Natural Draft or Round Mechanical Draft Cooling Towers at Oyster Creek Site", Pickard, Lowe & Garrick, Inc, July, 1977.

9. Ippen, A T, Estuary and Coastline Hydrodynamics, McGraw-Hill, Inc., 1966.

10. Pritchard, D, and Carpenter, "Recirculation and Effluent Distribution for Oyster Creek Site", Johns Hopkins University, 1964.

11. Patterson, W D, Leporati, J L, and Scarpa, M J, "The Capacity of Cooling Ponds to Dissipate Heat", Presented at 33rd Annual Meeting of the American Power Conference, April, 1971.

12. Woodward-Clyde Consultants, "The Physical Behavior of the Thermal Plume Discharged from the Oyster Creek Nuclear Generating Station", June 9, 1975.

13. Ballengee, D W, et al, "Data Report on Thermal Plume Surveys Conducted by Jersey Central Power and Light Company at the Oyster Creek Nuclear Generating Station, Barnegat Bay, New Jersey", JCP&L, 1976.

14. Ohori, G L, et al, "Data Report on Thermal Plume Surveys Conducted by Jersey Central Power and Light Company at the Oyster Creek Nuclear Generating Station, Barnegat Bay, New Jersey", JCP&L, 1977.

15. Carlson, J P, and Teplitzky, A, "Estimation and Impact of Environmental Noise from Natural Draft Cooling Towers", Noise Control Engineering, July-August, 1974.

16. Dyer, I, and Miller, L, "Cooling Tower Noise", Noise Control, pp 180-183, May, 1959.

17. Capano, G E, and Bradley, W E, "Noise Prediction Techniques for Siting Large Natural Draft and Mechanical Draft Cooling Towers", Presented at 78th Annual Meeting of the American Power Conference, April 20-22, 1976.

18. Barrett, S J C, Collected Papers on Aesthetics, Barnes and Noble, New York, New York, 1966.

19. Leopold, L B, et al, "A Procedure for Evaluating Environmental Impact", USGS Circular 645, Washington, DC, 1971.

20. McHarg, I L, Design with Nature, Doubleday & Company, Garden City, New York, 1969.

21. Kates, R, "The Pursuit of Beauty in the Environment", Landscape 16 (2):21-24.

22. Richards, B R, Rehm, A E, Bellmore, C I, and Hillman, R F L, Annual Report for the Period June 1, 1975 to May 31, 1976 on Woodborer Study Associated with the Oyster Creek Generating Station, Battelle Laboratories Annual Report 14729, 1976.

23. Turner, R D, "The Status of Systematic Work in the Teredinidae", Marine Boring and Fouling Organisms, Dixy Lee Ray, Editor, University of Washington Press, 1959.

24. Lane, L E, "Some Aspects of the General Biology of Teredo", Marine Boring and Fouling Organisms, Dixy Lee Ray, Editor University of Washington Press, 1959.

25. Turner, R D, "In the Path of a Warm, Saline Effluent", American Malocological Union, Inc. Bulletin for 1973, 1973.

26. Turner, R D, "Survey and Illustrated Catalog of the Teredinidae (Mollusca: Bivalvia)", Harvard University, 1966.

27. Murarka, I P, "A Model for Predicting Fish Impingement at Cooling Water Intakes", ANL/AA-8, Argonne National Laboratories, 1977.

28. Johns Hopkins University Applied Physics Laboratory and Chesapeake Bay Institute, "Synopsis of the Environmental Evaluation of the Proposed Brandon Shores Power Plant", Maryland Power Plant Siting Program, 1972.

29. Bernstein, L, "Effects of Salinity and Sodicity on Plant Growth", Annual Review of Phytopathology 13:295-312.

30. Roffman, A, et al, The State of the Art of Saltwater Cooling Towers for Steam Electric Generating Plants, 1973.

31. Boyce Thompson Institute, "Effects of Aerosol Drift Produced by a Cooling Tower at the Indian Point Generating Station on Native and Cultivated Flora in the Area", Consolidated Edison Company, New York (unpublished), 1974.

32. Mulchi, C L, and Armbruster, J A "Effects of Salt Sprays on the Yield and Nutrient Balance of Corn and Soybeans", Symposium Proceedings, Cooling Tower Environment - 1974, March, 1974.

33. Moser, B C, and Swain, R L, "Potential Effects of Salt Drift on Vegetation", JCP&L, 1971.

34. Moser, B C, "Airborne Sea Salt: Techniques for Experimentation and Effects on Vegetation", Symposium Proceedings, Cooling Tower Environment-1974, March, 1974.

35. Hindawi, I J, Raniere, L C, and Rea, J A, Ecological Effects of Aerosol Drift from a Saltwater Cooling System, EPA-600/3-76-078, Environmental Protection Agency, 1976.

36. McCune, D C, Silberman, D H, Mandl, R H, Weinstein, L H, Freudenthal, P C, and Giardina, D A, "Studies on the Effects of Saline Aerosols of Cooling Tower Origin on Plants", Presented at the 67th Annual Meeting of the Air Pollution Control Association, Denver, June 9-13, 1974.

37. LGL Limited, "An Examination of the Bird Impact Problem at the Nanticoke Plant of the Ontario Hydro Electric System, Phase II: August, 1972", 1972.

38. Blokpoel, H, "A Preliminary Study on Height and Density of Nocturnal Fall Migration", Studies of Bird Hazards to Aircraft, Canadian Wildlife Service Report Series 14, 95-104, 1971.

39. Overing, R, "The 1935 Fall Migration at the Washington Monument", Wilson Bulletin 48:222-224, 1936.

40. Rybak, E J, Jackson, W B, and Vessey, S H, "Impact of Cooling Towers on Bird Migration", Proceedings of the Sixth Bird Control Seminar, Bowling Green State University, 1973.

41. Bull, J, Birds of the New York Area, Harper and Row, New York, New York, 1964.

42. Williams, R E, and Jackson, W B, Semi-Annual Report for Bird Hazard Monitoring Contract, Davis-Besse Site, June, 1974, Bowling Green State University, 1974.

43. Mudge, J E, and Firth, R W, Jr, "Evaluation of Cooling Tower Effects: An Approach and Case History", Presented at 21st Annual Meeting of American Nuclear Society, New Orleans, 1975.

44. Gunn, W W H, Livingston, J A, and Lewis, F A, "A [illegible]liminary Examination of the Bird Impact Problem at the Nanticoke Plant, Ontario Hydro-Electric System", LGL Limited, 1971.

45. Title 10, United States Code of Federal Regulations, Part 50.

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 $T_{wb} = 74^{\circ}F$	$14^{\circ}F$
Cooling Range	$21.2^{\circ}F$
Circulating Water Flow	433 300 gpm
Circulating Water Temperature Entering/Leaving Cooling Tower	$109.2^{\circ}/88^{\circ}F$
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 $12^{\circ}F$. 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 $16^{\circ}F$. 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 $16^{\circ}F$, 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 $21.2^{\circ}F$. 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	30×10^6
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:

	gpm
Design Conditions (T_{wb} = 74°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:

Ambient Conditions	Condenser Pressure in. HgA	Turbine-Generator MW	Net Plant Output, MW
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 (Amertap) 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 Date" (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:

	LOCATION (miles in stated direction)	CONCENTRATION ($\mu g/m^3$)
Annual		
Oyster Creek	1.0 East-southeast	.07
Oyster Creek plus Forked River	3.0 North	.09
Summer		
Oyster Creek	3.0 North	.08
Oyster Creek plus 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:

	LOCATION (miles in stated direction)	DEPOSITION RATE (kg/km^2-month)
Annual		
Oyster Creek	.50 East-southeast	80
Oyster Creek plus Forked River	.75 Southeast	109
Summer		
Oyster Creek	.50 North	73
Oyster Creek plus 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 OCNGS 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, pla t 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 (SO_4) concentration above the makeup water SO_4 concentration by 20 ppm. This increase would be negligible (1.1%) when compared to the average 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.(2) 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.(3)

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 Center Frequency (Hz)	31.5	63	125	250	500	1K	2K	4K	8K	A Scale
Sound Pressure Level (dB) Re - 0.0002 Microbars	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. <u>Visual Effects</u>

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 diamter 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 (ΔT), 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[4], and breeding temperatures from Culliney[5] for *B gouldi*. For *T navalis* temperature limits were based on the work of Bulatov.[6]

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 OCNGS), 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 OCNGS 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[4] 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[4, 7], and for the latter it is 5-32 ppt[8]. 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[7]. 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[9] 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.[5] 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[8, 10, 11], although the relationship between DO and teredo remains somewhat unclear[12]. Measured DO levels in Oyster Creek have always been at or near saturation[13, 14]. 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)[14]. 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.[15]

Field and map determinations indicate that approximately 84,000 linear feet of wood bulkheading, dockage, and piers exist in the vicinity of the OCNGS[16]. Exhibit 174 shows where this wood is located, and the

following table summarizes the quantities involved:

Location	Linear Feet	Notes
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	11,550	
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°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 menhadem 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^3) 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 OCNGS 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[14]. 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[17] and indirectly noted elsewhere through the use of intermediary variables such as temperature changes and tidal movements[18, 19].

Impingement data for the OCNGS, 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 [20]. 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,

$$\text{Log}\,(I_c) - \text{Log}\,(I_o) = -\ .95\ xf/115{,}000$$

$$= -3.8\ x \text{ at maximum flow.}$$

The correction factor is that fraction c 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 x 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 impingement = m log 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 kg/km^2/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 kg/km^2/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 kg/km^2/month would still be well below the threshold for toxic soil salinity, 4,670 kg/km^2/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 kg/km^2/month

(Reference 22, p 35) plus a maximum cooling tower contribution of 109 kg/km^2/month would mean a maximum annual total deposition rate of 360 - 520 kg/km^2/month. Studies at the University of Maryland have identified a dry deposition rate of 1,100 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 OCNGS.

The predicted maximum summer season concentration from combined operation of Oyster Creek and Forked River cooling towers would be 0.13 $\mu g/m^3$. Background concentrations in the vicinity of this maximum average near 2-3 $\mu g/m^3$ (see Figure 23 of Reference 22). By comparison, average summer concentrations of 40 $\mu g/m^3$ 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(23) as injurious to sensitive vegetation of Island Beach State Park. Moser found that concentrations of 60 $\mu g/m^3$, 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

REFERENCES

1. New Jersey State Soil Conservation Committee, Soil Erosion and Sediment Control in New Jersey, New Jersey Department of Agriculture, 1974.

2. Jersey Central Power and Light Company, Environmental Report, Oyster Creek Nuclear Generating Station, 1969.

3. Environmental Engineers Handbook, Volume 1: Water Pollution, B G Liptak, Editor, Chilton Book Company, Radmor, Pennsylvania, 1974.

4. Turner, R D, "In the Path of a Warm Saline Effluent", American Malocological Union, Inc. Bulletin for 1973, pp. 36-41, 1973.

5. Culliney, J L, Larval Biology and Recruitment of the Shipworms Teredo Navalis and Bankia Gouldi in the Newport Estuary, North Carolina, Ph. D. Dissertation, 1970.

6. Bulatov, G A, "Response of the Larvae of the Black Sea Teredo Navalis (L) to Different Water Temperatures", Compt. Rend. (Doklady) de l'Acad. des Sci. USSR (A S) 32(4): 291-292,1941.

7. Sheltema, R S, and Truitt, R U, "The Shipworm Teredo Navalis in Maryland Coastal Waters", Ecology 3F: 841-843.

8. Blum, H F, "On the Effects of Low Salinity on Teredo Navalis", Third Annual Progress Report of San Francisco Bay Marine Piling Survey, pp 349-368, 1923.

9. Turner, R D, Survey and Illustrated Catalog of the Teredinidae (Mollusca: Bivalvia), Harvard University, 1966.

10. Lane, C E, "Some Aspects of the General Biology of Teredo", Marine Boring and Fouling Organisms, Dixy Lee Ray, Editor, University of Washington Press, 1959.

11. Trussell, P C, "Teredine Borers", Sea Frontiers - Magazine of the International Ocean Foundation 13(4): 235-243, 1967.

12. Richards, B R, Personal Communication, 1977.

13. Richards, B R, Rehm, A E, Bellmore C I, and Hillman, R E, "Woodborer Study Associated with the Oyster Creek Generating Station", Battelle Laboratories Annual Report 14729, 1976.

14. Ichthyological Associates, Inc., Preliminary Final Report of Ecological Studies for the Oyster Creek Generating Station, September, 1975 - August, 1976, 1977.

15. Nelson, T C, "The European Pileworm, a Dangerous Marine Borer in Barnegat Bay, New Jersey", New Jersey Agriculture Experimental Station, 1922.

16. Letter from J H Bennet to T M Crimmins, Jr, August 8, 1974 (S&L-2575).

17. Envirospnere Company, Demonstration of Best Technology Available for Minimizing Adverse Environmental Impact with Respect to Cooling Water Intake Design for Niagara Mohawk Power's Lake Erie Generating Station, Niagara Mohawk Power Company, Syracuse, New York, 1977.

18. Ichthyological Associates, Inc., Ecological Study of the Delaware River in the Vicinity of the Edge Moor Power Station, Delmarva Power and Light Company, Wilmington, Delaware (Series of Progress Reports Dated January, 1974 to September, 1975).

19. Texas Instruments, Inc., Indian Point Impingement Study Report, January 1, 1975 through December 31, 1975, Consolidated Edison Company, New York, New York, 1976.

20. Trent, L, Pullen, E J, and Proctor, R, "Abundance of Macrocrustaceans in a Natural Marsh and a Marsh Altered by Dredging, Bulkheading, and Filling", Fish Bulletin 74(1): 195-200.

21. Brehmer, M L, Virginia Electric Power Company, Personal Communication, 1977.

22. Jersey Central Power and Light Company, Environmental Report, Construction Permit Stage, Forked River Nuclear Generating Station, Unit No. 1, 1972.

23. Moser, B C, and Swain, R L, "Potential Effects of Salt Drift on Vegetation", Jersey Central Power and Light Company, 1971.

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, ^{o}F	96^{o}
Exit Air Volume per Fan, cfm	1.026×10^{6}
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:

	gpm
Design Conditions ($T_{wb} = 74^{o}F$)	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 coolin 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:

Ambient Conditions	Condenser Pressure in. HgA	Turbine-Generator MW	Net Plant Output, MW
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°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 Adjustments for Differential Net Capability & 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 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.

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:

	LOCATION (miles in stated direction)	CONCENTRATION ($\mu g/m^3$)
Annual		
Oyster Creek	1.0 East-southeast	0.80
Oyster Creek plus Forked River	1.0 East-southeast	0.86
Summer		
Oyster Creek	1.5 North-northeast	0.68
Oyster Creek plus 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:

	LOCATION (miles in stated direction)	DEPOSITION RATE (kg/km^2 - month)
Annual		
Oyster Creek	1.0 East-southeast	511
Oyster Creek plus Forked River	1.0 East-southeast	570
Summer		
Oyster Creek	1.5 North-northeast	502
Oyster Creek plus 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 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	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°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 kg/km^2/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 kg/km^2/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 .. $/km^2$/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 kg/km^2/month. It would also be within the range (1,100-2,200 kg/km^2/month) identified by Bernstein[3] 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 kg/km^2/month, yielding an expected maximum total deposition rate between 820 and 970 kg/km^2/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 kg/km^2/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 $\mu g/m^3$. Background sea salt concentration occurring in the area of the maximum is about 2 $\mu g/m^3$, indicating that total airborne salt concentrations would be roughly 3 $\mu g/m^3$. 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 '89, 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 $\mu g/m^3$.

The 30 - 55 $\mu g/m^3$ short term peak concentration should be compared to a threshold level of 60 - 100 $\mu g/m^3$ (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

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.

3. Bernstein, L, "Effects of Salinity and Sodicity on Plant Growth", Annual Review of Phytopathology 13:295-312, 1975.

4. Jersey Central Power and Light Company, Environmental Report, Construction Permit Stage, Forked River Nuclear Generating Station, Unit No. 1, 1972.

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°F	14°F
Cooling Range	20.0°F
Circulating Water Flow	458 400 gpm
Circulating Water Temperature Entering/Leaving Cooling Tower	108°/88°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°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°F to 21.2°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°F and a cooling range of 20°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, ^oF	100^oF
Exit Air Volume per Tower, cfm	15.8×10^6
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.

	gpm
Design Conditions ($T_{wb} = 74^oF$)	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:

Ambient Conditions	Condenser Pressure in HgA	Turbine-Generator MW	Net Plant Output, MW
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 Subsection 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 Adjustments for Differential Net Capability & 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 southeast 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:

	LOCATION (mi in stated direction)	CONCENTRATION ($\mu g/m^3$-month)
Annual		
Oyster Creek	2.5 East-southeast	0.20
Oyster Creek plus Forked River	3.5 East-southeast	0.25
Summer		
Oyster Creek	2.5 North	0.22
Oyster Creek plus 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:

	LOCATION (mi in stated direction)	DEPOSITION ($kg \cdot km^{-2} \cdot month$)
Annual		
Oyster Creek	.75 East-southeast	110
Oyster Creek plus Forked River	3.5 East-southeast	110
Summer		
Oyster Creek	2.5 North	110
Oyster Creek plus 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 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	[illegible]

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° 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 kg/km^2/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 kg/km^2/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 kg/km^2/month (including both wet and dry deposition). On land, at those locations where predicted levels are almost as high as 110 kg/km^2/month, background rates are expected to range from 300 to 1,000 kg/km^2/month. Total salt deposition, background and tower, is not expected to exceed 1,100 kg/km^2/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 kg/km^2/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 $\mu g/m^3$. 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 $\mu g/m^3$. 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.

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 $\mu g/m^3$, which is below the short-term threshold level of 60-100 $\mu g/m^3$ 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 $33,313,000 and the total comparable annual system cost, including adjustments for differential net capability and net annual generation, was estimated to be $ 9,131,000. Co- : frr 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°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 isotherm [illegible] 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 NGS has already verified that no severe water quality impacts to Barnegat Bay have resulted.[1] 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.[2] 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.[1, 3] 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 Center Frequency (Hz)	31.5	63	125	250	500	1K	2K	4K	8K	A Scale
Sound Pressure Level (dB) 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. <u>Visual Effects</u>

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. <u>Aquatic Ecology Effects</u>

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 ΔT's range from 4° to $11^{\circ}C$. 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 ΔT's of $20\text{-}30^{\circ}C$.

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 ΔT, 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 ΔT'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 ΔT'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 ΔT'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.(4) 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 OCNGS 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:

	All Sums in Millions of Dollars		
	Total Estimated Investment Cost, $\$ \times 10^6$	Comparable Annual System Cost, $\$ \times 10^6$	
		Total	Differential
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,[illegible]00,000/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°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:

Cooling Tower Type	Construction Time, Months
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.).

APPENDICES

TABLE OF CONTENTS

APPENDICES

APPENDICES

LIST OF EXHIBITS

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:

Description of Cooling System	Comment
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.

Description of Cooling System	Comment
(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.

Description of Cooling System	Comment
	Plant Net Generation with the existing cooling system was used as base value.
Annual Fixed Charges, $/yr	- The total Estimated Investment Cost has been defined. This cost multiplied by an Annual Fixed Charge Rate is equal to the Annual Fixed Charges.
Annual Plant and Cooling Water System Fuel Costs, $/yr	- 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.

Description of Cooling System	Comment
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 levelized cost times the levelized 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 levelized 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 (FWPCAA) of 1972 (PL92-500). The FWPCAA 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 $32^{\circ}F$ or less.

The rise of the moist buoyant tower effluent was calculated using the Briggs[1] plume rise equation for a dry gas as modified by Hanna[2] 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:

$$h_r = 1.6\, F_o^{1/3}\, (3.5\, X^*)^{2/3}/U \qquad (1)$$

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:

$$F_o = g W_o R_o^2 \left[\frac{T_{vpo} - T_{veo}}{T_{vpo}} \left(q_{po} - q_{eo} \right) \frac{L}{C_p T_{po}} \right] \quad (4)$$

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 (^oK),
- T_{veo} is the initial virtual temperature of environment (^oK),
- 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 ^oK), and
- T_{po} is the initial temperature of plume (^oK).

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:

$$X_f = 3.5X^* (m) \quad (5)$$

At distances closer than X_f, the plume rise was defined by:

$$h_r = 1.6 F_o^{1/3} X^{2/3} / U \qquad (6)$$

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[1] and modified by Hanna[2]. For other than very low wind speeds, the plume rise can be calculated by:

$$h_r = 2.9 (F_o/US)^{1/3} \qquad (7)$$

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 ($^oK/m$).

The following potential temperature gradients were used in Equation (7):

Stability Class	Potential Temperature Gradient ($^oK/m$)
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:

$$h_r = 5.0 \, F_o^{1/4} / X_f^{3/8} \qquad (8)$$

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:

$$X_f = 3.14 \left(\frac{U}{S}\right)^{1/2} \qquad (9)$$

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:

$$U = U_s \left(\frac{h_t}{h_s}\right)^p \qquad (10)$$

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 [3]. 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[1]:

$$h_d = 3(15 - W_o/U)D \qquad (11)$$

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:

$$h = h_t + h_r - h_d \qquad (12)$$

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 (4):

$$\chi = \frac{Q}{\pi \sigma_y \sigma_z U} \exp \left[-0.5 \left(\frac{h}{\sigma_z} \right)^2 \right] \qquad (13)$$

where:

- X = water vapor density at a given downwind distance from the tower (gm/m^3),
- Q = vapor release rate from a tower (gm/sec),
- σ_y = horizontal diffusion coefficient (m),
- σ_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 (5).

$$X_p = 5.7 \left[\frac{G}{102 \pi V} \right]^{1/2} \left[\frac{T_E - T_I}{T_p - T_I} - 1.0 \right]^{1/2} \qquad (14)$$

where:

- X_p = visible plume length (feet),
- G = total vapor rate from tower (m^3/hr),

V = wind speed (feet/sec),

T_E = temperature of plume at exit from tower (°C),

T_I = ambient temperature (°C), and

T_p = temperature at end of visible plume (°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:

$$r_e = 0.622 \; e_s / (P - e_s) \qquad (15)$$

where:

e_s is the saturation vapor pressure (lb/ft^2), and
P is the atmospheric pressure (lb/ft^2).

2. The saturation vapor pressure (e_s) was obtained using Tetens[6] equation:

$$e_s = 0.08864 \times 10^B \qquad (16)$$

where:

$$B = (715) \left[0.55 \; (T_E - 32)/237.3 + 0.55 \; (T_E - 32)\right] \qquad (17)$$

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 psychometric mixing process. The process is expressed by the following:

$$r_e = r_I + \frac{r_p - r_I}{T_p - T_I}(T_E - T_I) \qquad (18)$$

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 (^oF),
T_p is the plume exit temperature (^oF), and
T_E is the temperature at end of visible plume (^oF).

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[7] 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 OCNGS 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

1. Briggs, G A, Plume Rise, AEC Critical Review Series, TID-25075, National Technical Information Service, Springfield, Virginia, November 1969 .

2. Hanna, S R, "Rise and Condensation of Large Cooling Tower Plumes," Journal of Applied Meteorology, Vol. II, August 1972, pp. 793-799.

3. Reisman, J I, "A Study of Cooling Tower Recirculation." Presented at the ASME 93rd Annual Meeting, November 26-30, 1972, 30 pp.

4. Turner, D B, Workbook of Atmospheric Dispersion Estimates, Office of Air Programs, Environmental Protection Agency, Research Triangle Park, North Carolina, 1970 .

5. Baker, D G, "Water Cooling Tower Plumes," Chemical and Engineering Process January 1967.

6. Tetens, O, Zeitschrife Fur Geophysik, Vol II, 1930 .

7. Leung, P and R E Moore; Water Consumption For Steam Power Plant Cooling Towers-A Heat and Mass Balance Method, Bechtel Corp., November, 1970.

n/e/r/a
NATIONAL ECONOMIC RESEARCH ASSOCIATES, INC.
NEW YORK / WASHINGTON / PHILADELPHIA / LOS ANGELES / BOSTON

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

TABLE OF CONTENTS

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. These 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. Larger 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[1]

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

---

[1] 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.

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.[2] Estimated reductions were expressed in terms of gains in species population weight for all species with recognized commercial and/or recreational value.[3] 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

---

[2] 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.

[3] 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.

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.

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[a]

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,

---

[a] 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.

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 \$1[illegible].4 thousand in the best case to \$82.8 thousand in the worst case with a most likely estimate of \$50.[illegible] thousand for the natural draft tower. In the case of the fan-assisted natural draft 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 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 costs of meeting the noise regulations[5] 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

[5] 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.

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.

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 Ser[illegible] survey (1976) undertaken in 1973-74 estimated th[illegible] percent of the participants in marine recreation[illegible] were New Jersey residents. Since estimated recre[illegible] benefits constitute from 13.7 to 15.4 percent of [illegible] aquatic benefits, this suggests that roughly 7 perce[illegible] these total benefits accrue to out-[illegible]-state res[illegible].

The capital and operating costs of the fo[illegible] natives 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).[6] 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.

---

[6] 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 d-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, [illegible] increases in their populations could indirectly incr[illegible] benefits through beneficial effects on the populati[illegible] higher in the food chain, the state of the ar[illegible]ficiently 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.[7] Estimates of average juvenile

---

[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.

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 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 <u>net</u> 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:

$$\ln \frac{\text{Fishing Days}}{\text{Population}} = 1.655 - \underset{(.129)}{.259} \frac{\text{Expenditures}}{\text{Day}} \qquad [1]$$

R^2 = .365 (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 fishermen 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:

$$\frac{\text{Value}}{\text{Pounds}} = \frac{\text{Value}}{\text{Day}} \div \frac{\text{Pounds}}{\text{Day}} \qquad [2]$$

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.[8]

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

---

[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.

specific rates where the weights were based on Ebasco's (1977a) assumption of 138 hours of natural fog in the area. Thus,

$$\text{Accident Rate} = \frac{138}{8760} \times (\text{accident rate, fog}) + \frac{8622}{8760} \times (\text{accident rate, non-fog}) \quad [3]$$

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,[9] 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 is 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

---

[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).

period, vehicle miles traveled in the impacted road sections were allowed to grow at a rate of 4 percent annually.[10] 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.

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

---

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 Planning.

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.[11] 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.

---

[11] Conversation with Thomas Keenan of the New Jersey Department of Transportation, Bureau of Traffic Engineering.

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 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[12] and vehicle occupancy rates of 1.5 persons per automobile and 1.0 persons per truck.[13]

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.

---

[12] Based on correspondence with Mr. Joseph Kanda, New Jersey Department of Transportation, Bureau of Data Resources.

[13] 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.

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:

Fatalities	Injuries
Valuation of Life	Market and Home Production
Community Production	Community Production
Hospital Costs	Hospital and Rehabilitation Costs
Physician, Coroner, 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 Damage Costs	Vehicle Damage Costs
Traffic Delay Costs	Traffic Delay Costs

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. The estimates of these costs were replaced with a single value designed to reflect the compensation that a group of individuals must be paid to assume increased risks of mortality.[14]

---

[14] 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 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.

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 scaled 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 ti[illegible] 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 1[illegible] 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 11; 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 corrosive, low alloy steels, aluminum and aluminum-based alloys,[15] copper and copper-based 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.[16]

---

[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).

[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.

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.[17]

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

[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).

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 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,

$$\Delta RCR_{ij} = \beta_j \Delta S_i \qquad [4]$$

where, $\beta_j = \frac{\Delta RCR_{KBj}}{\Delta S_{KB}}$,

ΔRCR_{ij} = change in relative corrosion rate of the jth metal associated with the operation of cooling tower alternative i,

ΔS_i = estimated average change in salt deposition rates in the impact zone resulting from operation of cooling tower alternative i,

ΔS_{KB} = the difference in rates of salt deposition at the Kure Beach, North Carolina, 80-foot and 800-foot sites, and

ΔRCR_{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,

$$\Delta C_{ij} = \frac{\Delta RCR_{ij}}{\Delta RCR_j} \times \Delta C_j \qquad [5]$$

where, ΔC_{ij} = the incremental cost of increased corrosion to the jth metal associated with the operation of cooling tower alternative i,

ΔRCR_{ij} = the change in relative corrosion rate of the jth metal associated with the operation of cooling tower alternative i,

ΔRCR_{j} = change in relative corrosion rate of the jth metal between polluted environment (New York City) and unpolluted environment (State College, Pennsylvania), and

ΔC_{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 judgments.

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.[18] 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

---

[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.

versus an unpolluted environment.[19,20] 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

---

[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 Mäler 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.

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 rural population in 1970; in all other instances, national stocks were adjusted by the ratio of impact-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 are 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 to a number 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 then 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:

$$\ln MV = \underset{(0.3610)}{-0.5799} + \underset{(1.4041)}{0.0286\, T} - \underset{(6.8419)}{0.7907\, Z} + \underset{(18.5725)}{0.8611 \ln AV} \quad [6]$$

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 Lacy 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.[21] 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

---

[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.

dollars, of relocation for a one-family 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

	Canal-to-Bay Discharge	Natural Draft Tower	Fan-Assisted Natural Draft Towers	Round Mechanical Draft Towers
	(Thousands of Dollars)			
	(1)	(2)	(3)	(4)
Capital Costs:				
Circulating Water System	7,523	13,484	12,823	12,463
Replacement of Capacity Loss	128	857	1,111	1,017
Operating Costs:				
Fuel	1,057	5,265	6,428	6,424
Maintenance	338	606	785	748
Water	85	156	156	155
Total	9,131	20,368	21,303	20,807

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.

n/e/r/a

TABLE 1

SUMMARY OF THE LEVELIZED ANNUAL ENVIRONMENTAL BENEFITS AND COSTS
FROM OPERATION OF ALTERNATIVE COOLING SYSTEMS

Benefit/Cost Category	Natural Draft Tower: Best Case	Natural Draft Tower: Most Likely Case	Natural Draft Tower: Worst Case	Fan-Assisted Natural Draft Towers: Best Case	Fan-Assisted Natural Draft Towers: Most Likely Case	Fan-Assisted Natural Draft Towers: Worst Case	Round Mechanical Draft Towers: Best Case	Round Mechanical Draft Towers: Most Likely Case	Round Mechanical Draft Towers: Worst Case
	(Thousands of Dollars)								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Aquatic Benefits									
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
Total	19.5	11.7	3.9	19.5	11.7	3.9	19.5	11.7	3.9
Fog/Ice Costs									
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	-	-	-
Total	0.0	0.6	0.0	0.2	0.2	0.3	-	-	-
Salt Deposition Costs									
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
Total	41.6	73.8	106.0	65.8	117.1	168.4	68.6	122.3	175.9
Noise Costs									
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
Total	68.0	68.3	68.6	1,142.0	1,145.1	1,148.2	1,142.0	1,145.1	1,148.2
Total Benefits Less Costs	-90.1	-130.4	-170.7	-1,188.5	-1,250.7	-1,313.0	-1,191.1	-1,255.7	-1,320.2

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.

n/e/r/a

TAB. 2

SUMMARY OF THE AGGREGATE LEVELIZED ANNUAL BENEFITS AND COSTS FROM OPERATION OF ALTERNATIVE COOLING SYSTEMS

	Total Benefits	Total Costs		Total Benefits Less Costs
	Environmental	Environmental	Capital and Operating	
	(Thousands of Dollars)			
				(1)-(2)-(3)
	(1)	(2)	(3)	(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,[illegible]58	-20,458
Most Likely Case	12	142	20,3[illegible]	-20,498
Worst Case	4	175	20,368	-20,53[illegible]
Fan-Assisted Natural 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 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, IMPINGMENT AND COLD SHOCK MORTALITIES RESULTING FROM REPLACEMENT OF EXISTING OCNGS COOLING SYSTEM WITH CLOSED-CYCLE ALTERNATIVES, BY SELECTED SPECIES

	Entrainment Total Weight		Impingement Total Weight	Cold Shock Total Weight	
	Maximum	Minimum		Maximum	Minimum
	(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 impingment 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.

TABLE 5

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 1970 Catch		Value per Pound[1]				Weighted Value per Pound	
	Commercial	Recreational	Commercial		Recreational		High	Low
			High	Low	High	Low		
			(dollars per Pound)					
							[(1)x(3)+(2)x(5)]÷100	[(1)x(4)+(2)x(6)]÷100
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Atlantic Menhaden	100.00	0.00	0.0229	0.0114	n.c.	n.c.	0.0229	0.0114
Blue Fish	3.[illegible]	96.08	0.0922	0.0461	0.1271	0.0635	0.1257	0.0628
Summer Flounder	43	56.11	0.3235	0.1618	0.4452	0.2226	0.3918	0.1959
Weakfish	30.	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[2]	100.00	0.00	0.2219	0.1110	n.c.	n.c.	0.2219	0.1110

n.c. - Denotes "not calculated."

[1] 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.

[2] 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

	Fishing Days per Capita	Ln Fishing Days per Capita	Expenditures per Day (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	19.56
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 <u>1970 Survey of Fishing and Hunting</u>, <u>op</u>. <u>cit</u>.

TABLE 7

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 Route 9 Impacted (Miles)	Additional Hours of Fog		Additional Hours of Ice	
		Round Mechanical Draft Towers	Fan-Assisted Natural Draft Towers	Round Mechanical Draft Towers	Fan-Assisted Natural Draft Towers
	(1)	(2)	(3)	(4)	(5)
Direction from Towers					
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 Accidents	Fatal and Injury Accidents	Property Damage Only Accidents	Accident Rates per Million Vehicle Miles[1] Low	Most Likely	High
	----(Per Accident)----					
			(1)-(2)			
	(1)	(2)	(3)	(4)	(5)	(6)
Weather Conditions:						
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)[2]	0.0038*	-0.0116*	0.0116*	-0.285	0.000	1.765
Road Conditions:						
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)[2]	-0.0030**	-0.0969*	0.0969*	n.c.	0.000	n.c.

n.c. - denotes "not calculated."

[1]Accident rates are estimated for Route 9, Lacey Township in 1984. See text for further explantion.
[2]*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.

TABLE 8

COST ESTIMATES FOR ACCIDENT DAMAGES
1975 DOLLARS

Cost Category	Fatality Accident (1)	Injury Accident (2)	Property Damage Only Accident (3)
Value of Life[1]	$437,436.00	$ 0.00	$ 0.00
Market/Home Production[1]	0.00	531.44	0.00
Community Production[1]	5,675,94	19.56	0.00
Losses to Others[1]	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	66.41	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.

[1] 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.

TABLE 10

COST ESCALATION RATES FOR ACCIDENT DAMAGES

Cost Category	Cost Escalation Rates (Percent) (1)	Basis for Escalation (2)
Value of Life	7.50	Average annual earnings of male full-time workers[1]
Market/Home Production	6.36	Average annual earnings of all workers[1]
Community Production	6.36	Average annual earnings of all workers[1]
Losses to Others	6.36	Average annual earnings of all workers[1]
Hospital Rehabilitation	5.95	Consumer Price Index (CPI), Hospital Service Charges[2]
Physician/Coroner/Medical Examiner	5.54	CPI, Physician Fees[2]
Emergency Transport	5.49	CPI, Medical Care[2]
Legal Costs	6.67	CPI, Legal Services (short form will)[2]
Court Costs	7.40	Average state and local government, nonschool (other) wages and salaries[3]
Insurance Administration	3.93	CPI, Automobile Insurance Premiums[2]
Vehicle Damage	5.99	CPI, Automobile Repair and Maintenance[2]
Traffic Delays:		
Automobile	10.61	Average annual earnings of all workers[1,4]
Trucks	12.14	Average hourly earnings of male truck drivers, Metropolitan Northeast.[2,4]

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.

[1] U.S. Bureau of the Census, Current Population Reports, Series P-60, Nos. 60 and 105.
[2] U.S. Bureau of Labor Statistics, Handbook of Labor Statistics, Washington, 1976.
[3] U.S. Bureau of Economic Analysis, unpublished data.
[4] Underlying cost escalation rate scaled upward by a factor of 1.64 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 Deposition Rate (Kg/Km /month)	Two Fan-Assisted Natural Draft Cooling Towers	Natural Draft Cooling Tower	Two Round Mechanical Draft 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 Salt Deposition 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 in Impact Zone[2] (1975) (Sq. Ft.)	Extra Annual Maintenance Costs per Unit of Exposed Area[1]: Natural Draft Tower	Fan-Assisted Natural Draft Towers	Round Mechanical Draft Towers	Extra Annual Maintenance Costs: Natural Draft Tower	Fan-Assisted Natural Draft Towers	Round Mechanical Draft Towers
		(1975 Dollars)					
					(1)x(2)	(1)x(3)	(1)x(4)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Steel Systems							
Tanks:							
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
Street Lighting Fixtures:							
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
Galvanized Roofing, Siding, Roof Drainage							
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
Structural Steel - External Use:							
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
Metal Doors:							
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
Prefabricated and Portable Steel Buildings, Roofing and Siding:							
Industrial	4,557,468	0.00015	0.00024	0.00025	684	1,094	1,135
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[3]	n.c.	n.c.	n.c.	n.c.	422	666	693
Total	n.c.	n.c.	n.c.	n.c.	6,871	13,994	14,548

n.c. - Denotes "not calculated."

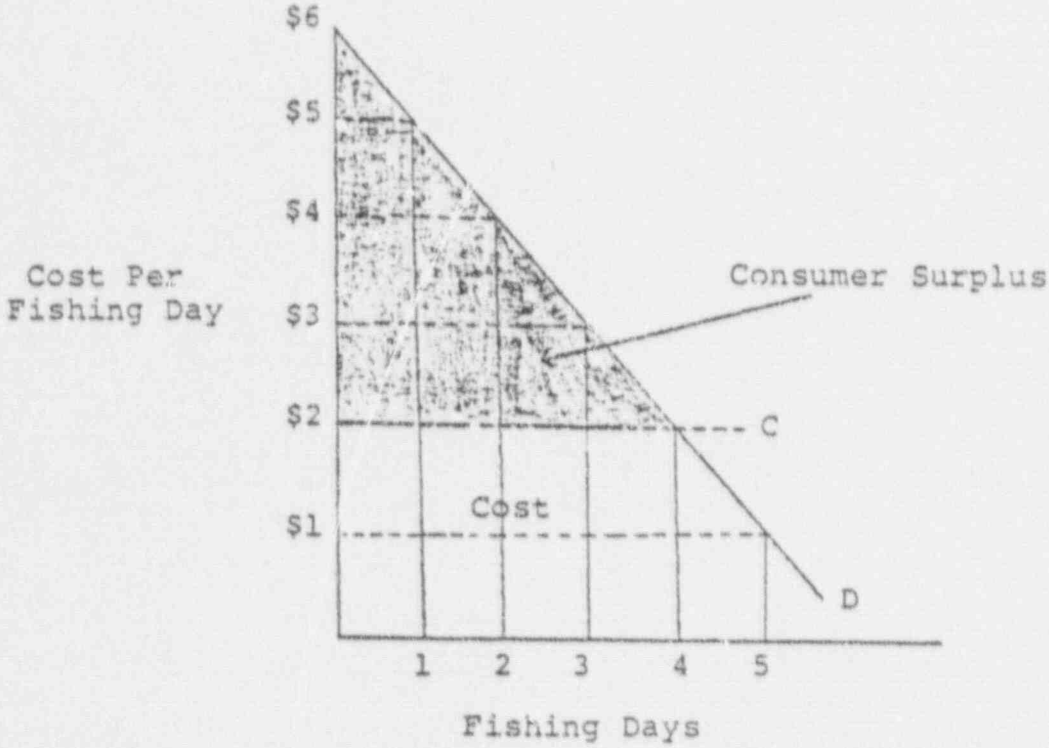
[1]Estimates derived from those presented by Fink, et. al. (1971). Expressed in terms of levelized annual values based on present values for 1975 calculated using an 11.22 percent discount rate.
[2]Based on 1970 national stock estimates from Fink, et. al. (1971). National estimates were inflated to 1975 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.
[3]Cost estimates assumed to be 5 percent of other materials-damage costs. (See Gillette, 1974.)

TABLE 13

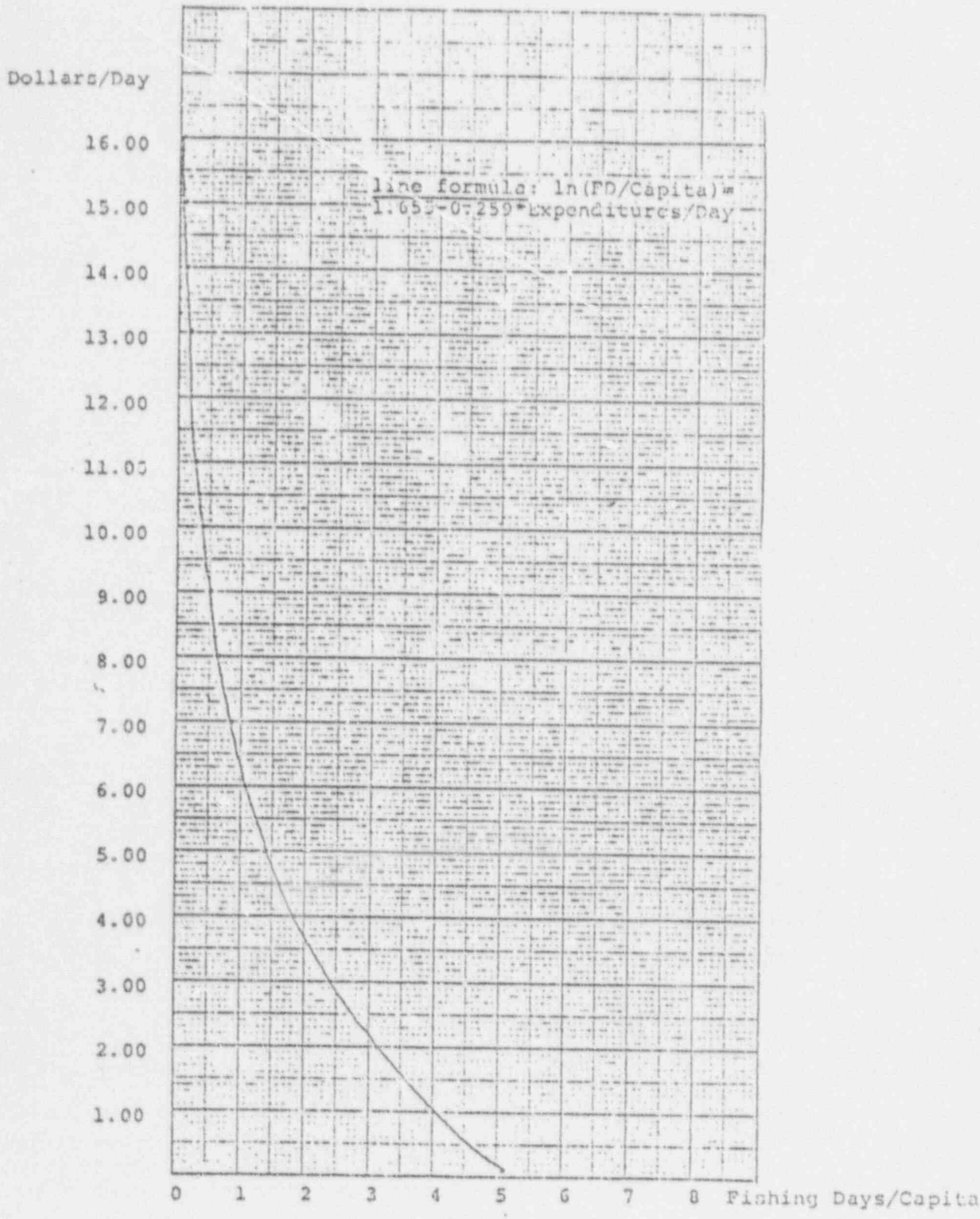
n/e/r/a

FIGURES

A HYPOTHETICAL DEMAND CURVE
FOR RECREATIONAL FISHING

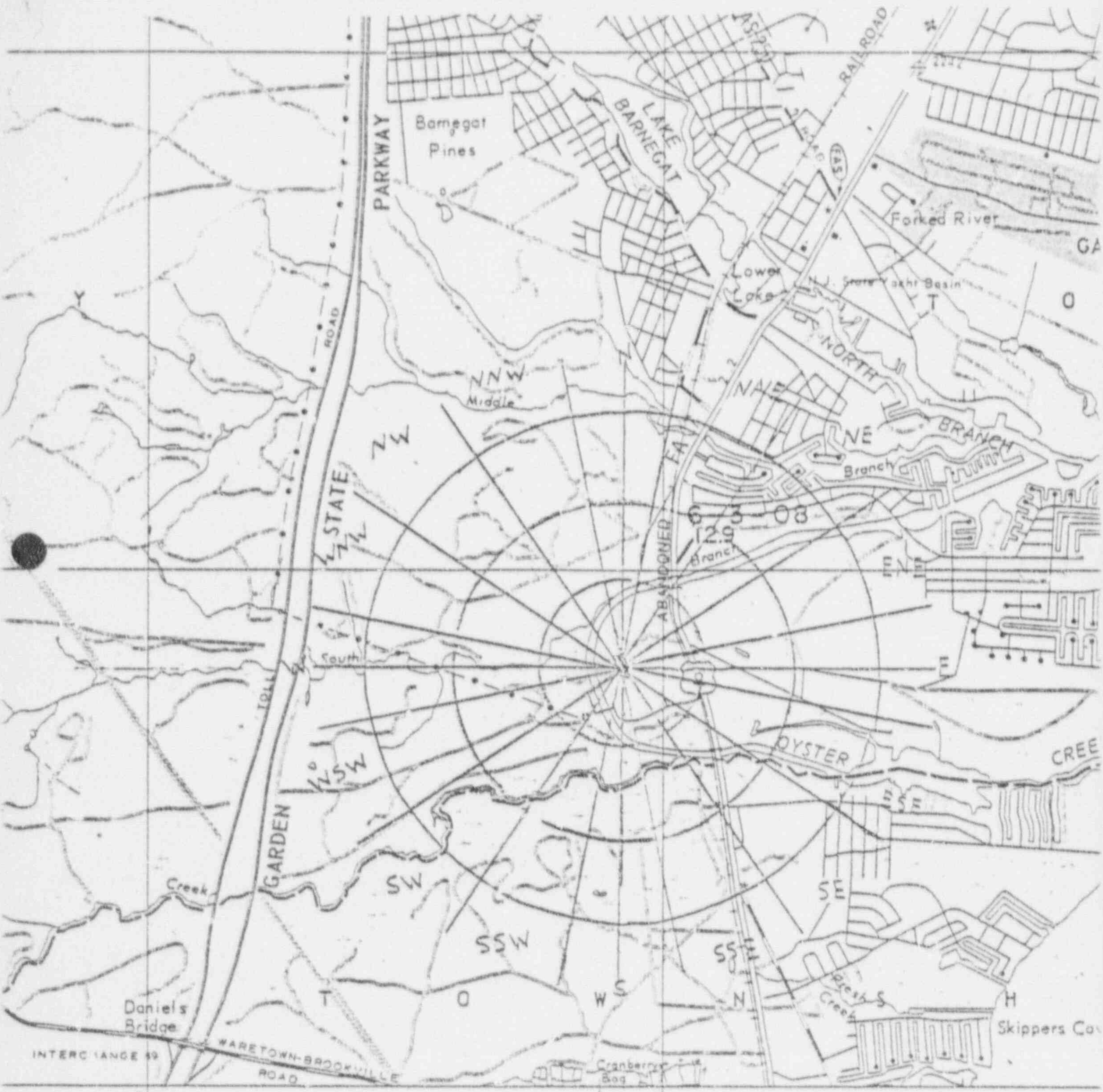


DEMAND FOR SALTWATER FISHING AS A FUNCTION
OF COST OF FISHING PER DAY



Source: NERA Estimates.

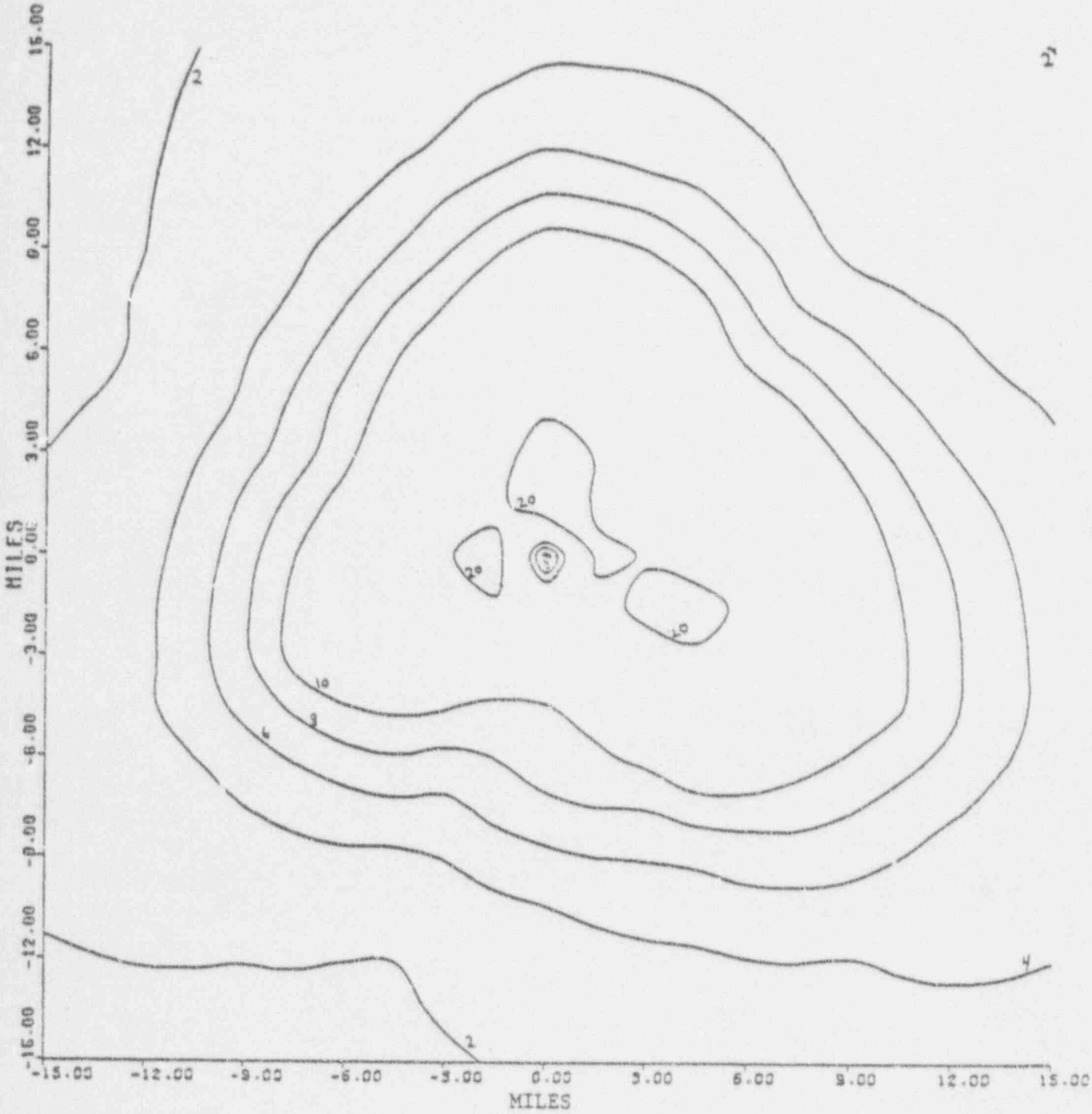
FOG AND ICE IMPACT AREAS:
FAN-ASSISTED NATURAL DRAFT
AND ROUND MECHANICAL DRAFT TOWERS



Note: Concentric circles with radii equal to 500, 1000 and 1500 meters.

Source: Ebasco Services, Inc. (1977).

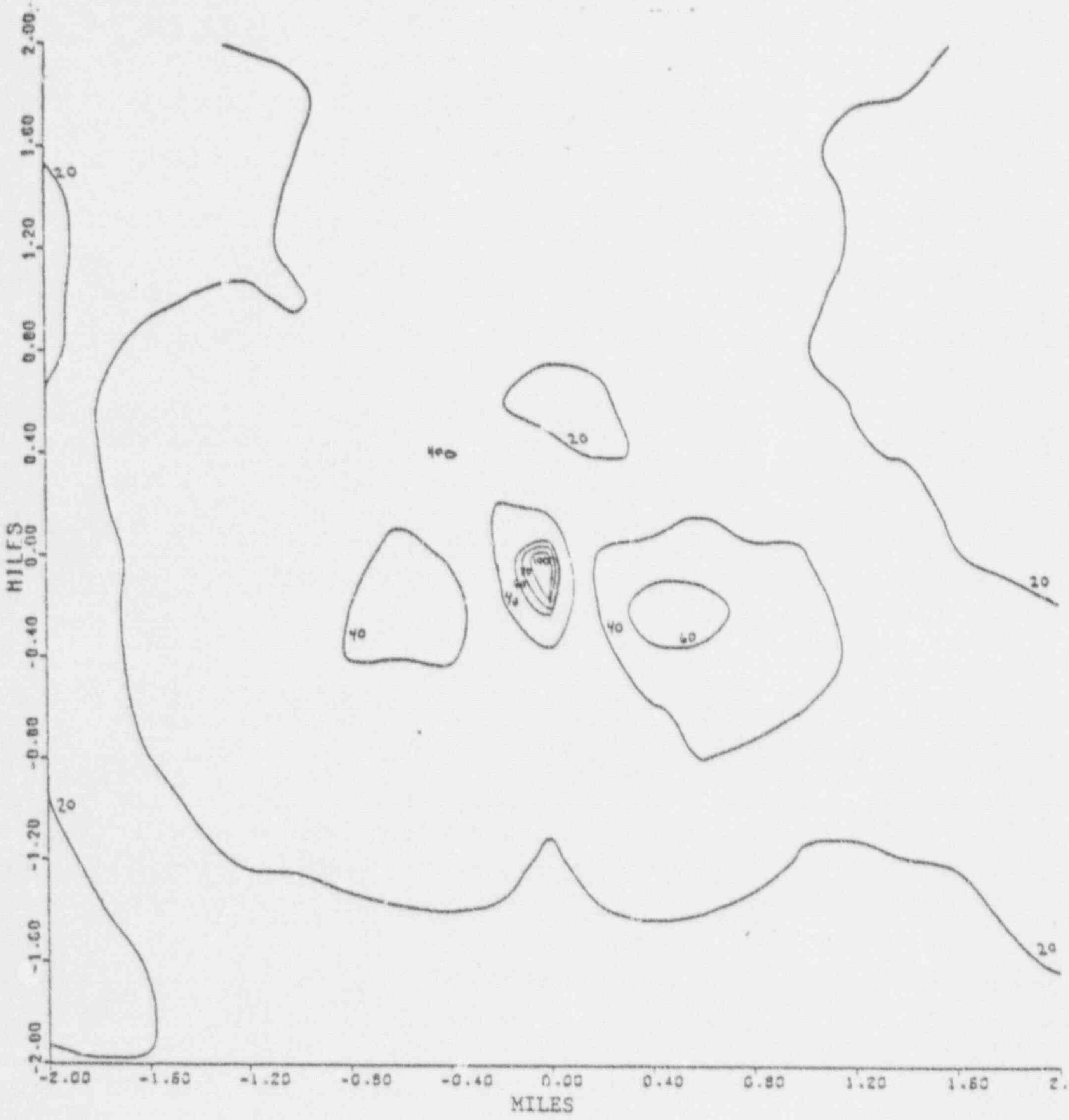
IMPACT AREA ISOPLETHS OF ANNUAL AVERAGE GROUND DRY DEPOSITION RATES IN KG/KM^2/MONTH: NATURAL DRAFT TOWER (0-15 MILES)



Source: Pickard, Lowe and Garrick, Inc. Estimates

Figure 5

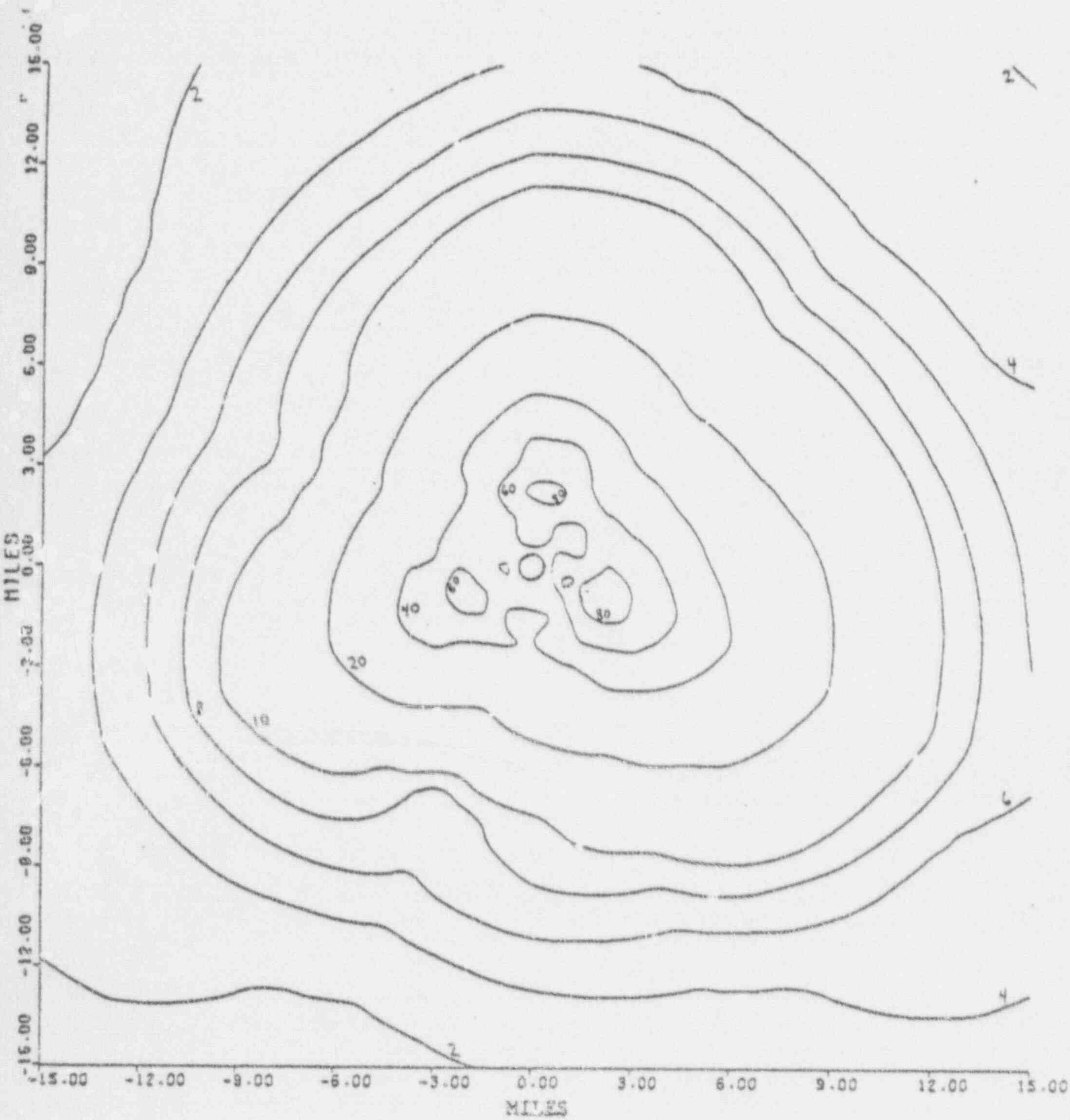
IMPACT AREA ISOPLETHS OF ANNUAL AVERAGE GROUND DRY DEPOSITION RATES IN KG/KM^2/MONTH: NATURAL DRAFT TOWER (0-2 MILES)



Source: Pickard, Lowe and Garrick, Inc. Estimates

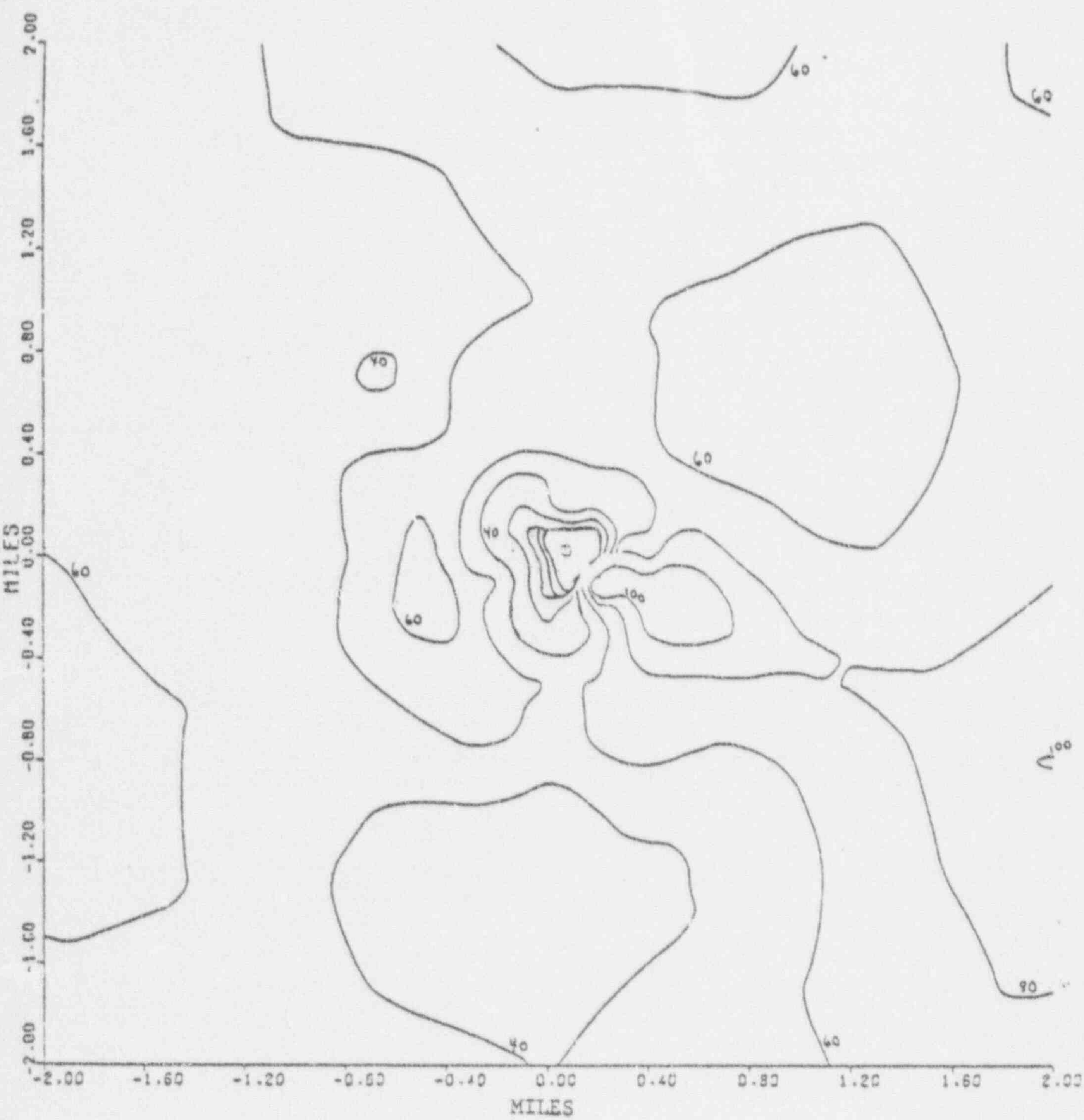
n/e/r/a

IMPACT AREA ISOPLETHS OF ANNUAL AVERAGE GROUND DRY DEPOSITION RATES IN KG/KM²/MONTH: FAN-ASSISTED NATURAL DRAFT TOWERS (0-15 MILES)



Source: Pickard, Lowe and Garrick, Inc. Estimates

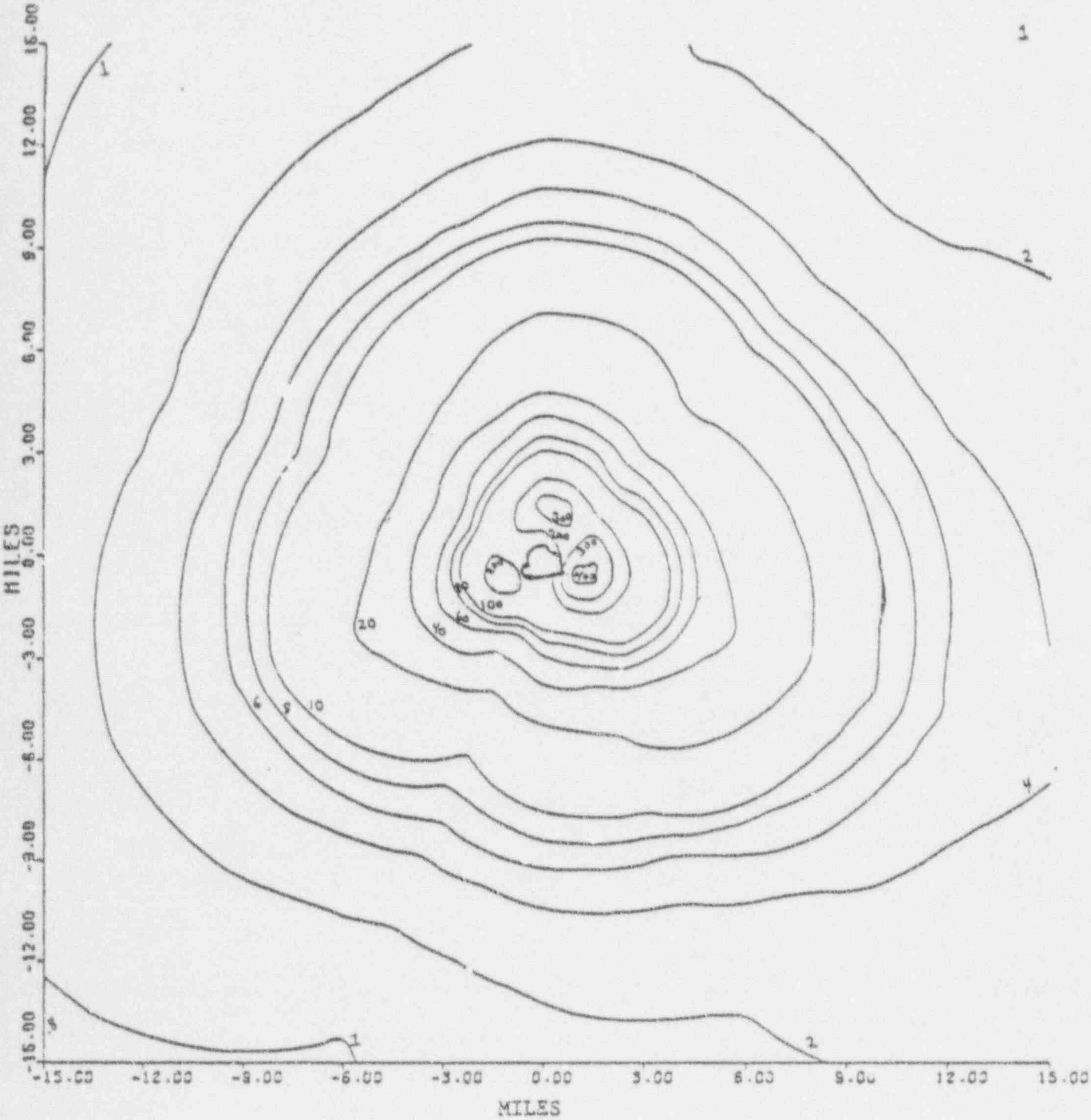
IMPACT AREA ISOPLETHS OF ANNUAL AVERAGE
GROUND DRY DEPOSITION RATES IN KG/KM^2/MONTH:
FAN-ASSISTED NATURAL DRAFT TOWERS
(0-2 MILES)



Source: Pickard, Lowe and Garrick, Inc. Estimates

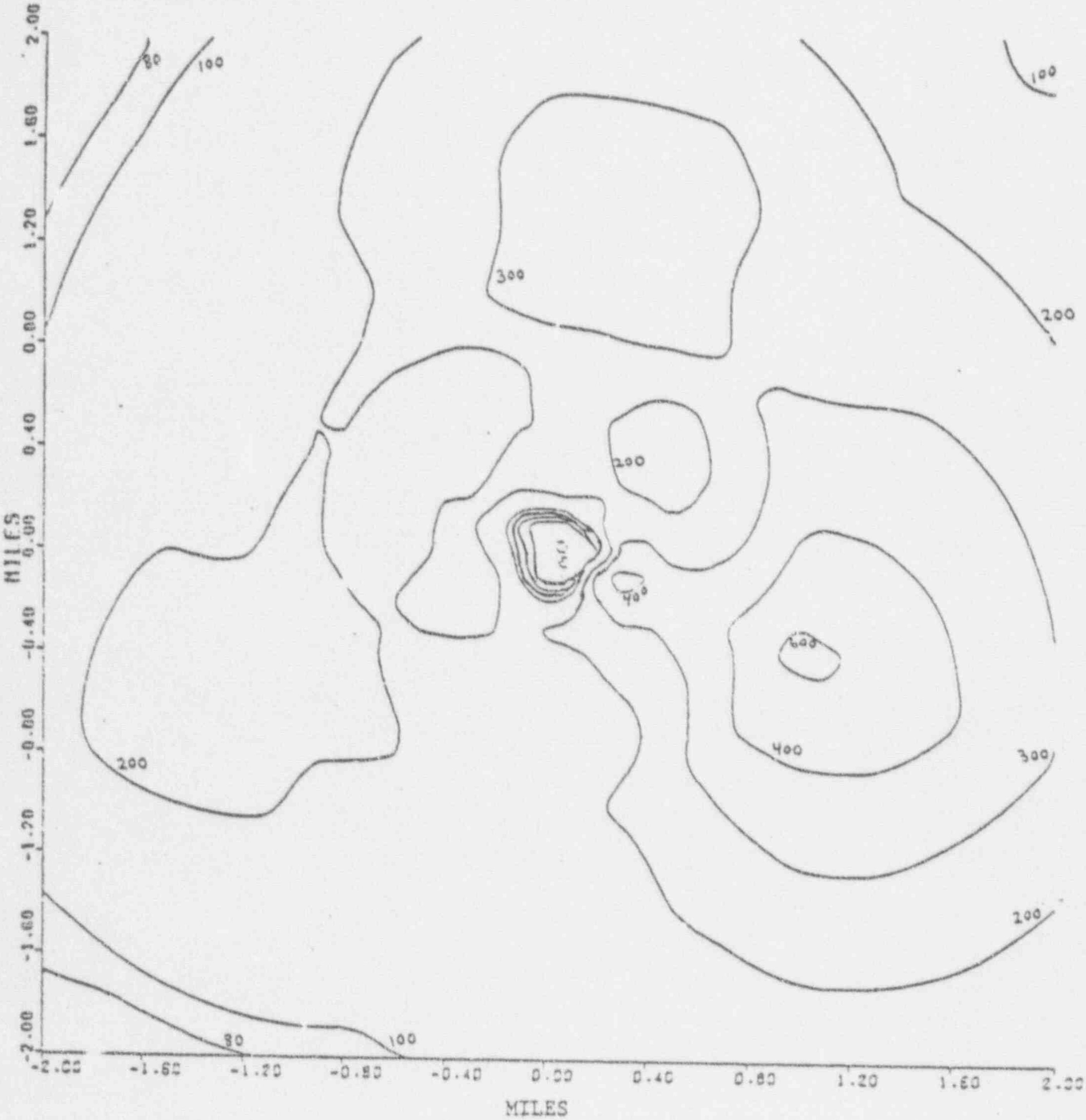
Figure 8

IMPACT AREA ISOPLETHS OF ANNUAL AVERAGE GROUND DRY DEPOSITION RATES IN $KG/KM^2/MONTH$: ROUND MECHANICAL DRAFT TOWERS (0-15 MILES)



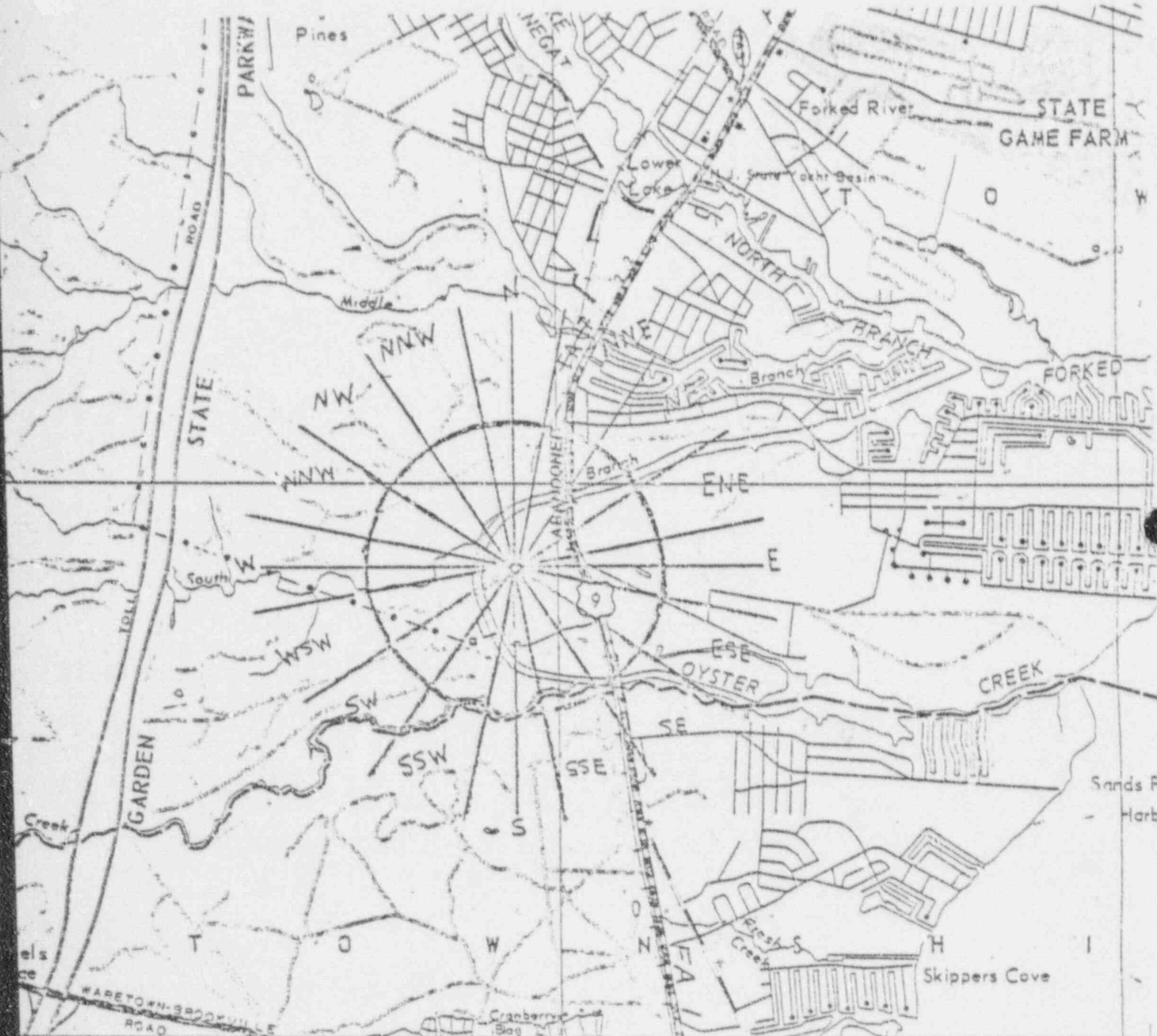
Source: Pickard, Lowe and Garrick, Inc. Estimates

IMPACT AREA ISOPLETHS OF ANNUAL AVERAGE GROUND DRY DEPOSITION RATES IN KG/KM^2/MONTH: ROUND MECHANICAL DRAFT TOWERS (0-2 MILES)



Source: Pickard, Lowe and Garrick, Inc. Estimates

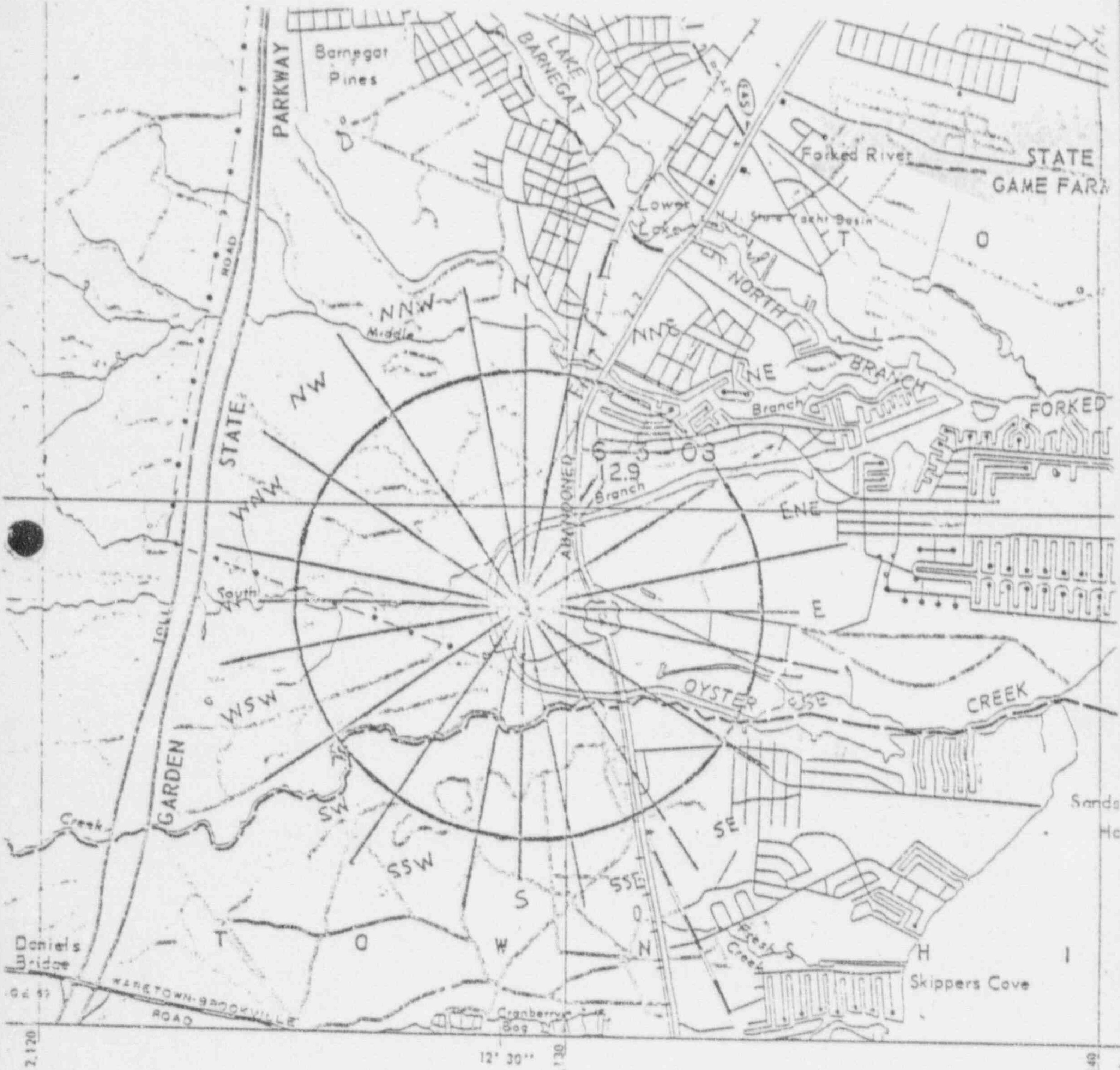
NOISE IMPACT AREA:
NATURAL DRAFT TOWER



Note: Circle with radius equal to 2500 feet and estimated dB(A) of 46 at perimeter.

Source: Ebasco Services, Inc. (1977).

NOISE IMPACT AREA:
FAN-ASSISTED NATURAL DRAFT AND
ROUND MECHANICAL DRAFT TOWERS



Note: Circle with radius equal to 5000 feet and estimated dB(A) of 48 at perimeter.

Source: Ebasco Services, Inc. (1977).

BIBLIOGRAPHY

Ambler, H.R. and A.A.J. Bain. "Corrosion of Metals in the Tropics." Journal of Applied Chemistry, September 1955, pp. 437-466.

American Society for Testing and Materials. "Corrosiveness of Various Atmospheric Test Sites as Measured by Specimens of Steel and Zinc." Metal Corrosion in the Atmosphere, ASTM STP 435, 1968, pp. 360-391.

Butler, Gary T. "A 'Crying' Need for Fog Highway Safety Education." Journal of Traffic Safety Education, January 1976, pp. 23-25.

Con Edison. Indian Point Unit No. 2 Environmental Report: Eliminate Requirement for Termination of Operation with Once-Through Cooling System. New York, 1977.

Copson, H.R. "Atmospheric Corrosion of Low Alloy Steels." Presented at the Fifty-fifth Annual Meeting of the American Society for Testing Materials. Philadelphia, June 23-27, 1952.

__________. "Long-Time Atmospheric Corrosion Tests on Low-Alloy Steels." Presented at the Sixty-third Annual Meeting of the American Society for Testing Materials. Philadelphia, June 27-July 1, 1960.

Ebasco Services Incorporated. Jersey Central Power and Light Company Oyster Creek Nuclear Generating Station Alternative Cooling Water System Study, Vols. II and III. New York, 1977a.

__________________________. "Equivalent Annual Adult Losses," Personal Correspondences. September, November, 1977b.

Fink, F.W. and W.K. Boyd. The Corrosion of Metals in Marine Environments. Battelle Memorial Institute, Columbus, Ohio, 1970.

_________, et. al. Technical-Economic Evaluation of Air-Pollution Corrosion Costs on Metals in the U.S. Battelle Memorial Institute, Columbus, Ohio, 1971.

Foldvary, L.A. and H.T. Ashton. "Road Accidents and Weather." Proceedings of the Australian Road Research Board, Vol. I, Part I, 1962, pp. 529-595.

Gillette, Donald G. "SO_2 Standards and Material Damage." Paper presented at the Air Pollution Control Association Meeting, Denver, 1974.

Gronwald, Ronald and David R. Mears. "A Report on the Effects of a Salt Water Cooling Tower on Off-Site Structures." August 1971.

Guttman, Herbert and P.J. Sereda. "Measurement of Atmospheric Factors Affecting the Corrosion of Metals." Metal Corrosion in the Atmosphere, ASTM STP 435. American Society for Testing and Materials, 1968, pp. 326-359.

Ichthyological Associates. Preliminary Final Report of Ecological Studies for the Oyster Creek Generating Station, September 1975-August 1976, Vol. 1, Part 1. Ithaca, New York, 1977a.

________________. Report of Data Collected for Ecological Studies for the Oyster Creek Generating Station, September 1976-February 1977, Part 1. Ithaca, New York, 1977b.

Kocmond, Warren C. and Kenneth Perchonok. Project Highway Fog Final Report. Highway Research Board, National Academy of Sciences, Washington, D.C., 1969.

Mäler, Karl Goran and Ronald E. Wyzga. Economic Measurement of Environmental Damage: A Technical Handbook. Organization for Economic Co-operation and Development, Paris, 1976.

Mishan, E.J. "Evaluation of Life and Limb: A Theoretical Approach." Journal of Political Economy, July/August 1971, pp. 687-705.

Moore, R.L. and L. Cooper. Fog and Road Traffic. Transport and Road Research Laboratory, Department of the Environment, Berkshire, 1972.

New Jersey Department of Environmental Protection. Studies of the Upper Barnegat System. Nacote Creek Research Station, New Jersey, 1974.

New Jersey Department of Transportation. 1973 Accident Data Traffic Volumes and Mileage on the State Highway System by Route, County and Municipality. Trenton, 1973.

________________. Summary of Motor Vehicle Traffic Accidents. Trenton, various years.

Organization for Economic Cooperation and Development. Road Research: Adverse Weather, Reduced Visibility and Road Safety. Paris, 1976.

Perchonok, Kenneth. "Driving in Fog." Published in Second Annual Symposium on Visibility and Driving. The Institute of Transportation and Traffic Engineering, Berkeley, 1969, pp. 7-10.

Perl, Lewis J. "Cost-Benefit Analysis of Improvements in Water Quality." Published in Earnest F. Gloyna (ed.) Water Management by the Electric Power Industry. Center for Research in Water Resources, Austin, Texas, 1975, pp. 383-398.

Pittman, Mary Ann and Roy C. Loutzenheiser. A Study of Accident Investigation Sites on the Gulf Freeway. Texas Transportation Institute, College Station, 1972.

Salmon, Richard L. Systems Analysis of the Effects of Air Pollution on Materials. Midwest Research Institute, Kansas City, 1970.

Schelling, T.C. "The Life You Save May Be Your Own." Published in S.B. Chase (ed.) Problems in Public Expenditures. The Brookings Institution, Washington, 1968, pp. 127-162.

Spence, J.W. and F.H. Haynie. Paint Technology and Air Pollution: A Survey and Economic Assessment. Environmental Protection Agency, Research Triangle Park, 1972.

Thaler, Richard and S. Rosen. "The Value of Saving a Life: Evidence for the Labor Market." Presented at the National Bureau of Economic Research Conference on Income and Wealth, Household Production and Consumption. Washington, November 1973.

Theobald, David J. "Fog, Drivers' Reaction and Accidents in California." Published in Second Annual Symposium on Visibility and Driving. The Institute of Transportation and Traffic Engineering, Berkeley, 1969, pp. 18-22.

Tri-State Regional Planning Commission. Automobile Usage in the Tri-State Region, Interim Technical Report 4193. New York, 1970.

U.S. Bureau of the Census. 1970 Census of Housing: Detailed Housing Characteristics, New Jersey. Washington, 1972.

U.S. Department of Labor, Bureau of Labor Statistics. Handbook of Labor Statistics 1976. Washington, 1976.

________________________________. Employment and Earnings, States and Areas 1939-75. Washington, 1977.

U.S. Department of Transportation. 1975 Societal Costs of Motor Vehicle Accidents. Washington, 1976.

U.S. Fish and Wildlife Service. National Survey of Fishing and Hunting. Washington, 1970.

U.S. Department of Health, Education and Welfare, Public Health Service. Air Quality Criteria for Particulate Matter. Washington, 1969.

U.S. National Marine Fisheries Service. Fishery Statistics of the United States, 1970. Washington, 1973a.

____________________. 1970 Salt-Water Angling Survey. Current Fishery Statistics, No. 6200, Washington, 1973b.

____________________. Fisheries of the United States, 1975. Washington, 1976.

____________________. Current Fisheries Statistics, Nos. 7183, 7184, 7213 and 7216. Washington, 1977.

Waddell, Thomas E. The Economic Damages of Air Pollution. U.S. Environmental Protection Agency, Washington, 1974.

Watson, P.L. The Value of Time; Behavioral Models of Mode Choice. Lexington, Mass.: Lexington Books, 1974.

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

VOLUME 3

EXHIBITS

Ebasco Services Incorporated
Two Rector Street
New York, N Y

November 1977

VOLUME 3

PREFACE

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

Volume 3 contains copies of all Exhibits cited in the study.

Volume 1 contains the Executive Summary (Chapter I).

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). These chapters present the approach, methodology, analysis and results of the study in detail.

EXHIBITS

CHAPTER I

LIST OF EXHIBITS

CHAPTER 11

LIST OF EXHIBITS

No of Exhibits	Title
7	Oyster Creek NGS Site & Vicinity
8	Existing Cooling Water System

CHAPTER III

LIST OF EXHIBITS

CHAPTER III

Cont'd

LIST OF EXHIBITS

Cont'd

LIST OF EXHIBITS

Cont'd

LIST OF EXHIBITS

Cont'd

LIST OF EXHIBITS

CHAPTER III

Cont'd

LIST OF EXHIBITS

Cont'd

LIST OF EXHIBITS

CHAPTER IV

LIST OF EXHIBITS

Cont'd

LIST OF EXHIBITS

Cont'd

LIST OF EXHIBITS

Cont'd

LIST OF EXHIBITS

Cont'd

LIST OF EXHIBITS

Cont'd

LIST OF EXHIBITS

Cont'd

LIST OF EXHIBITS

Cont'd

LIST OF EXHIBITS

APPENDICES

LIST OF EXHIBITS

EXHIBIT 1

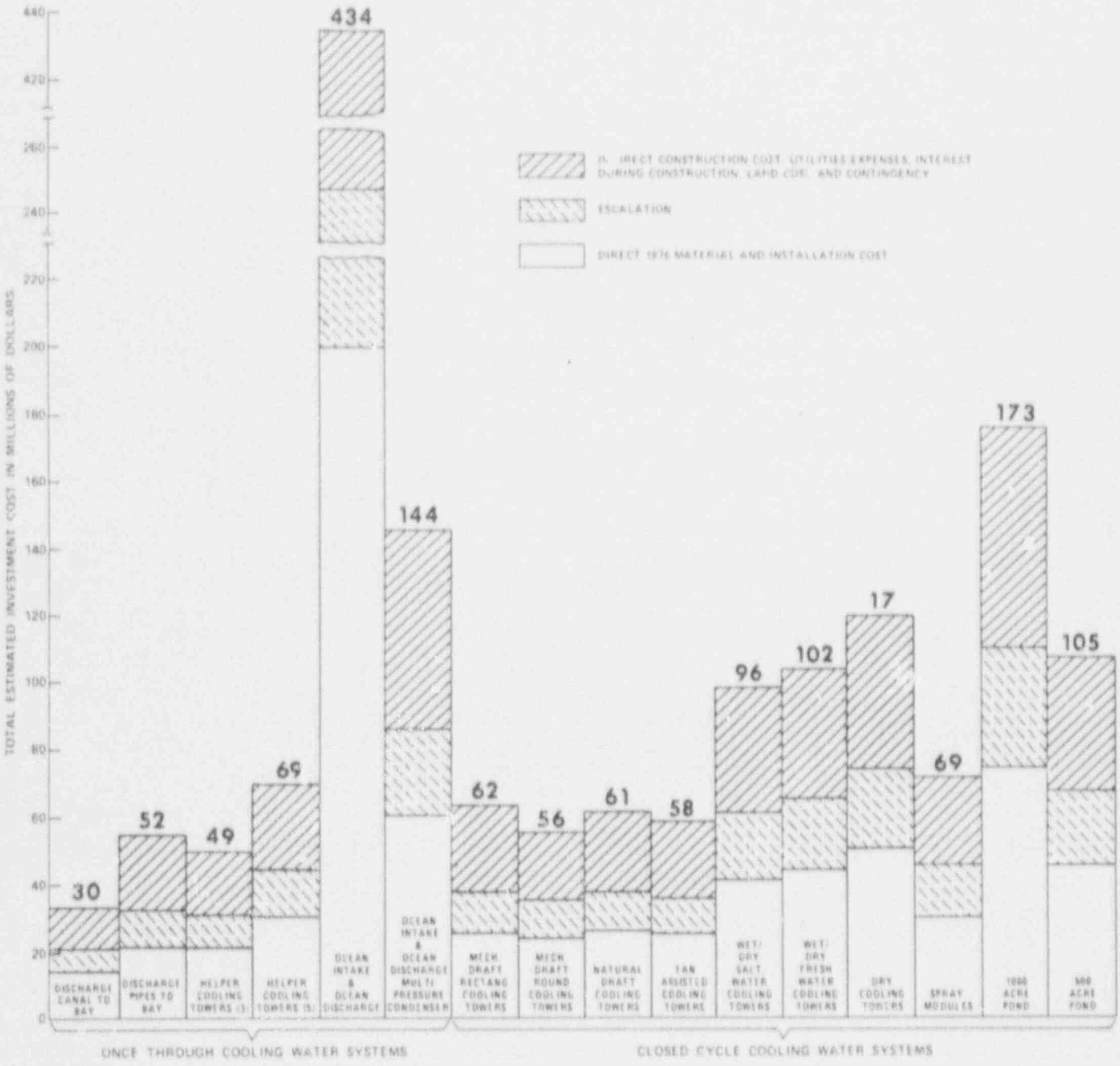
TOTAL COMPARABLE ANNUAL SYSTEM COSTS

	Total Comparable Annual Costs Including Adjustments in Million Dollars	Differential Comparable Annual Cost in 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 Cold Water Temperature 50° F	16.6	16.1
Natural Draft Cooling Tower (CT)	20.4	19.9
Mechanical Draft Round CT	20.8	20.3
Fan-Assisted CT	21.3	20.8
Mechanical Draft Rectangular CT	21.7	21.2
Helper CT with Minimum Cold Water Temperature 43.8° F	22.8	22.3
Spray Cooling Module Canal	21.8	21.3
500 Acre Cooling Pond	28.7	28.2
Wet/Dry Salt Water CT	33.0	32.5
Ocean Intake & Discharge with Coated Steel Pipelines & Multipressure Condenser	37.4	36.9
Wet/Dry Fresh Water CT	40.3	39.8
1,000 Acre Cooling Pond	41.0	40.5
Dry Cooling Tower	44.5	44.0
Ocean Intake & Discharge with Concrete Pipelines and the Existing Condenser	102.7	102.2

EXHIBIT 2

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

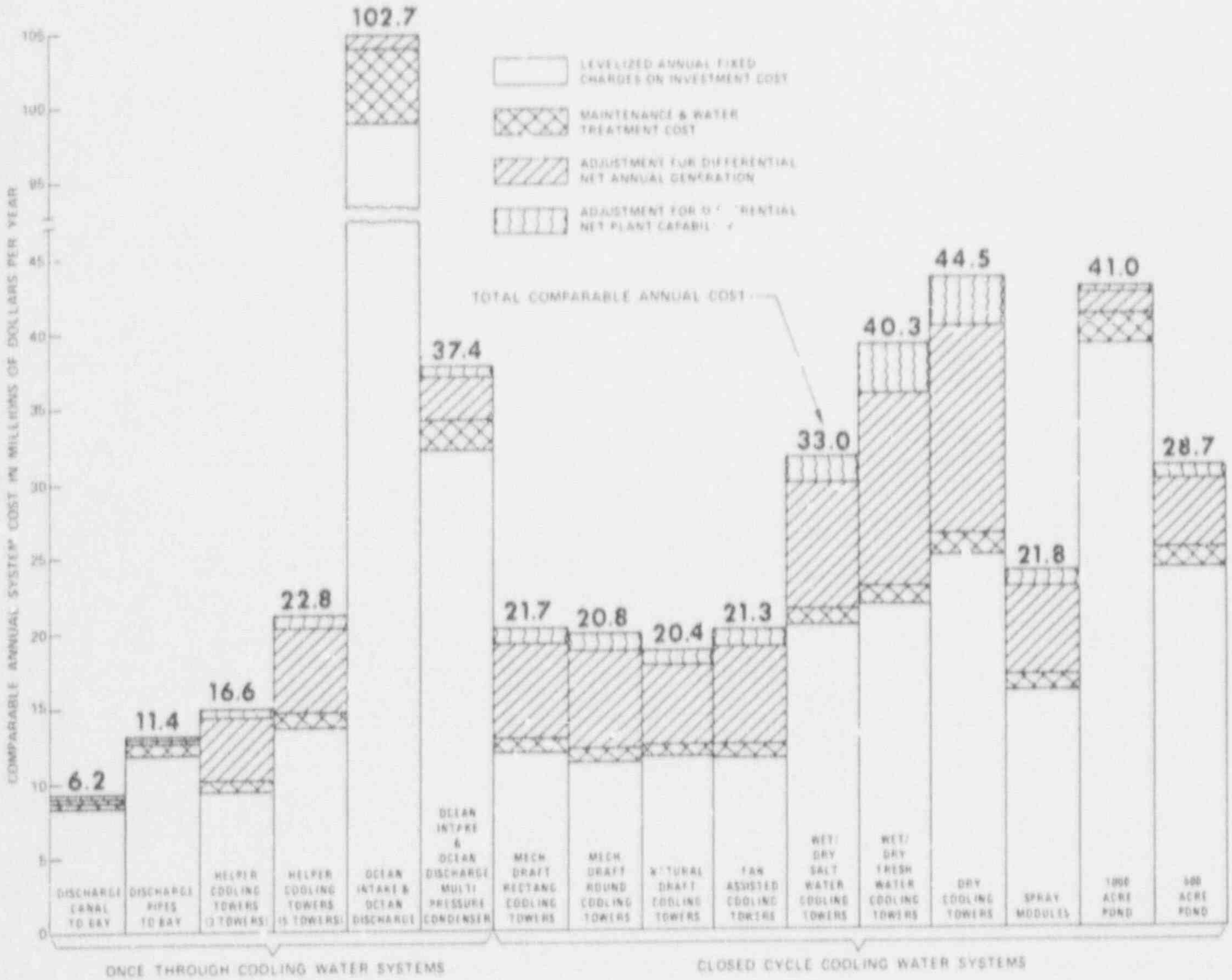
TOTAL ESTIMATED INVESTMENT COST



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

EXHIBIT 3

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

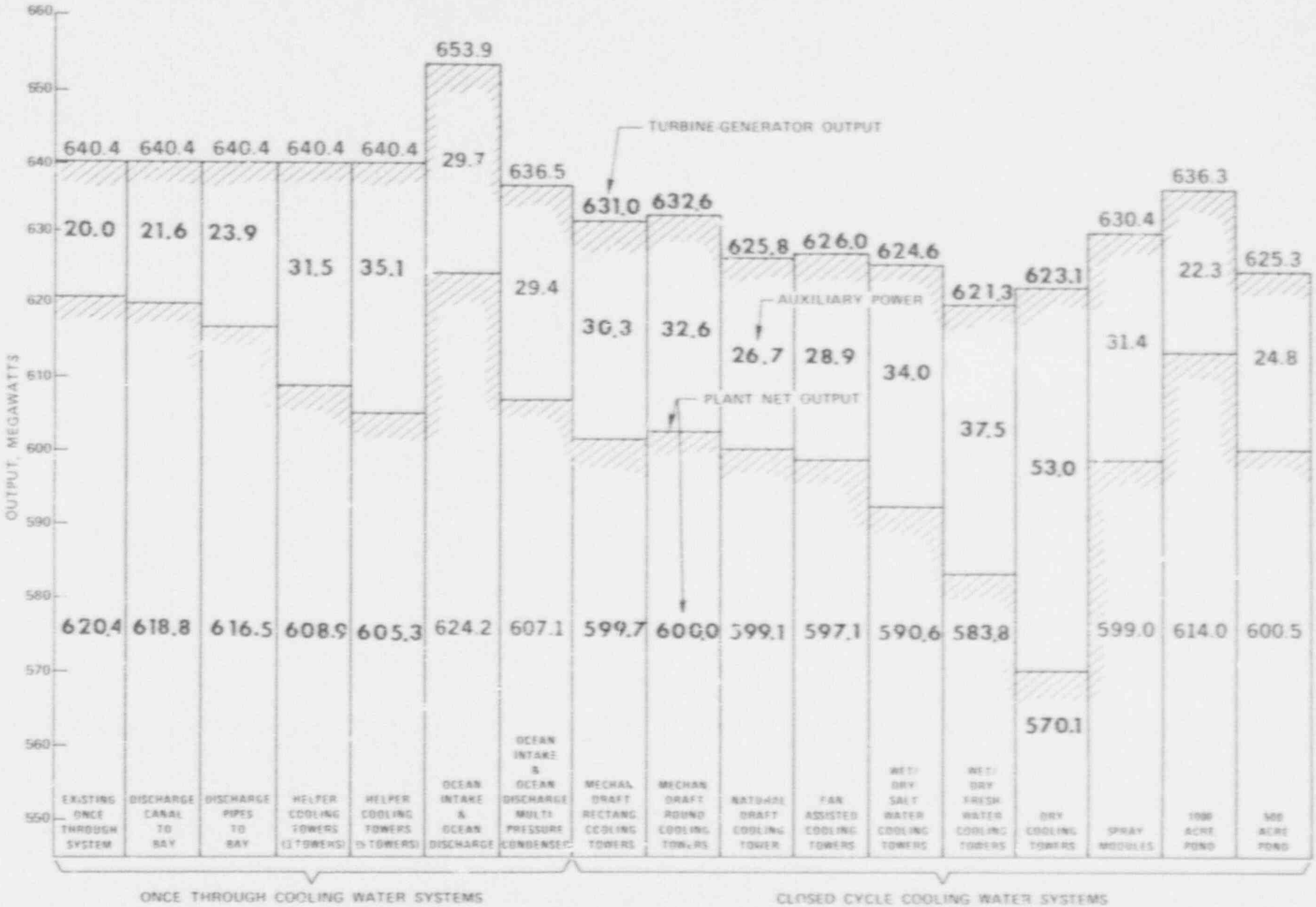


EXHIBIT 4

EXHIBIT 5

COMPARATIVE ANALYSIS OF ENVIRONMENTAL AND REGULATORY ASPECTS FOR PREFERRED COOLING SYSTEMS

Environmental Factors	Units	Natural Draft Cooling Tower	Fan-Assisted Natural Draft Cooling Tower	Round Mechanical Cooling Tower	Canal-To-Bay System	Existing System	Existing System with Ristroph Bucket Screens
1. Atmospheric Effects							
1.1 Elevated Visible Plume	Hrs/Summer (Max)	3	22	3	0	[illegible]	0
1.2 Ground Level Fogging	Hrs/yr (Max)	<1	9-12	2	ND (3)	[illegible]	ND
1.3 Salt Aerosol Concentration (max annual)	Ugm/m^3	.06	0.20	0.80	0	0	0
1.4 Salt Deposition (max annual)	Kg/Km-month	80	110	311	0	0	0
2. Air Quality							
2.1 Particulate Emission Rate	% of Standard	353	336	336	0	0	0
3. Water Quality							
3.1 Construction Effects	Qualitative	Low	Low	Low	Moderate	NA (4)	NA
3.2 Operation Effects	% Change	+3	+3	+3	Low	NA	Low
4. Thermal Discharge Characteristics							
4.1 Heat Dissipation (Annual Avg)	Btu/Hr x 10^6	202	208	178	4460	4460	4460
4.2 Area of 1.5° F (Summer Max)	Acres	0	0	0	~2300	~2300	~2300
5. Noise							
5.1 Noise Level at Property Line (Without Mitigative Measures)	dB(A) above NJ Criterion (50 dB(A))	4	11.5	10	13	ND	ND
6. Visual/Esthetic Effects							
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						
7. Land Use							
7.1 Total Area Required	Acres	~[illegible]	~10	~10	~25	NA	0
8. Terrestrial Ecology							
8.1 Sensitive Habitat Required	Acres	Low	Low	Low	15	NA	0
8.2 Potential for Salt Effects on Vegetation	Qualitative	Low	Low	Moderate	NA	NA	0
8.3 Potential for Bird Collisions	Qualitative	Moderate	Low	Low	NA	NA	0

EXHIBIT 5

COMPARATIVE ANALYSIS OF ENVIRONMENTAL AND REGULATORY ASPECTS FOR PREFERRED COOLING SYSTEMS

Environmental Factors	Units	Natural Draft Cooling Tower	Fan-Assisted Natural Draft Cooling Tower	Round Mechanical Cooling Tower	Canal-To-Bay System	Existing System	Existing System with Ristroph Bucket Screens
9. Aquatic Ecology							
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 [5]
9.4 Wood Borer Population-Potential Change in Oyster Creek	Qualitative	Reduction [2]	Reduction	Reduction	Reduction	Base	NC
9.6 Cold Shock Potential - Oyster Creek	Qualitative	Reduction	Reduction	Reduction	Reduction	Base	NC
10. Radiological Effects							
10.1 Dose to Highest Organ (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.

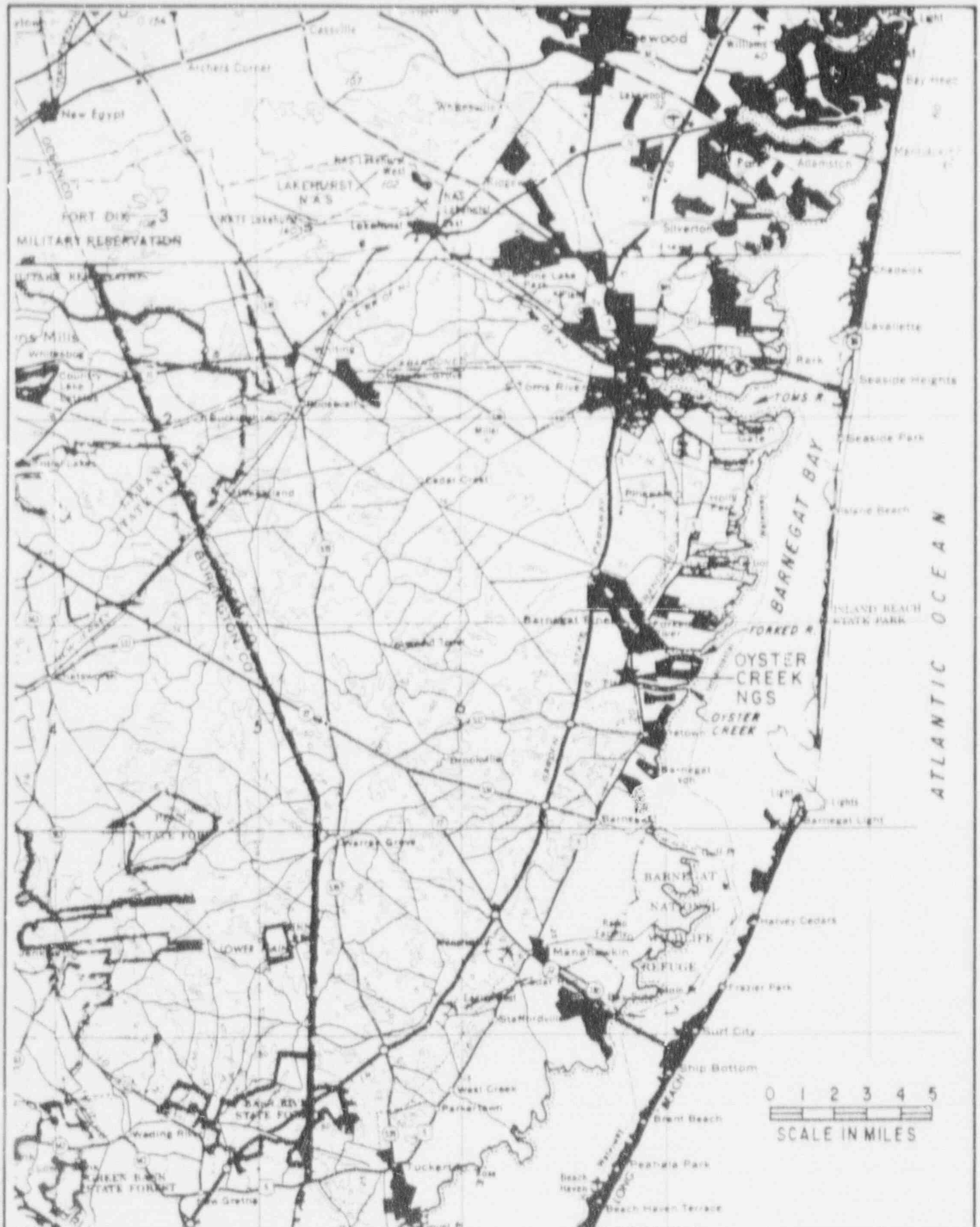
EXHIBIT 6

SUMMARY OF PREFERRED AND RECOMMENDED SYSTEM SELECTION PROCESS

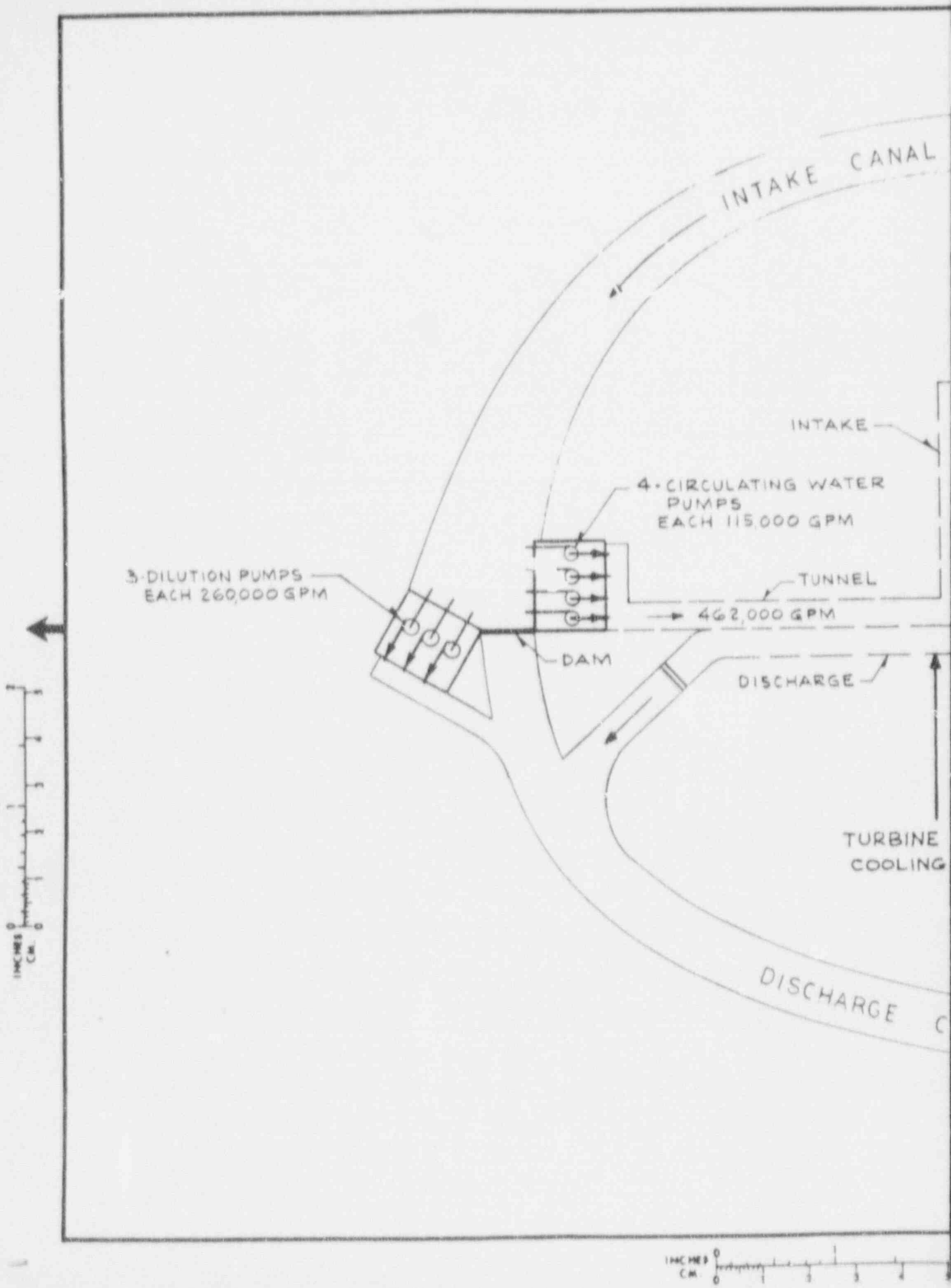
	Differential Comparable Annual Cost (million dollars)	Differential Plant Net Output[1] (MW)	Elimination Rationale Alternative Systems[2]	Elimination Rationale for Preferred Systems
Discharge Canal to the Bay	7.2	-1.6	Preferred	Insufficient Mitigation of Aquatic Impact
Discharge Pipelines to the Bay	12.6	-3.9	NCA	
Helper Cooling Towers with Minimum 50° F Cold Water Temperature	16.5	-11.5	OEI-Fogging/Icing, Salt Deposition	
Natural Draft Cooling Tower (CT)	20.2	-21.3	Preferred	Recommended
Round Mechanical Draft CT	20.6	-20.4	Preferred	Exceeding of Noise Criteria
Fan-Assisted Natural Draft CT	21.2	-23.3	Preferred	Lack of Operating Experience and Noise Control Experience
Rectangular Mechanical Draft CT	21.6	-20.7	OEI-Fogging/Icing, Salt Deposition	
Helper CT with Minimum 63.8° F Cold Water Temperature	22.8	-15.1	OEI-Fogging/Icing, Salt Deposition	
Spray Cooling Module Canal	22.8	-21.4	OEI-Fogging/Icing, Salt Deposition	
500 Acre Cooling Pond	30.5	-19.9	OEI-Fogging/Icing, Terrestrial and Aquatic Ecology	
Wet/Dry Salt Water CT	33.0	-29.8	OEI-Salt Deposition	
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/Icing, Terrestrial and Aquatic Ecology	
Dry Cooling Tower	44.7	-50.3	SCR	
Ocean Intake and Discharge with Existing Condenser	103.3	+3.8	NCA	

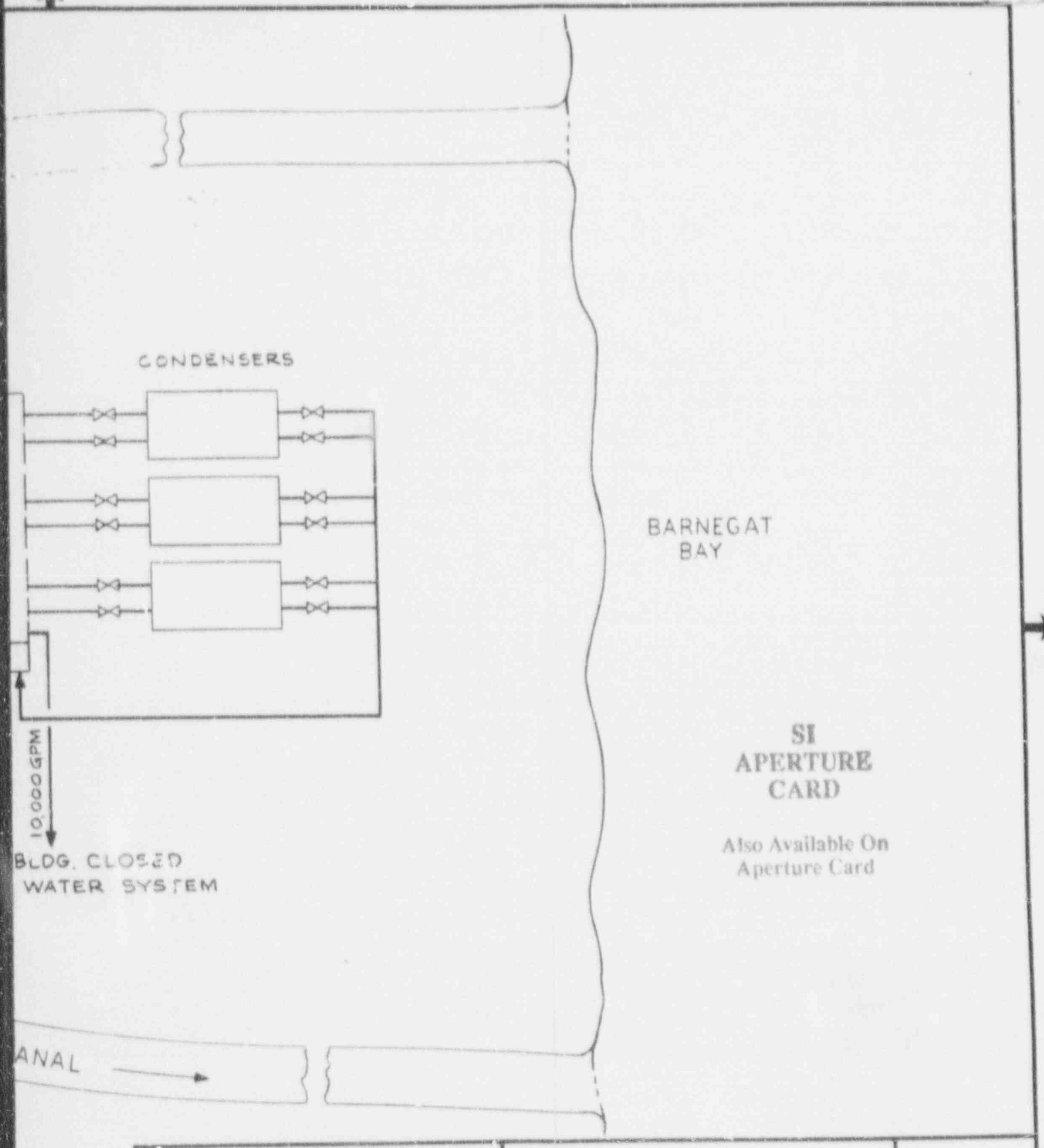
(1) Computed as (Existing System Net Output - Alternative System Net Output) for Average Summer Conditions

(2) NCA: No Compensating Advantage Rationale
OEI: Overriding Environmental Impact Rationale
SCR: Significant Commercial Risk Rationale
See Section I-F for discussion



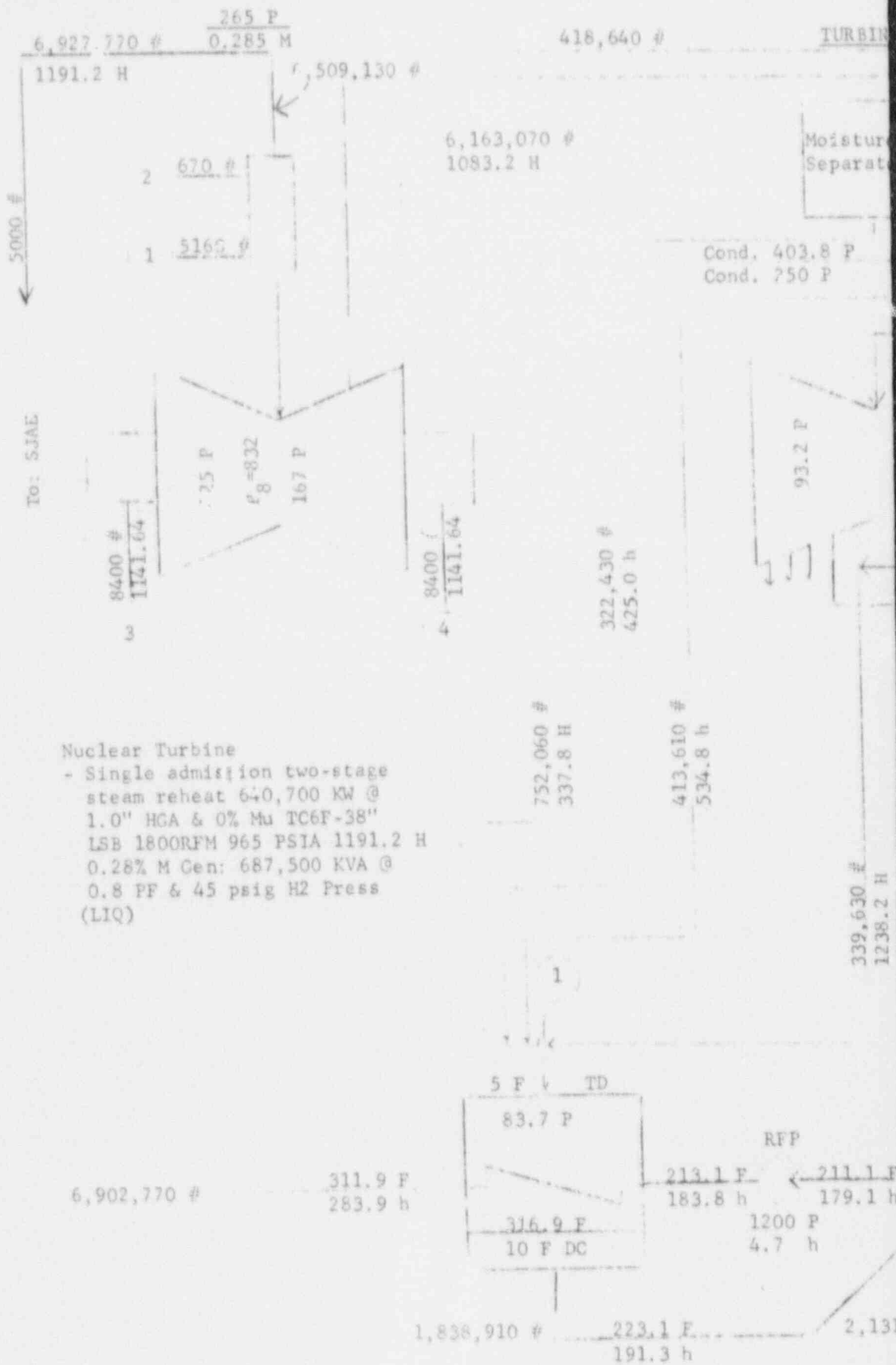
JERSEY CENTRAL POWER & LIGHT CO. EBASCO SERVICES INCORPORATED New York	OYSTER CREEK NGS SITE & VICINITY	EXHIBIT 7


INTAKE CANAL
INTAKE
4-CIRCULATING WATER PUMPS EACH 115,000 GPM
3-DILUTION PUMPS EACH 260,000 GPM
TUNNEL
462,000 GPM
DAM
DISCHARGE
TURBINE COOLING
DISCHARGE C
INCHES
CM.



EBASCO SERVICES INCORPORATED		JERSEY CENTRAL POWER & LIGHT OYSTER CREEK NUCLEAR GEN STATION EXISTING COOLING WATER SYSTEM	EXHIBIT - 8
DIV MECH DR RMcK CH DATE MAR 31, 1977	APPROVED		

9111110048-01

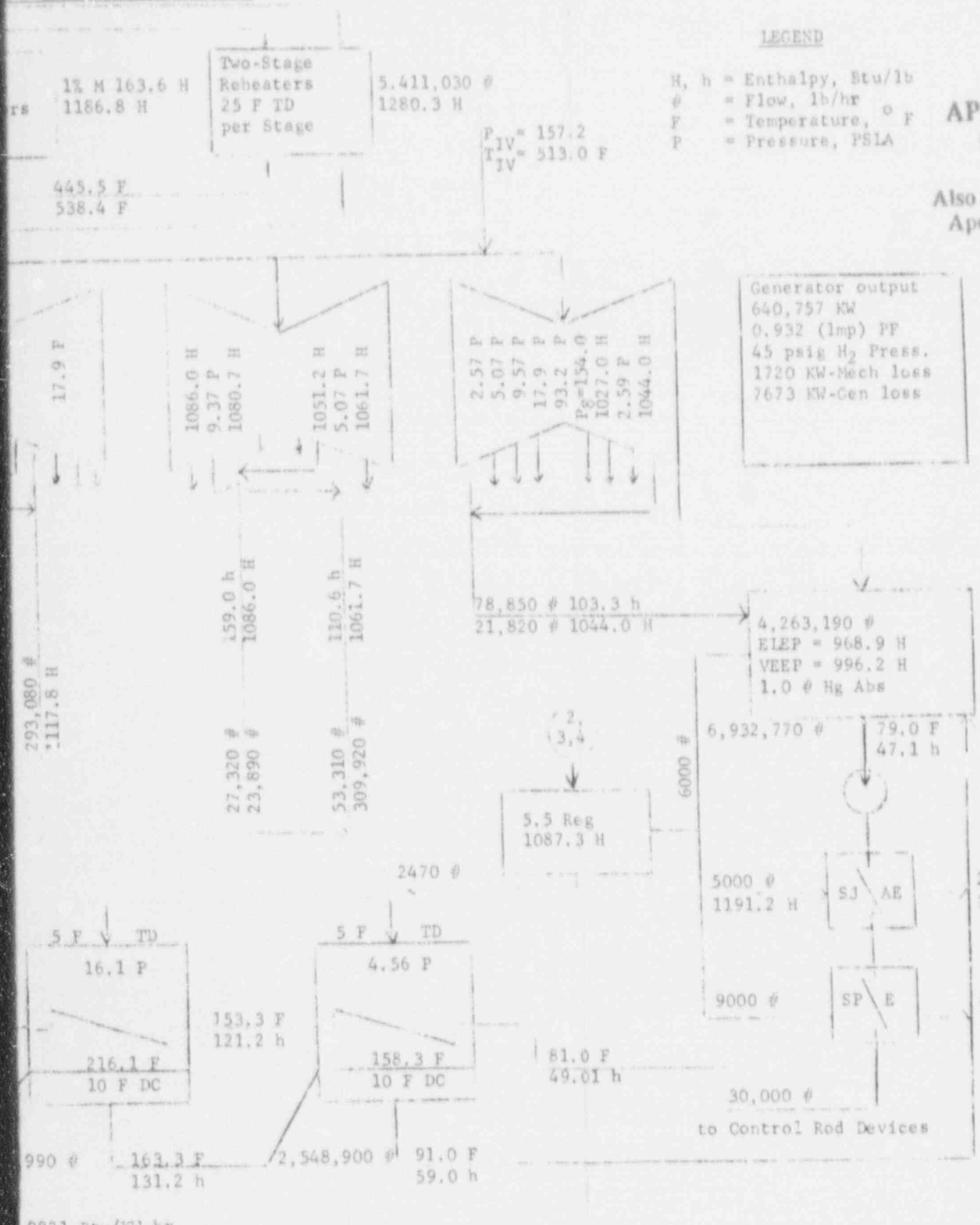


$$\text{Gross Heat Rate} = \frac{6,927,770\ (1191.2 - 283.9) + 30,000\ (283.9 - 49.01)}{640,757} =$$

Source: General Electric Company

EXHIBIT 9

GENERATOR HEAT BALANCE

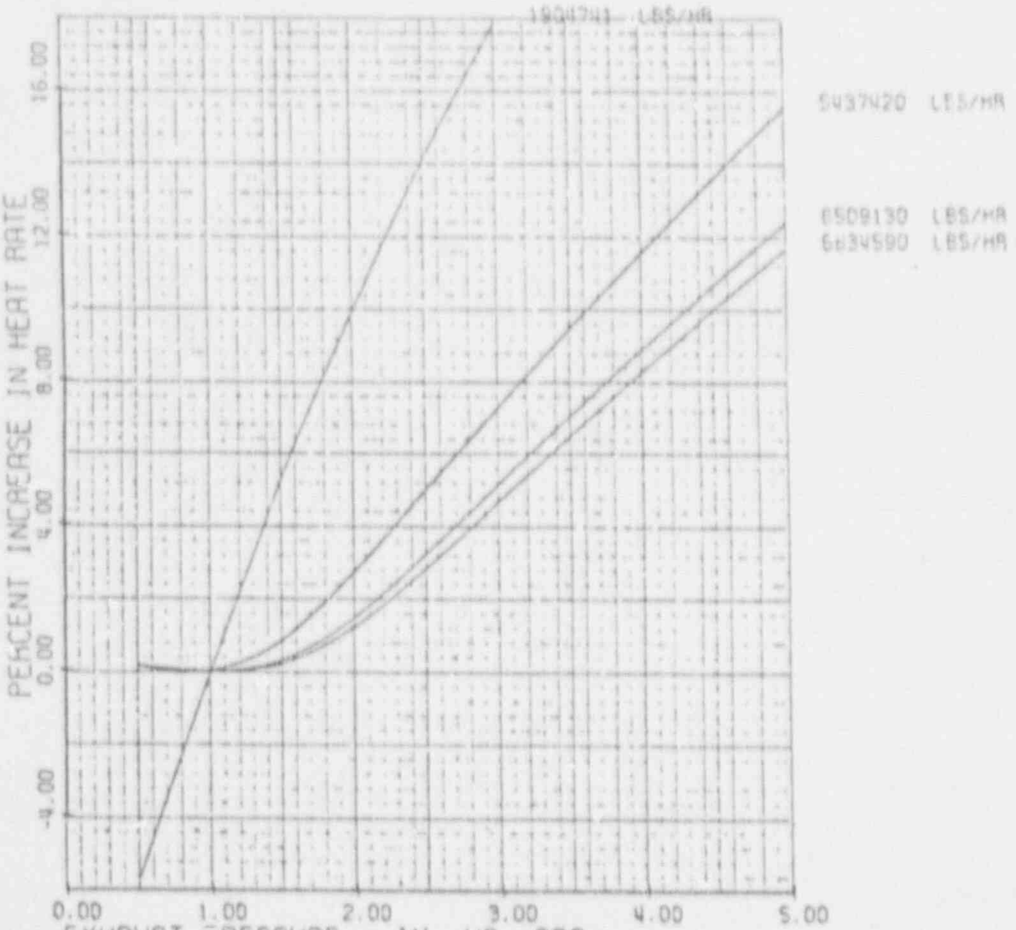


SI APERTURE CARD

Also Available On Aperture Card

9111110048 -02

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



METHOD OF USING CURVE

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 POWER & LIGHT COMPANY EBASCO SERVICES INCORPORATED New York	EXHAUST PRESSURE CORRECTION FACTORS	EXHIBIT 10

PERIOD OF START 00 TO [illegible] FOR MONTHS 1 TO 12

[illegible] SPEED ALL MPH

WET BULB

DRY BULB	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	TOTAL DRY BULB
58	31	34	43	47	64	110	116	100	70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	639
59	29	25	30	45	50	73	67	89	127	47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	591
60	36	21	32	41	43	76	64	90	122	123	80	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	737
61	22	18	20	42	34	38	46	69	79	77	116	61	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	628
62	32	18	20	13	29	42	38	64	67	84	110	104	38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	670
63	21	22	20	35	31	51	46	50	53	53	95	119	115	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	753
64	29	20	21	32	20	33	35	25	50	53	71	109	93	127	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	762
65	18	15	23	24	29	42	32	22	50	51	72	63	113	99	129	43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	820
66	6	10	10	32	29	29	26	31	33	44	51	60	80	76	104	147	39	0	0	0	0	0	0	0	0	0	0	0	0	0	819
67	6	7	10	21	25	22	19	29	31	39	49	47	56	72	64	124	114	46	0	0	0	0	0	0	0	0	0	0	0	0	783
68	4	7	0	13	23	23	19	23	39	46	38	46	63	66	61	98	119	119	32	0	0	0	0	0	0	0	0	0	0	0	845
69	8	5	6	14	20	25	10	16	32	33	42	33	45	57	60	64	75	115	146	25	0	0	0	0	0	0	0	0	0	0	791
70	4	5	19	11	8	25	20	24	20	30	48	45	44	40	43	69	78	82	144	115	34	0	0	0	0	0	0	0	0	0	951
71	0	0	3	5	8	10	12	15	20	21	29	35	32	33	35	36	47	52	73	99	115	19	0	0	0	0	0	0	0	0	713
72	0	6	7	4	5	21	10	14	38	26	32	33	40	42	40	45	47	47	95	99	158	95	34	0	0	0	0	0	0	0	939
73	0	1	4	2	7	13	10	15	23	22	31	30	36	49	35	52	42	31	52	62	169	106	80	18	0	0	0	0	0	0	836
74	0	1	2	4	3	9	8	16	17	22	37	34	38	45	29	44	35	36	45	58	83	55	104	65	14	0	0	0	0	0	796
75	0	0	0	3	2	9	6	14	19	19	24	20	40	45	46	40	37	38	63	47	82	48	113	93	63	16	0	0	0	0	855
76	0	0	0	2	1	1	6	23	15	24	19	30	30	29	27	44	42	26	43	29	68	43	45	51	55	30	0	0	0	0	684
77	0	0	0	0	4	6	6	10	11	18	17	22	25	27	31	30	35	20	43	40	50	32	39	37	42	25	5	0	0	0	585
78	0	0	0	0	4	0	5	9	10	17	15	21	19	25	30	34	28	44	39	27	42	33	33	30	40	32	10	2	0	0	555
79	0	0	0	0	0	3	1	8	2	15	11	15	28	15	25	15	20	27	31	39	40	35	30	33	23	31	13	2	0	0	468
80	0	0	0	0	0	1	4	8	4	12	17	13	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	0	2	2	5	3	11	6	16	16	12	16	15	18	24	19	33	35	32	23	32	34	23	4	0	0	384
82	0	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	0	1	3	6	8	5	11	13	16	12	21	15	19	31	25	26	33	41	30	14	3	1	0	325

84	[illegible]	0	0	0	0	0	0	0	2	2	3	10	4	4	[illegible]	7	8	11	14	14	16	6	19	23	24	28	15	7	[illegible]	[illegible]	237
85	0	0	0	0	0	0	0	0	0	1	2	2	4	5	4	19	9	9	11	11	20	0	23	22	21	29	13	3	5	0	236
86	0	0	0	0	0	0	0	0	0	0	0	1	1	5	2	13	4	4	10	10	15	8	13	13	21	25	20	8	2	2	177
87	0	0	0	0	0	0	0	0	0	0	0	2	6	2	0	4	12	7	7	7	8	16	18	14	23	18	9	11	4	2	164
88	0	0	0	0	0	0	0	0	0	6	0	0	0	0	1	2	7	3	5	6	9	14	15	7	14	17	[illegible]	13	6	3	133
89	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	2	4	7	2	5	7	8	11	10	[illegible]	[illegible]	8	4	1	97
90	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	1	0	2	1	5	6	6	11	5	12	6	8	6	1	74
91	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	2	1	2	6	4	3	9	5	12	10	4	4	2	67
92	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	3	0	0	3	1	4	7	4	11	5	4	2	0	47
93	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	3	0	2	2	1	2	1	4	3	2	4	2	4	4	0	36
94	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2	1	2	0	1	5	1	3	1	1	1	20
95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	1	5	3	2	0	0	0	0	14
96	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	1	1	1	0	1	2	1	0	0	0	0	7
97	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	0	1	0	0	0	5
TOTAL WET BULB	236	215	304	397	458	674	628	779	966	894	1034	991	1009	955	868	1029	873	812	922	790	1009	665	748	583	510	428	193	92	41	12	

Exhibit 11
Sheet 2 of 2

CUM [illegible]

TEMP	JAN	FEB	MAR	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	ANNL
-25	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-24	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-23	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-22	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-21	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-20	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-19	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-18	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-17	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-16	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-15	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-14	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-13	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-12	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-11	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-10	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-9	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-6	0.0267	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0023
-5	0.0530	0.0507	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0091
-4	0.0890	0.0557	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0114
-3	0.1075	0.0631	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0160
-2	0.1344	0.1466	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0228
-1	0.1882	0.1701	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	[illegible]	0.0000	0.0000	0.0297
0	0.2151	0.1701	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	[illegible]	0.0000	0.0000	0.0319
1	0.2419	0.2035	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	[illegible]	0.0000	0.0000	0.0365
2	0.2688	0.2340	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	[illegible]	0.0000	0.0000	0.0411
3	0.5452	0.3522	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	[illegible]	0.0000	0.1076	0.0912
4	1.3404	0.4670	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1882	0.1414
5	1.6129	0.6437	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2689	0.2099
6	2.0430	0.9079	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.3496	0.2737
7	2.8226	1.2320	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.4840	0.3764
8	3.4946	1.5850	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.8336	0.4973
9	4.4591	2.0272	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.5596	0.6419
10	5.7947	2.5530	0.1344	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	2.2318	0.8053
11	6.3140	3.1993	0.3495	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	2.8502	1.0220
12	7.0649	3.6376	0.8333	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	3.6031	1.2592
13	8.0645	4.1385	1.0215	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0278	5.0282	1.5216
14	9.1935	4.8723	1.2697	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1112	6.2313	1.7976
15	10.7740	5.6996	1.6396	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1668	7.6634	2.1763
16	12.1137	6.9269	2.0968	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2223	9.5456	2.5732
17	13.4172	8.1010	2.6075	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.3057	11.0782	2.9884
18	15.7527	9.3924	3.2796	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.4447	12.8790	3.4743
19	17.7151	10.6292	4.3548	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.5281	14.7089	3.9967
20	19.4387	11.9714	5.4839	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.6115	17.4509	4.6104
21	22.0968	14.0299	6.6657	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.6392	20.1667	5.2947
22	24.2142	16.7183	7.7151	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.8060	22.6556	6.0202
23	26.9892	19.7534	9.1935	0.0634	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.9172	25.2487	6.8300
24	29.4731	22.5416	10.7796	0.1667	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.1951	27.9376	7.7106
25	33.1333	26.0643	13.1183	0.2779	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.6120	31.2450	8.7736
26	35.4841	30.5721	15.2151	0.6113	0.0000	0.0000	0.0000	0.0000	0.0000	0.0269	2.3346	34.0414	9.8914
27	39.2650	35.0161	17.6763	1.1392	0.0000	0.0000	0.0000	0.0000	0.0000	0.1344	3.5019	37.7252	11.2145
28	43.3213	39.1557	20.5108	1.6671	0.0000	0.0000	0.0000	0.0000	0.0000	0.1613	5.1140	41.5165	12.5696

Exhibit 12
Sheet 1 of 6

Exhibit 12

Sheet 2 of 6

29	47.[illegible]	53.2932	23.9907	2.5941	0.0000	0.0000	0.0[illegible]	0.00[illegible]	[illegible]	[illegible]	6.9202	45.9263	14.0387
30	51.7473	47.6734	26.5551	3.0399	0.0000	0.0000	0.0000	0.0000	[illegible]	[illegible]	8.2824	51.3848	15.8591
31	55.4220	52.5205	27.5161	4.4735	0.0000	0.0000	0.0000	0.0000	[illegible]	1.1730	10.5330	55.7677	17.3716
32	59.4024	57.9001	33.3865	5.4737	0.0000	0.0000	0.0000	0.0000	[illegible]	1.5094	14.0912	61.1992	19.4543
33	63.1220	64.0310	37.5269	7.4465	0.0000	0.0000	0.0000	0.0000	[illegible]	2.5300	17.1762	65.1519	21.3363
34	67.3118	68.3593	41.5800	9.7865	0.1076	0.0000	0.0000	0.0000	[illegible]	3.3063	19.9833	67.9753	23.8541
35	71.8492	72.1430	46.9800	12.4479	0.4034	0.0000	0.0000	0.0000	0.0834	4.4380	24.0961	71.6590	25.1916
36	75.0530	74.5524	51.4247	13.8055	0.5648	0.0000	0.0000	0.0000	0.1390	5.9140	27.5431	73.8639	26.9185
37	78.1183	77.6930	55.9140	19.0053	1.3179	0.0000	0.0000	0.0000	0.1996	7.6675	31.2674	76.6673	28.8186
38	81.1559	80.6201	60.5914	22.7363	1.0945	0.0000	0.0000	0.0000	0.3094	8.8716	35.1020	79.4031	30.7099
39	84.0860	82.5175	64.3017	26.4130	2.3131	0.0000	0.0000	0.0000	0.5115	10.4639	39.0217	82.1457	32.5532
40	86.9280	86.1402	67.1398	31.6755	3.3489	0.0000	0.0000	0.0000	0.9724	12.5530	43.1073	84.7002	34.6884
41	88.7300	88.2800	72.8699	35.7599	4.6530	0.0000	0.0000	0.0000	1.3463	14.7332	46.3591	85.9909	36.2967
42	90.5914	90.4600	75.2600	41.3726	5.8763	0.0000	0.0000	0.0000	1.6934	17.8510	49.9444	87.4429	38.1832
43	91.5000	92.1330	78.6559	46.9019	7.9304	0.0000	0.0000	0.0820	2.0567	20.4391	53.2790	88.6798	39.9307
44	92.6495	93.5134	81.5860	52.0422	9.8440	0.0000	0.0000	0.0000	2.5292	23.3671	56.8649	89.8360	41.6596
45	93.9247	94.3645	84.4086	57.0992	12.9989	0.0556	0.0000	0.0000	3.1005	27.3050	61.1729	91.0729	43.5920
46	94.7849	94.9222	85.6667	60.7947	16.3796	0.1667	0.0000	0.0000	3.8577	30.9077	64.6740	92.7938	45.2847
47	95.9153	95.6500	89.4409	64.3234	20.0646	0.5001	0.0000	0.0538	4.5303	33.3065	68.1768	94.0844	46.8975
48	97.0430	96.3890	89.5430	67.4076	24.2066	1.1114	0.0000	0.0867	5.8288	36.5591	71.4266	95.2675	48.5355
49	97.6344	96.8301	90.4032	69.5471	28.0258	1.5202	0.0000	0.2131	7.1429	40.4101	73.7910	96.3969	49.9658
50	98.1065	97.5051	91.8548	72.5479	32.1947	2.2506	0.0807	0.4899	9.5807	44.2131	77.4597	96.9078	51.7794
51	98.7703	98.0620	92.8763	74.7946	35.8795	3.3065	0.2420	0.6991	11.6732	48.6259	80.3270	97.5800	53.3625
52	99.1935	98.5911	94.0054	77.1325	40.6939	5.0014	0.5378	1.3713	14.2023	52.5806	82.6914	97.8989	55.1160
53	99.5430	99.0314	95.5376	79.7999	44.3249	7.4187	0.9949	2.2310	17.1206	56.6611	85.2140	98.4673	57.0193
54	99.6237	99.3543	96.4785	83.0231	48.7897	9.6694	1.3982	3.0653	19.7610	60.6720	87.1317	98.7631	58.7919
55	99.7581	99.5891	97.5806	85.9128	55.3523	13.1703	2.1780	4.3022	23.4257	65.2957	89.2996	98.9782	61.0571
56	99.4387	99.7065	98.3871	87.9967	60.0861	16.3379	3.0116	5.4853	26.4667	69.1398	90.9612	99.5160	62.9049
57	99.9194	99.7945	99.0054	89.7472	65.0688	20.0056	4.4098	7.3407	29.9889	72.6082	92.3047	99.6504	64.8326
58	100.0000	99.8826	99.4086	91.7755	69.6880	23.4510	6.3450	9.8414	34.6581	77.2043	94.2460	99.8924	67.0362
59	100.0000	99.8826	99.7043	93.9150	74.1797	27.3469	8.6851	12.2395	38.9383	80.4301	95.4975	100.0000	69.0756
60	100.0000	99.9413	99.8118	95.4987	79.1017	31.7866	12.1538	15.2970	44.2190	84.0054	97.2201	100.0000	71.4344
61	100.0000	100.0000	99.9462	96.6380	83.1899	37.3993	15.9451	17.8605	48.7771	87.7419	98.6659	100.0000	73.6951
62	100.0000	100.0000	100.0000	97.4715	87.6398	42.9842	20.3012	21.7800	54.1690	90.7527	99.0626	100.0000	75.9969
63	100.0000	100.0000	100.0000	98.0628	90.1022	48.6246	24.7647	26.7545	58.7827	93.3005	99.2496	100.0000	78.1755
64	100.0000	100.0000	100.0000	98.7774	92.3346	54.2373	28.6698	30.9492	63.3963	95.3645	99.4997	100.0000	80.1556
65	100.0000	100.0000	100.0000	99.6666	94.4325	60.7669	34.2296	37.5101	67.7599	97.3387	99.7221	100.0000	82.5030
66	100.0000	100.0000	100.0000	99.8069	96.0194	66.9630	39.6612	43.1500	71.2340	98.4140	99.8808	100.0000	84.4945
67	100.0000	100.0000	100.0000	100.0000	97.2297	72.2101	45.1734	48.1830	75.4368	99.0860	100.0000	100.0000	86.3466
68	100.0000	100.0000	100.0000	100.0000	98.1980	76.9936	53.1595	54.7459	79.6276	99.7312	100.0000	100.0000	88.4501
69	100.0000	100.0000	100.0000	100.0000	98.5745	81.1892	60.2312	60.1500	83.9355	99.8925	100.0000	100.0000	90.2523
70	100.0000	100.0000	100.0000	100.0000	99.3814	87.0791	68.8357	66.6200	87.4931	100.0000	100.0000	100.0000	92.5541
71	100.0000	100.0000	100.0000	100.0000	99.6772	90.9697	75.4235	74.6166	88.7775	100.0000	100.0000	100.0000	94.0711
72	100.0000	100.0000	100.0000	100.0000	99.9193	94.1095	81.9037	81.2[illegible]	92.3[illegible]	100.0000	100.0000	100.0000	95.7592
73	100.0000	100.0000	100.0000	100.0000	100.0000	96.2767	87.5504	87.0604	94.4[illegible]	100.0000	100.0000	100.0000	97.0892
74	100.0000	100.0000	100.0000	100.0000	100.0000	97.7216	92.3904	92.7131	96.3867	100.0000	100.0000	100.0000	98.2526
75	100.0000	100.0000	100.0000	100.0000	100.0000	99.0831	96.4236	97.0153	98.3046	100.0000	100.0000	100.0000	99.2289
76	100.0000	100.0000	100.0000	100.0000	100.0000	99.5832	98.2791	98.8970	99.3052	100.0000	100.0000	100.0000	99.6692
77	100.0000	100.0000	100.0000	100.0000	100.0000	99.8333	99.2202	99.6230	99.8888	100.0000	100.0000	100.0000	99.8791
78	100.0000	100.0000	100.0000	100.0000	100.0000	99.9444	99.8118	99.9193	100.0000	100.0000	100.0000	100.0000	99.9726
79	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
80	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
81	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
82	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
83	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
84	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
85	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
86	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
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
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
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
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

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	100.0000	100.0000	100.0000
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	100.0000	100.0000	100.0000
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	100.0000	100.0000	100.0000
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	100.0000	100.0000	100.0000
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	100.0000	100.0000	100.0000
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	100.0000	100.0000	10J.0000
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	100.0000	100.0000	100.0000
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	100.0000	100.0000	100.0000
100	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	100.0000	100.0900	100.000.
101	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	100.0000	100.0000	100.0000
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	100.0000	100.0000	100.0000
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	100.0000	100.0000	100.0000
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	100.0000	100.0000	100.0000
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	100.0000	100.0006	100.0000
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	100.0000	100.0000	100.0000

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	3718.	3599.	3719.	3719.	3598.	3720.	3598.	3719.	43836.

Avg [illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	64.309	67.400	64.905	61.354	51.215	42.909	30.371	48.337

Exhibit 12
Sheet 3 of 6

[illegible]

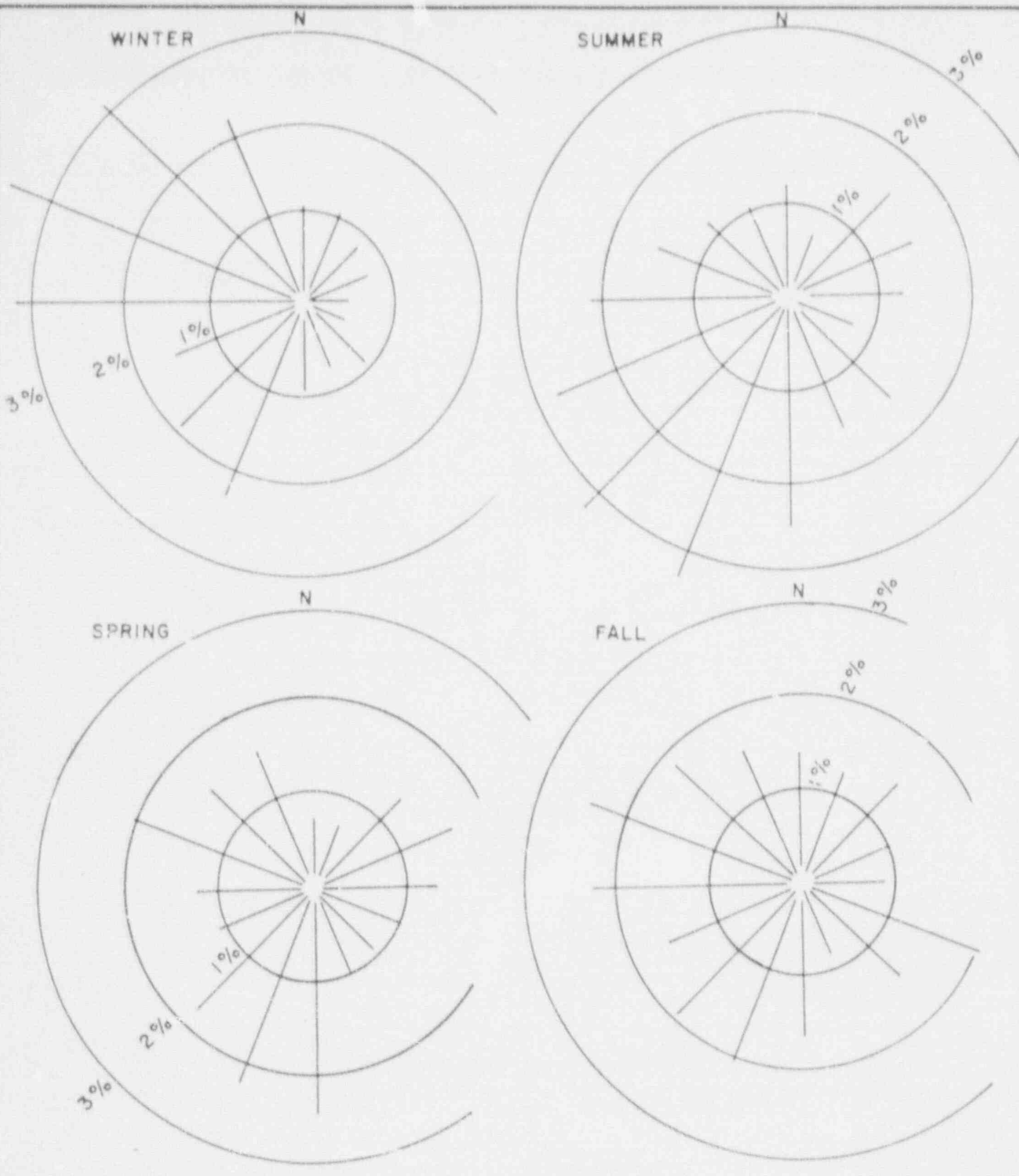
TEMP	JAN	FEB	MAR	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	ANNUAL
-5	[illegible]	[illegible]	[illegible]	0.0000	0.0000	0.0000	0.0000	[illegible]	[illegible]	[illegible]	0.0000	0.0000	0.0023
-4	[illegible]	[illegible]	[illegible]	0.0000	[illegible]	0.0000	0.0000	[illegible]	[illegible]	0.0000	0.0000	0.0000	0.0068
-3	[illegible]	[illegible]	[illegible]	0.0000	[illegible]	0.0000	0.0000	0.0000	[illegible]	0.0000	0.0000	0.0000	[illegible]
-2	[illegible]	[illegible]	[illegible]	0.0000	0.0000	0.0000	0.0000	0.0000	[illegible]	0.0000	0.0000	0.0000	0.0160
-1	[illegible]	[illegible]	[illegible]	0.0000	0.0000	0.0000	0.0000	0.0000	[illegible]	0.0000	0.0000	0.0000	0.0228
0	[illegible]	[illegible]	[illegible]	0.0000	0.0000	0.0000	0.0000	0.0000	[illegible]	0.0000	0.0000	0.0000	0.0274
1	[illegible]	[illegible]	[illegible]	0.0000	0.0000	0.0000	0.0000	0.0000	[illegible]	0.0000	0.0000	0.0000	0.0319
2	[illegible]	[illegible]	[illegible]	0.0000	.0000	0.0000	0.0000	0.0000	[illegible]	0.0000	0.0000	0.0000	0.0365
3	[illegible]	[illegible]	[illegible]	0.0000	0.0000	0.0000	0.0000	0.0000	[illegible]	0.0000	0.0000	0.0000	0.0548
4	[illegible]	[illegible]	[illegible]	0.0000	0.0000	0.0000	0.0000	0.0000	[illegible]	0.0000	0.0000	0.0000	0.0707
5	[illegible]	[illegible]	[illegible]	0.0000	0.0000	0.0000	0.0000	0.0000	[illegible]	0.0000	0.0000	0.1344	0.1369
6	[illegible]	[illegible]	[illegible]	0.0000	0.0000	0.0000	0.0000	0.0000	[illegible]	0.0000	0.0000	0.2151	0.1848
7	[illegible]	[illegible]	[illegible]	0.0000	0.0000	0.0000	0.0000	0.0000	[illegible]	0.0000	0.0000	0.4302	0.2738
8	[illegible]	[illegible]	[illegible]	0.0000	0.0000	0.0000	0.0000	0.0000	[illegible]	0.0000	0.0000	0.5109	0.3673
9	[illegible]	[illegible]	[illegible]	0.0000	0.0000	0.0000	0.0000	0.0000	[illegible]	0.0000	0.0000	0.7798	0.4494
10	[illegible]	[illegible]	[illegible]	0.0000	0.0000	0.0000	0.0000	0.0000	[illegible]	0.0000	0.0000	1.2907	0.5612
11	[illegible]	[illegible]	[illegible]	0.0000	0.0000	0.0000	0.0000	0.0000	[illegible]	0.0000	0.0000	2.1242	0.7300
12	[illegible]	[illegible]	[illegible]	0.0000	0.0000	0.0000	0.0000	0.0000	[illegible]	0.0000	0.0000	2.6351	0.8783
13	[illegible]	[illegible]	[illegible]	0.0000	0.0000	0.0000	0.0000	0.0000	[illegible]	0.0000	0.0278	3.3342	1.0996
14	[illegible]	[illegible]	[illegible]	0.0000	0.0000	0.0000	0.0000	0.0000	[illegible]	0.0000	0.1112	4.1947	1.3049
15	[illegible]	[illegible]	[illegible]	0.0000	0.0000	0.0000	0.0000	0.0000	[illegible]	0.0000	0.1390	5.2971	1.5650
16	[illegible]	[illegible]	[illegible]	0.0000	0.0000	0.0000	0.0000	0.0000	[illegible]	0.0000	0.1668	6.3458	1.8205
17	[illegible]	[illegible]	[illegible]	0.0000	0.0000	0.0000	0.0000	0.0000	[illegible]	0.0000	0.1946	7.6902	2.1284
18	[illegible]	[illegible]	[illegible]	0.0000	0.0000	0.0000	0.0000	0.0000	[illegible]	0.0000	0.2501	9.2767	2.5185
19	[illegible]	[illegible]	[illegible]	0.0000	0.0000	0.0000	0.0000	0.0000	[illegible]	0.0000	0.3057	10.8094	2.9109
20	[illegible]	[illegible]	[illegible]	.0000	0.0000	0.0000	0.0000	0.0000	[illegible]	0.0000	0.3891	12.5840	3.3740
21	[illegible]	[illegible]	[illegible]	0.0000	0.0000	0.0000	0.0000	0.0000	[illegible]	0.0000	0.5003	14.3318	3.7687
22	[illegible]	[illegible]	[illegible]	0.0000	0.0000	0.0000	0.0000	0.0000	[illegible]	0.0000	0.5281	16.7518	4.3230
23	[illegible]	[illegible]	[illegible]	0.0000	0.0000	0.0000	0.0000	0.0000	[illegible]	0.0000	0.5837	18.6878	4.8774
24	[illegible]	[illegible]	[illegible]	0.0000	0.0000	0.0000	0.0000	0.0000	[illegible]	0.0000	0.7226	20.7852	5.4545
25	[illegible]	[illegible]	[illegible]	[illegible]	0.0000	0.0000	0.0000	0.0000	[illegible]	0.0000	0.7782	23.4203	6.2621
26	[illegible]	[illegible]	[illegible]	0.1111	0.0000	0.0000	0.0000	0.0000	[illegible]	0.0269	0.9450	25.8672	7.0423
27	[illegible]	[illegible]	[illegible]	0.1667	0.0000	0.0000	0.0000	0.0000	[illegible]	0.1344	1.4175	29.0401	7.9754
28	[illegible]	[illegible]	[illegible]	[illegible]	0.0000	0.0000	0.0000	0.0000	[illegible]	0.1344	1.9177	32.1861	8.8970
29	[illegible]	[illegible]	[illegible]	[illegible]	0.0000	0.0000	0.0000	0.0000	[illegible]	0.1344	2.5292	35.3052	9.8757
30	[illegible]	[illegible]	[illegible]	[illegible]	0.0000	0.0000	0.0000	0.0000	[illegible]	0.1882	3.4742	39.1503	11.2285
31	[illegible]	[illegible]	[illegible]	[illegible]	0.0000	0.0000	0.0000	0.0000	[illegible]	0.2957	4.6137	42.9685	12.4535
32	[illegible]	[illegible]	[illegible]	[illegible]	0.0000	0.0000	0.0000	0.0000	[illegible]	0.6720	5.5870	47.4659	13.9364
33	[illegible]	[illegible]	[illegible]	[illegible]	0.0000	0.0000	0.0000	0.0000	[illegible]	0.8602	8.3380	52.3528	15.5310
34	[illegible]	[illegible]	[illegible]	[illegible]	0.0000	0.0000	0.0000	0.0000	[illegible]	1.4785	10.7838	56.6012	17.1826
35	[illegible]	[illegible]	[illegible]	[illegible]	0.0000	0.0000	0.0000	0.0000	[illegible]	2.2312	13.2010	60.4195	18.9346
36	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.0000	0.0000	0.0000	[illegible]	3.0376	15.5986	63.7537	20.4129
37	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.0000	0.0000	0.0000	[illegible]	3.7903	18.6770	67.0879	22.1421
38	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.0000	0.0000	0.0000	[illegible]	4.4624	21.8177	69.9382	23.8873
39	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.0000	0.0000	[illegible]	[illegible]	24.8749	73.2186	25.6416
40	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.0000	0.0000	0.0000	[illegible]	[illegible]	27.6543	76.5797	27.4370
41	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.0000	0.0000	[illegible]	[illegible]	7.0968	30.7949	78.8922	28.9289
42	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.0000	0.0000	0.0000	[illegible]	[illegible]	34.2412	81.2315	30.5486
43	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.0000	0.0000	0.0000	[illegible]	[illegible]	37.7154	82.9255	32.2026
44	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.0000	0.0000	0.0000	1.0561	[illegible]	[illegible]	84.8077	33.8793
45	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.0000	0.0000	0.0000	[illegible]	15.0538	44.2190	86.5555	35.6313
46	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.0000	0.0000	0.0000	[illegible]	[illegible]	47.5542	88.8411	37.3081
47	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.0000	0.0000	0.0000	[illegible]	19.7312	50.6392	90.4275	38.9483
48	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.0000	0.0000	[illegible]	[illegible]	53.7521	91.8795	40.5703
49	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.0000	[illegible]	[illegible]	[illegible]	56.9483	93.1782	41.9893

Exhibit 12
Sheet 4 of 6

Exhibit 12

Sheet 6 of 6

	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3720.	3598.	3719.	4383[illegible]
AVG TEMP													
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	47.311	33.344	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 (mph)	Season			
	Winter	Spring	Summer	Fall
0-3[a]	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

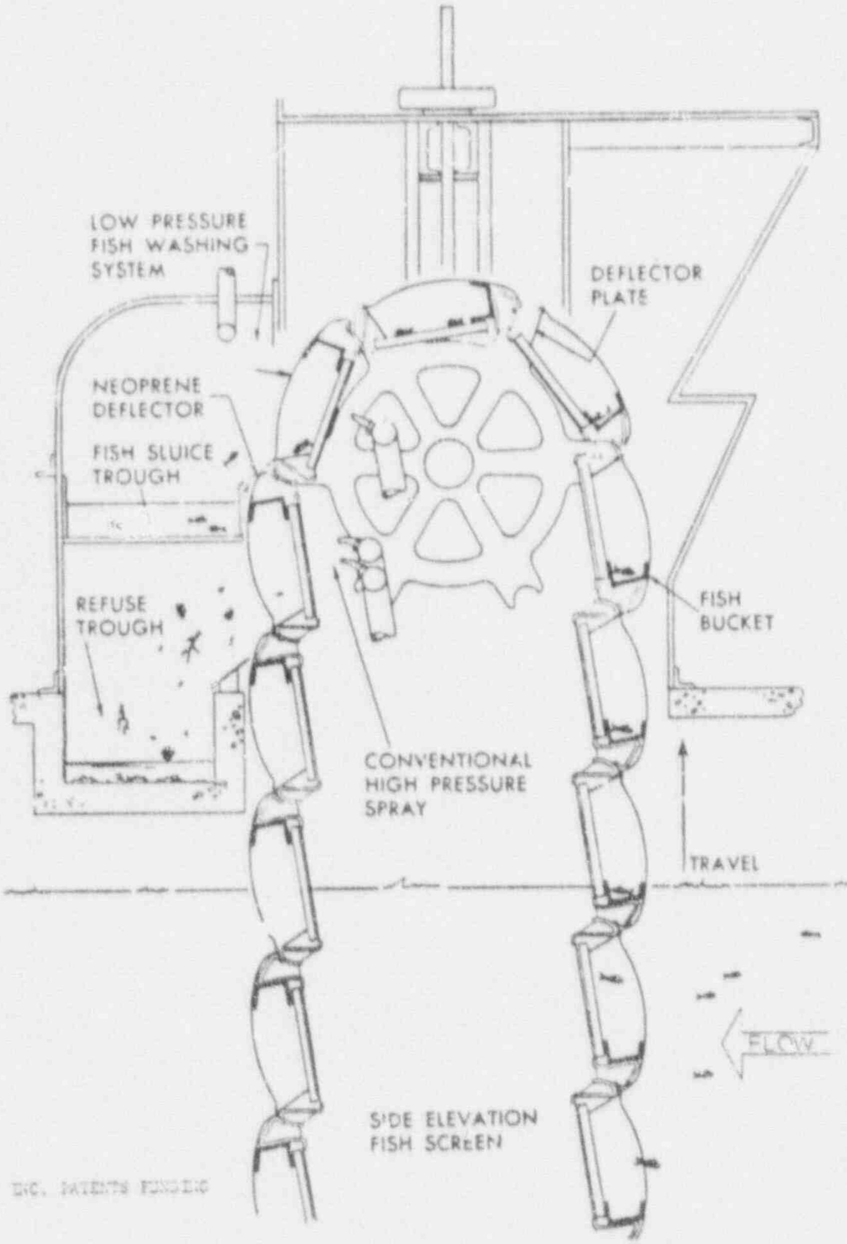
a. 88 hours of calm are included in total of 8016 hours.

Note: Total of all columns adds to about 100%.

BARNEGAT BAY AND ATLANTIC OCEAN WATER QUALITY

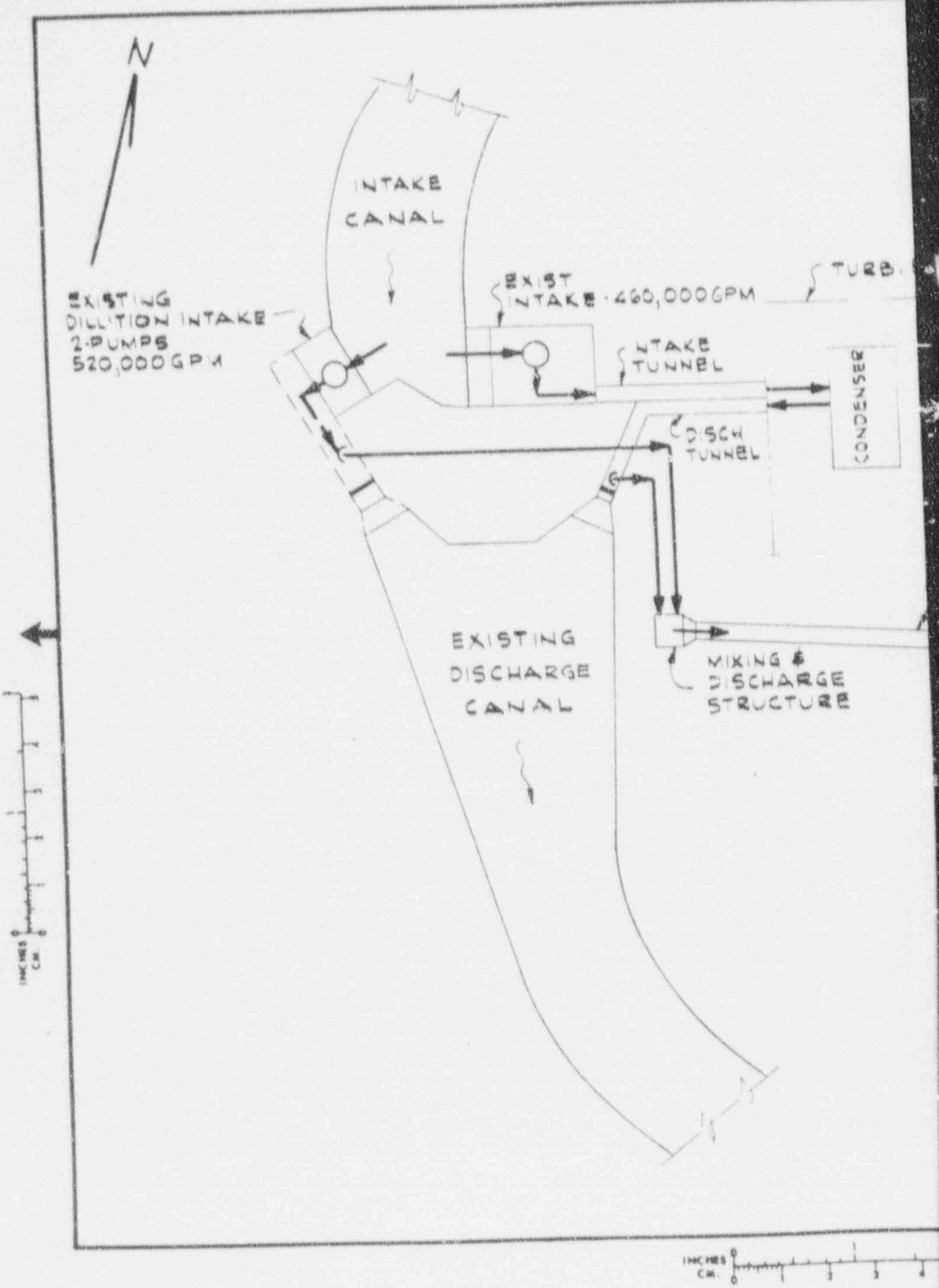
Parameter	Barnegat Bay Average	Barnegat Bay Maximum	Atlantic Ocean Average
Calcium	278	348	406
Magnesium	886	1,107	1,292
Sodium	7,547	9,183	10,714
Potassium	264	330	385
Chloride	13,200	16,500	19,250
Sulfate	1,843	2,304	2,688
Nitrate		-	-
Phosphate	0.08	0.1	0.12
Bicarbonate	100	123	144
Silica	2.2	2.7	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 $CaCO_3$	82	104	118
pH	7.7	8.3	8.3

Note: All units are in ppm, except pH which is in standard units.

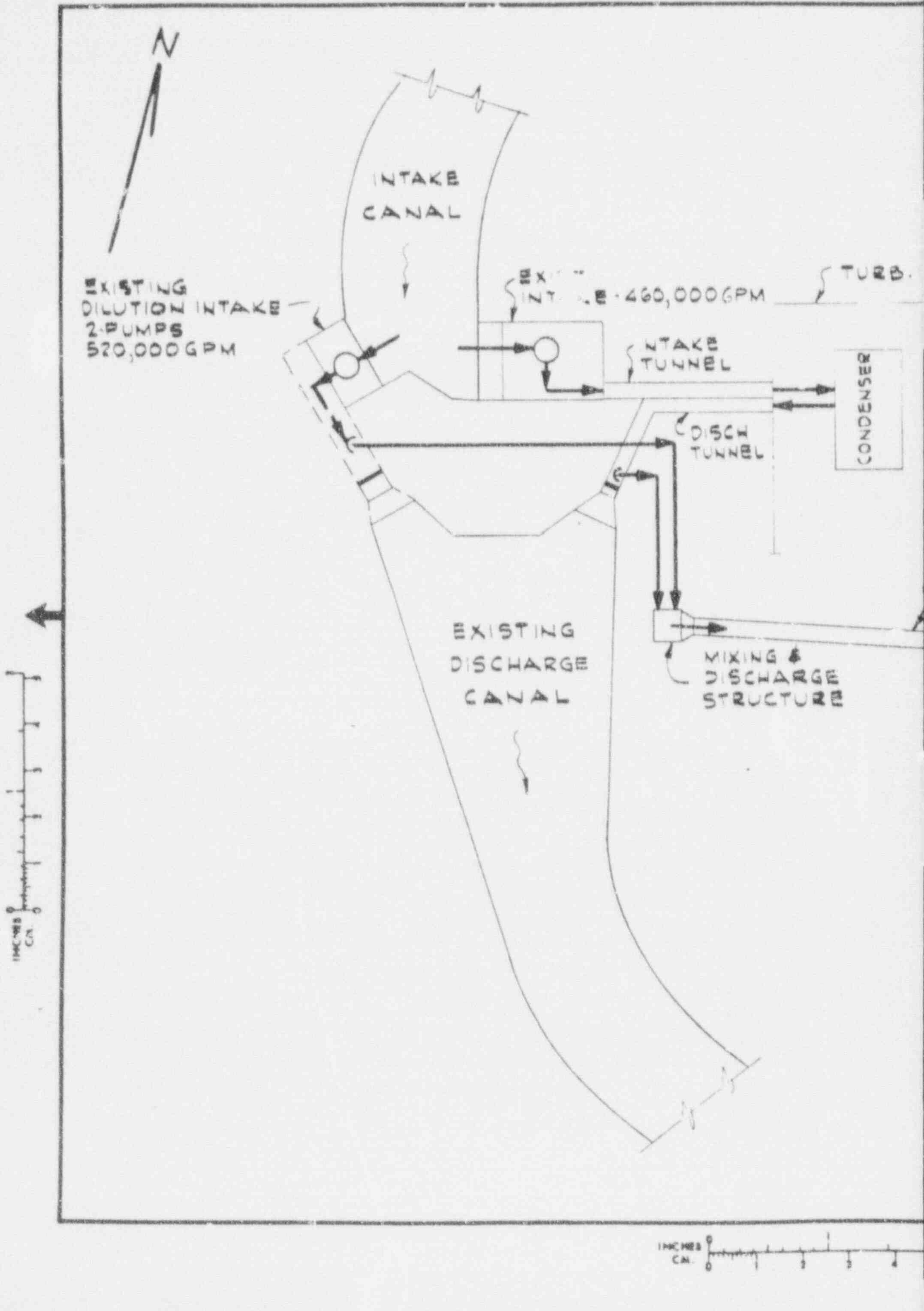


PERMISSION BY ENVIREX, INC. PATENTS PENDING

JERSEY CENTRAL POWER & LIGHT COMPANY EBASCO SERVICES INCORPORATED New York	TRAVELING SCREEN WITH RISTROPH BUCKETS	EXHIBIT 15

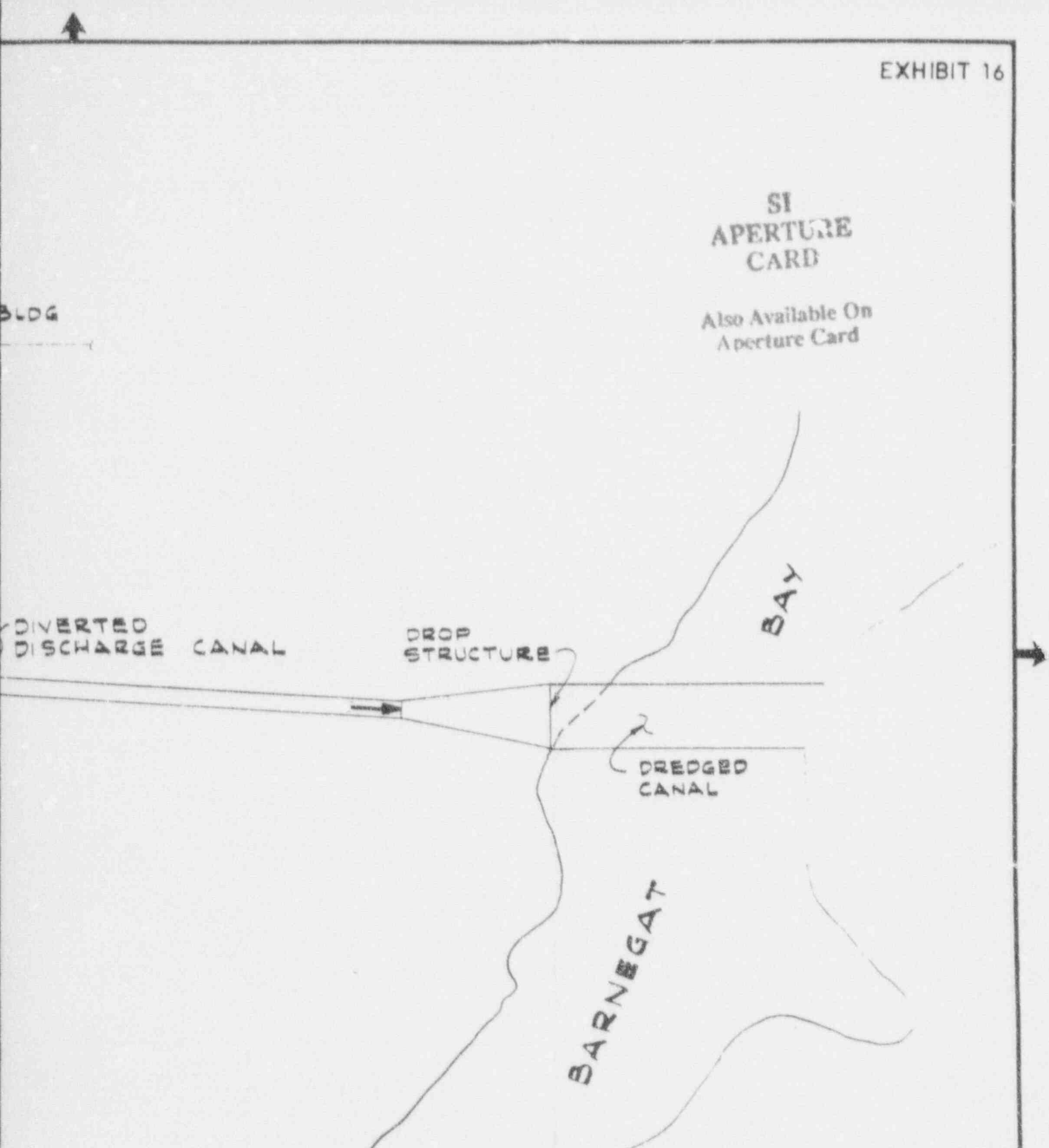

N
INTAKE
CANAL
EXISTING
DILLUTION INTAKE
2-PUMPS
520,000GPM
EXIST
INTAKE · 460,000GPM
TURB.
INTAKE
TUNNEL
CONDENSER
DISCH
TUNNEL
EXISTING
DISCHARGE
CANAL
MIXING &
DISCHARGE
STRUCTURE
INCHES
CM.

GARDEN STATE PARKWAY
CANAL
EXIST. DUTCH PUMPHOUSE
DISCH STRUCT
BRIDGE
DIVERTED DISCH
OYSTER CREEK
CENTRAL RAILROAD OF N.J.
ROUTE 9
FRESH CR
WARETOWN
WARETOWN CREEK
BROOKVILLE ROAD
PLAN
1"=1000'
DISCH STRUCT
EXIST CANAL
ROAD & R.R. BRIDGE
BERM
ORIGINAL GROUND
TOP EMBANKMENT
WATER SURFACE
HIGH POINT EL 2.75
BOT/CANAL-EL VARIES
LOW POINT EL 1.75
DRAIN LINE
DROP STRUCTURE 400' LONG
PROFILE - DIVERTED CANAL
VERT 1"=20'
HORIZ 1"=1000'



N
INTAKE CANAL
EXISTING DILUTION INTAKE 2-PUMPS 520,000 GPM
INTAKE TUNNEL
TURB.
CONDENSER
DISCH TUNNEL
EXISTING DISCHARGE CANAL
MIXING & DISCHARGE STRUCTURE
INCHES
CM.

EXHIBIT 16

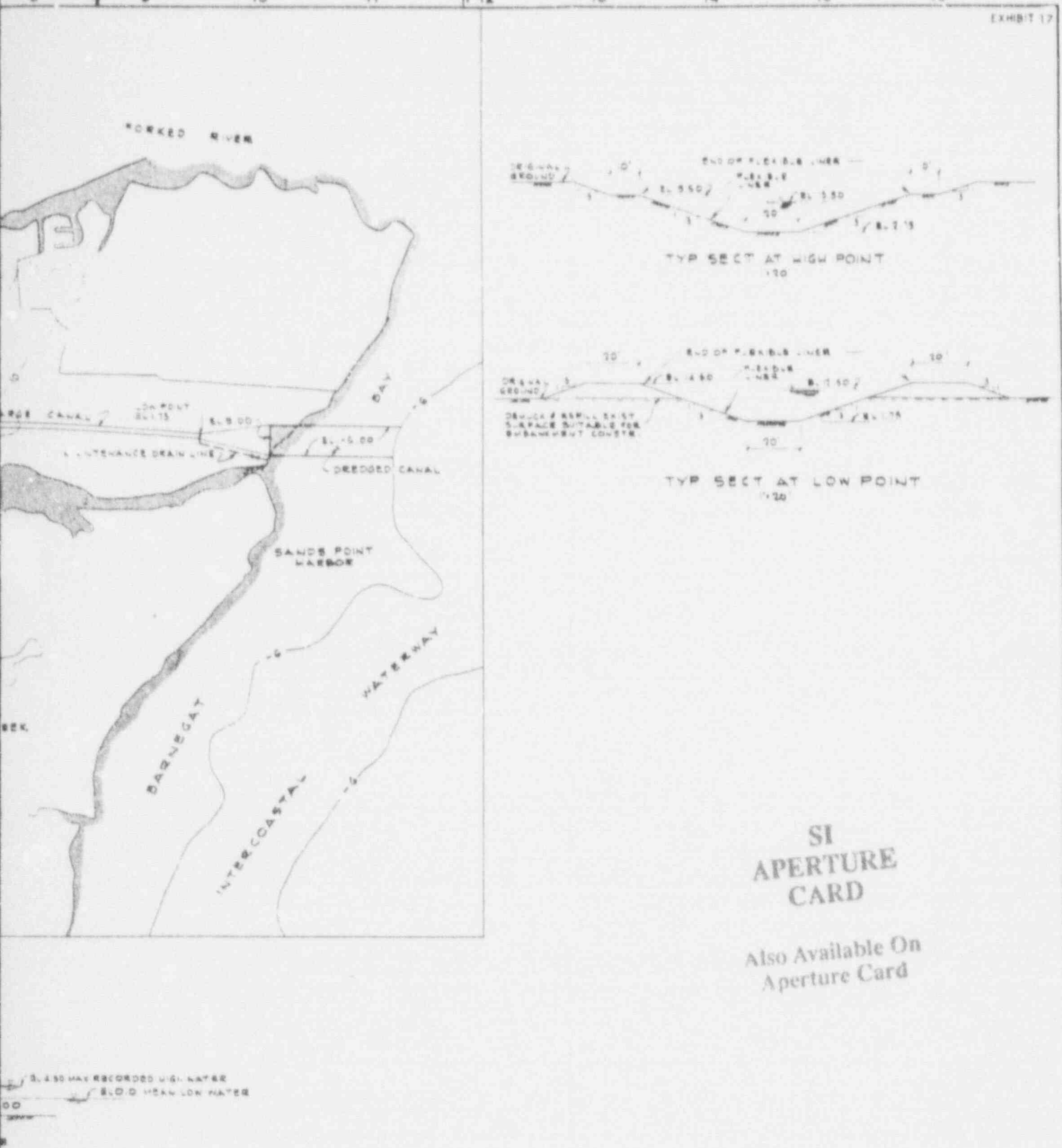


EBASCO SERVICES INCORPORATED		JERSEY CENTRAL POWER & LIGHT OYSTER CREEK NUCLEAR GEN. STATION ALTERNATIVE COOLING WATER SYS. STUDY DISCHARGE CANAL TO BAY	JCP - 7037 EXHIBIT 16
DIV CIVIL DR GA SCALE NTS CH. DATE FEB 1977	APPROVED		

9111110048 - 03

GARDEN STATE PARKWAY
OYSTER CREEK
WARETOWN CREEK
WARETOWN
BROOKVILLE ROAD
CANAL
DIVERTED DISCH
FRESH CR
PLAN
PROFILE - DIVERTED CANAL
ROAD & R.R. BRIDGE
ORIGINAL GROUND
WATER SURFACE
BOT/CANAL EL VARIES
LOW POINT
HIGH POINT
DROP STRUCTURE

EXHIBIT 17



JERSEY CENTRAL POWER & LIGHT CO.
OYSTER CREEK NUCLEAR GENERATING STATION

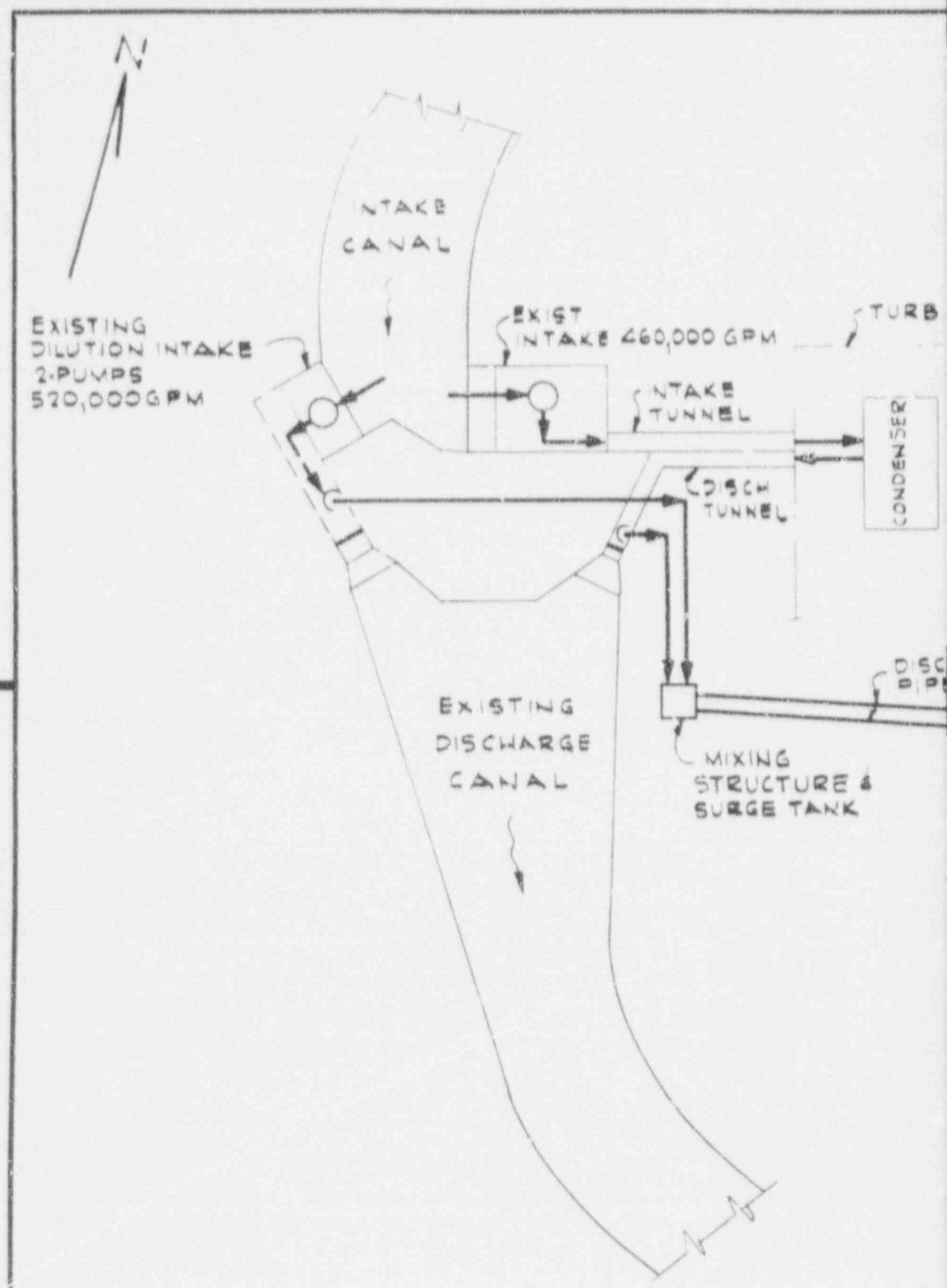
ALTERNATIVE COOLING WATER SYSTEM STUDY
DISCHARGE CANAL TO BAY

EDASCO SERVICES INCORPORATED

JCP-7037

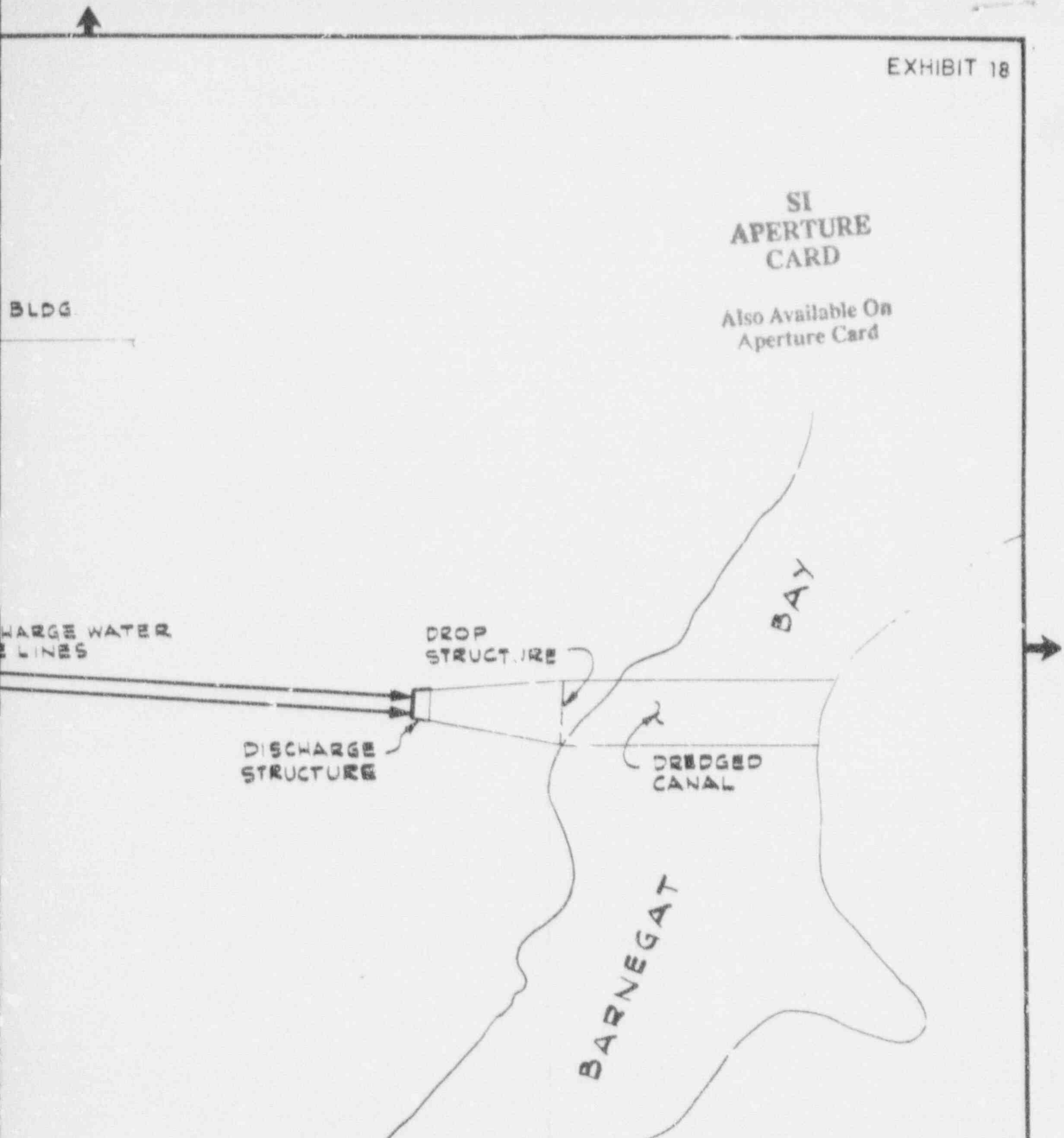
EXHIBIT 17

9111110048-04



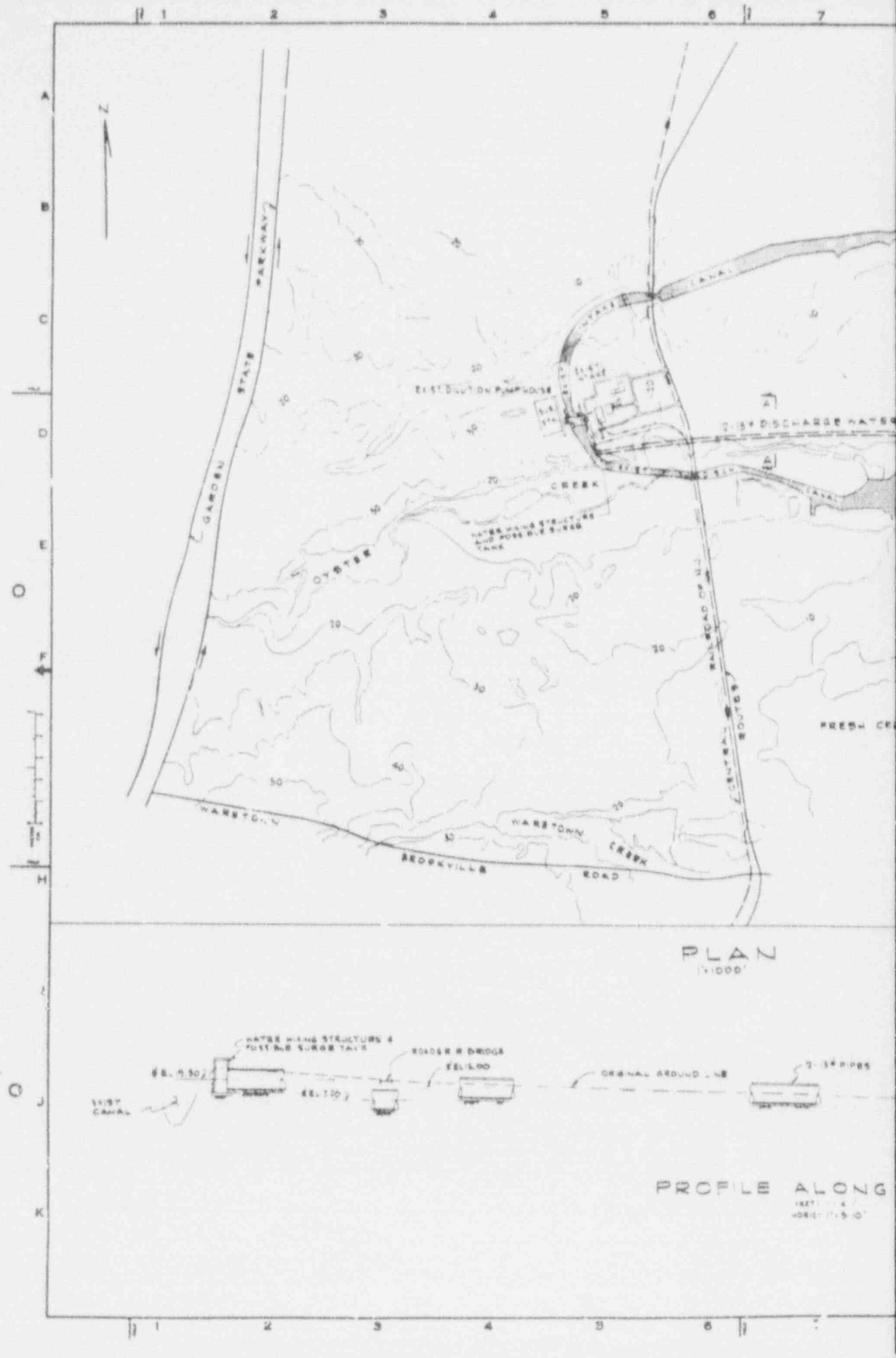
N
INTAKE
CANAL
EXISTING
DILUTION INTAKE
2-PUMPS
520,000 GPM
EXIST
INTAKE 460,000 GPM
TURB
INTAKE
TUNNEL
CONDENSER
DISCH
TUNNEL
EXISTING
DISCHARGE
CANAL
MIXING
STRUCTURE &
SURGE TANK
INCHES
CM.

EXHIBIT 18

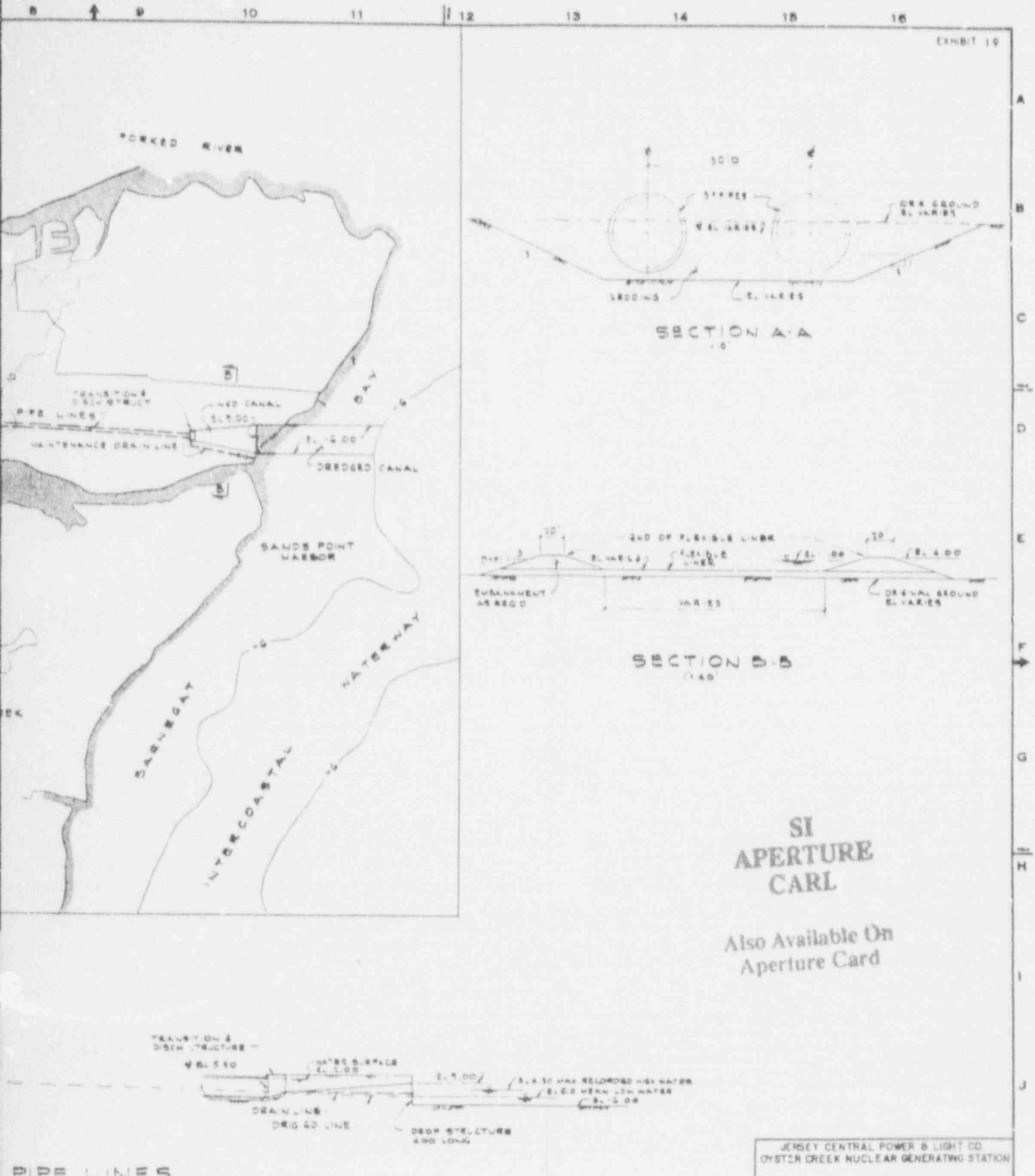


EBASCO SERVICES INCORPORATED		JERSEY CENTRAL POWER & LIGHT OYSTER CREEK NUCLEAR GEN. STATION ALTERNATIVE COOLING WATER SYS STUDY DISCHARGE PIPE LINES TO BAY	JCP - 7037 EXHIBIT 18
DIV. CIVIL DR. GA SCALE NTS CH. [illegible] DATE FEB 1977	APPROVED		

9111110048 - 05



GARDEN STATE PARKWAY
EXIST. DILUTION PUMPHOUSE
CANAL
OYSTER CREEK
WARETOWN CREEK
WARETOWN
BROOKVILLE ROAD
PLAN
PROFILE ALONG



JERSEY CENTRAL POWER & LIGHT CO.
OYSTER CREEK NUCLEAR GENERATING STATION

ALTERNATIVE COOLING WATER SYSTEM STUDY
DISCHARGE PIPE LINES TO BAY

EBASCO SERVICES INCORPORATED

SCALE AS NOTED	APPROVED	DATE FEB 1977
		JCP - 7037
		EXHIBIT 19

SI
APERTURE
CARD

Also Available On
Aperture Card

9111110048-06

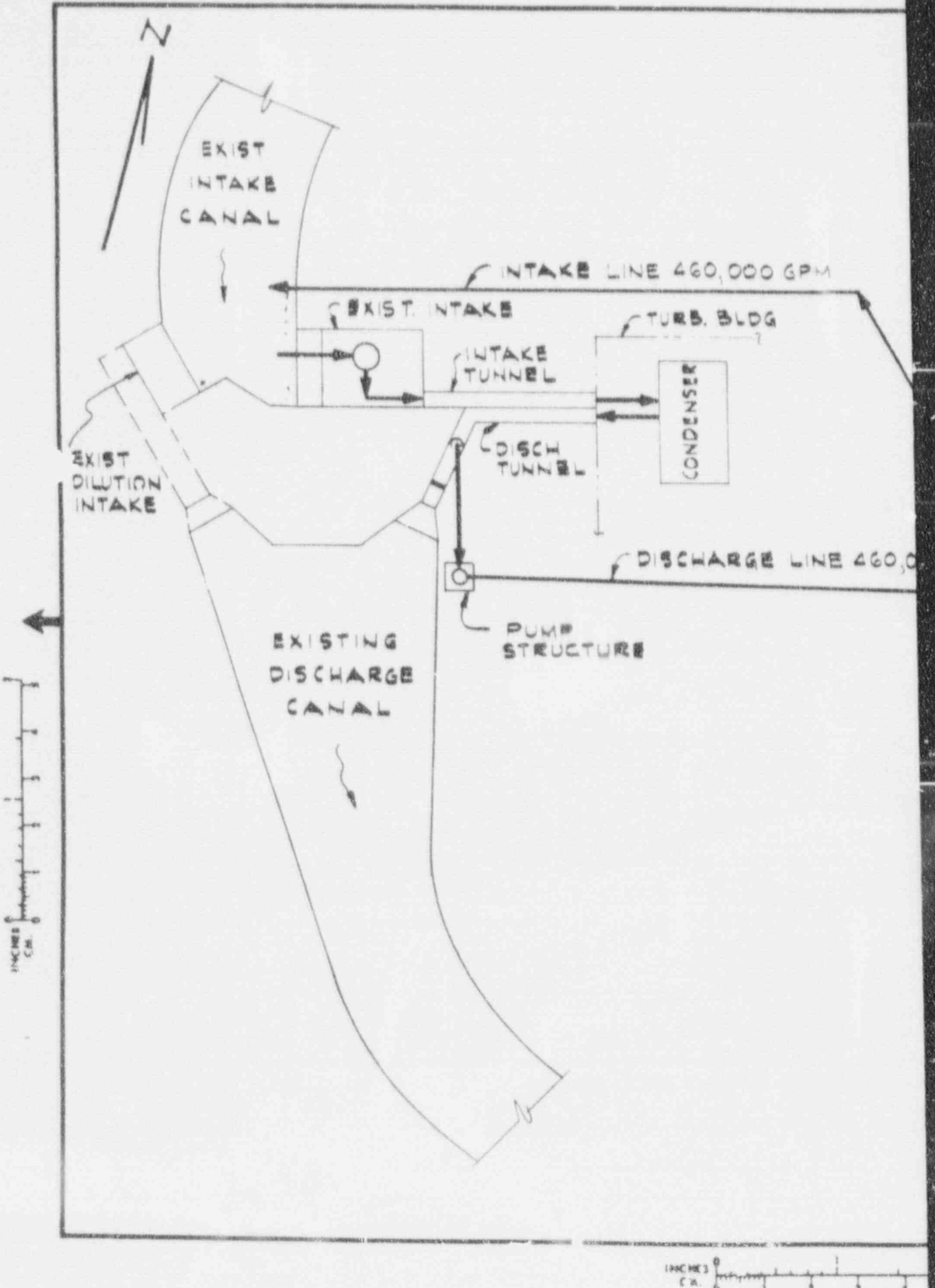
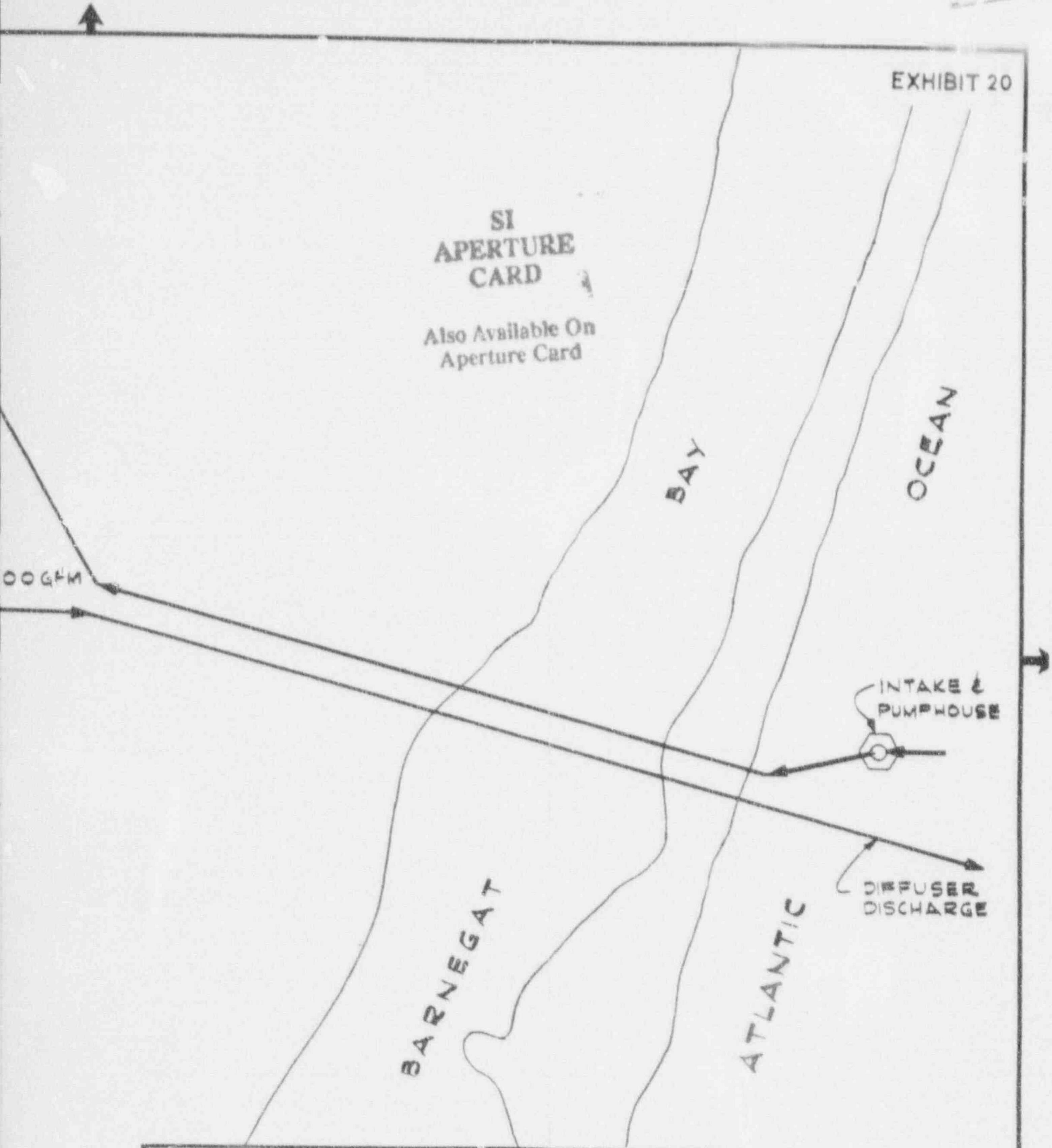
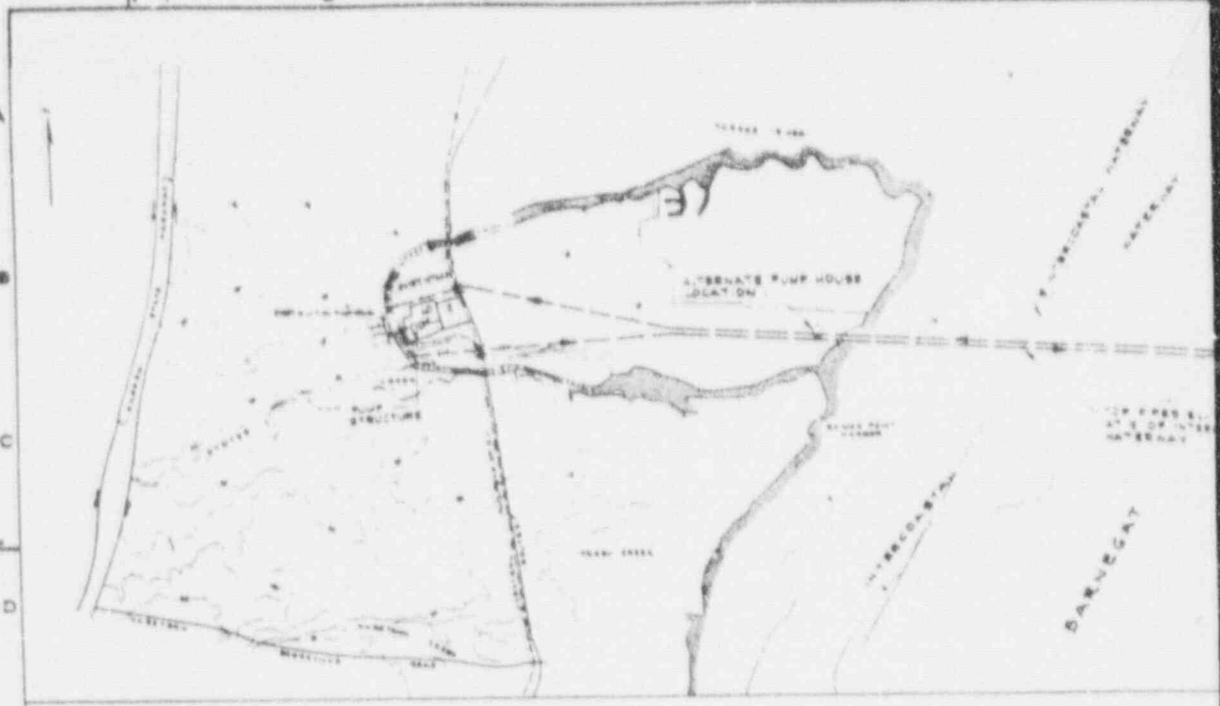

N
EXIST
INTAKE
CANAL
INTAKE LINE 460,000 GPM
EXIST. INTAKE
TURB. BLDG
INTAKE
TUNNEL
CONDENSER
DISCH
TUNNEL
EXIST
DILUTION
INTAKE
DISCHARGE LINE 460,0
PUMP
STRUCTURE
EXISTING
DISCHARGE
CANAL
INCHES
C.M.
0
1
2
3
4

EXHIBIT 20



EBASCO SERVICES INCORPORATED		JERSEY CENTRAL POWER & LIGHT OYSTER CREEK NUCLEAR GEN STATION ALTERNATIVE COOLING WATER SYS STUDY OCEAN INTAKE & DISCHARGE PIPE LINE	JCP-7037 EXHIBIT 20
DIV CIVIL DR GA SCALE NTS CH DATE FEB 1977	APPROVED		

9111110048-07



PLA

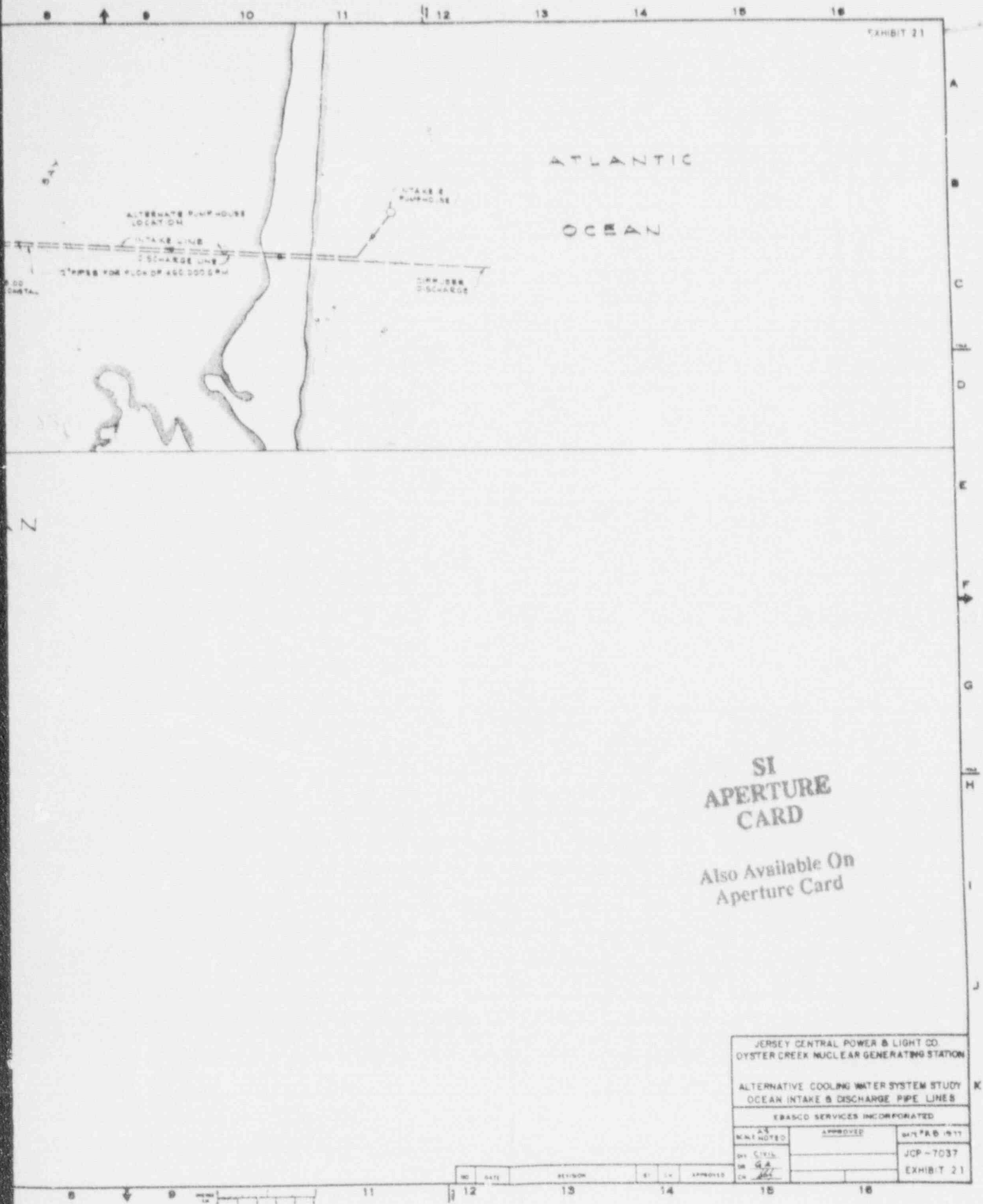
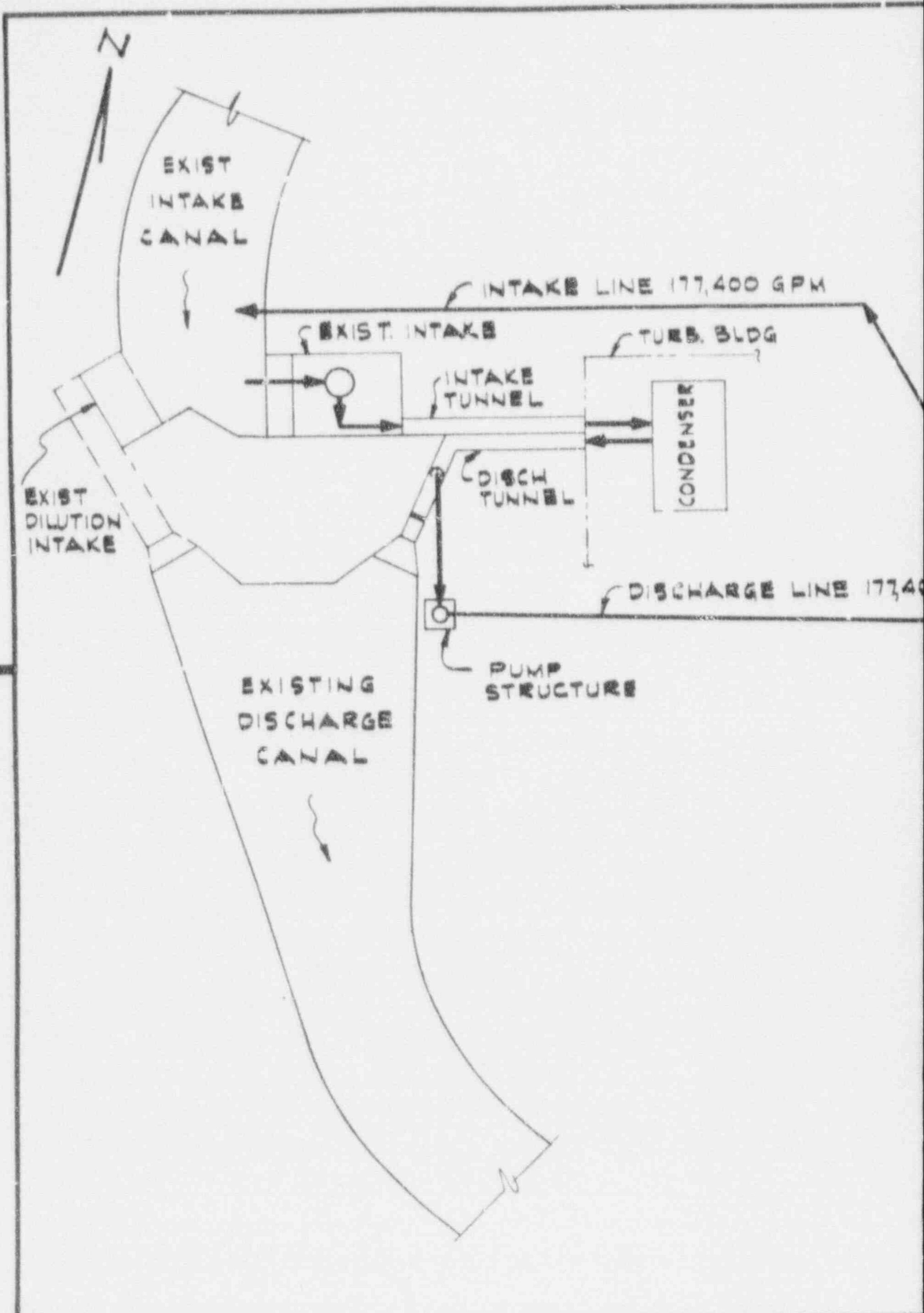
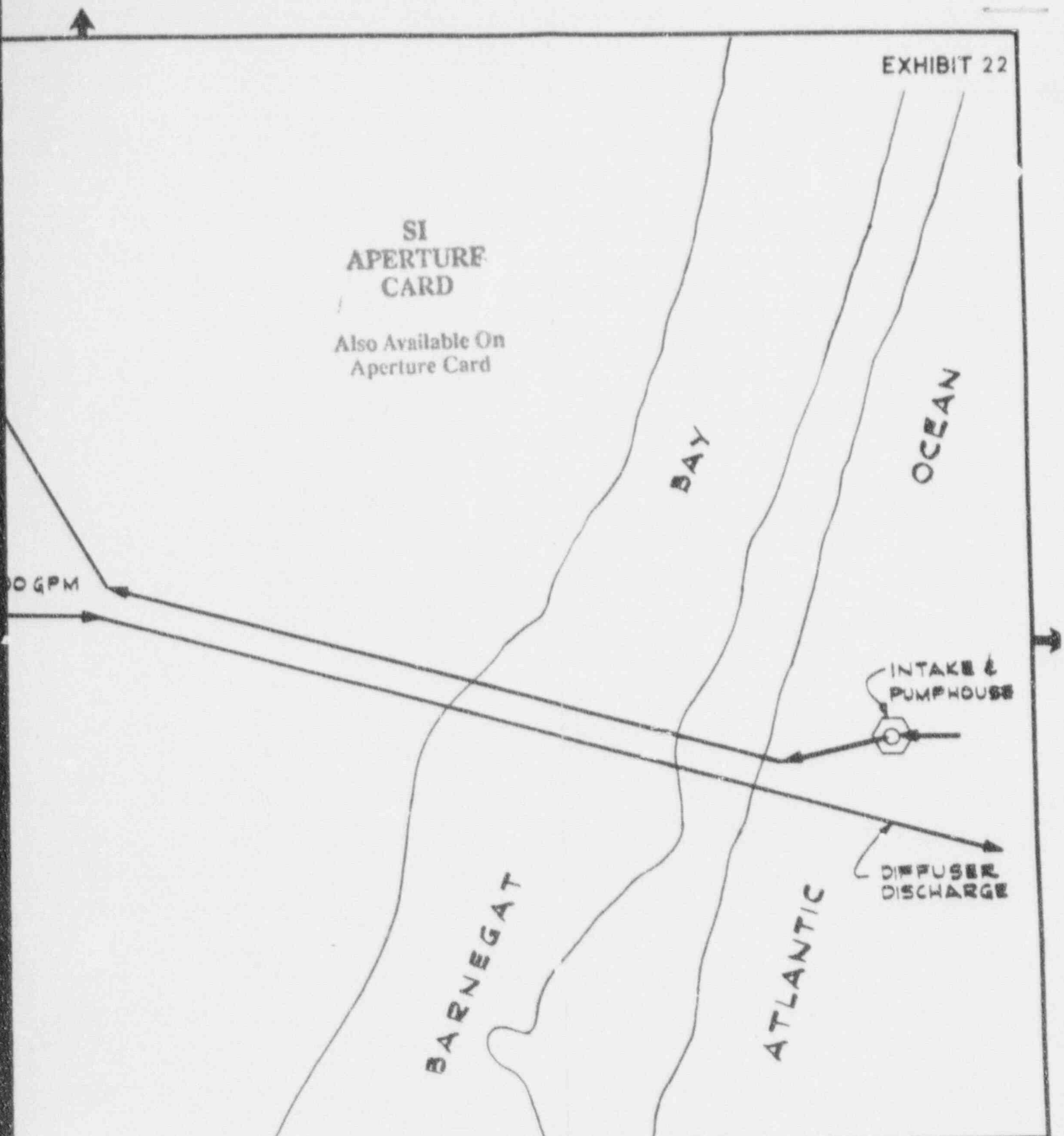


EXHIBIT 21
ATLANTIC
OCEAN
ALTERNATE PUMPHOUSE LOCATION
INTAKE LINE
DISCHARGE LINE
INTAKE & PUMPHOUSE
DIFFUSER DISCHARGE
JERSEY CENTRAL POWER & LIGHT CO.
OYSTER CREEK NUCLEAR GENERATING STATION
ALTERNATIVE COOLING WATER SYSTEM STUDY
OCEAN INTAKE & DISCHARGE PIPE LINES
EBASCO SERVICES INCORPORATED
SCALE AS NOTED
APPROVED
JCP - 7037
EXHIBIT 21


N
EXIST
INTAKE
CANAL
INTAKE LINE 177,400 GPM
EXIST. INTAKE
TURB. BLDG
INTAKE
TUNNEL
CONDENSER
DISCH
TUNNEL
EXIST
DILUTION
INTAKE
DISCHARGE LINE 177,40
PUMP
STRUCTURE
EXISTING
DISCHARGE
CANAL

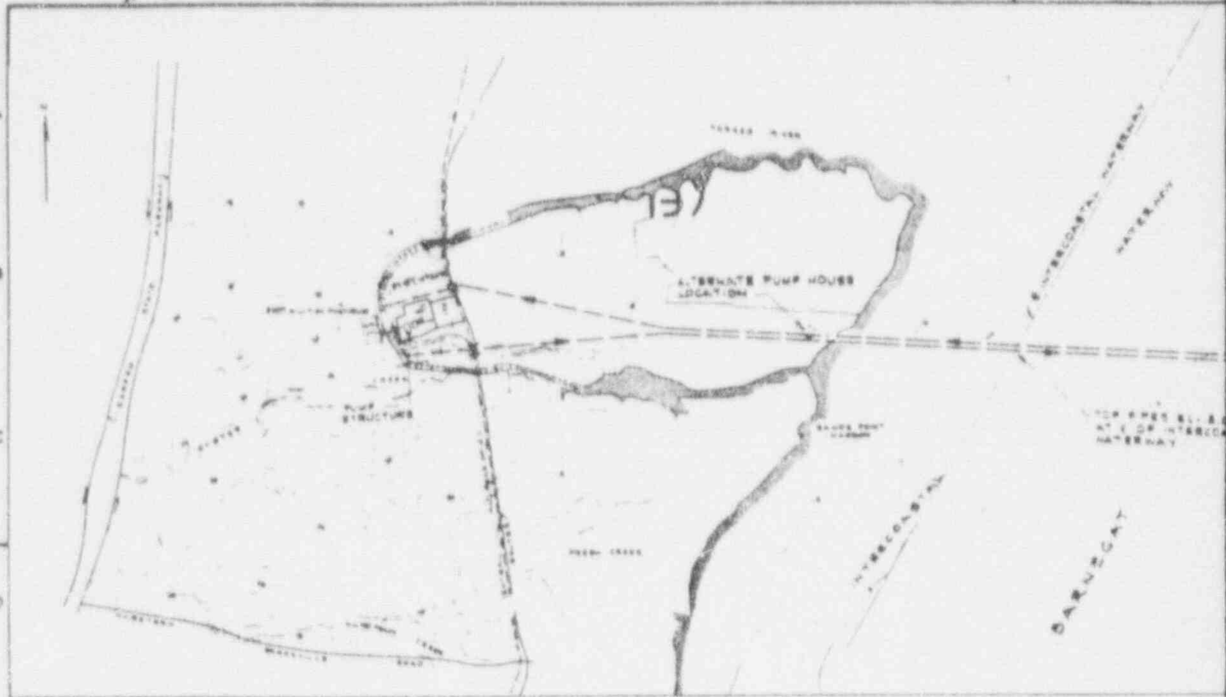
SI
APERTURE
CARD

Also Available On
Aperture Card



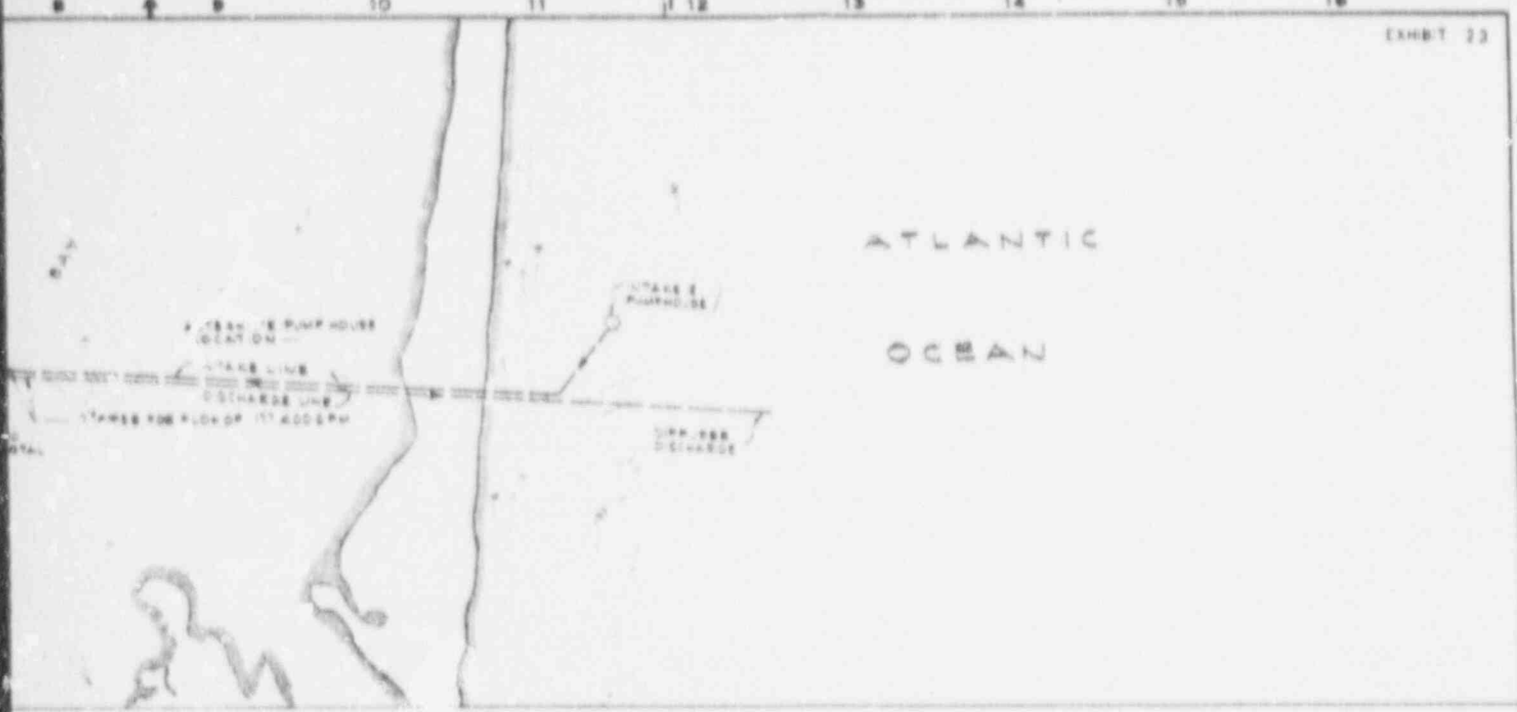
EBASCO SERVICES INCORPORATED		JERSEY CENTRAL POWER & LIGHT OYSTER CREEK NUCLEAR GEN. STATION ALTERNATIVE COOLING WATER SYS. STUDY OCEAN INTAKE & DISCHARGE PIPE LINE WITH MULTIPRESSURE CONDENSER	JCP-7037 EXHIBIT 22
DIV. CIVIL DR. GA SCALE NTS CH. [illegible] DATE FEB 1977	APPROVED		

9111110048-09


ALTERNATE PUMP HOUSE
LOCATION
PUMP
STRUCTURE
BARNEGAT
137

PLA

1:1000'



SI
APERTURE
CARD

Also Available On
Aperture Card

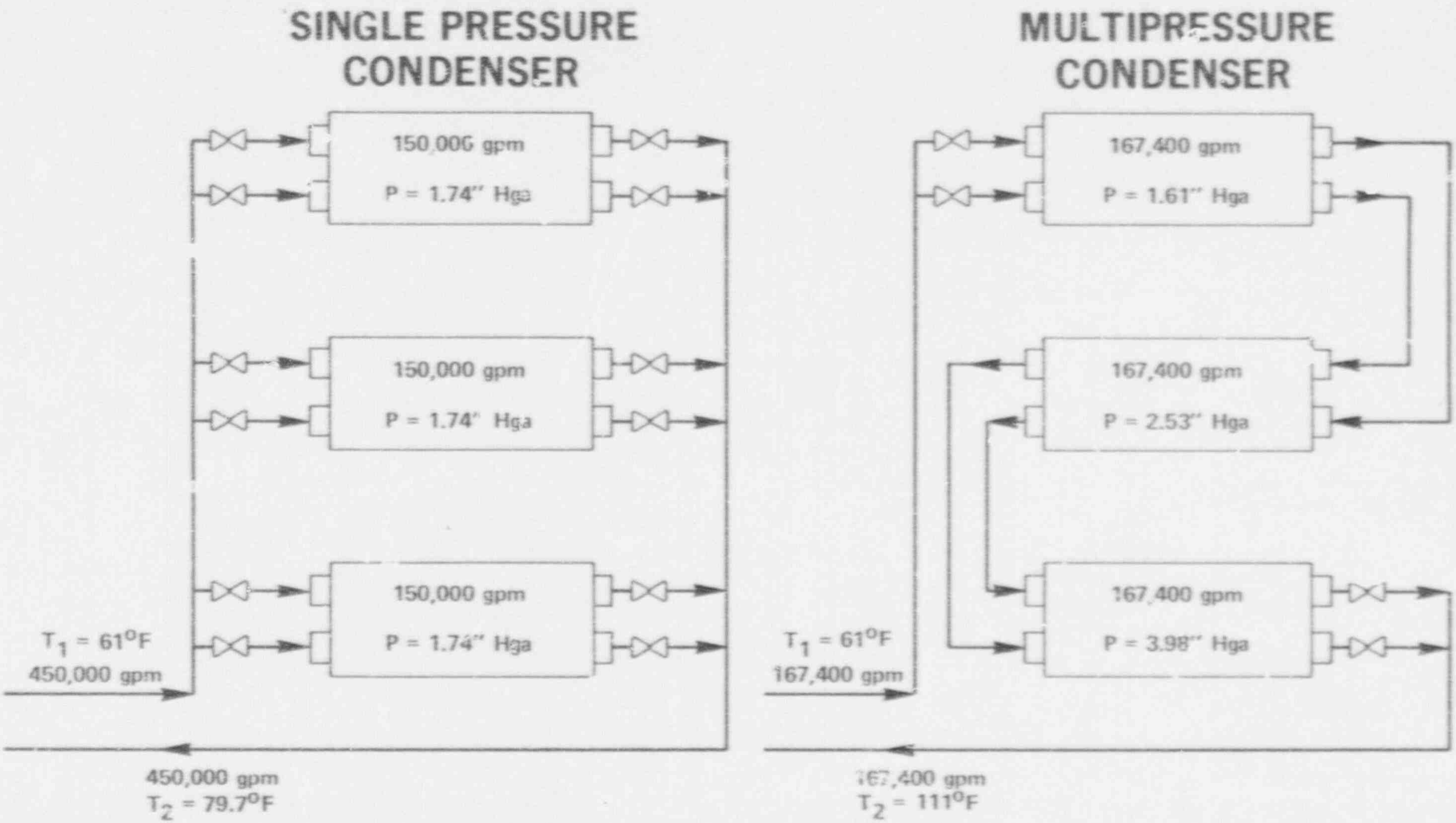
JERSEY CENTRAL POWER & LIGHT CO.
OYSTER CREEK NUCLEAR GENERATING STATION
ALTERNATIVE COOLING WATER SYSTEM STUDY
OCEAN INTAKE & DISCHARGE PIPE LINES
WITH MULTIPRESSURE CONDENSER

EBASCO SERVICES INCORPORATED

SCALE AS NOTED	APPROVED	DATE FEB 1977
BY CIVIL / DR GA / CH		JCP - 7037 EXHIBIT 23

9111110048-10

MULTIPRESSURE AND SINGLE PRESSURE CONDENSERS - WATER FLOW DIAGRAMS



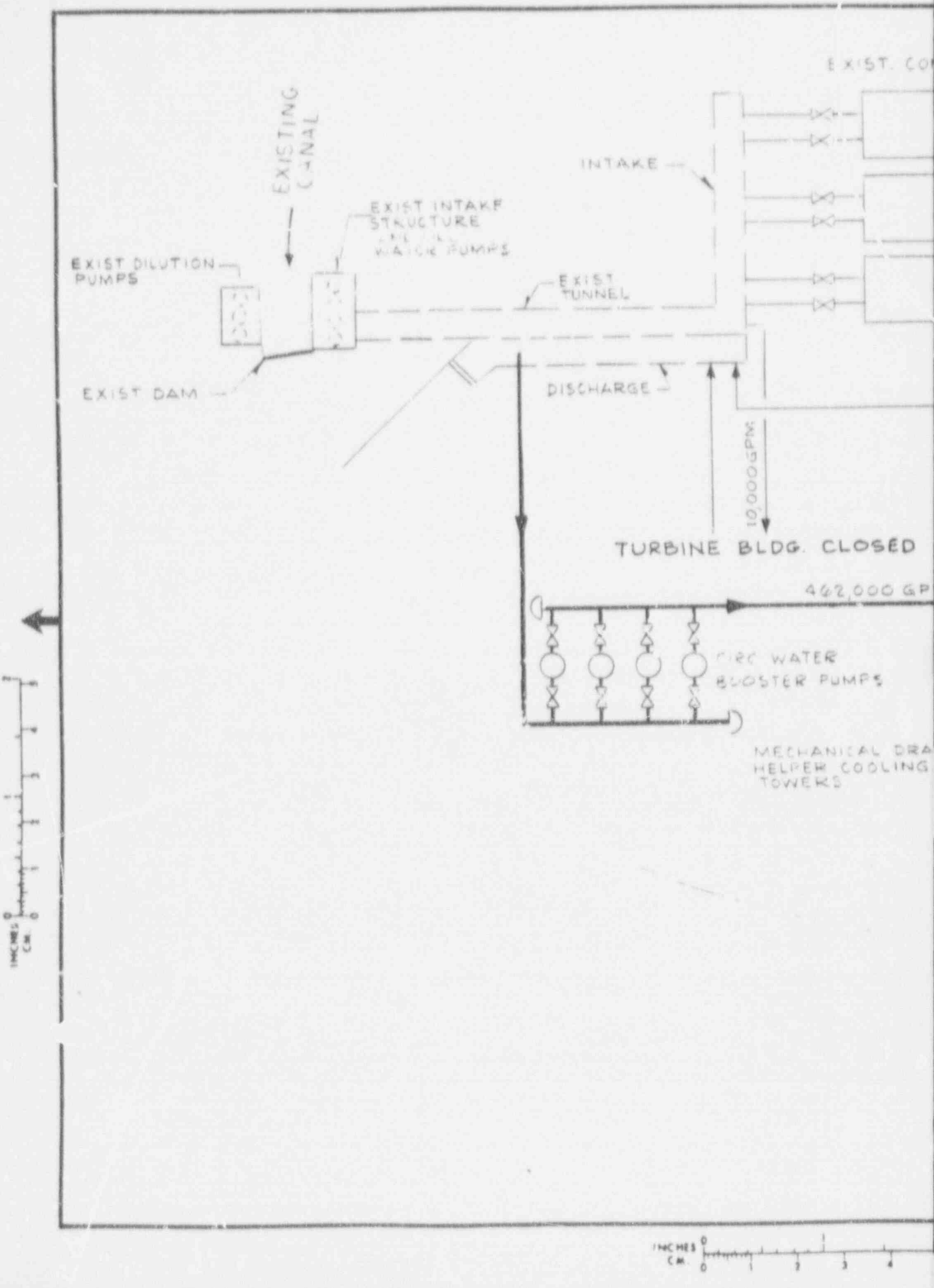
PLANT NET OUTPUT 624.2 MW

CW PIPES 2 X 12' I.D.

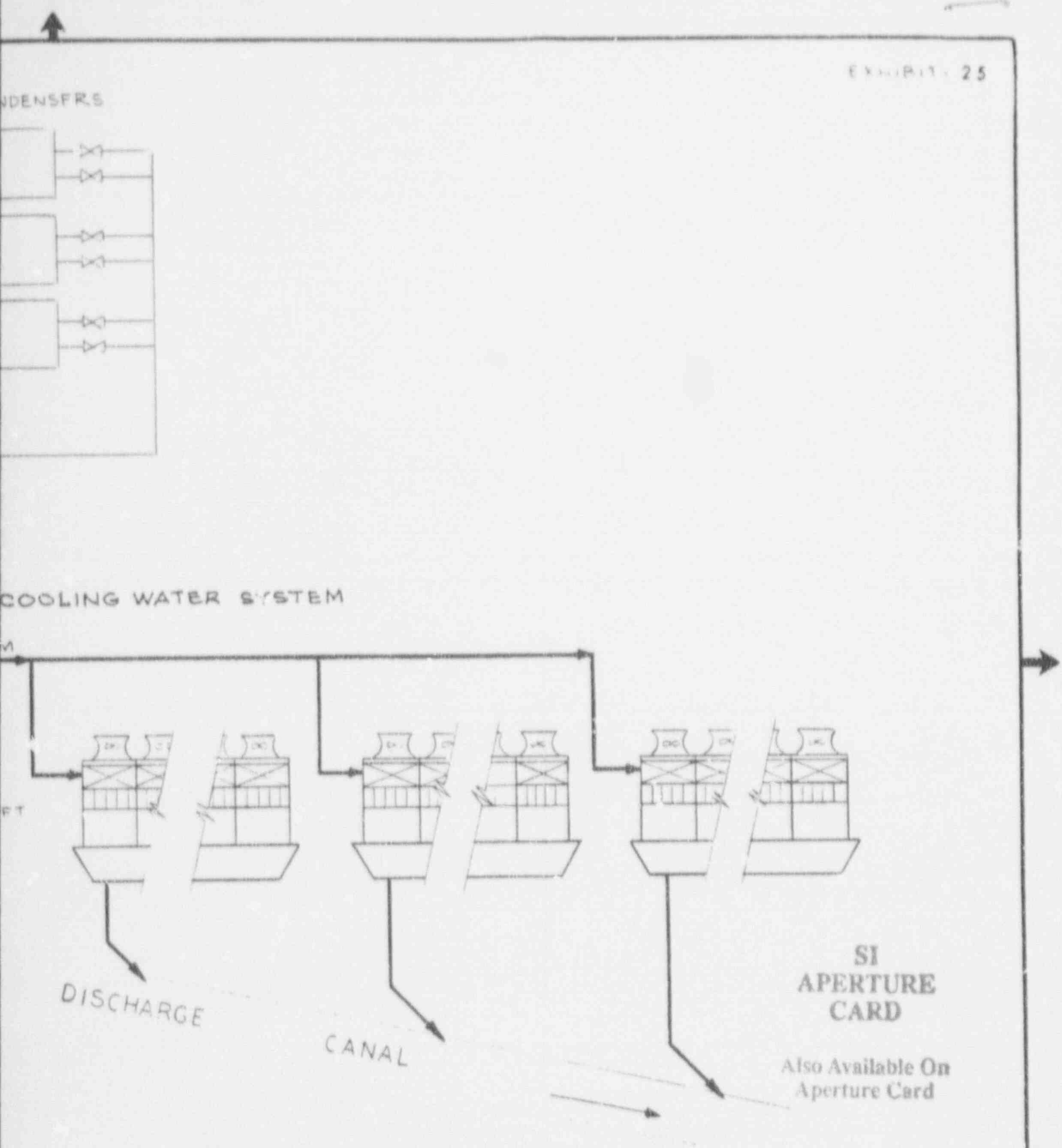
PLANT NET OUTPUT 607.1 MW

CW PIPES 2 X 7' I.D.

Exhibit 24



EXIST. CO
EXISTING CANAL
INTAKE
EXIST INTAKE STRUCTURE
EXIST DILUTION PUMPS
EXIST TUNNEL
EXIST DAM
DISCHARGE
10,000 GPM
TURBINE BLDG. CLOSED
462,000 GP
CIRC WATER BOOSTER PUMPS
MECHANICAL DRA
HELPER COOLING
TOWERS
INCHES
CM.

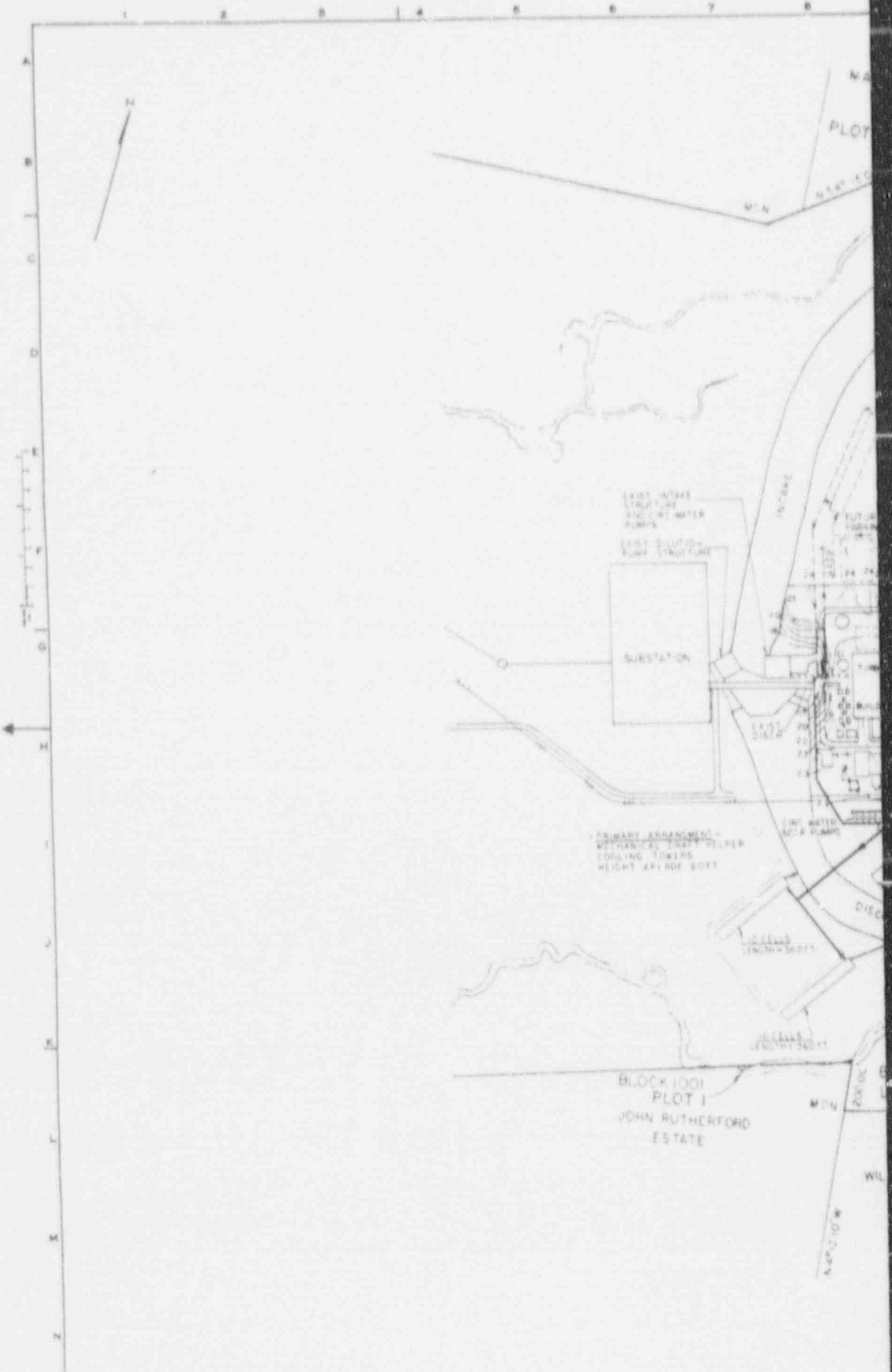


SI
APERTURE
CARD

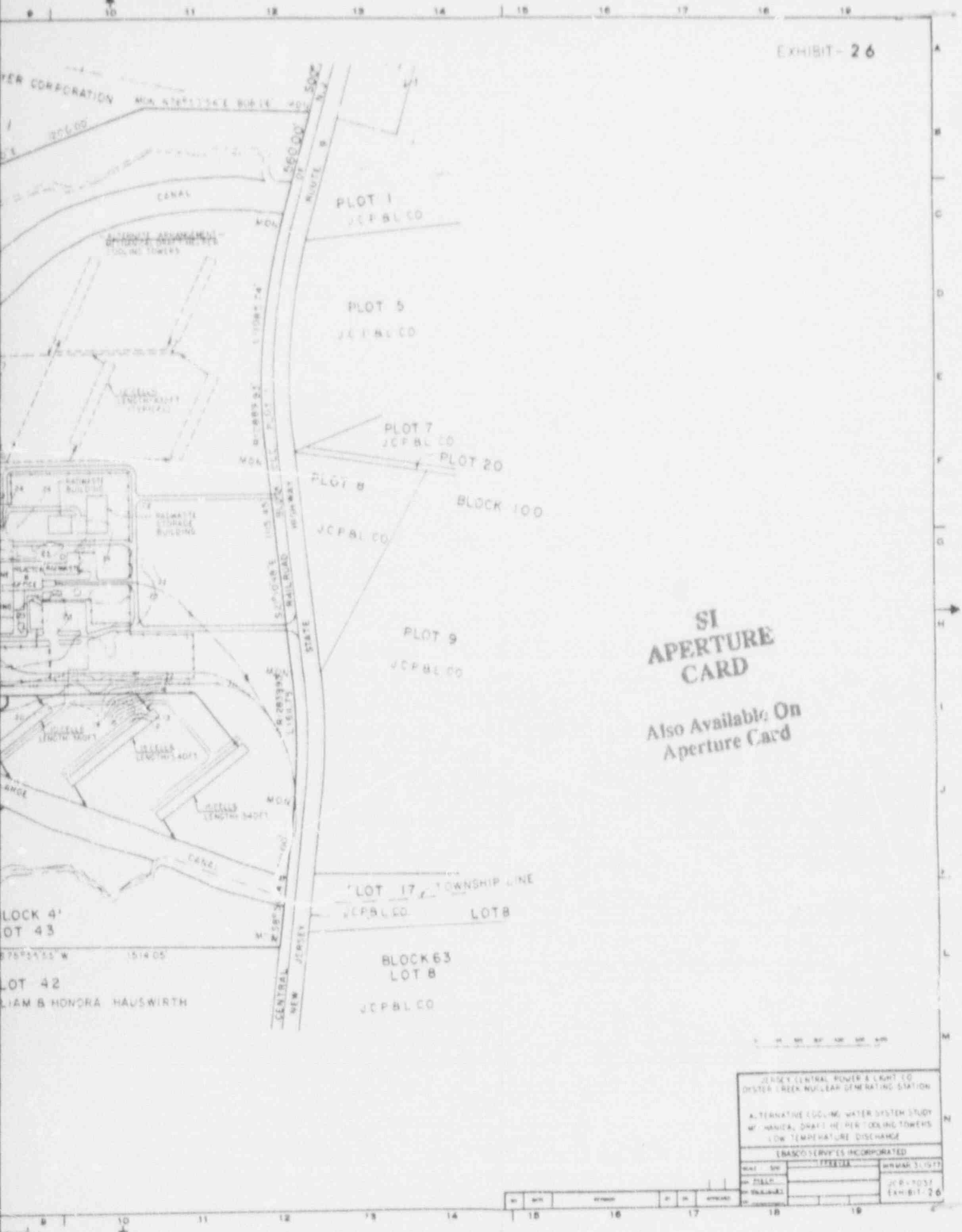
Also Available On
Aperture Card

EBASCO SERVICES INCORPORATED DIV MECH DR RMLK APPROVED CH DATE MAR 31 1977	JERSEY CENTRAL POWER & LIGHT OYSTER CREEK NUCLEAR GEN STATION ALTERNATIVE COOLING WTR SYSTEM STUDY MECHANICAL DRAFT HELPER COOLING TOWER SYSTEM	JCP-7037 EXHIBIT-25

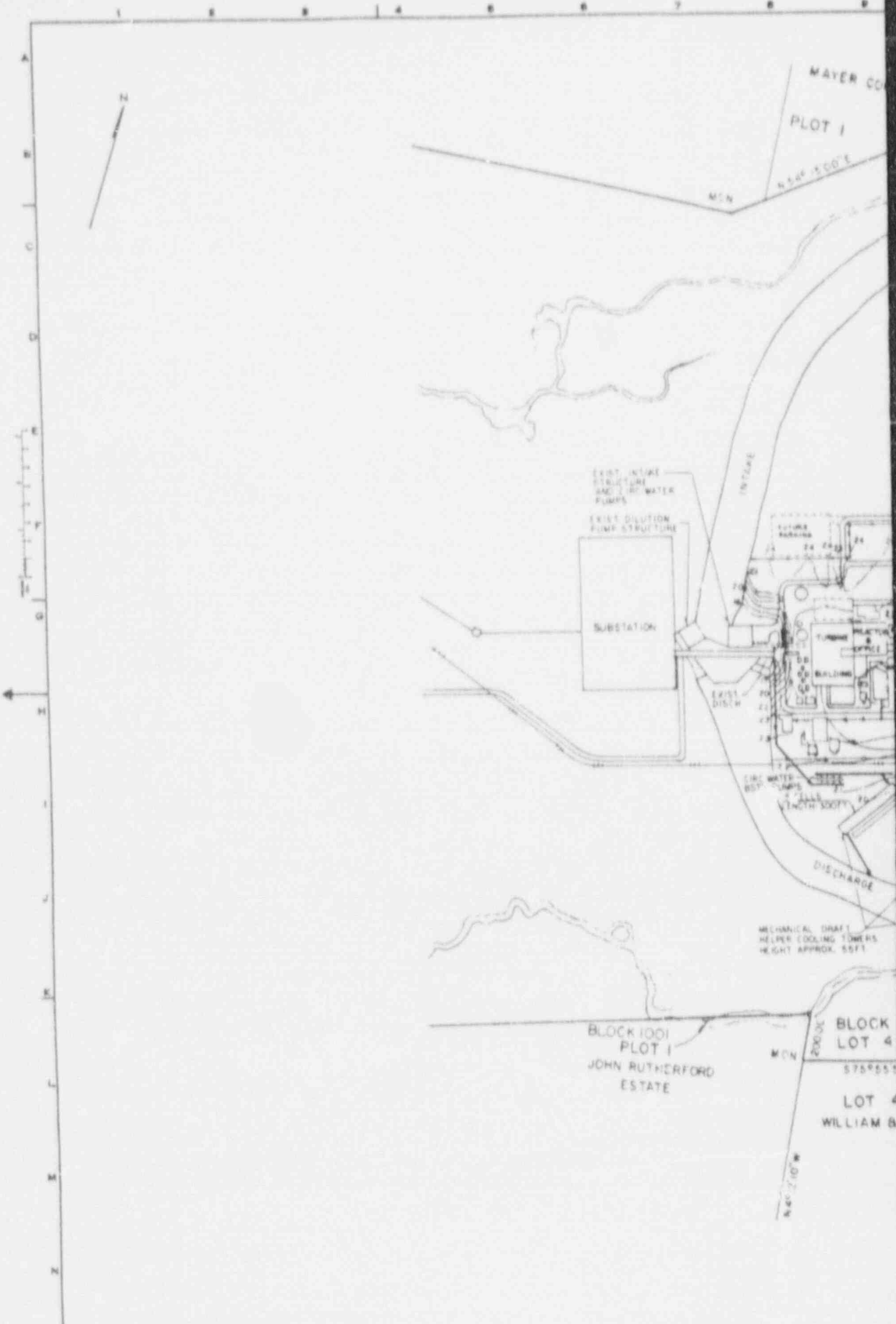
9111110048 -11



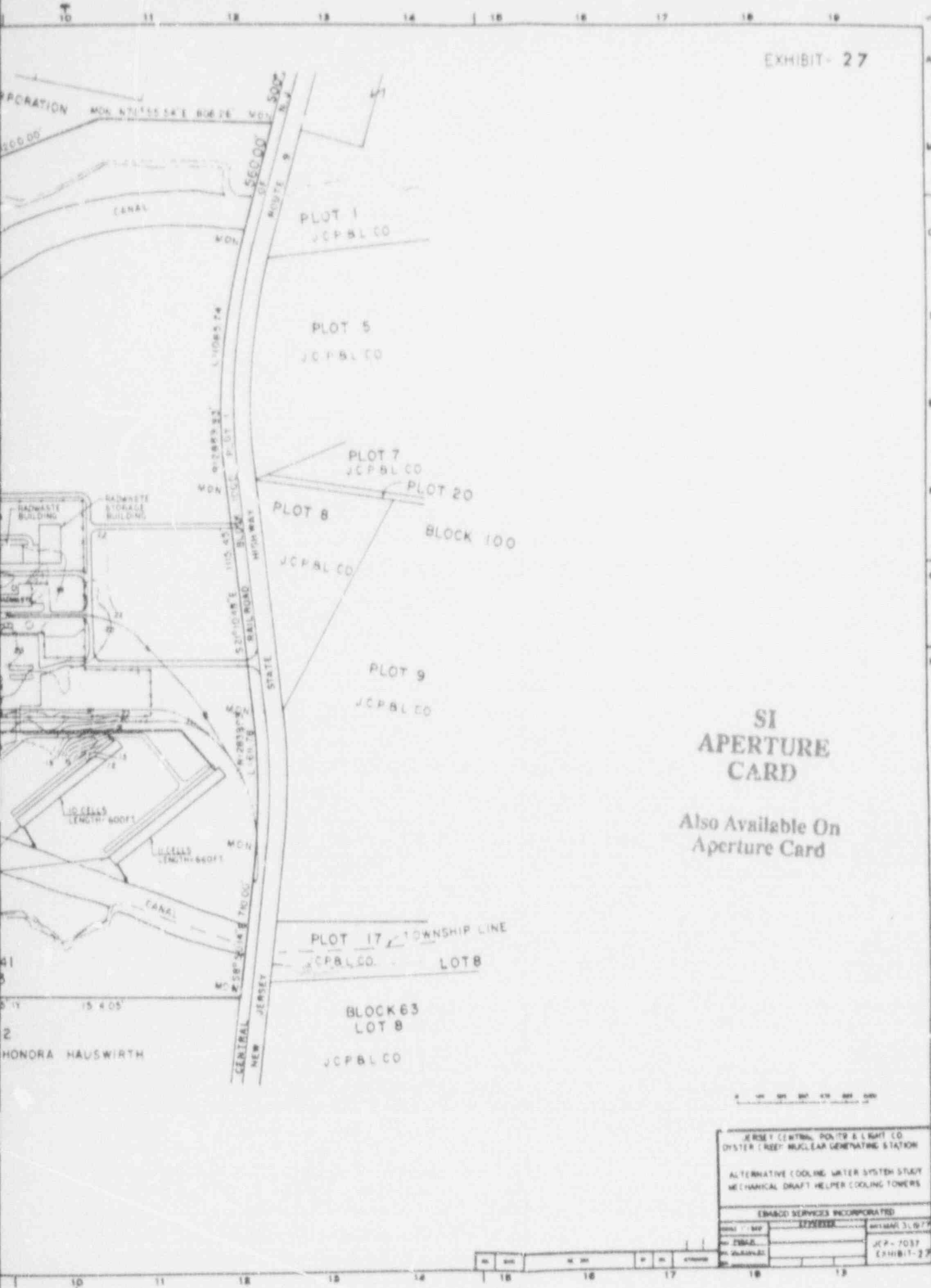
SUBSTATION
BLOCK 1001
PLOT 1
JOHN RUTHERFORD
ESTATE



9111110048 - 12



N
MAYER CO
PLOT I
MON
INTAKE
EXIST. INTAKE STRUCTURE AND CIRC. WATER PUMPS
EXIST. DILUTION PUMP STRUCTURE
SUBSTATION
TURBINE
BUILDING
EXIST. DISCH
DISCHARGE
MECHANICAL DRAFT HELPER COOLING TOWERS HEIGHT APPROX. 55FT
BLOCK 1001
PLOT I
JOHN RUTHERFORD ESTATE
MON
BLOCK
LOT 4
LOT 4
WILLIAM B

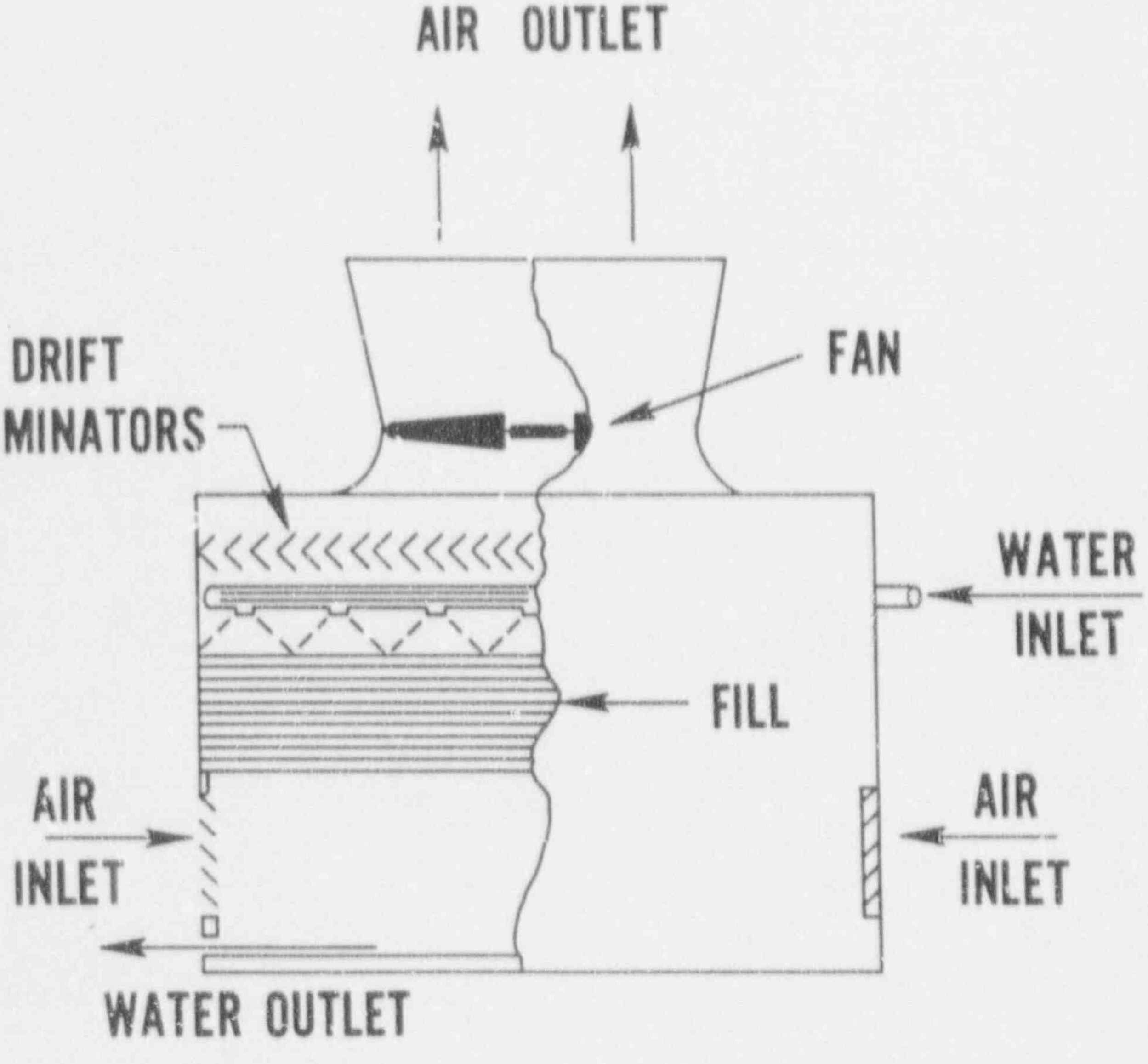


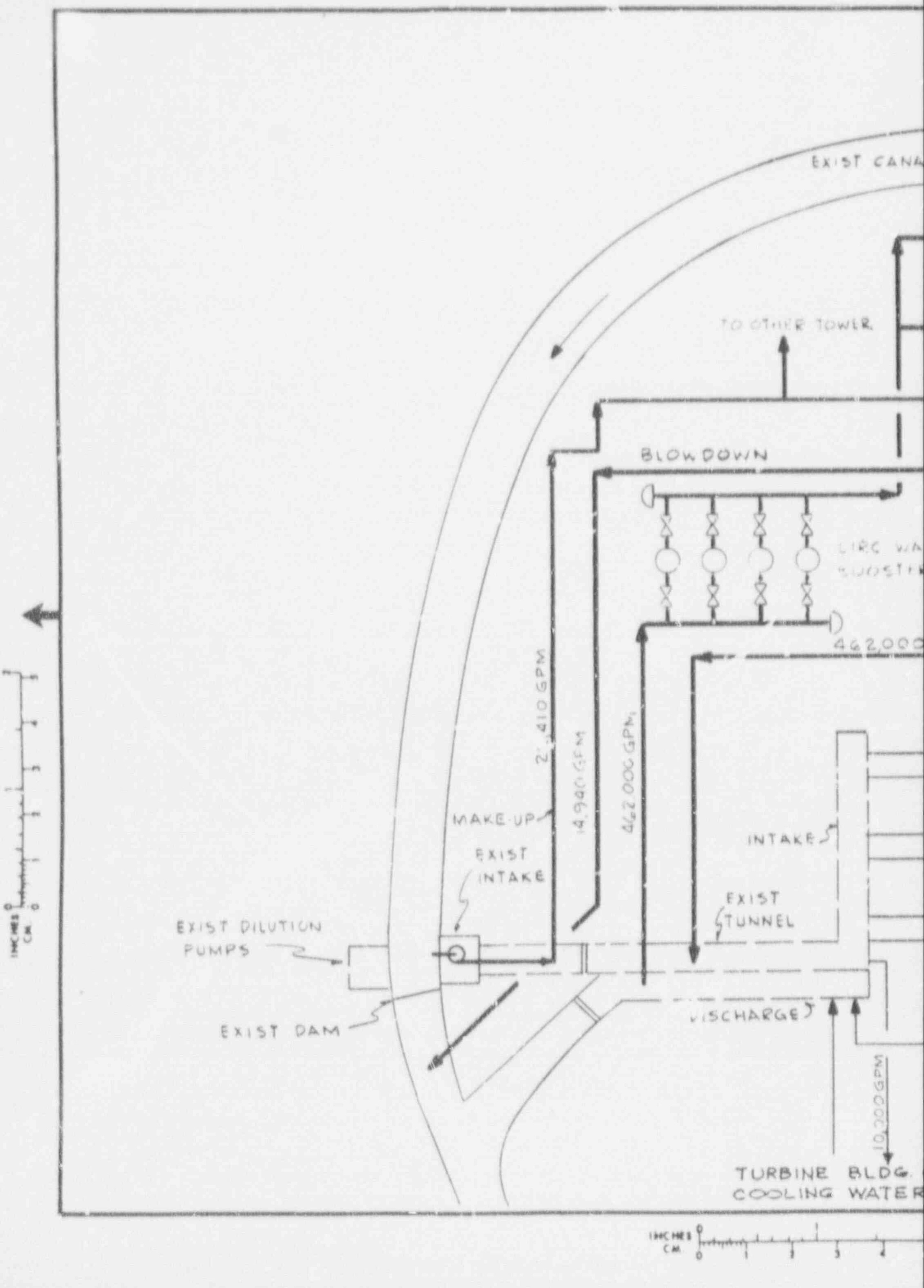
SI
APERTURE
CARD

Also Available On
Aperture Card

9111110048-/3

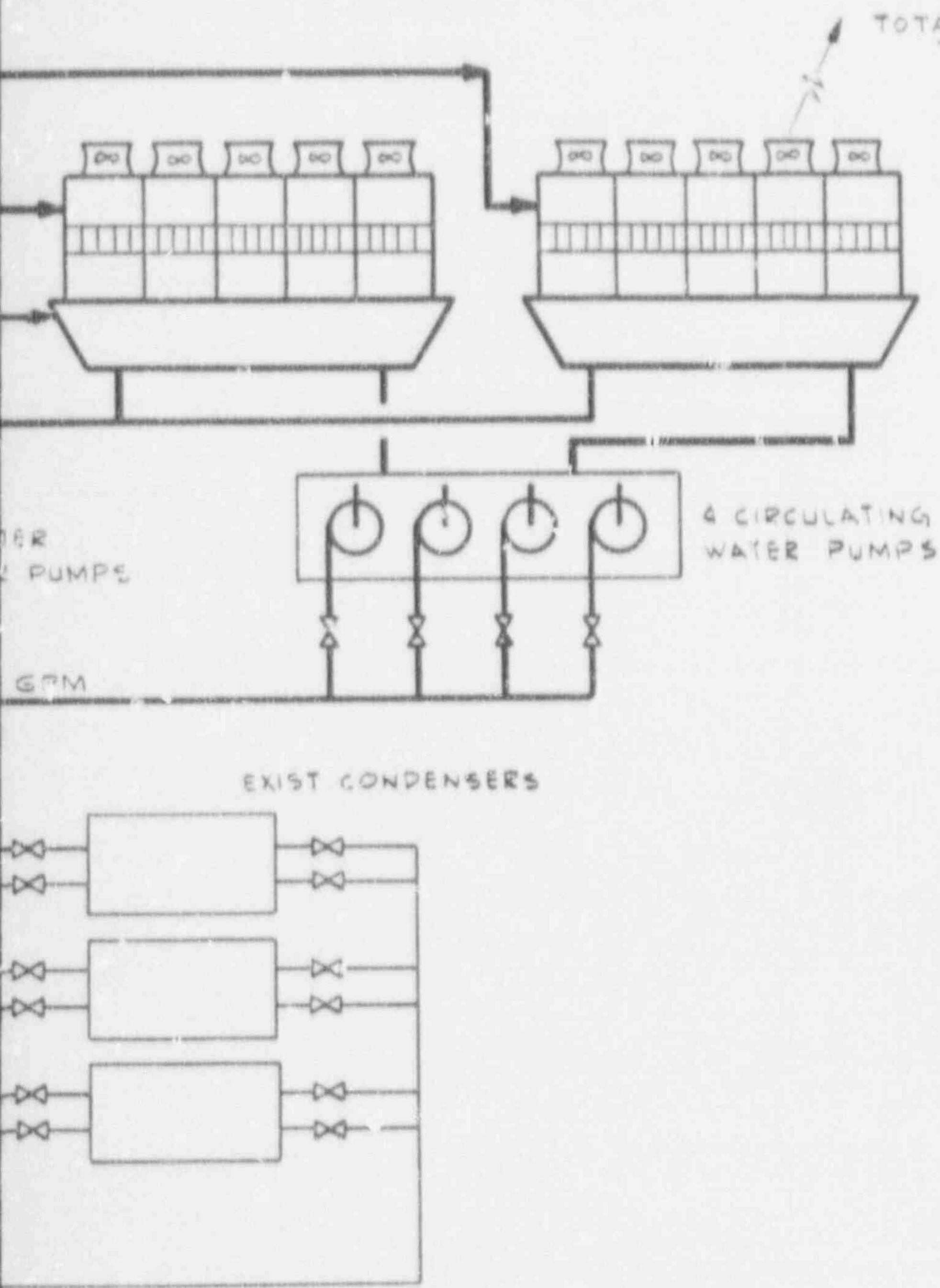
MECHANICAL DRAFT COUNTER-FLOW TOWER





TO OTHER TOWER
BLOWDOWN
14,900 GPM
462,000 GPM
MAKE-UP
EXIST INTAKE
INTAKE
EXIST TUNNEL
EXIST DILUTION PUMPS
EXIST DAM
DISCHARGE
10,000 GPM
TURBINE BLDG.
COOLING WATER
INCHES
CM.

EXHIBIT - 29



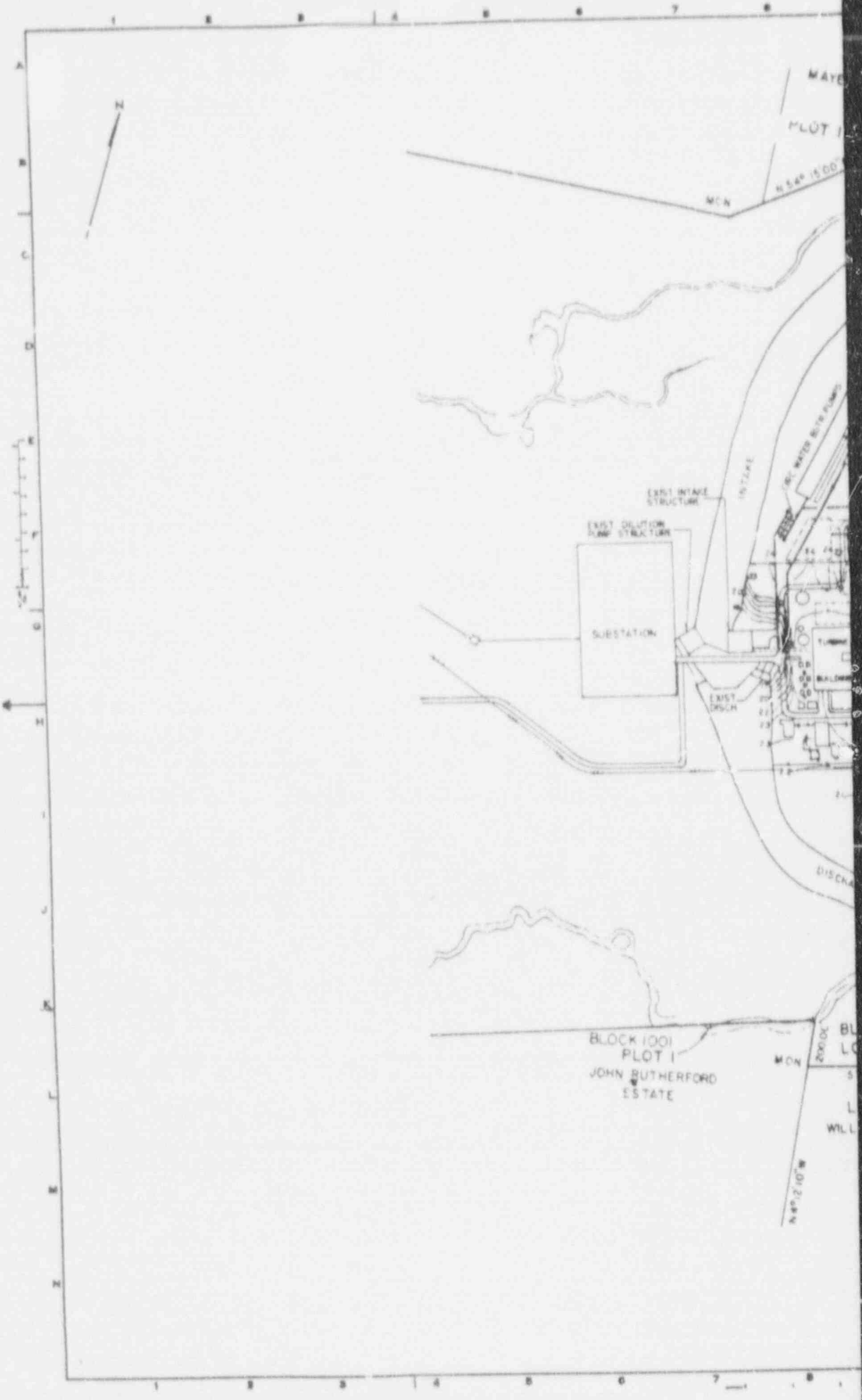
SI
APERTURE
CARD

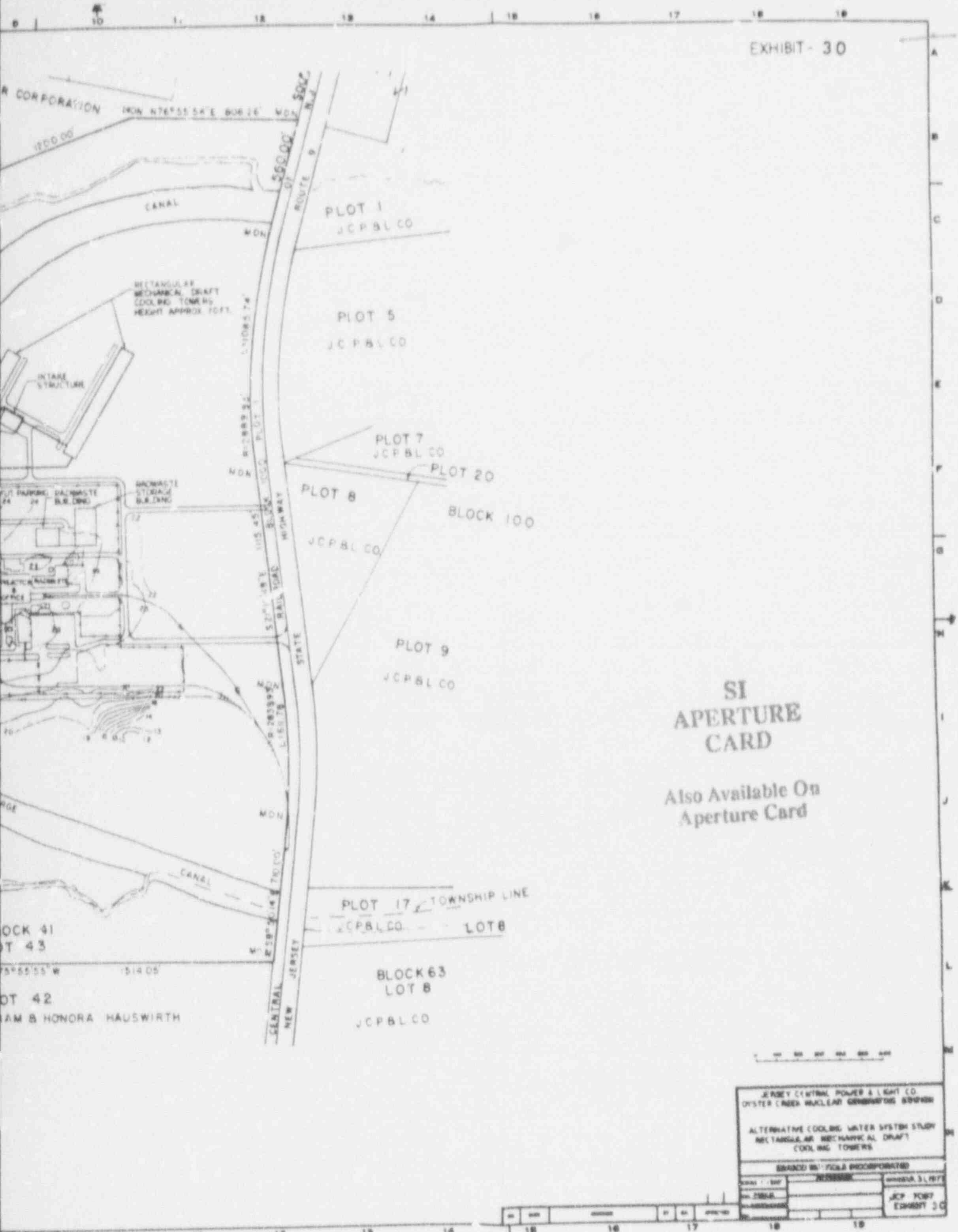
Also Available On
Aperture Card

EBASCO SERVICES INCORPORATED DIV MECH DR. WA CH. DATE MAR. 31 1977	APPROVED	JERSEY CENTRAL POWER & LIGHT OYSTER CREEK NUCLEAR GEN STATION ALTERNATIVE COOLING WTR SYSTEM STUDY RECTANGULAR MECHANICAL DRAFT COOLING TOWER SYSTEM	JCP 7037 EXHIBIT - 29

CLOSED
SYSTEM

9111110048 -14


N
MAYE
PLOT I
MON
EXIST INTAKE STRUCTURE
EXIST DILUTION PUMP STRUCTURE
SUBSTATION
INTAKE
EXIST DISCH
BLOCK 1001
PLOT I
JOHN RUTHERFORD ESTATE
MON



SI
APERTURE
CARD

Also Available On
Aperture Card

9111110048 -/5

SALT WATER COOLING TOWERS

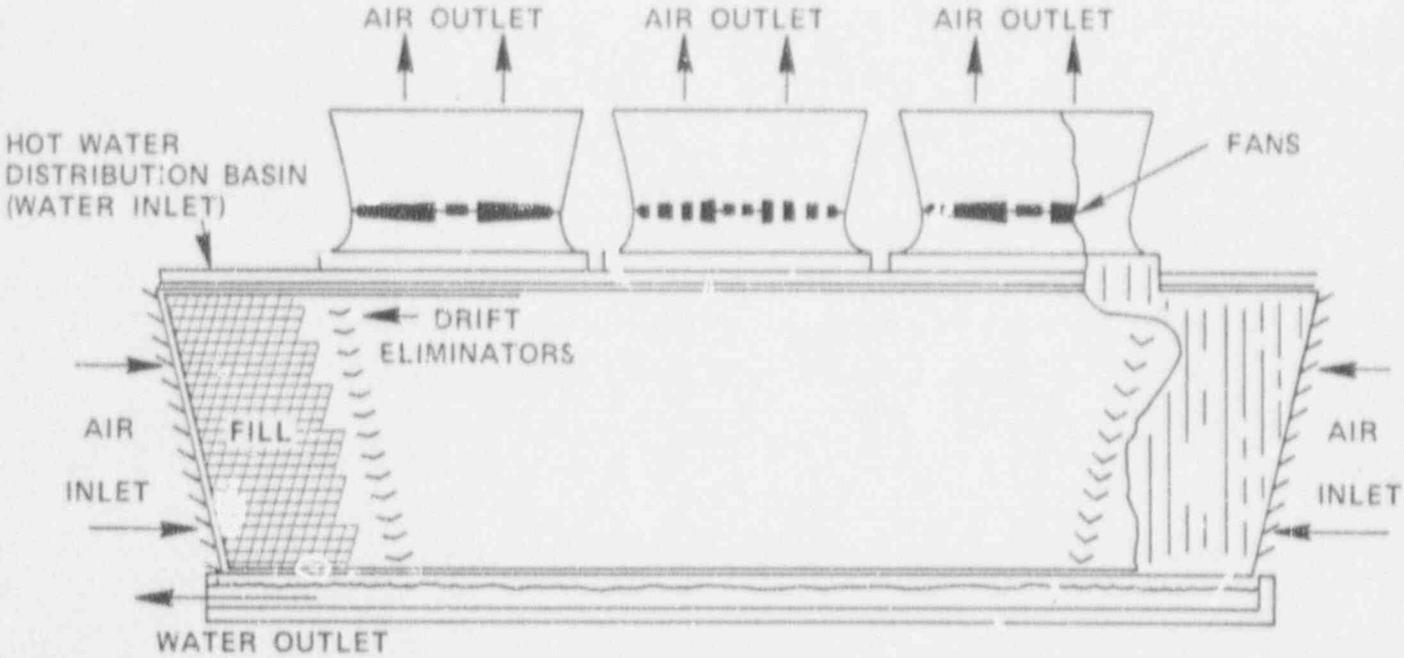
A. MECHANICAL DRAFT COOLING TOWERS

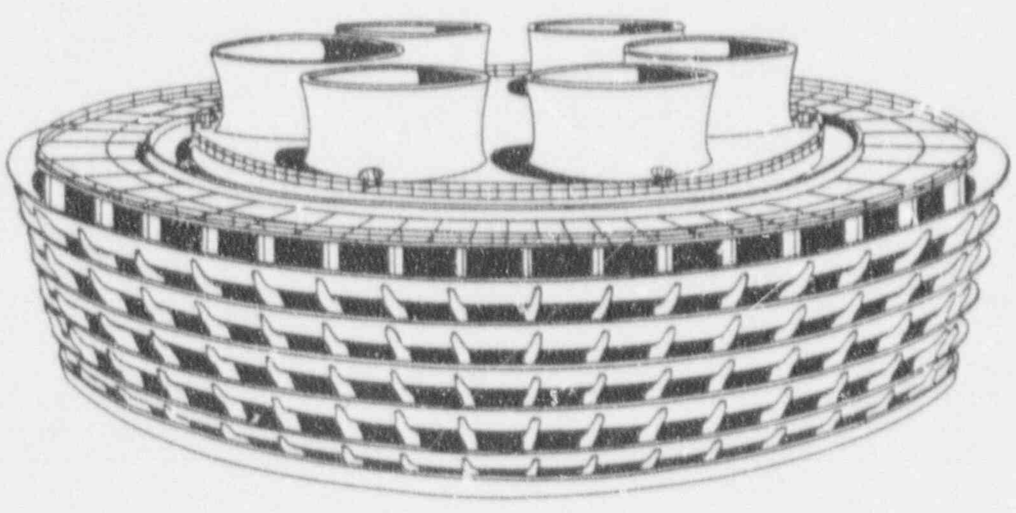
Plant & Location	Cooling Tower Size And Manufacturer	Water Quality In Closed Cycle	Experience	In Operation
Enjay Chemical Co Bayway, N J	4 cells, wood structure extended (40 ft) stacks 22 000 gpm, Marley Co	Salinity, 20 000 - 30 000 ppm (makeup from Arthur Kill)	Corrosion of galvinized iron conduits, silicon-bronze bolting, biofouling.	1968
Chevron Oil Co, Perth Amboy, N J	5 cells, wood structure 12 000 gpm, Gallagher Mfg, 5 cells wood structure, 12 000 gpm, Fluor Co & F&W Co	Same as for Item 1	Deterioration of wood, fan blades of monel had to be replaced by fiberglass blades. No biofouling. Drift effects are observed in proximity of the tower.	1957
Mohave Plant, Southern Calif Edison Co	60 cells, wood structure 540 000 gpm, Marley Co	16 000 ppm	No corrosion problems during first two years.	1970
Power Plant Bari, Italy	12 cells, reinforced concrete with asbestos cement fill, 133 000 gpm, Balcke Co	18 000 ppm	To reduce drift loss the drift eliminators were covered with a wire mesh	1960
Esso Chemicals Stenungsund, Sweden	Fiberglass and wood, 20 000 ppm, 77 000 gpm, L T Mart Co	20 000 ppm	Same corrosion problems with bolting	1969

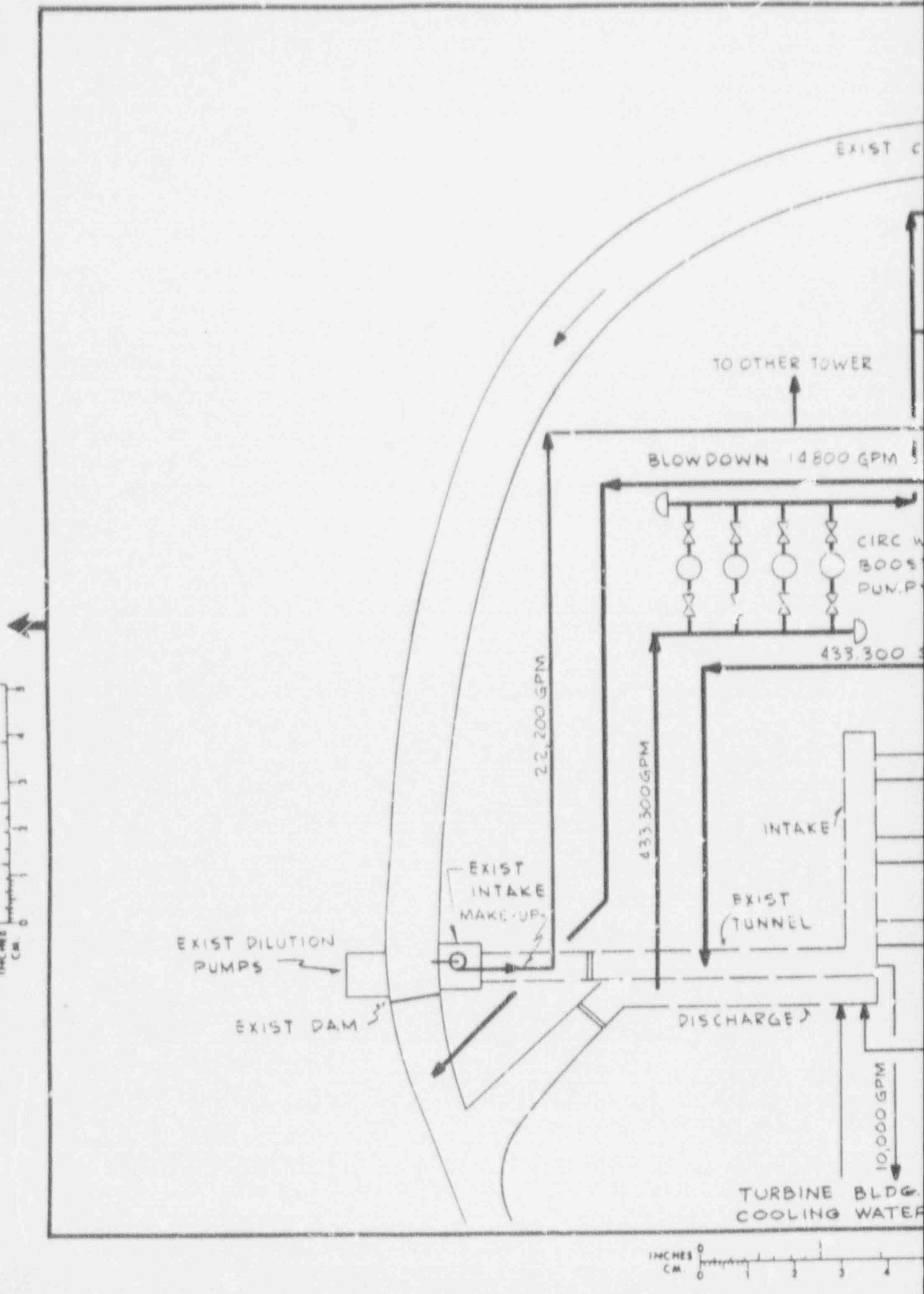
[illegible]. NATURAL DRAFT COOLING TOWERS

Plant & Location	Cooling Tower Size And Manufacturer	Water Quality In Closed Cycle	Experience	In Operation
Fleetwood, CEGB, England	2 towers, diam. 216 ft, height 250 ft, 2 x 37 500 gpm, shells of reinforced concrete, fill of treated wood	40 000 ppm	Satisfactory operation, even the redwood fill is well preserved	1955
B L England Station, N J	1 tower, diam 180 ft, height 208 ft, 63 500 gpm, shell of reinforced concrete fill of asbestos cement	50 000 ppm	At high wind velocity drift is blown through the air inlet and causes salt deposition in vicinity	1974

ROUND MECHANICAL DRAFT CROSS-FLOW TOWER

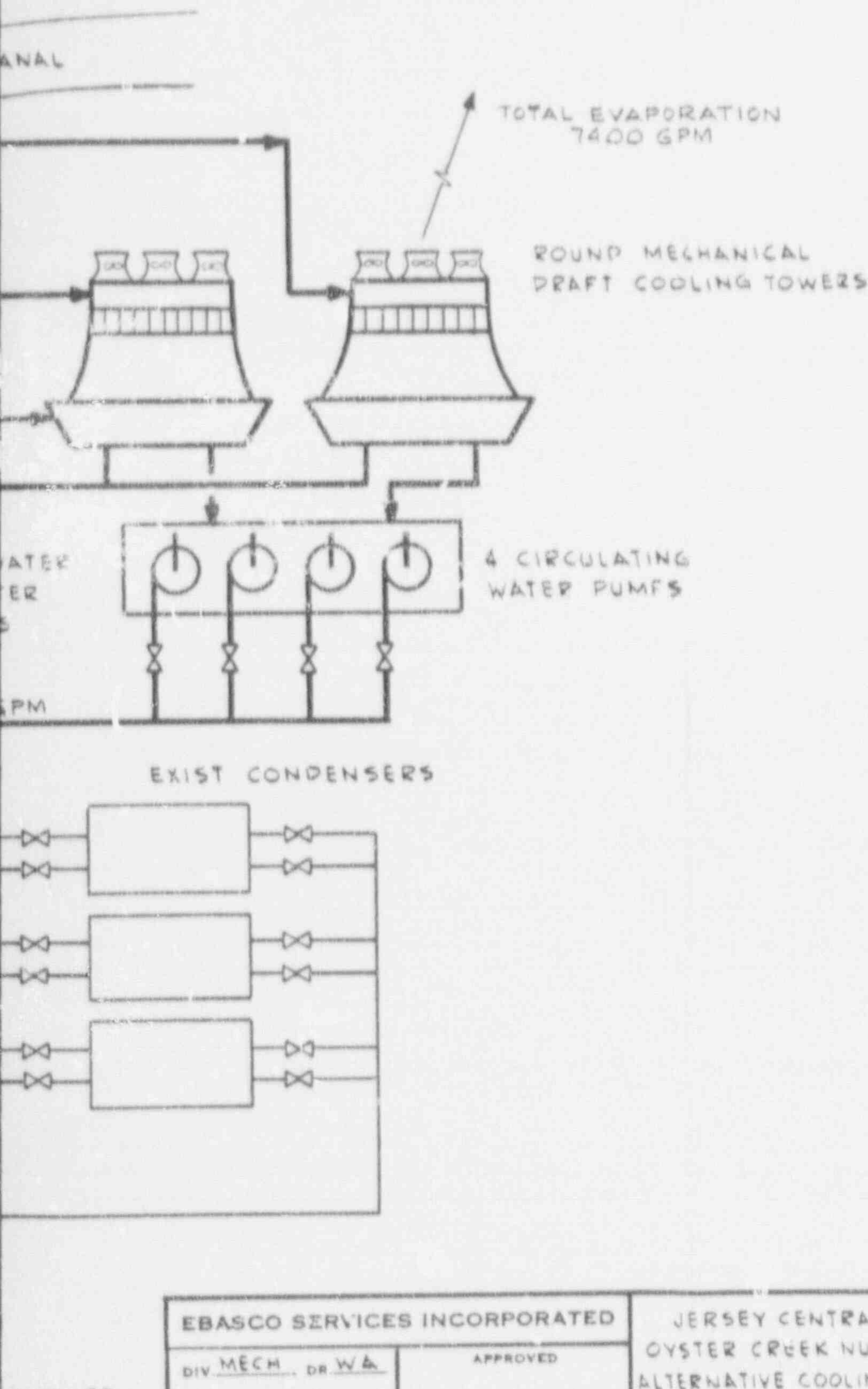






EXIST C
TO OTHER TOWER
BLOWDOWN 14800 GPM
CIRC W
BOOST
PUMP
433.300
22,200 GPM
433,300 GPM
INTAKE
EXIST
INTAKE
MAKE-UP
EXIST
TUNNEL
EXIST DILUTION
PUMPS
EXIST DAM
DISCHARGE
10,000 GPM
TURBINE BLDG.
COOLING WATER
INCHES
CM.

EXHIBIT - 33



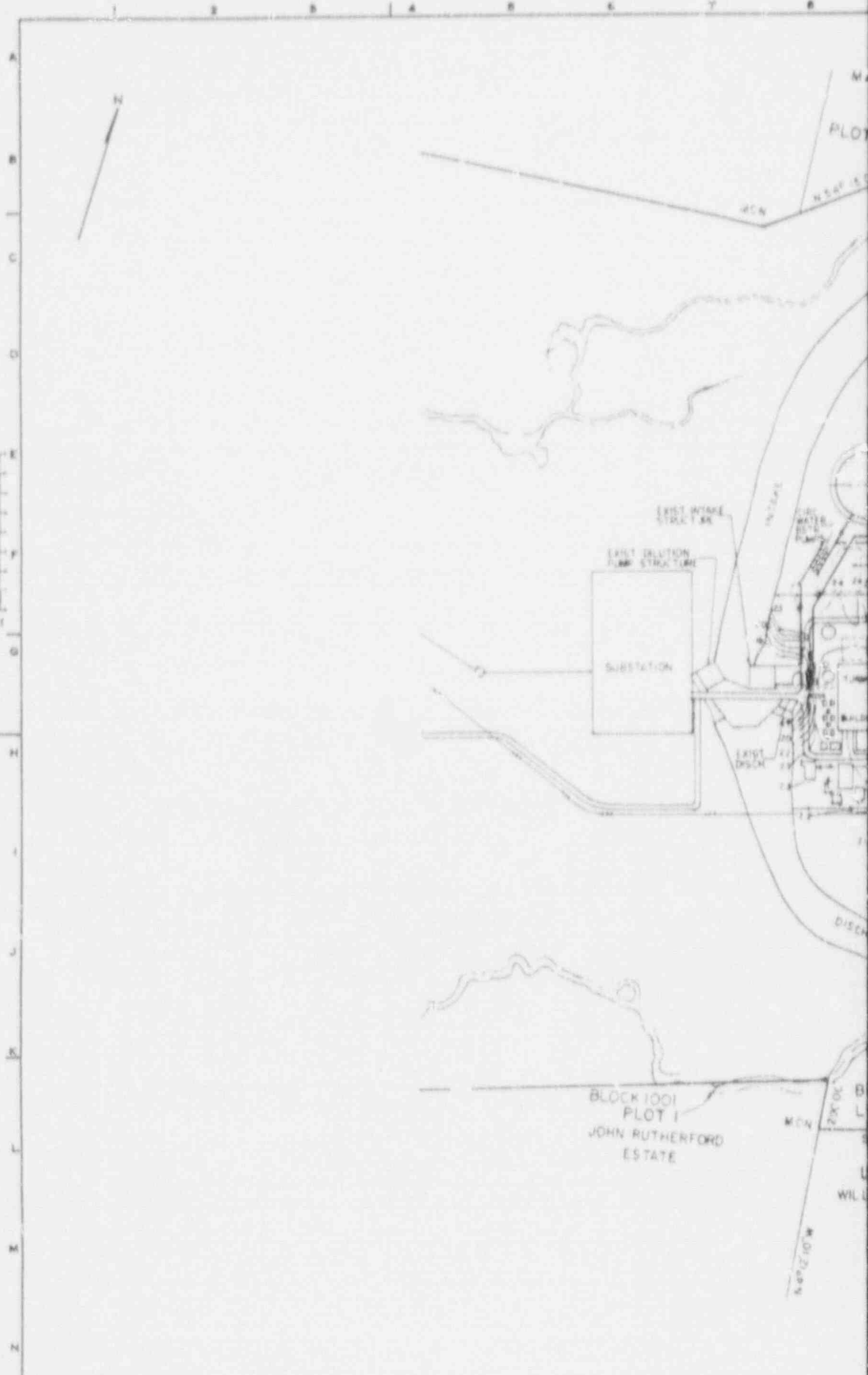
SI
APERTURE
CARD

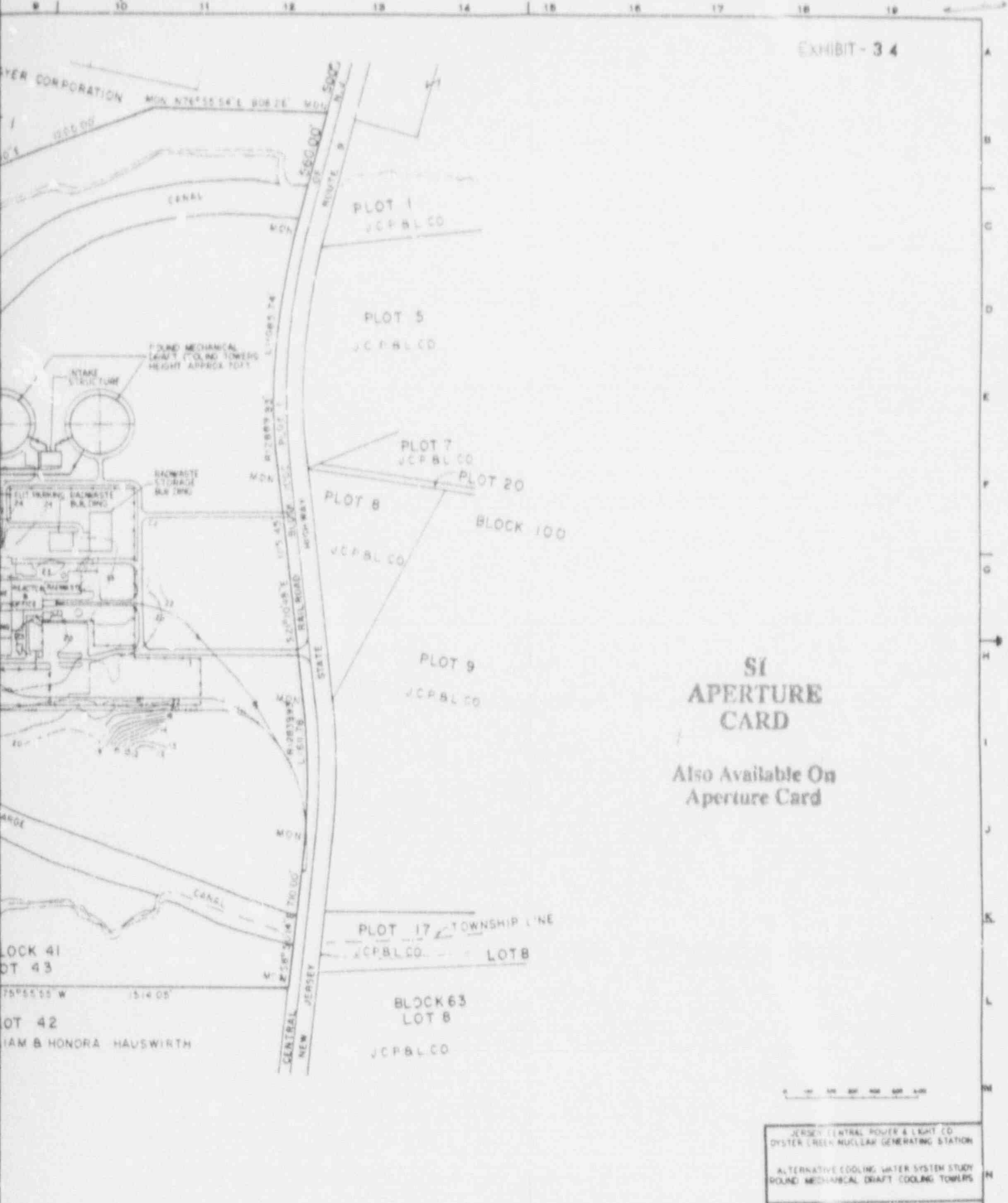
Also Available On
Aperture Card

CLOSED
SYSTEM

EBASCO SERVICES INCORPORATED		JERSEY CENTRAL POWER & LIGHT OYSTER CREEK NUCLEAR GEN STATION ALTERNATIVE COOLING WTR SYSTEM STUDY ROUND MECHANICAL DRAFT C T SYSTEM	JCP 76-37 EXHIBIT-33
DIV MECH DR WA CH DATE MAR. 31, 1977	APPROVED		

9111110048-16


N
PLOT
EXIST INTAKE STRUCT.RE
EXIST DILUTION PUMP STRUCTURE
SUBSTATION
INTAKE
EXIST DISCH
BLOCK 1001
PLOT 1
JOHN RUTHERFORD ESTATE



SI
APERTURE
CARD

Also Available On
Aperture Card

9111110048-17

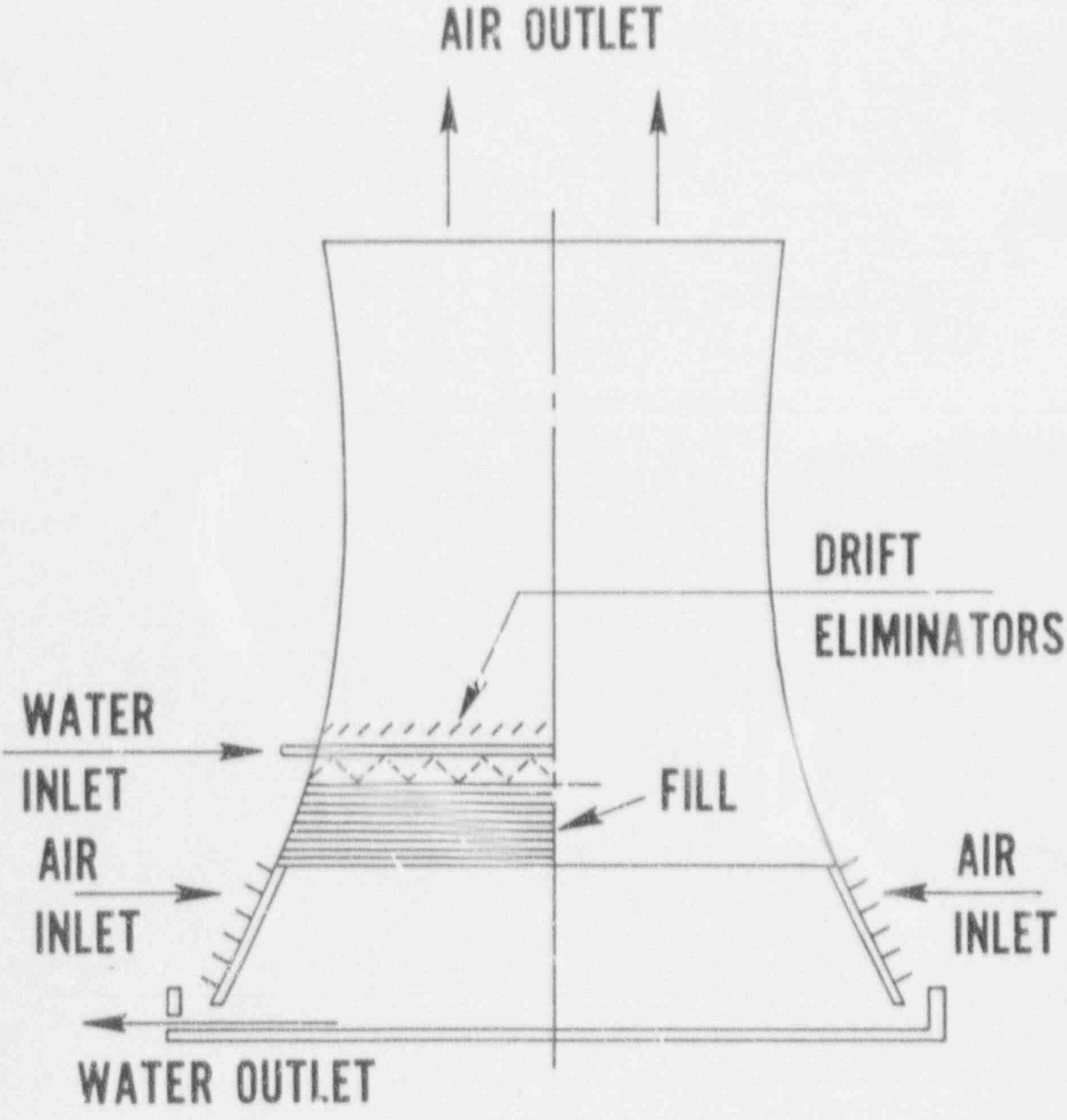
ROUND MECHANICAL DRAFT MULTI-FAN COOLING TOWERS

	TWB F	Approach F	Range F	Unit Rating	CW Flow per Tower GPM	Number of Towers & Size
a) Crossflow Design						
Washington Public Power Supply System Hanford Unit 2 Richland, Washington	60	16.3	28	1100 MW (Nuclear)	95 000	6 @ 6 Fans
Mississippi Power Company Jack Watson Unit 5 Gulfport, Mississippi	80	10	30	550 MW	172 000*	1 @ 13 Fans
Gulf States Utilities Sabine Unit 5 Bridge City, Texas	81	10	21	480 MW	127 500	2 @ 7 [illegible]
Duke Power Company Catawba Unit 1 & 2 York, South Carolina	76	12	24	2 @ 1180 MW (Nuclear)	221 300	6 @ 13 Fans
Kansas Power and Light Co Energy Center-Units 1 & 2 Belvue, Kansas	80	12.7	21.3	2 @ 640 MW	166 000	4 @ 8 Fans Wood Structure and Fill
Gulf States Utilities River Bend Station Units 1 & 2 West Feliciana Parish, La	81	12	25.5	2 @ 934 MW (Nuclear) 1 109 580 GPM	138 700	8 @ 7 Fans
Louisville Gas & Elec Co Mill Creek - Unit No. 3 Louisville, Kentucky	78	17	21.0	425 MW	205 000	1 @ 8 Fans
Gulf State Utilities Roy S Nelson Unit No. 5 Lake Charles, La	82	9	26.2	550 MW	212 400	1 @ 13 Fans
b) Counterflow Design						
Washington Public Power Supply System Hanford Units 1 & 4	66.4	16	26	2 [illegible] 1100 MW (Nuclear)	219 500	6

* Brackish Water

Exhibit 35

HYPERBOLIC NATURAL DRAFT COUNTER-FLOW TOWER



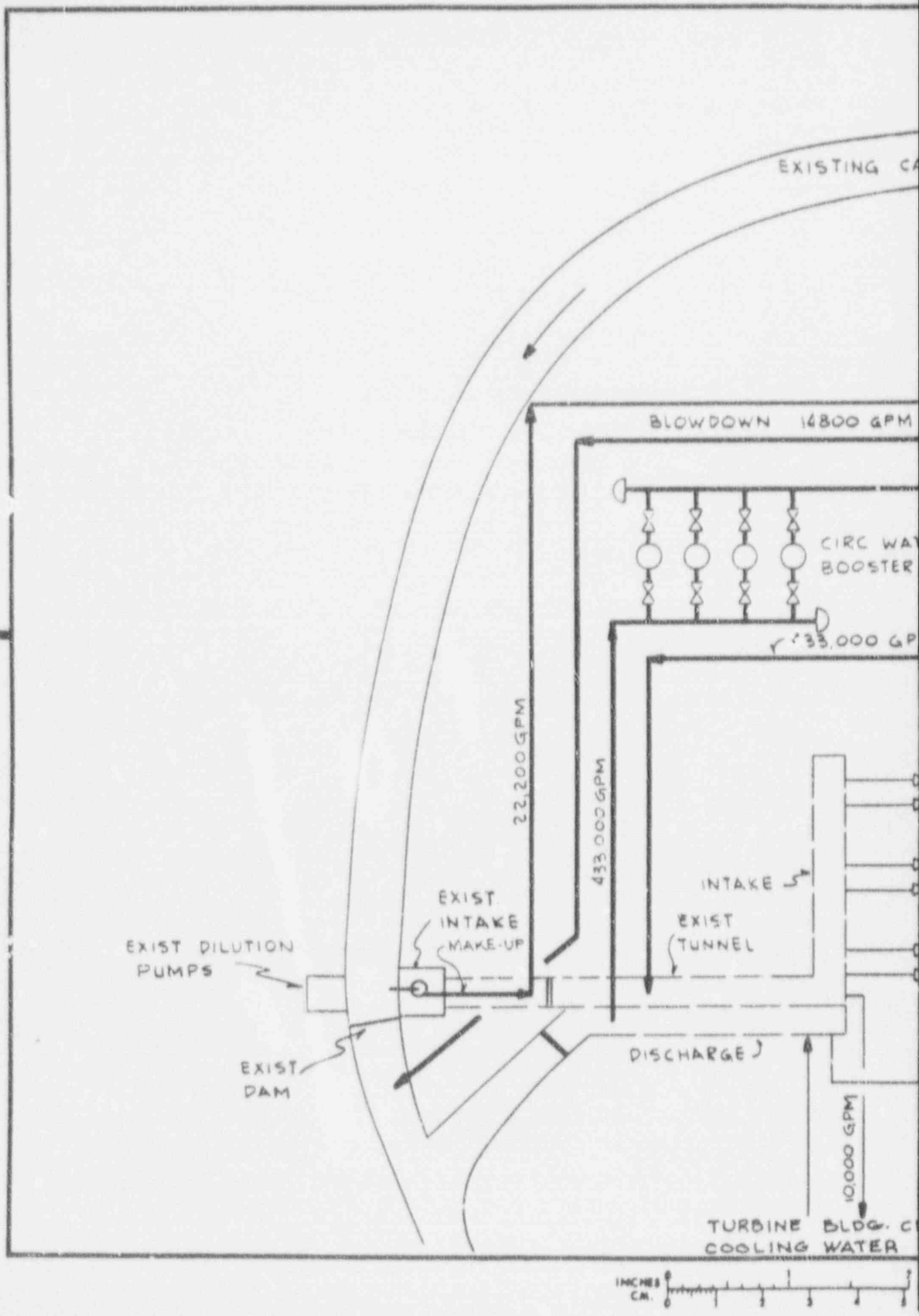
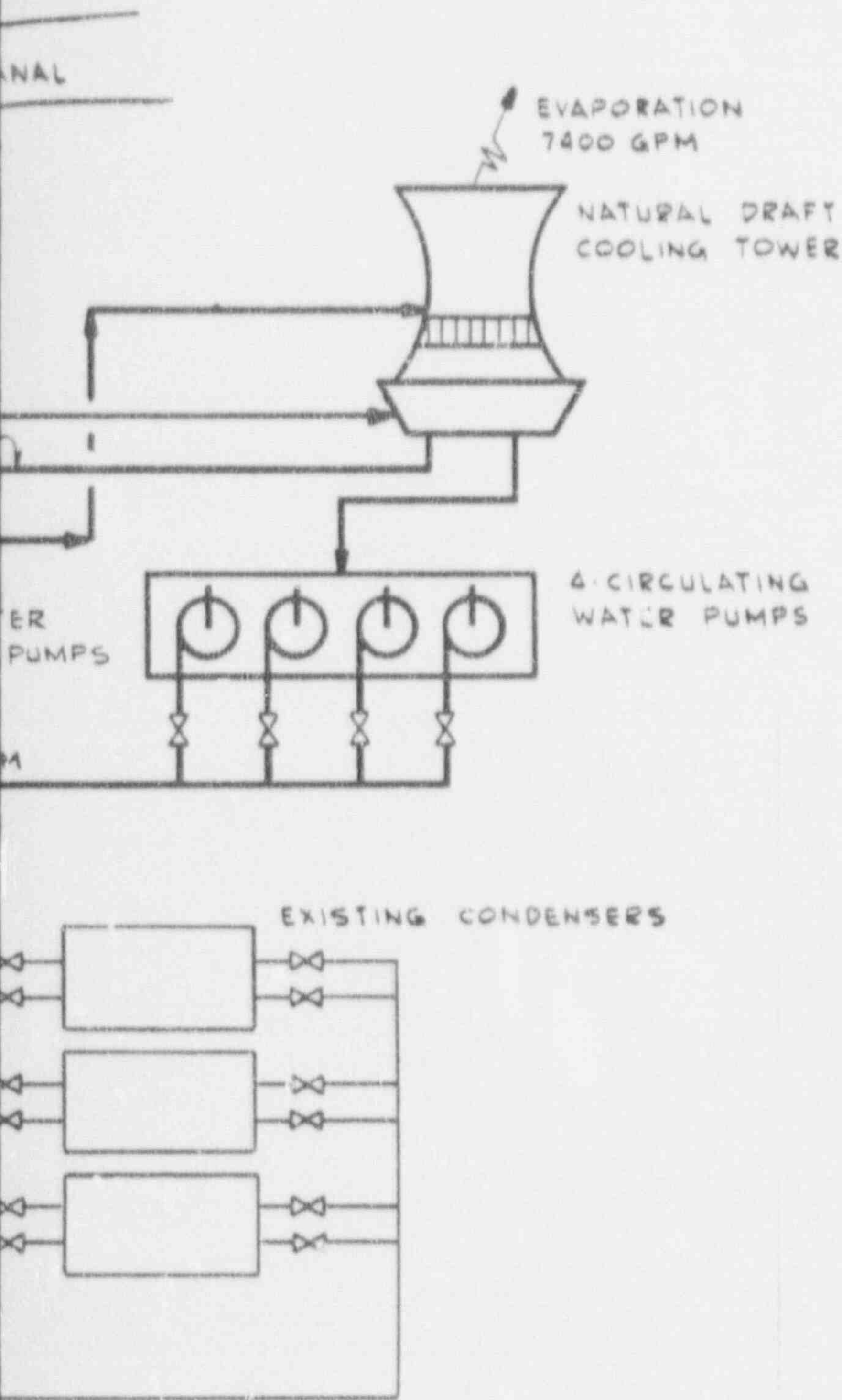

EXISTING CA
BLOWDOWN 16800 GPM
CIRC WA
BOOSTER
33,000 GP
22,200 GPM
433,000 GPM
INTAKE
EXIST TUNNEL
EXIST INTAKE
MAKE-UP
EXIST DILUTION PUMPS
EXIST DAM
DISCHARGE
10,000 GPM
TURBINE BLDG. C
COOLING WATER

EXHIBIT - 37



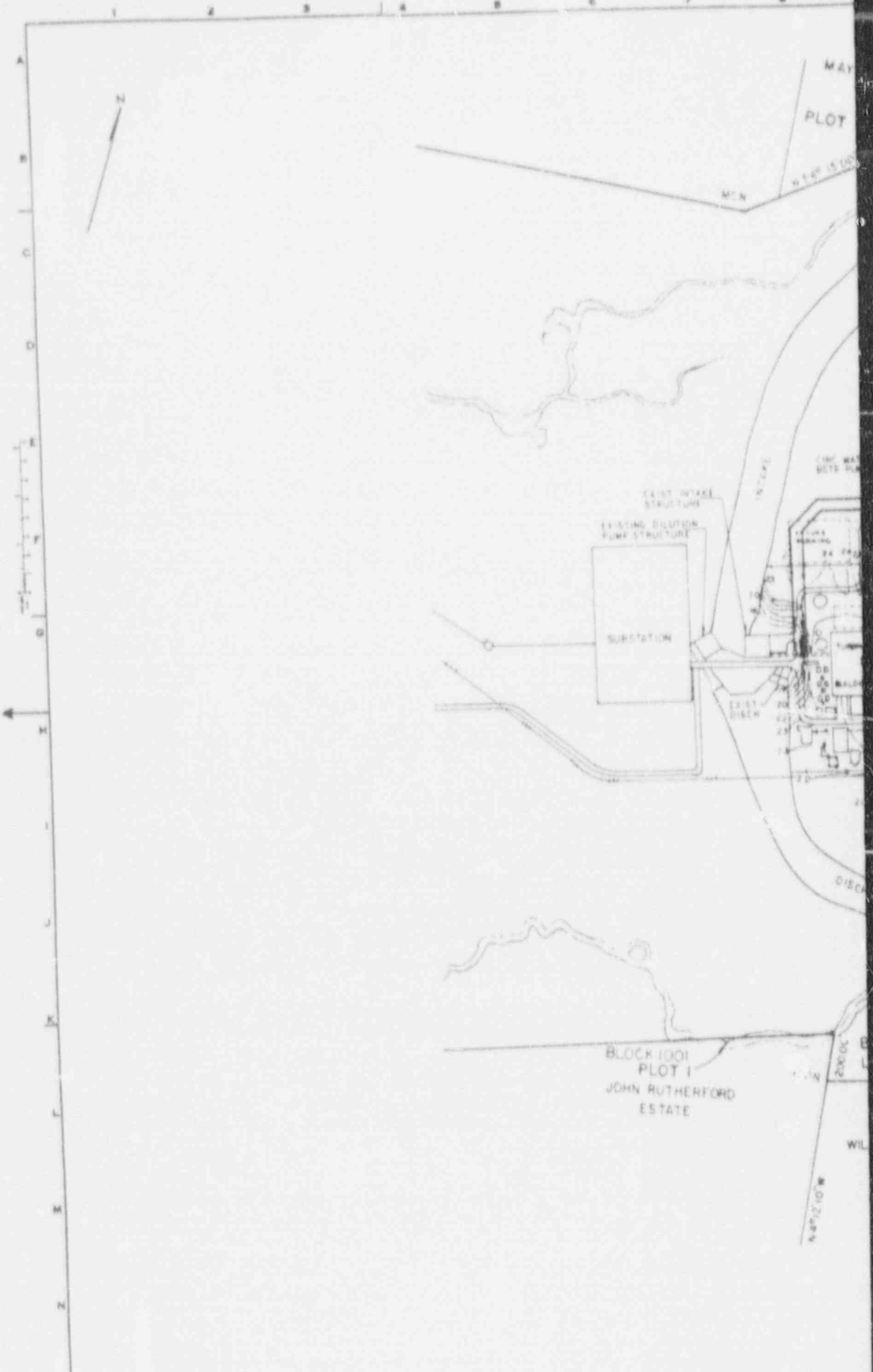
SI
APERTURE
CARD

Also Available On
Aperture Card

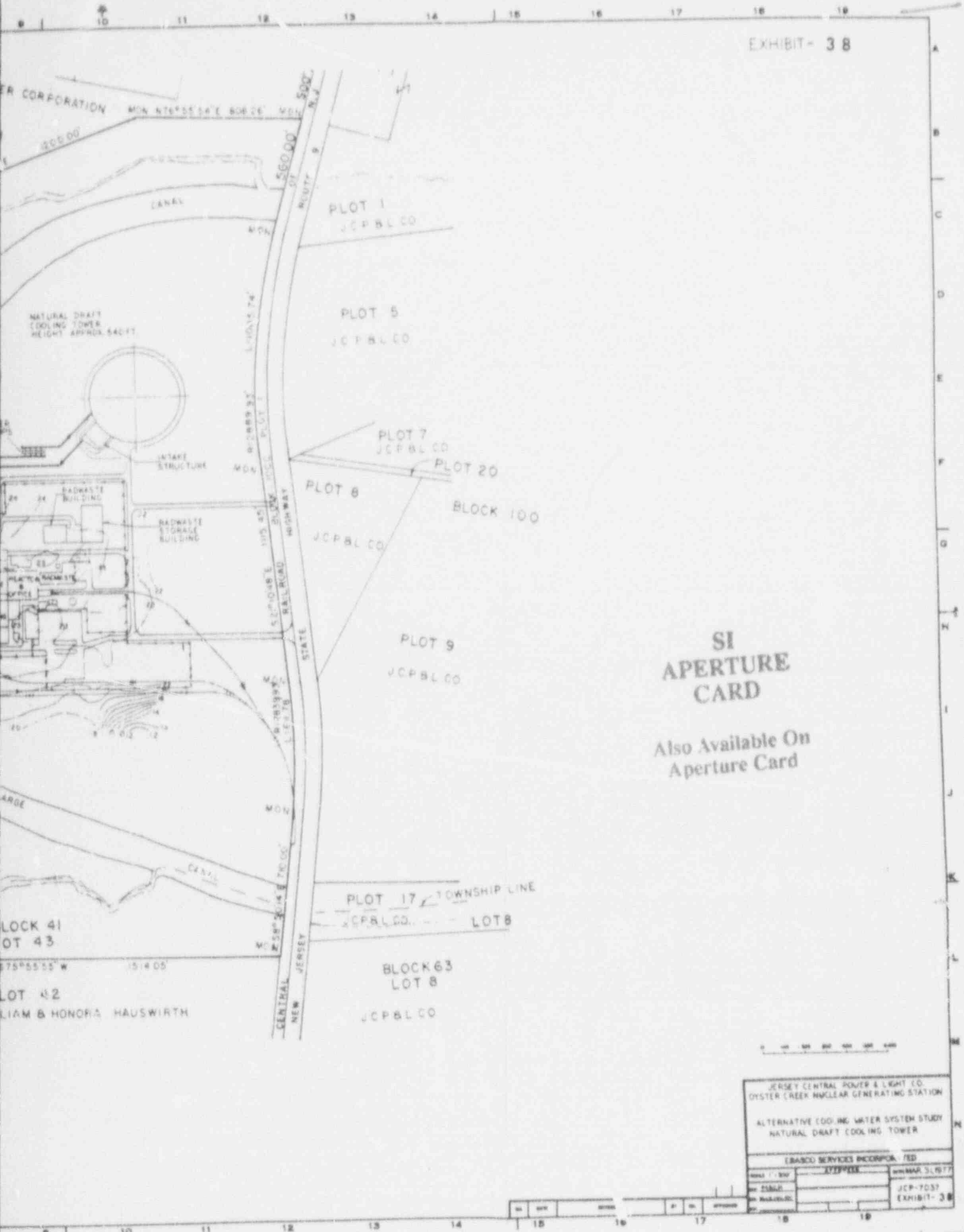
EBASCO SERVICES INCORPORATED		JERSEY CENTRAL POWER & LIGHT OYSTER CREEK NUCLEAR GEN STATION ALTERNATIVE COOLING WTR SYSTEM STUDY NATURAL DRAFT COOLING TOWER SYS	JCP 7037 EXHIBIT-37
DIV. MECH DR. W.A. CH. DATE MAR. 31, 1977	APPROVED		

LOSED
SYSTEM

9111110048 - 18



PLOT
EXIST INTAKE STRUCTURE
EXISTING DILUTION PUMP STRUCTURE
INTAKE
SUBSTATION
BLOCK 1001
PLOT 1
JOHN RUTHERFORD
ESTATE



SI
APERTURE
CARD

Also Available On
Aperture Card

9111110048 - 19

Exhibit 39

LARGEST NATURAL DRAFT COOLING TOWERS

Counterflow Design

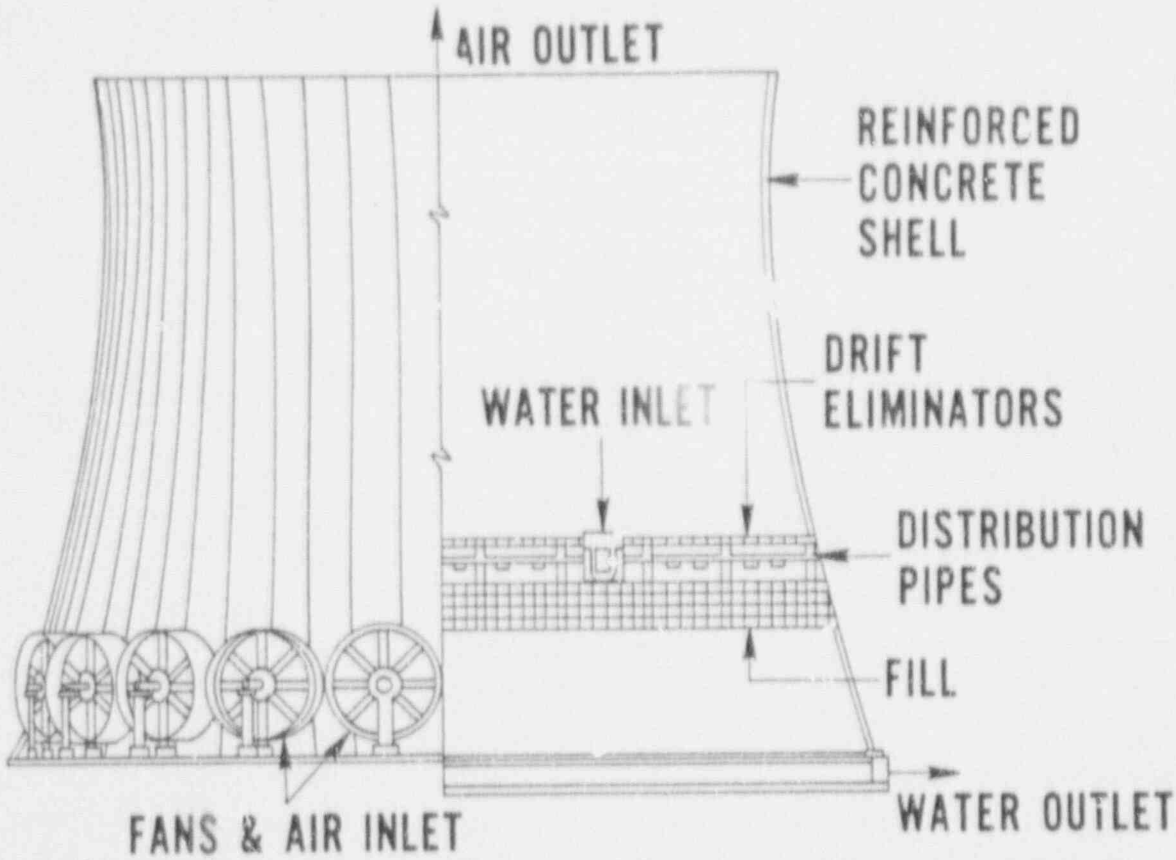
Owner	Plant Name	Height, ft	Diam Ft	Flow, gpm
Ohio Power Co	Gavin	492	400	600 000
Portland General Electric	Trojan NGS No. 1	492	385	425 000
TVA	Watts Bar 1 & 2	506	405	410 000

Crossflow Design

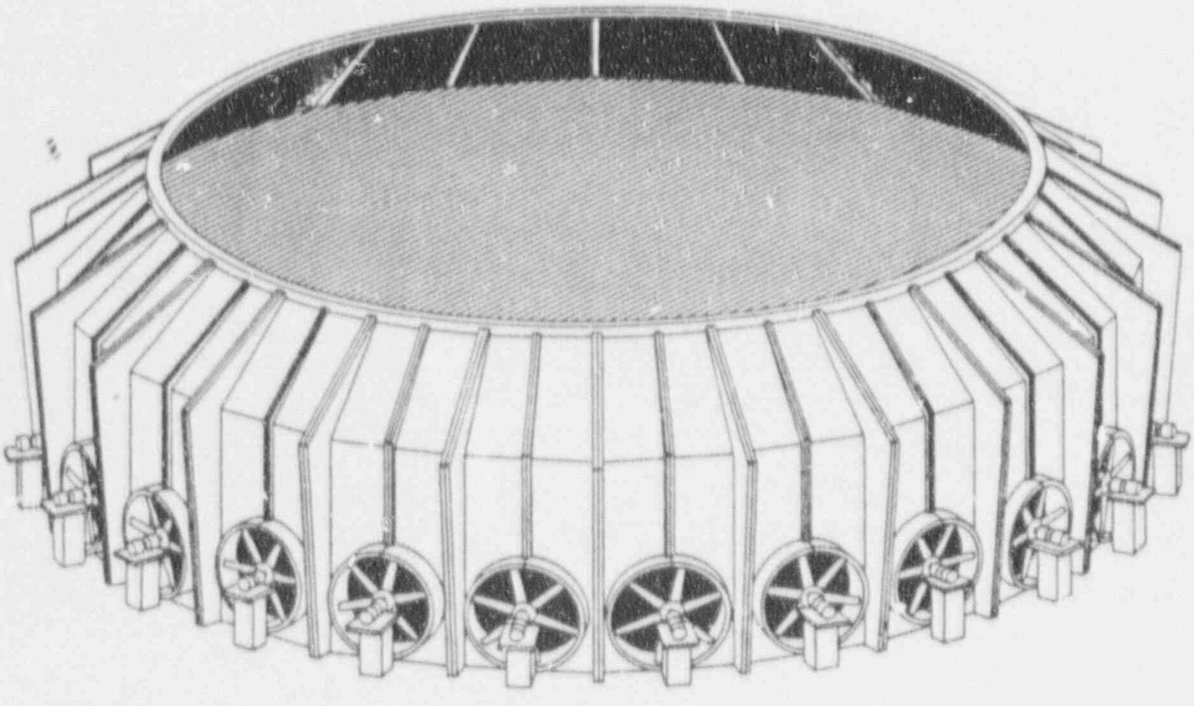
Owner	Plant Name	Height, ft	Diam Ft	Flow, gpm
Duquesne Power & Light and Ohio Edison Co	Beaver Valley No. 1	500	475	507 000
Appalachian Power AEP System	Project 1301	500	465	600 000

MECHANICAL FORCED DRAFT COUNTERFLOW MULTI FAN COOLING TOWER

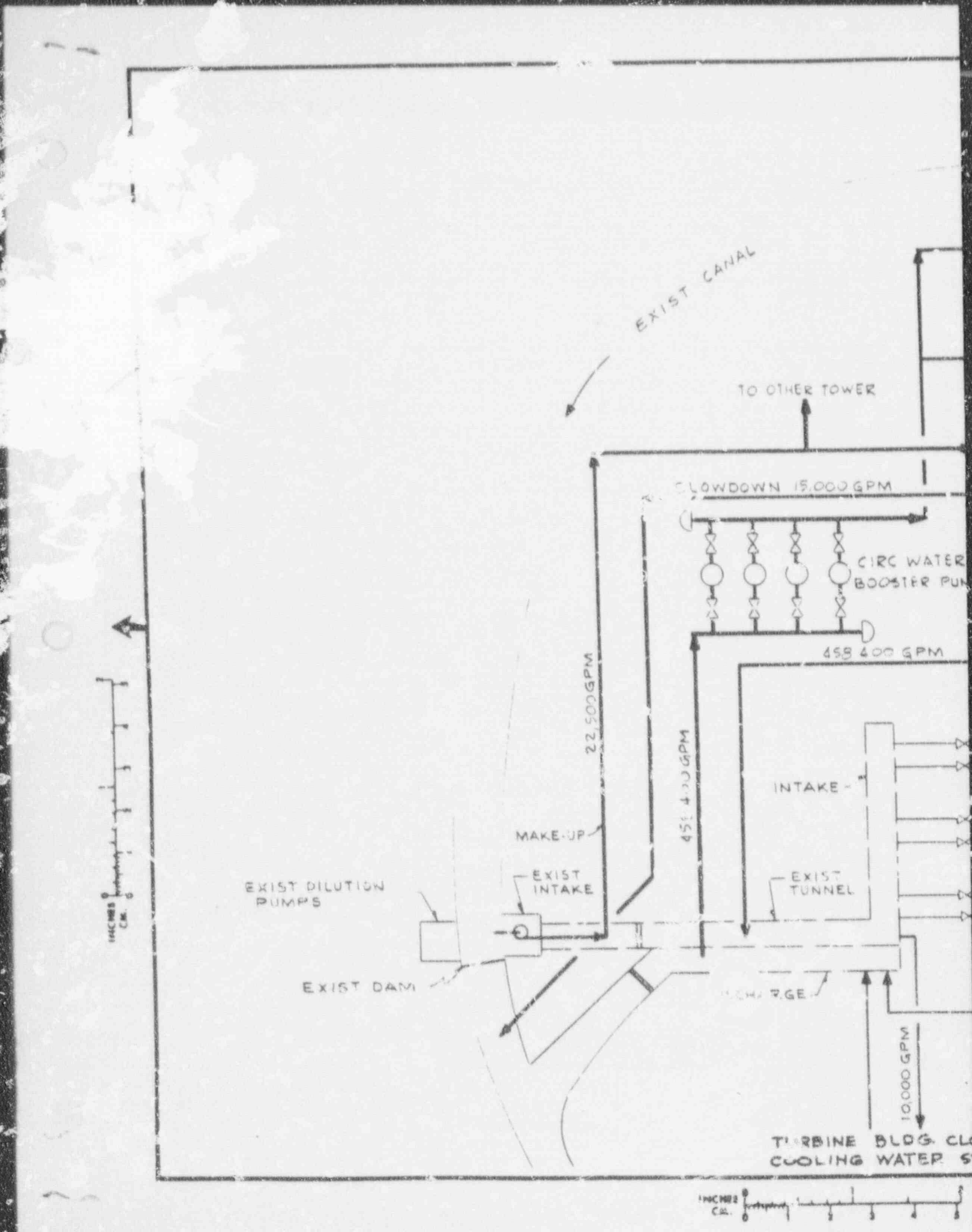
Exhibit 40



A) ELEVATED DESIGN (FAN ASSISTED NATURAL DRAFT)

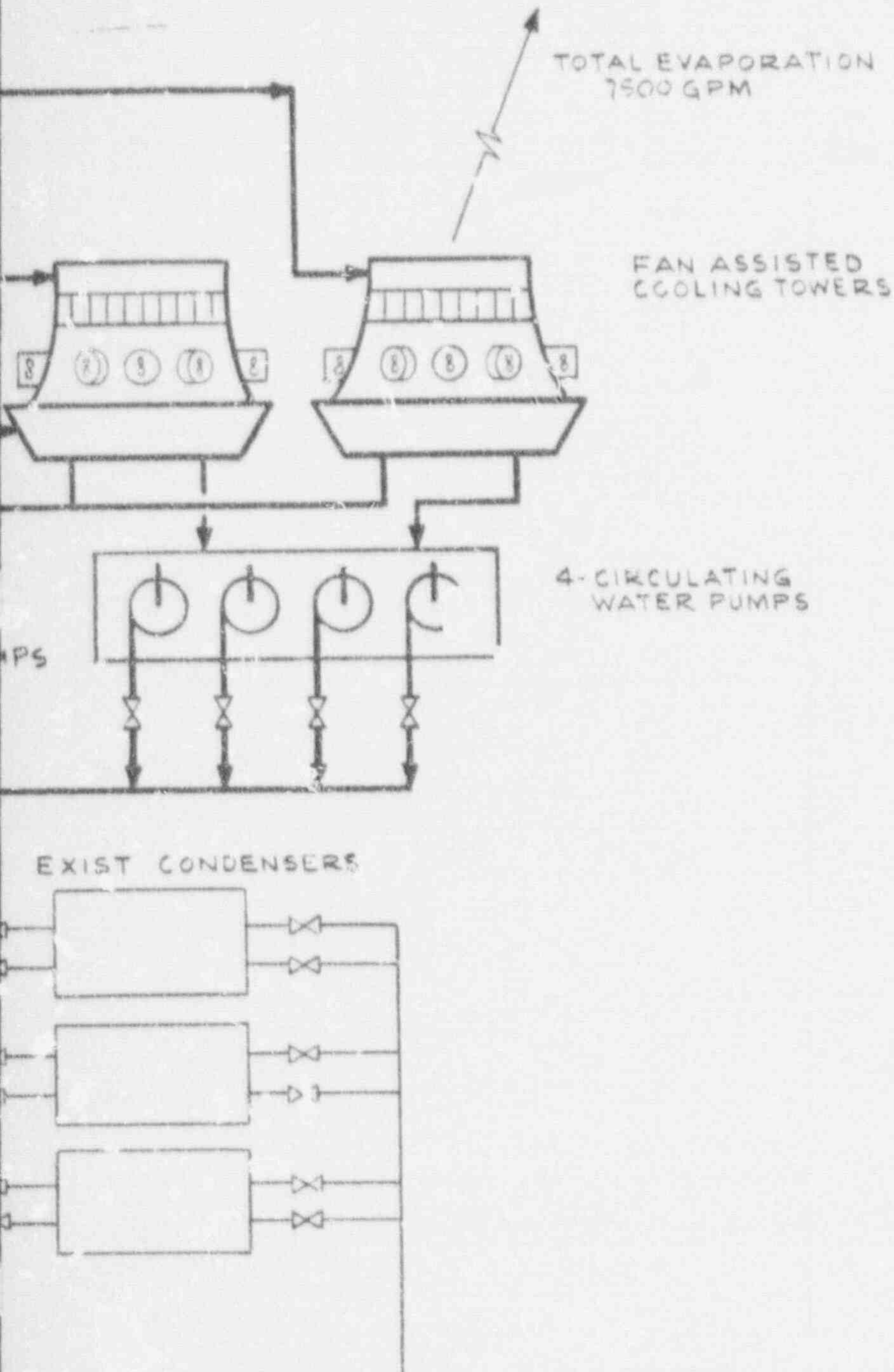


B) LOW PROFILE DESIGN



EXIST CANAL
TO OTHER TOWER
BLOWDOWN 15,000 GPM
CIRC WATER
BOOSTER PU
458 400 GPM
22,500 GPM
INTAKE
MAKE-UP
EXIST INTAKE
EXIST TUNNEL
EXIST DILUTION PUMPS
EXIST DAM
10,000 GPM
TURBINE BLDG CL
COOLING WATER S
INCHES
CM.

EXHIBIT - 41



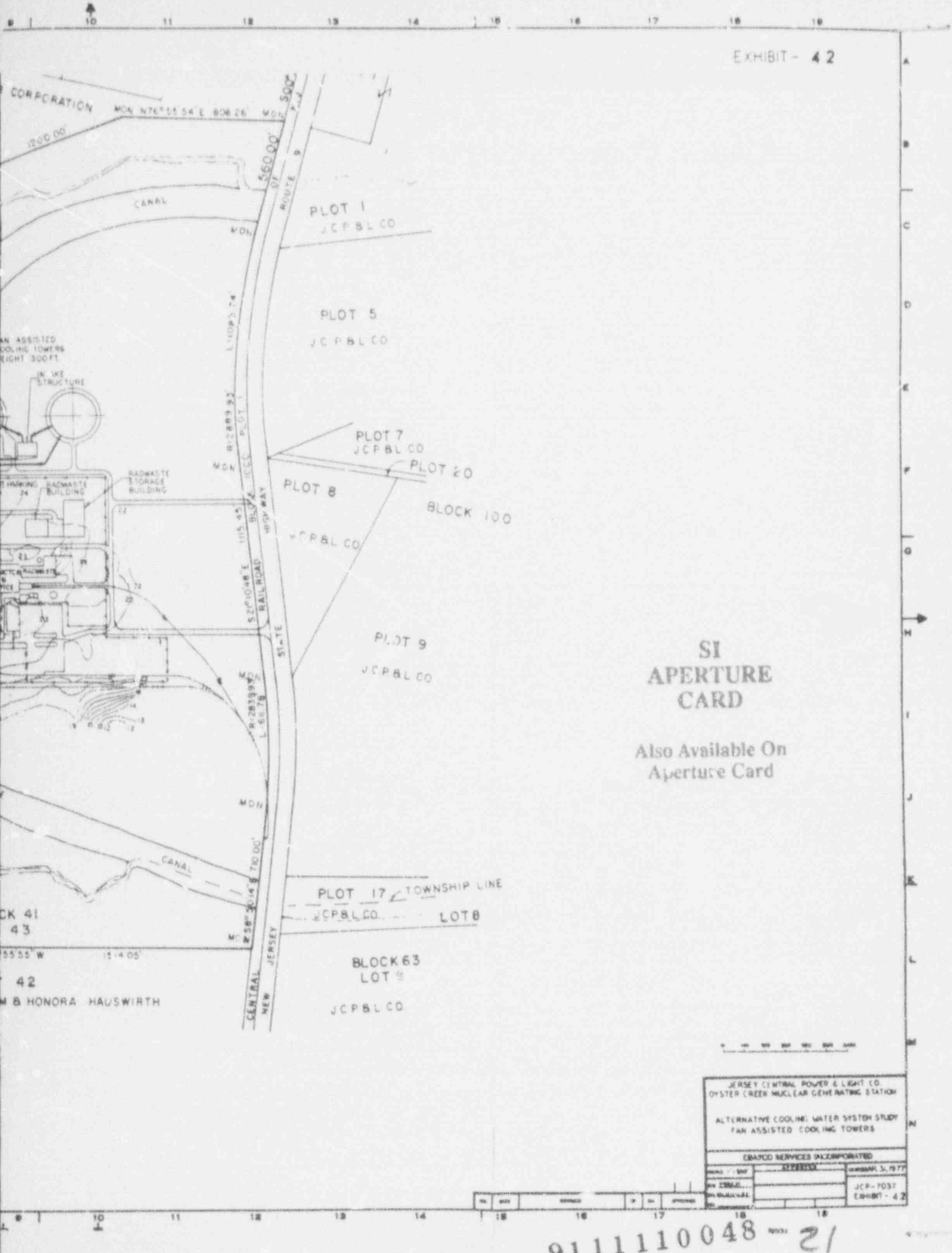
EBASCO SERVICES INCORPORATED		JERSEY CENTRAL POWER & LIGHT OYSTER CREEK NUCLEAR GEN. STATION ALTERNATIVE COOLING WTR SYSTEM STUDY FAN ASSISTED COOLING TOWER SYSTEM	JCP-7037 EXHIBIT - 41
DIV. MECH. DR. BMcK DATE 3/31/77 CH. SCALE ~	APPROVED		

SI
APERTURE
CARD

Also Available On
Aperture Card

8111110048 - 20

PLOT I
MON
EXIST. INTAKE STRUCTURE
EXIST. DILUTION PUMP STRUCTURE
INTAKE
SUBSTATION
EXIST. DISCH
BLOCK 1001
PLOT I
JOHN RUTHERFORD
ESTATE
MON



9111110048 - 21

FAN ASSISTED COOLING TOWERS

Country & Owner	Plant Name	Diam ft	Height ft	No. of Towers	Water gpm	Wet Bulb F	RH %	Range F	Appr F	In Operation
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 Lichterfeld-										
Bewag	Berlin			2**						
England-ICI	Wilton			1						
England-CEGB	Ince "B"	307	375	1****	490 000					Under Constr

*Manufactured by Hamon Sobelco

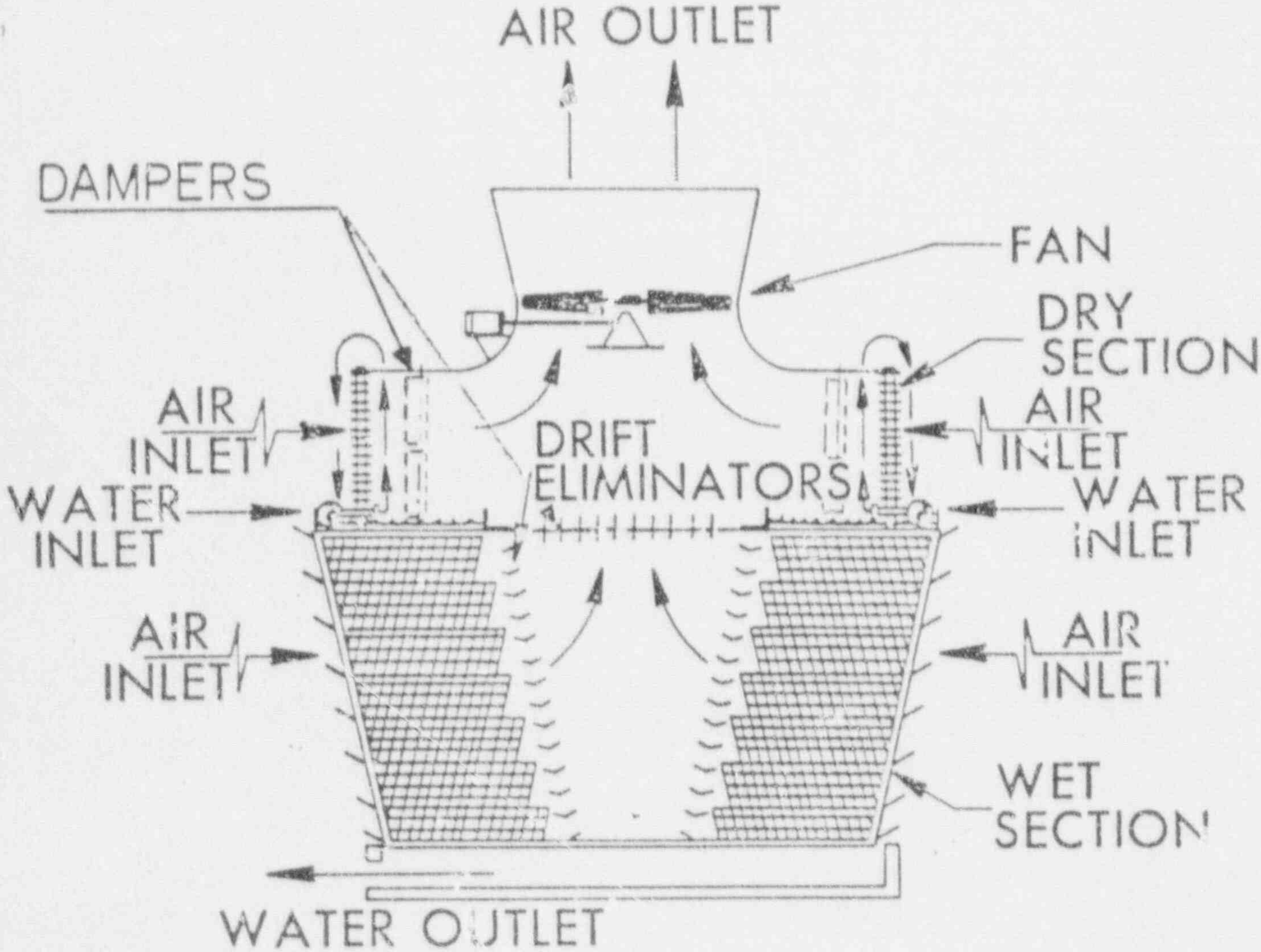
**Manufactured by Balck

***Used as helper towers during summer months

****Induced draft fans

Exhibit 43

PARALLEL PATH WET-DRY TOWER



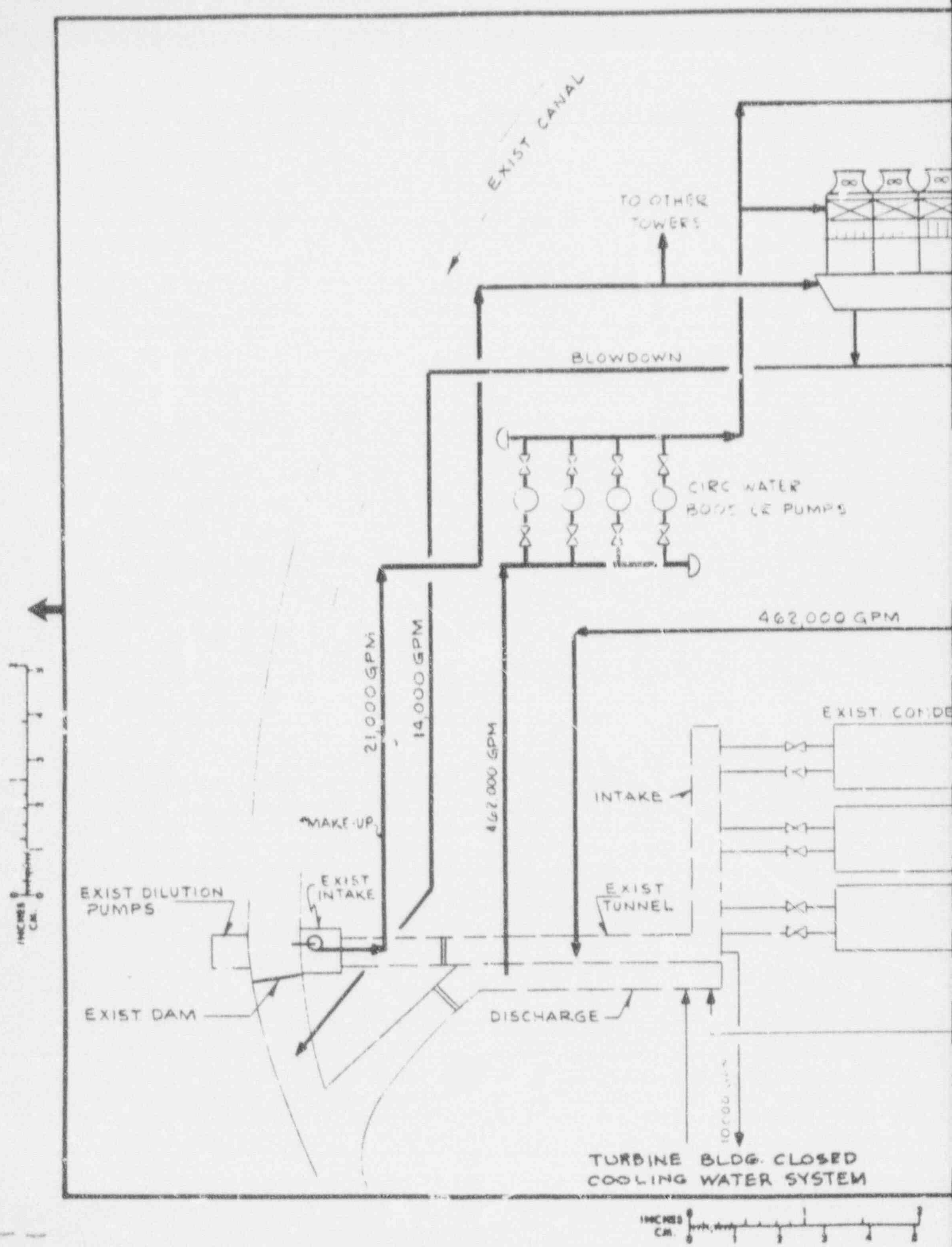
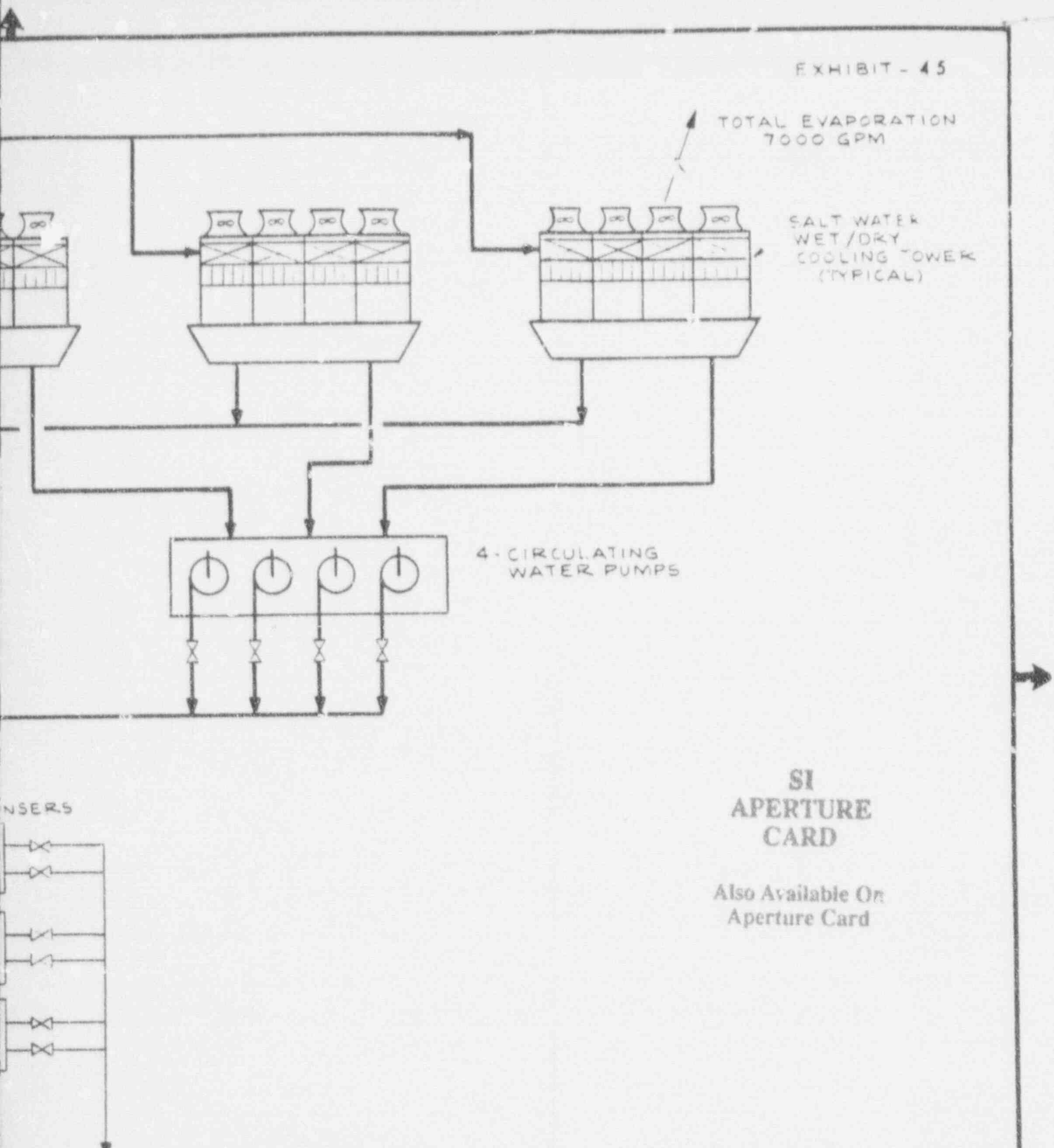
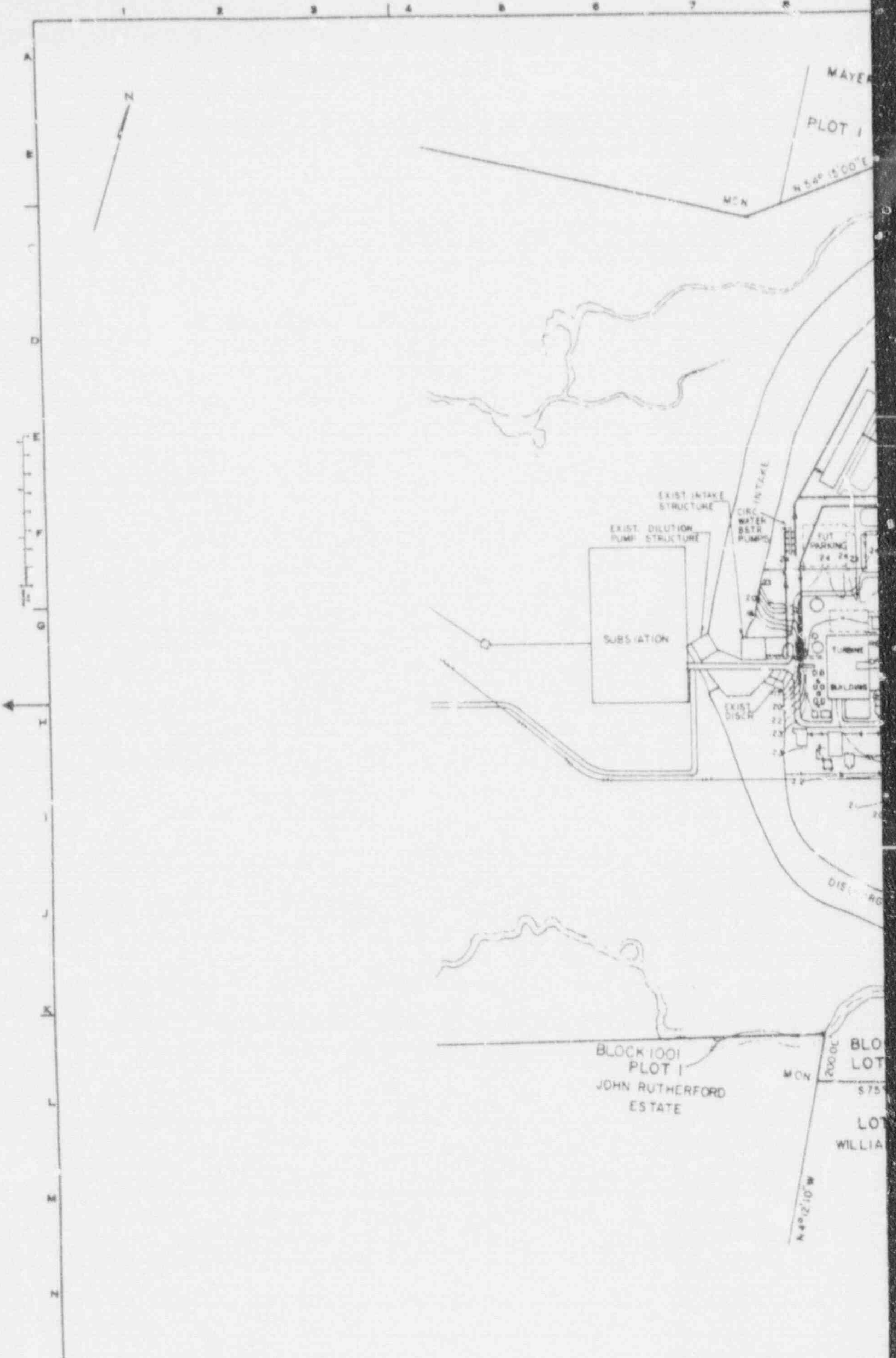

EXIST CANAL
TO OTHER TOWERS
BLOWDOWN
CIRC WATER BOOSTER PUMPS
462,000 GPM
21,000 GPM
14,000 GPM
462,000 GPM
EXIST. CONDE
INTAKE
MAKE-UP
EXIST DILUTION PUMPS
EXIST INTAKE
EXIST TUNNEL
EXIST DAM
DISCHARGE
TURBINE BLDG. CLOSED COOLING WATER SYSTEM
INCHES
CM.

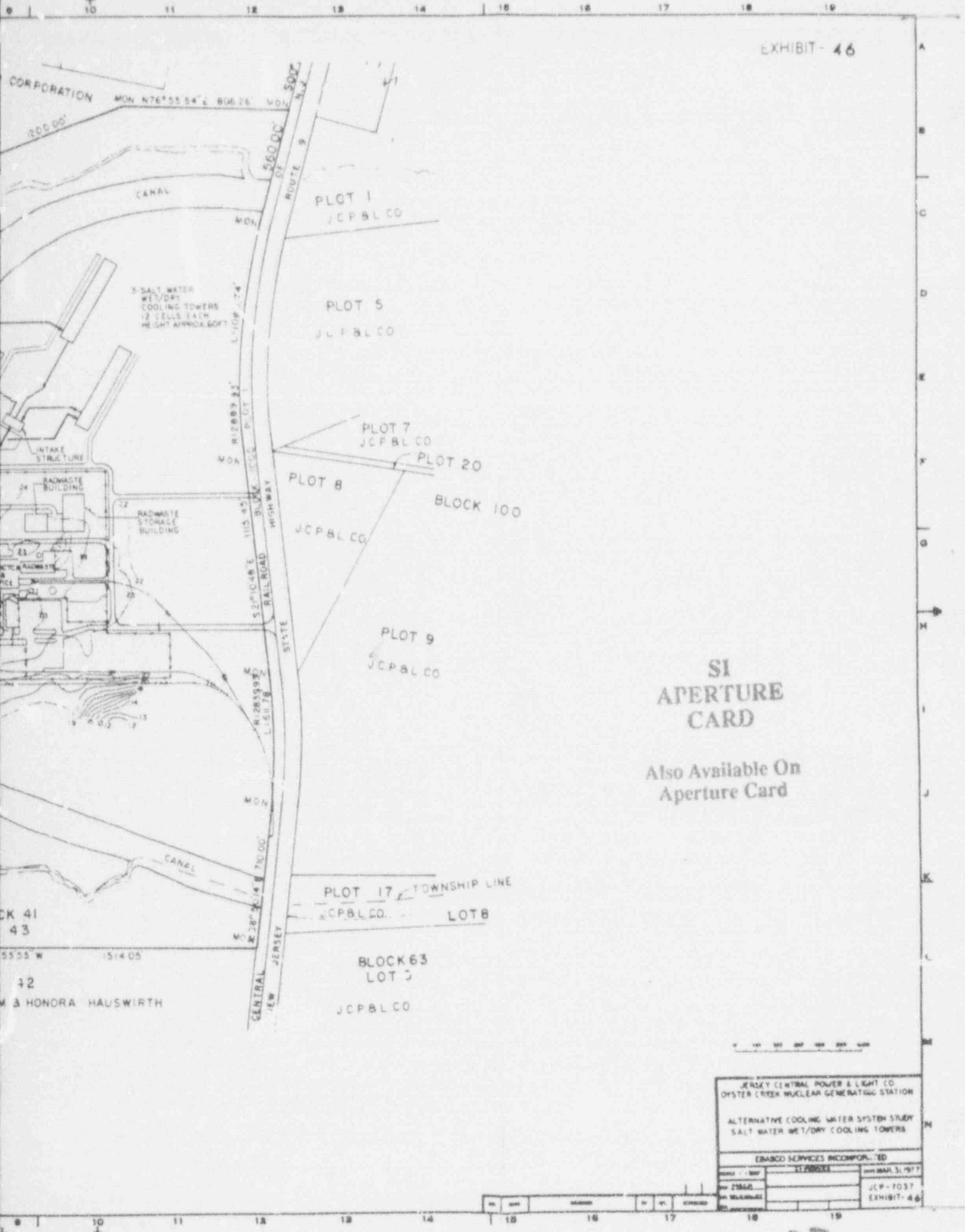
EXHIBIT - 45



EBASCO SERVICES INCORPORATED		JERSEY CENTRAL POWER & LIGHT OYSTER CREEK NUCLEAR GEN STATION ALTERNATIVE COOLING WTR SYSTEM STUDY SALT WATER WET/DRY COOLING TOWER SYSTEM	JCP-7037 EXHIBIT-45
DIV. MECH DR. BMcK DATE 3/31/77 CH.____ SCALE ~	APPROVED		



MAYER
PLOT I
MON
EXIST. INTAKE STRUCTURE
EXIST. DILUTION PUMP STRUCTURE
CIRC WATER BSTR PUMPS
INTAKE
SUBSTATION
TURBINE BUILDING
EXIST. DISCH.
BLOCK 1001
PLOT I
JOHN RUTHERFORD ESTATE
MON



SI
APERTURE
CARD

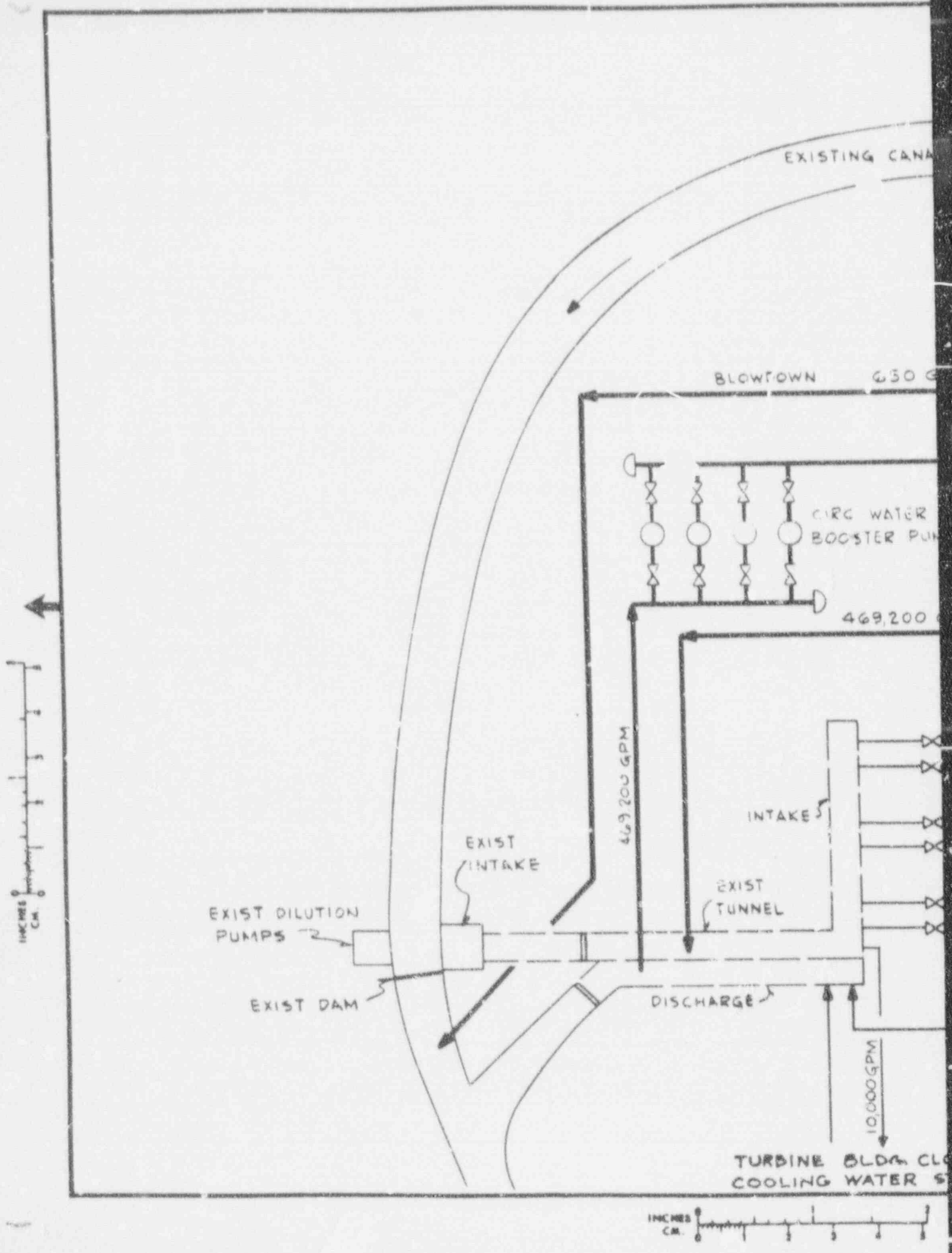
Also Available On
Aperture Card

9111110048 - 23

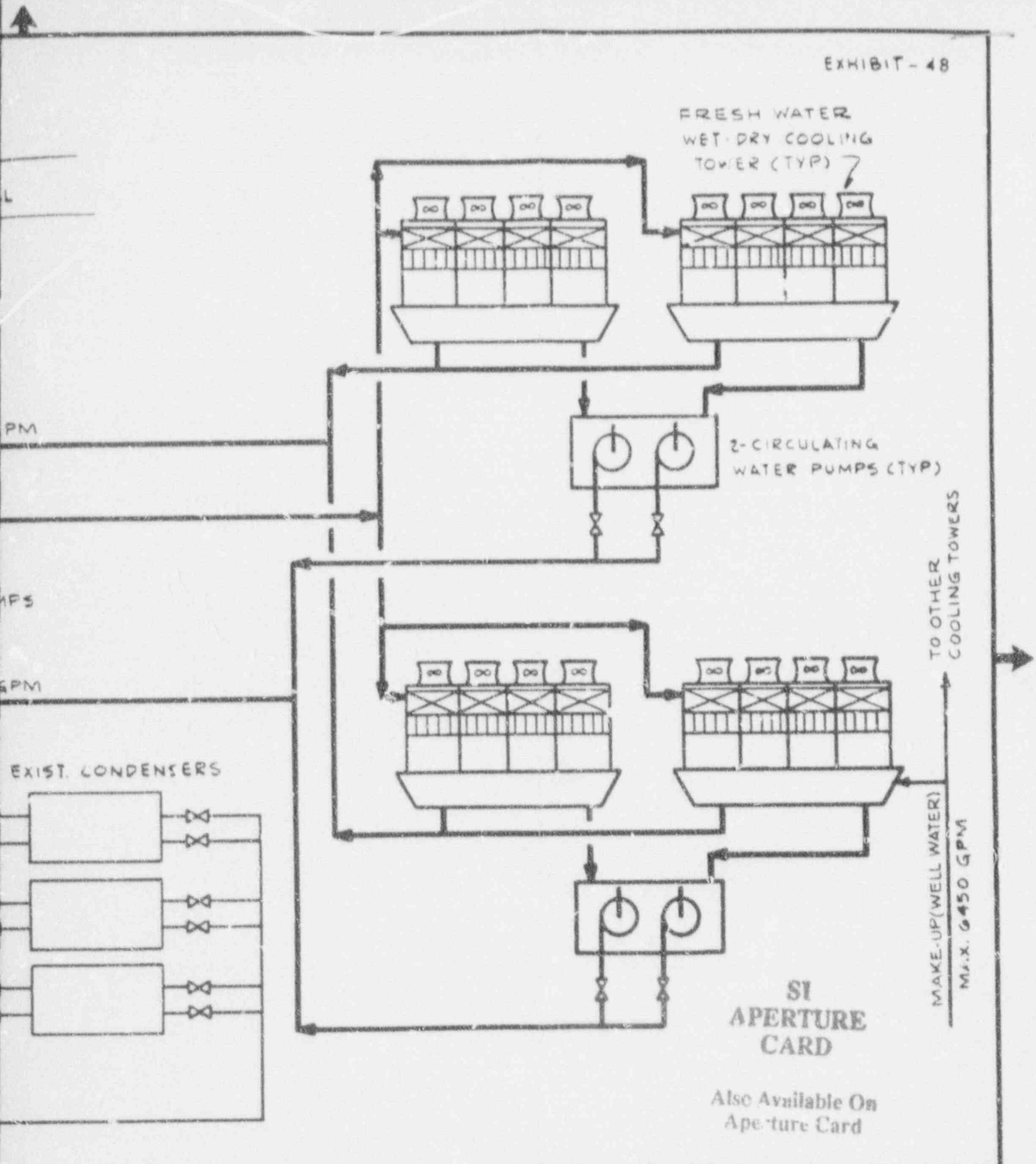
WET/DRY COOLING TOWERS

Owner	Location & Plant Name	No. of Towers	No. of Cells/Tower	Flow/Tower gpm	$T_1/T_2/T_{wb}$	Manufacturer	In Operation
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

Exhibit 47



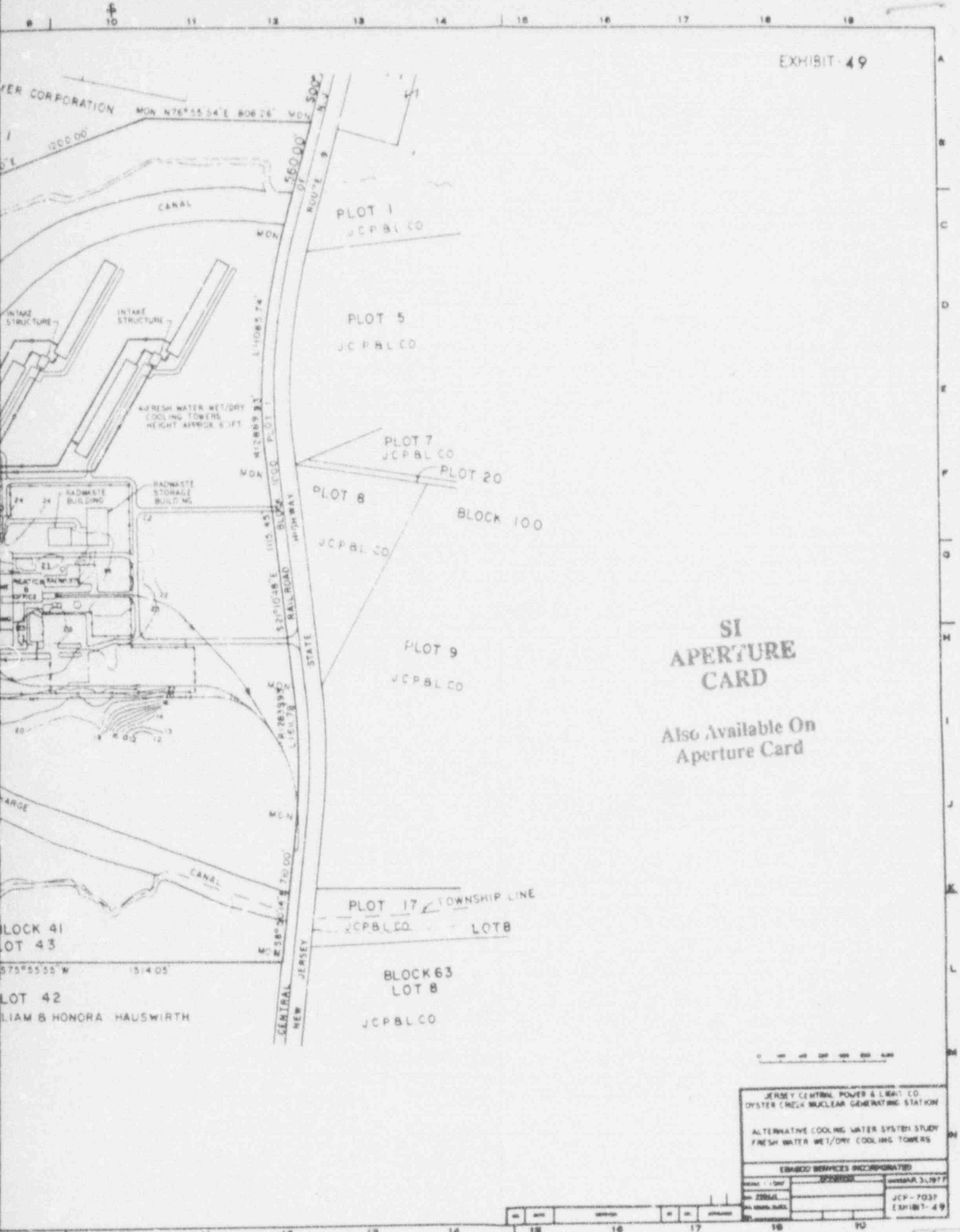
EXISTING CANA
BLOWDOWN 630 G
CIRC WATER
BOOSTER PU
469,200
469,200 GPM
INTAKE
EXIST INTAKE
EXIST TUNNEL
EXIST DILUTION PUMPS
EXIST DAM
DISCHARGE
10,000 GPM
TURBINE BLDG CL
COOLING WATER S
INCHES
CM.



EBASCO SERVICES INCORPORATED DIV. MECH DR. WA CH. ____ DATE MAR 31 1977	APPROVED	JERSEY CENTRAL POWER & LIGHT OYSTER CREEK NUCLEAR GEN STATION ALTERNATIVE COOLING WTR SYSTEM STUDY FRESH WATER WET/DRY COOLING TOWER SYSTEM	JCP-7031 EXHIBIT-48

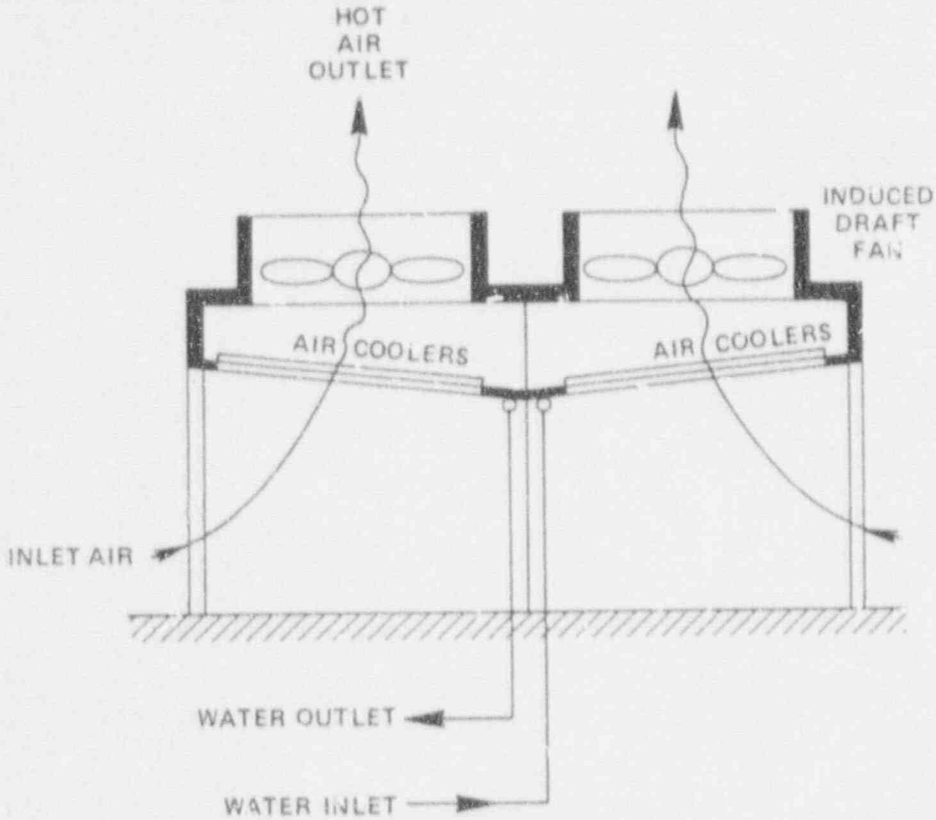
9111110048 - 24


N
PLOT
MON
EXIST. INTAKE STRUCTURE
EXIST. DILUTION PUMP STRUCTURE
INTAKE
CIRC WATER BSTR PUMPS
PARKING
SUBSTATION
EXIST DISCH
BLOCK 100:
PLOT 1
JOHN RUTHERFORD
ESTATE
MON

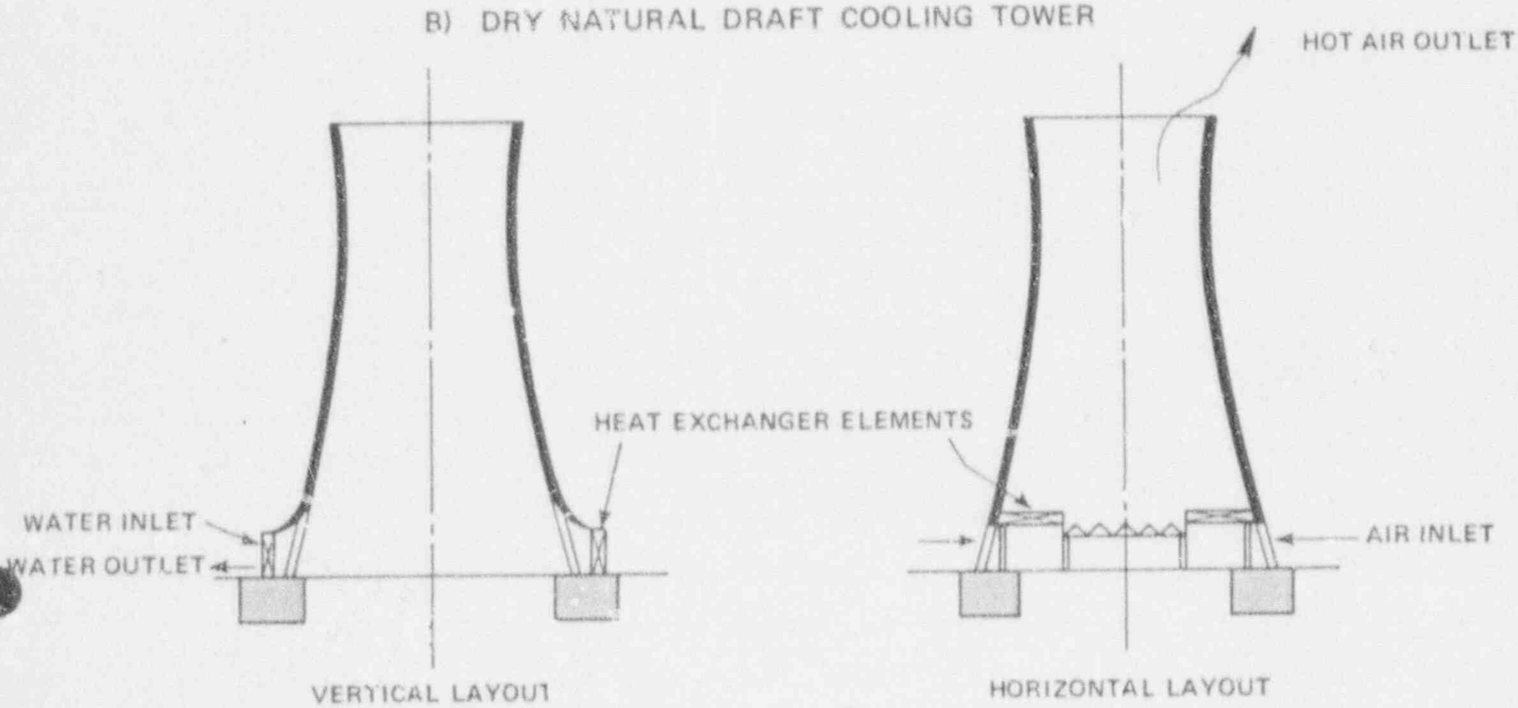


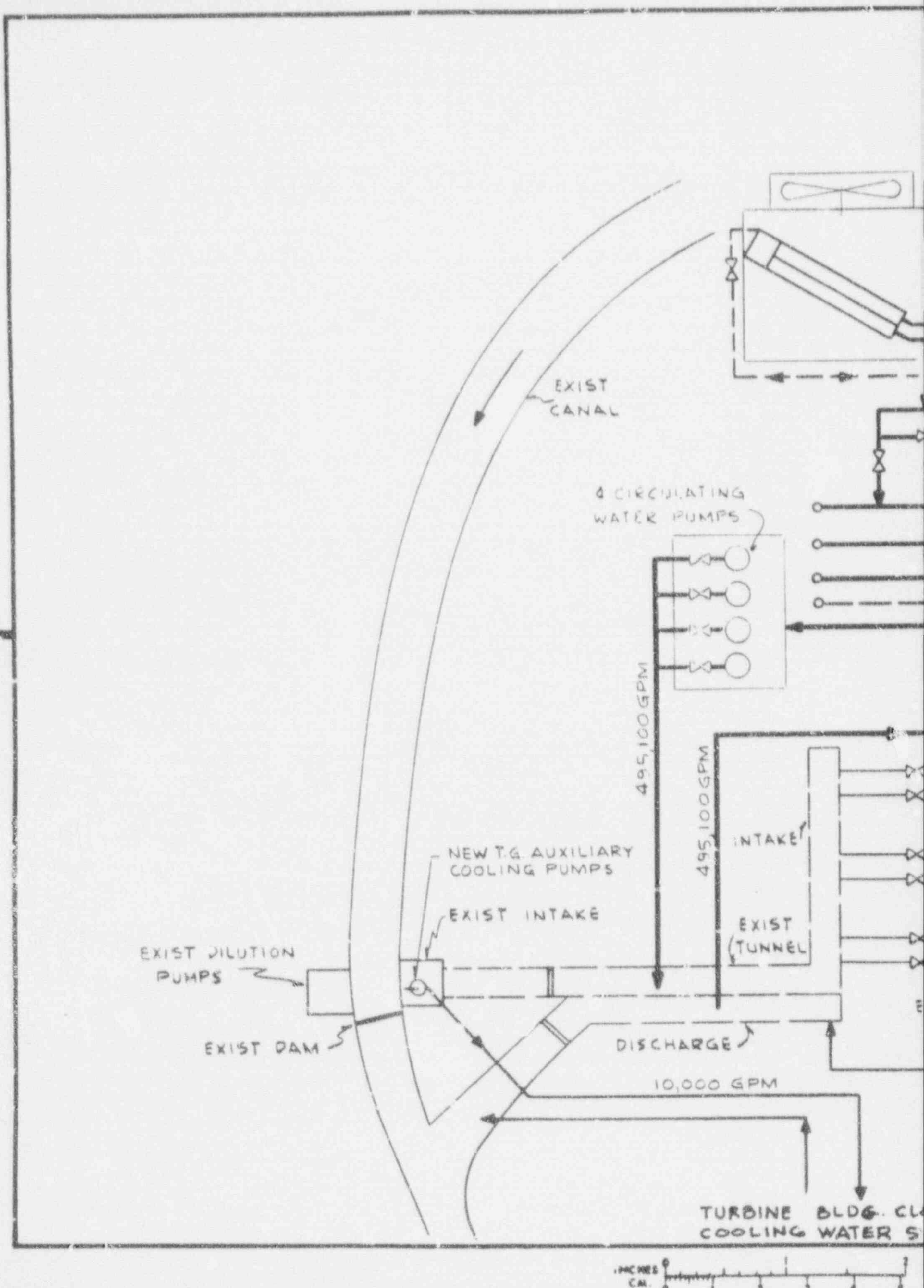
9111110048 -25

A) DRY MECHANICAL DRAFT COOLING TOWER

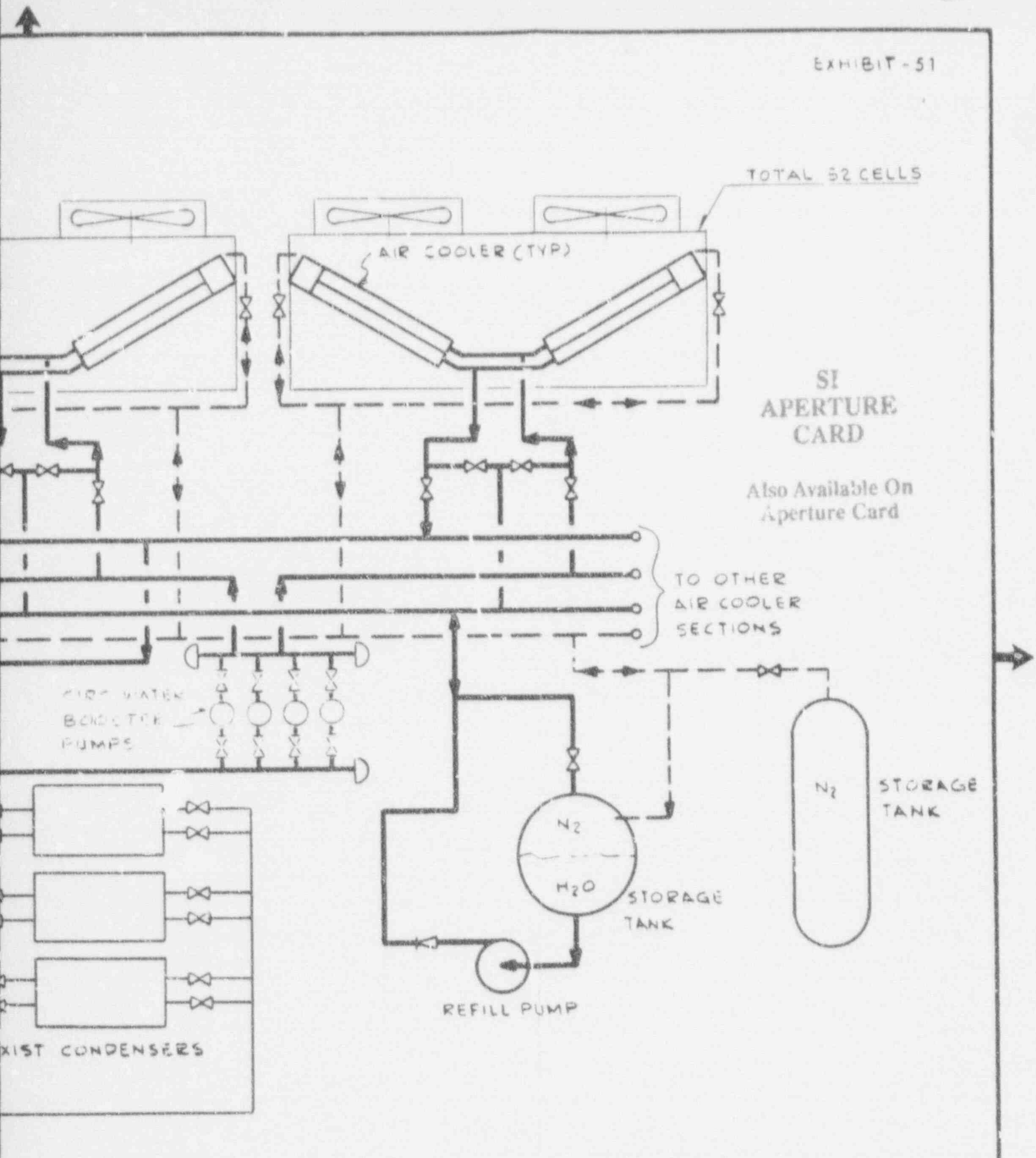


B) DRY NATURAL DRAFT COOLING TOWER





EXIST CANAL
4 CIRCULATING WATER PUMPS
495,100 GPM
495,100 GPM
INTAKE
NEW T.G. AUXILIARY COOLING PUMPS
EXIST INTAKE
EXIST TUNNEL
EXIST DILUTION PUMPS
EXIST DAM
DISCHARGE
10,000 GPM
TURBINE BLDG. CL
COOLING WATER S
INCHES
CM.

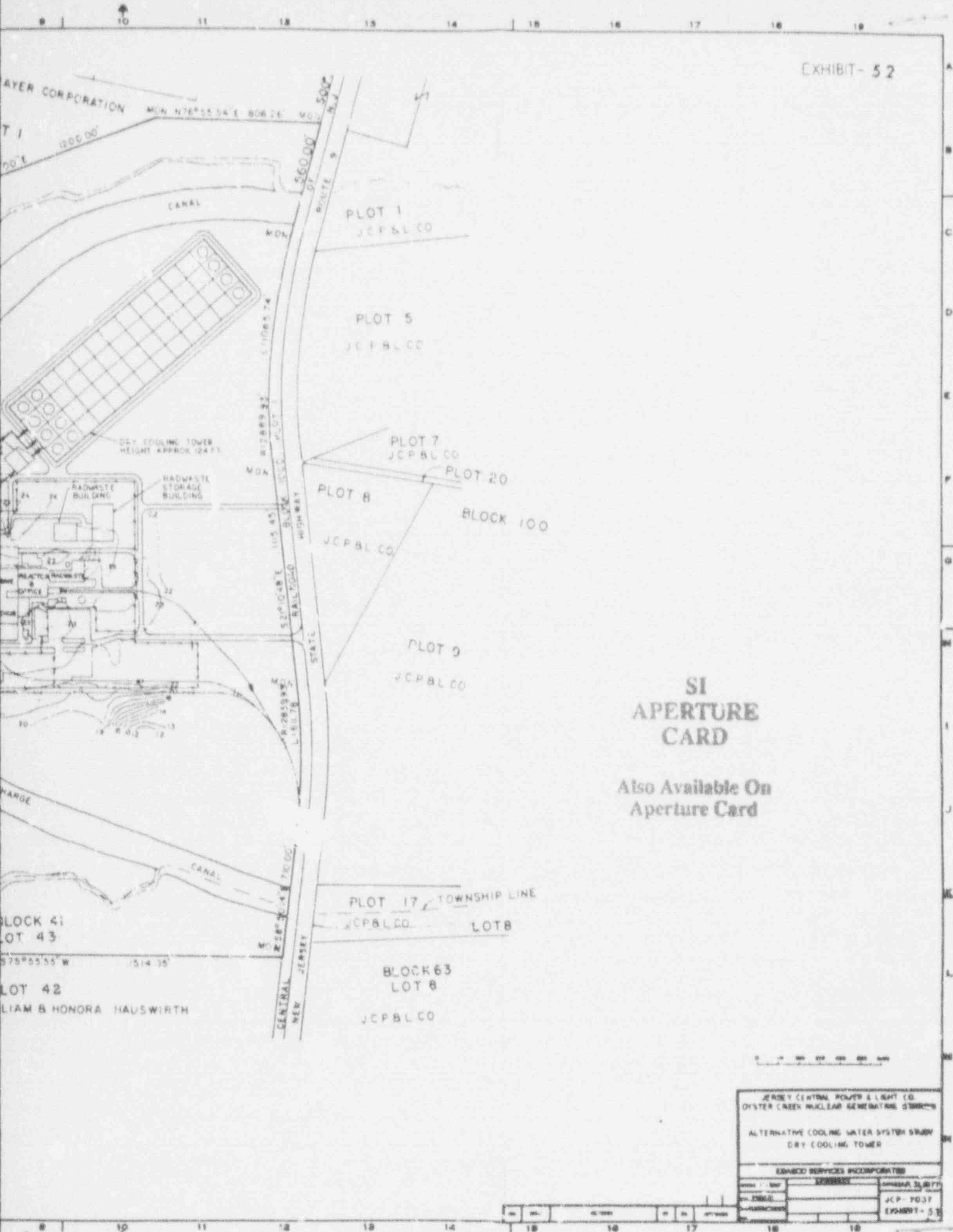


OSED
YSTEM

EBASCO SERVICES INCORPORATED		JERSEY CENTRAL POWER & LIGHT OYSTER CREEK NUCLEAR GEN STATION ALTERNATIVE COOLING WTR SYSTEM STUDY DRY COOLING TOWER SYSTEM	JCP 7037 EXHIBIT-51
DIV MECH DR WA CH DATE MAR. 31, 1977	APPROVED		

9111110048 -26

N
MON
INTAKE STRUCTURE
EXIST INTAKE STRUCTURE
EXIST DILUTION PUMP STRUCTURE
FUTURE PARKING
SUBSTATION
EXIST DISCH
BLOCK 1001
PLOT 1
JOHN RUTHERFORD
ESTATE
MON



SI
APERTURE
CARD

Also Available On
Aperture Card

9111110048 -27

EXHIBIT 53

GENERATING PLANTS WITH DRY-TYPE COOLING TOWERS

Location	Rating	Type of Dry Tower	Year Commissioned
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 (Indirect)	1971
Gyongyos, Hungary	2-100 MW	Heller	1969
	2-200 MW	Heller	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-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

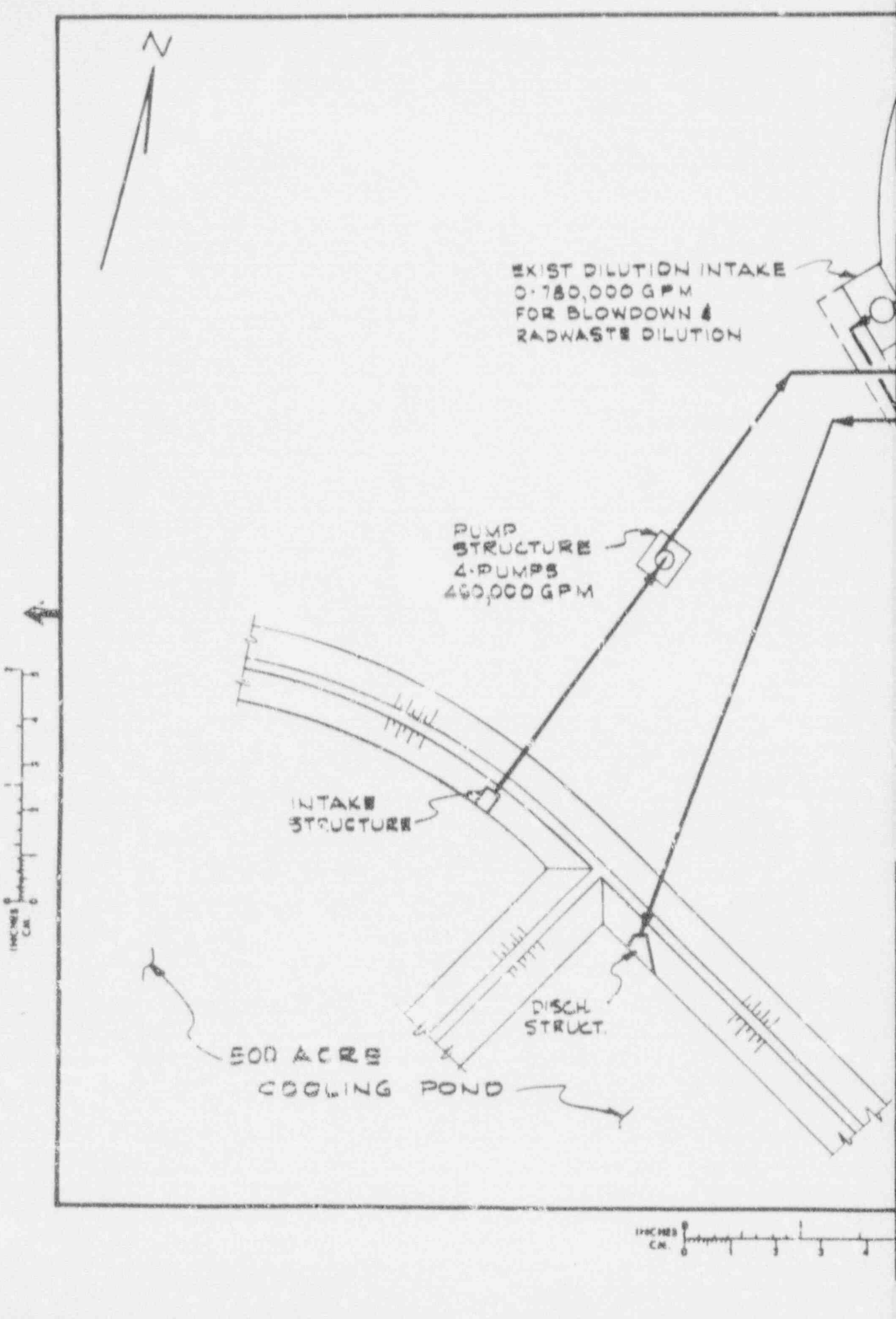
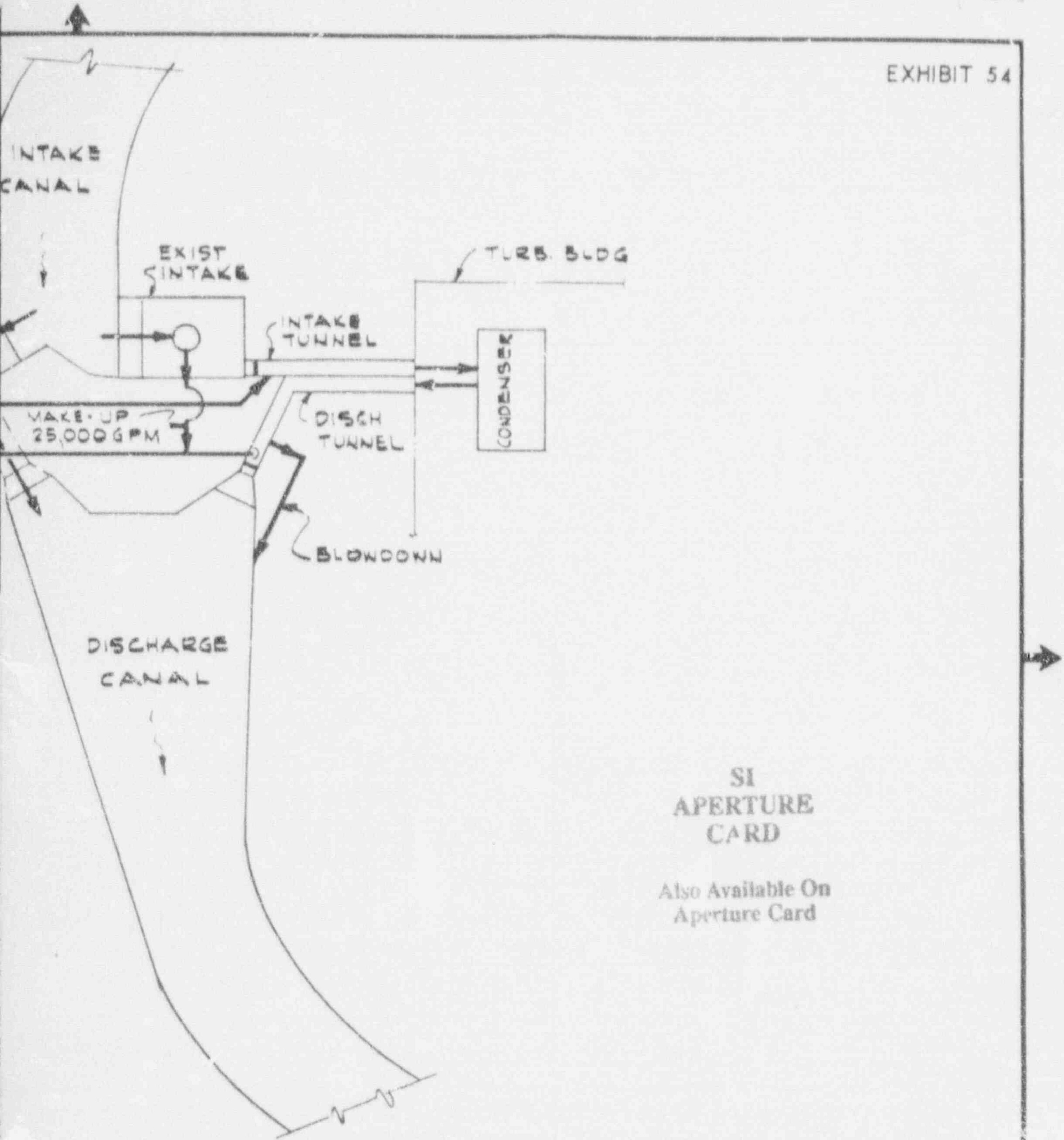

N
EXIST DILUTION INTAKE
0-780,000 GPM
FOR BLOWDOWN &
RADWASTE DILUTION
PUMP
STRUCTURE
4-PUMPS
460,000 GPM
INTAKE
STRUCTURE
DISCH.
STRUCT.
500 ACRE
COOLING POND
INCHES
CM.

EXHIBIT 54

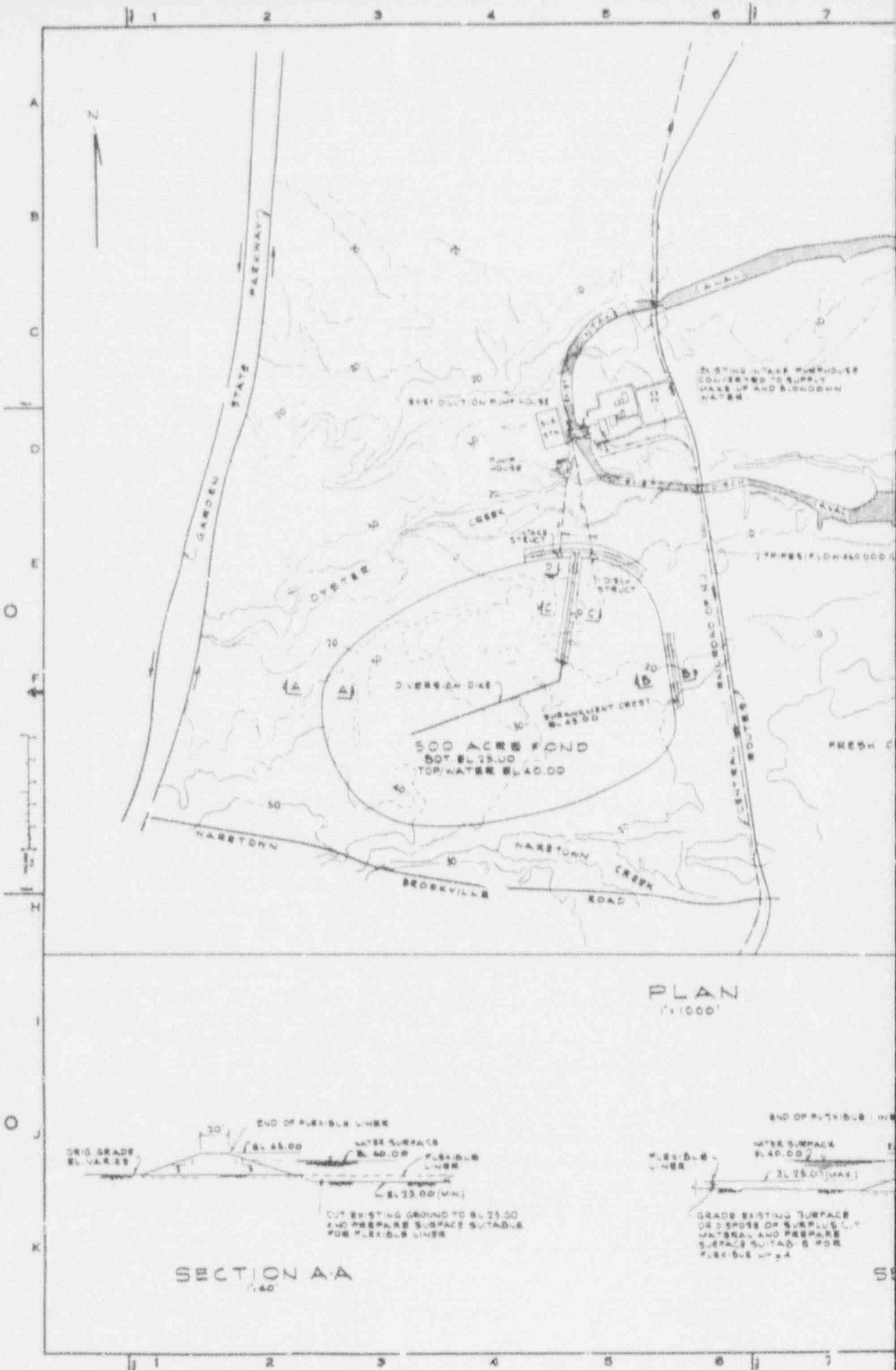


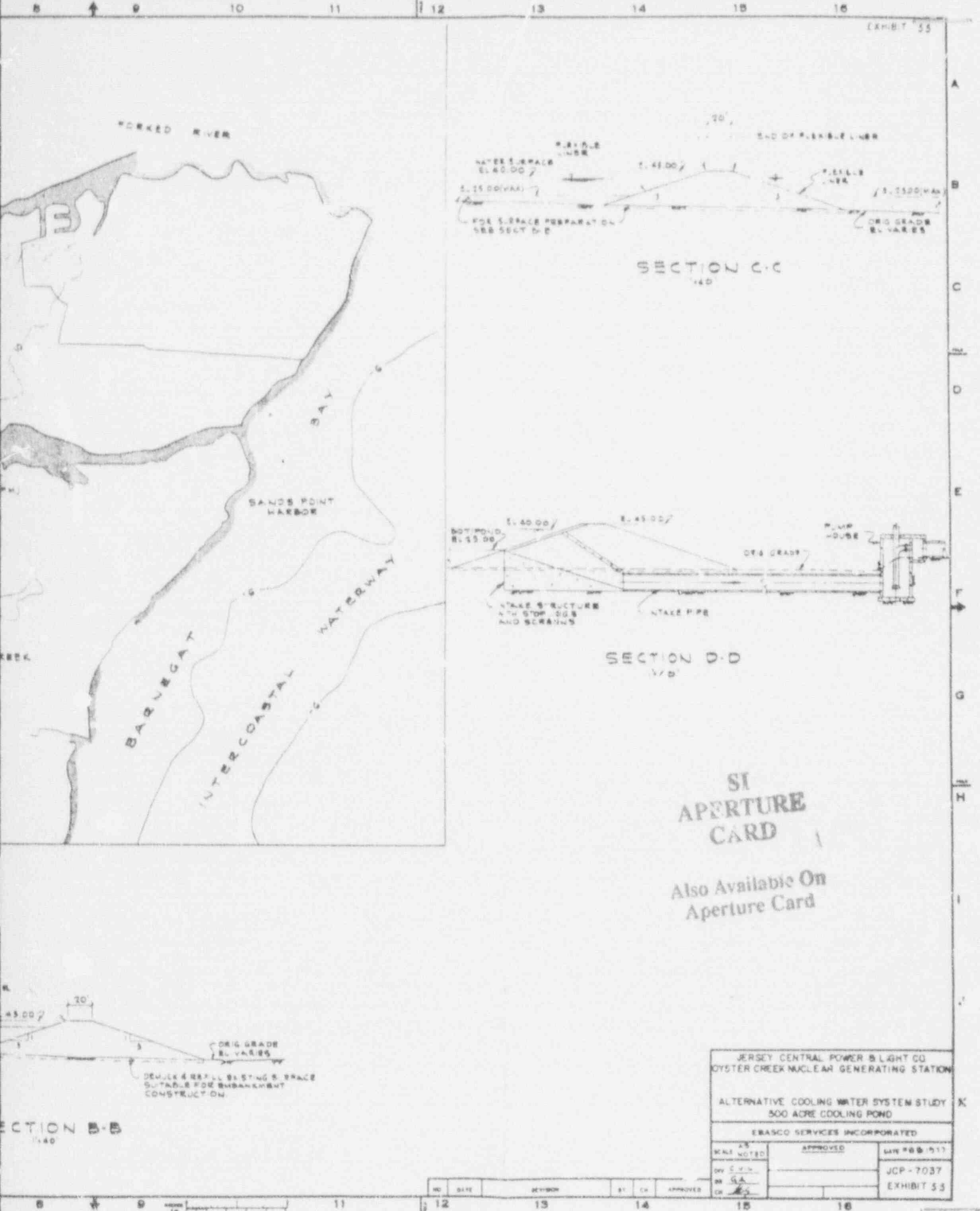
SI
APERTURE
CARD

Also Available On
Aperture Card

EBASCO SERVICES INCORPORATED		JERSEY CENTRAL POWER & LIGHT OYSTER CREEK NUCLEAR GEN. STATION ALTERNATIVE COOLING WATER SYS STUDY 500 ACRE COOLING POND	JCP - 7037 EXHIBIT 54
DIV. CIVIL DR. GA SCALE NTS CH. [illegible] DATE FEB 1977	APPROVED		

9111110048 - 28


GARDEN STATE PARKWAY
OYSTER CREEK
DIVERSION DIKE
500 ACRE POND
BOT EL 25.00
TOP/WATER EL 40.00
WARETOWN
BROOKVILLE ROAD
WARETOWN CREEK
PLAN
1"=1000'
SECTION A-A
1"=40'



9111110048 - 29

1

IMAGE EVALUATION TEST TARGET (MT-3)

150mm

6"

1

IMAGE EVALUATION TEST TARGET (MT-3)

150mm

6"

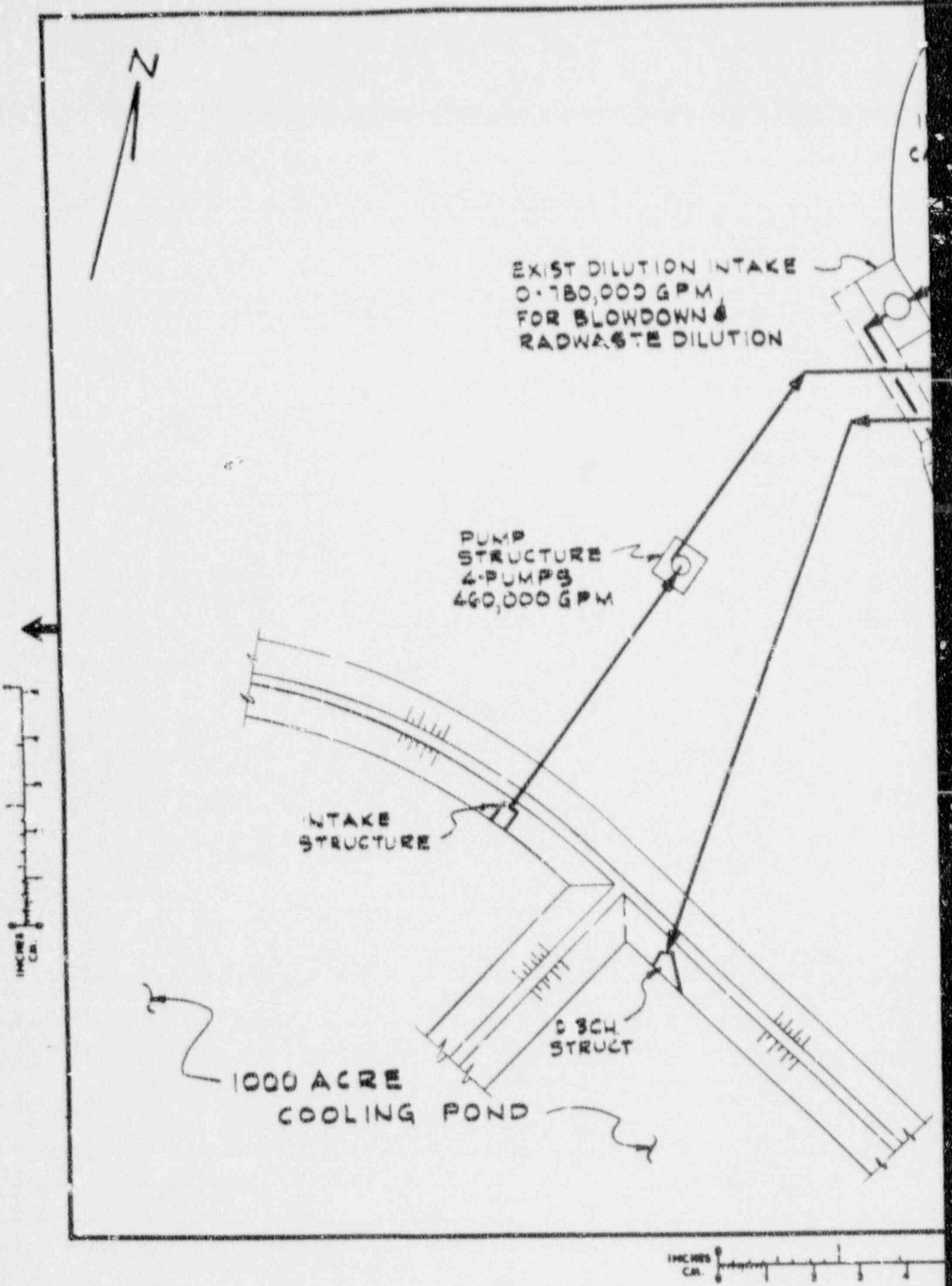
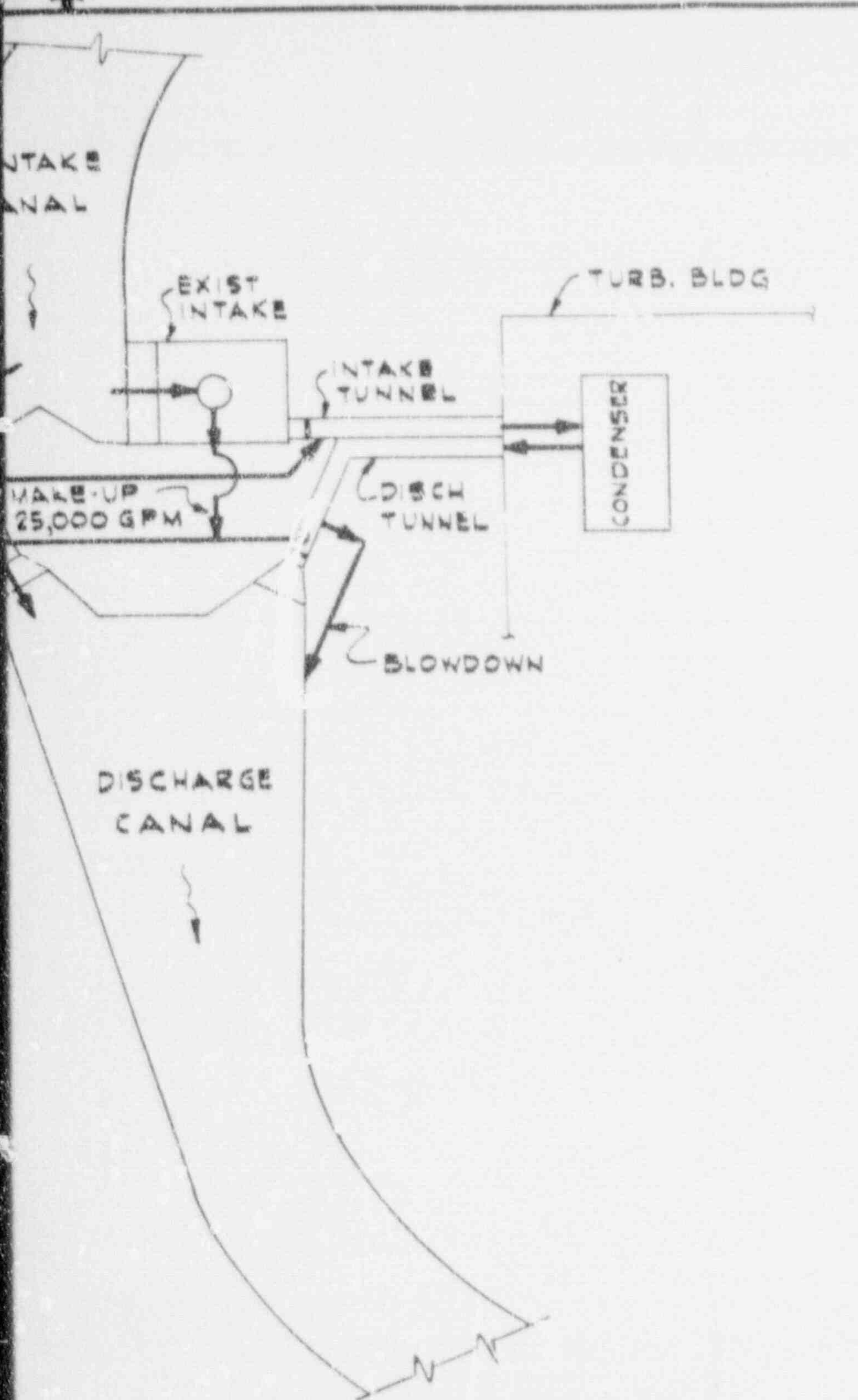
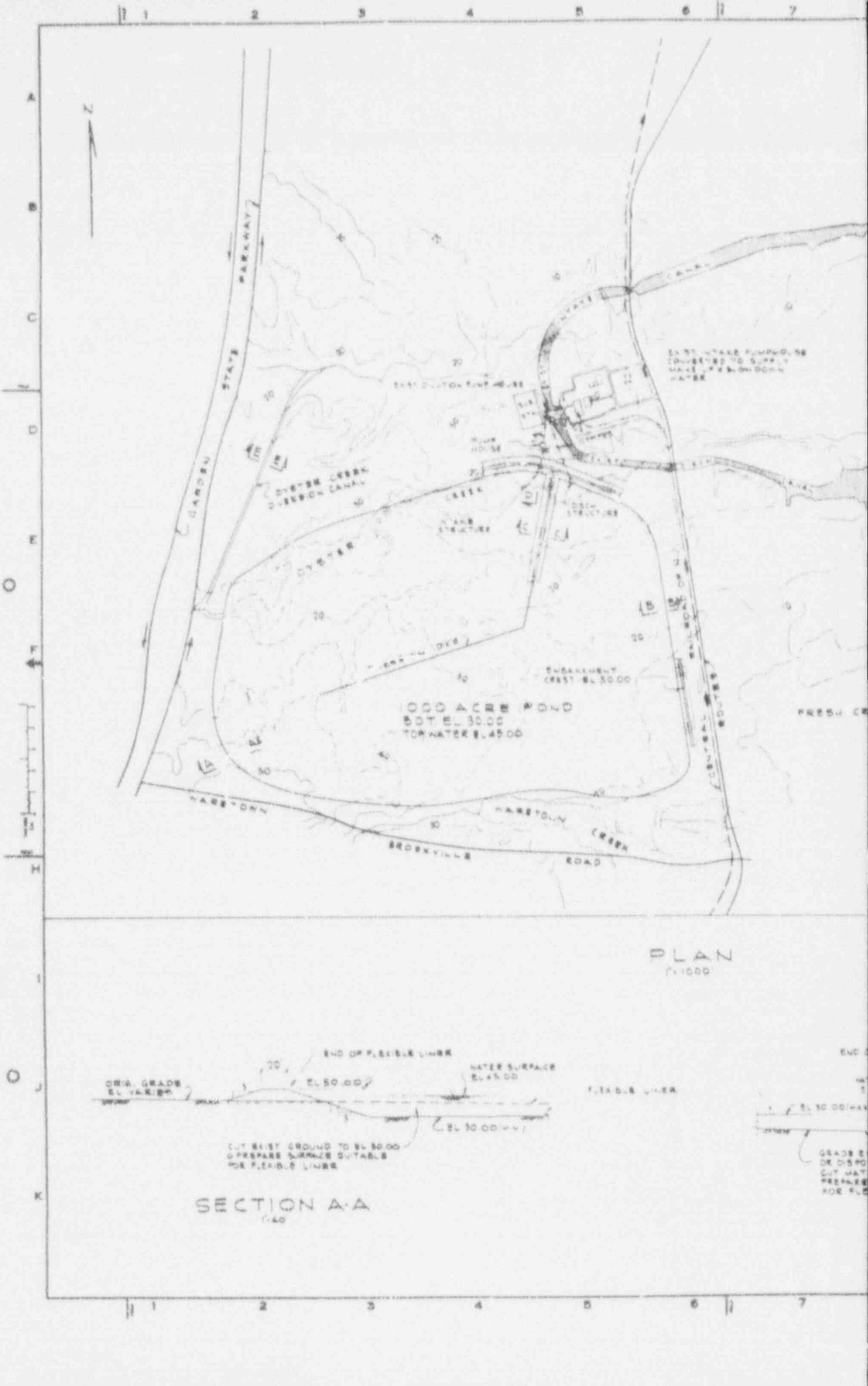

N
EXIST DILUTION INTAKE
0-780,000 GPM
FOR BLOWDOWN &
RADWASTE DILUTION
PUMP
STRUCTURE
4-PUMPS
460,000 GPM
INTAKE
STRUCTURE
DSCH
STRUCT
1000 ACRE
COOLING POND
INCHES
CM.

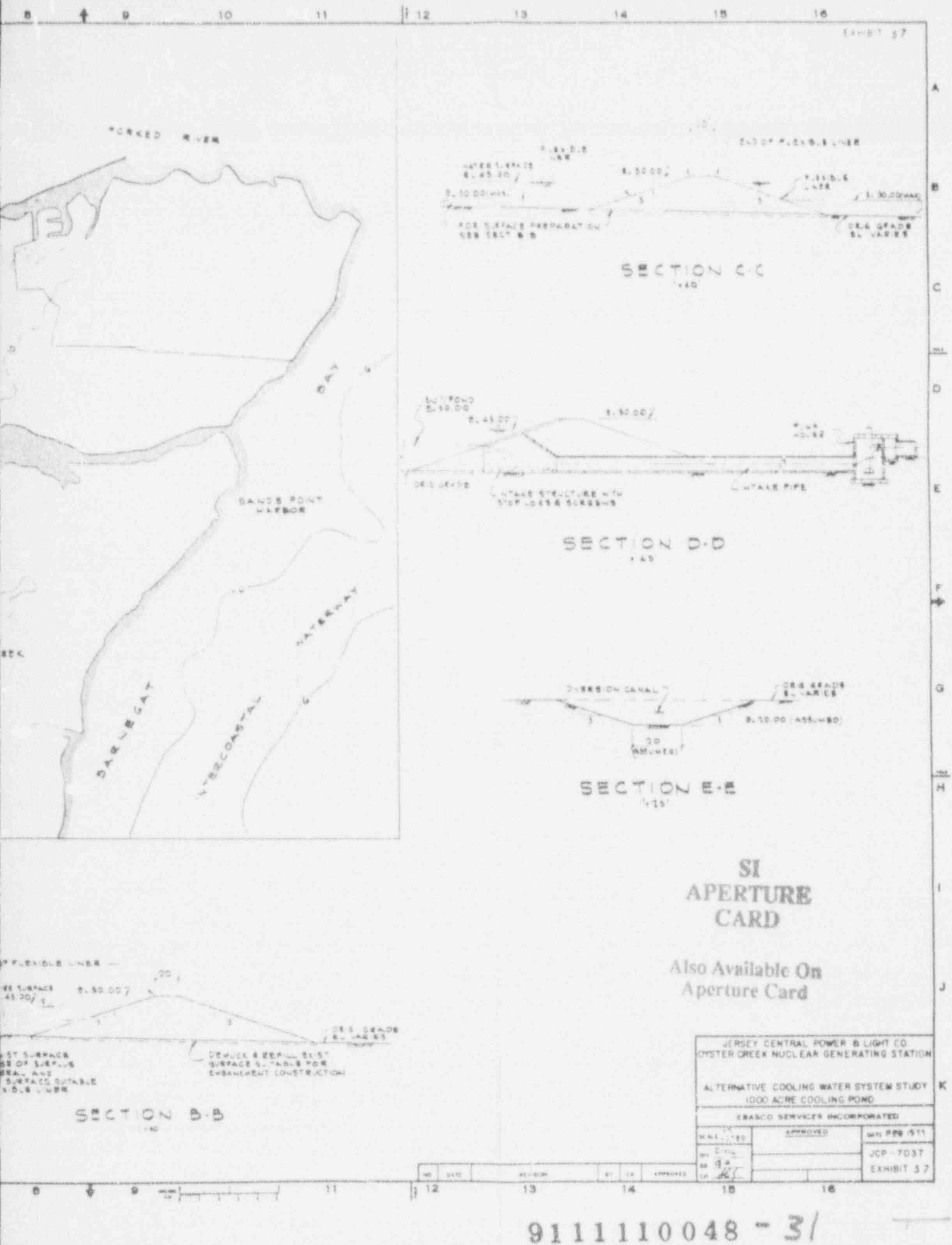
EXHIBIT 56



EBASCO SERVICES INCORPORATED DIV CIVIL SCALE NTS 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



GARDEN STATE PARKWAY
OYSTER CREEK DIVERSION CANAL
OYSTER CREEK
INTAKE STRUCTURE
EMBANKMENT CREST EL. 50.00
1000 ACRE POND
BOT. EL. 30.00
TOP WATER EL. 45.00
WARETOWN
WARETOWN CREEK
BROOKVILLE ROAD
PLAN
END OF FLEXIBLE LINER
WATER SURFACE EL. 45.00
ORIG. GRADE EL. VARIES
EL. 50.00
EL. 30.00
FLEXIBLE LINER
CUT EXIST. GROUND TO EL. 30.00 & PREPARE SURFACE SUITABLE FOR FLEXIBLE LINER
SECTION A-A



SI APERTURE CARD

Also Available On Aperture Card

JERSEY CENTRAL POWER & LIGHT CO.
OYSTER CREEK NUCLEAR GENERATING STATION

ALTERNATIVE COOLING WATER SYSTEM STUDY
1000 ACRE COOLING POND

EBASCO SERVICES INCORPORATED

JCP - 7037
EXHIBIT 57

9111110048 - 31

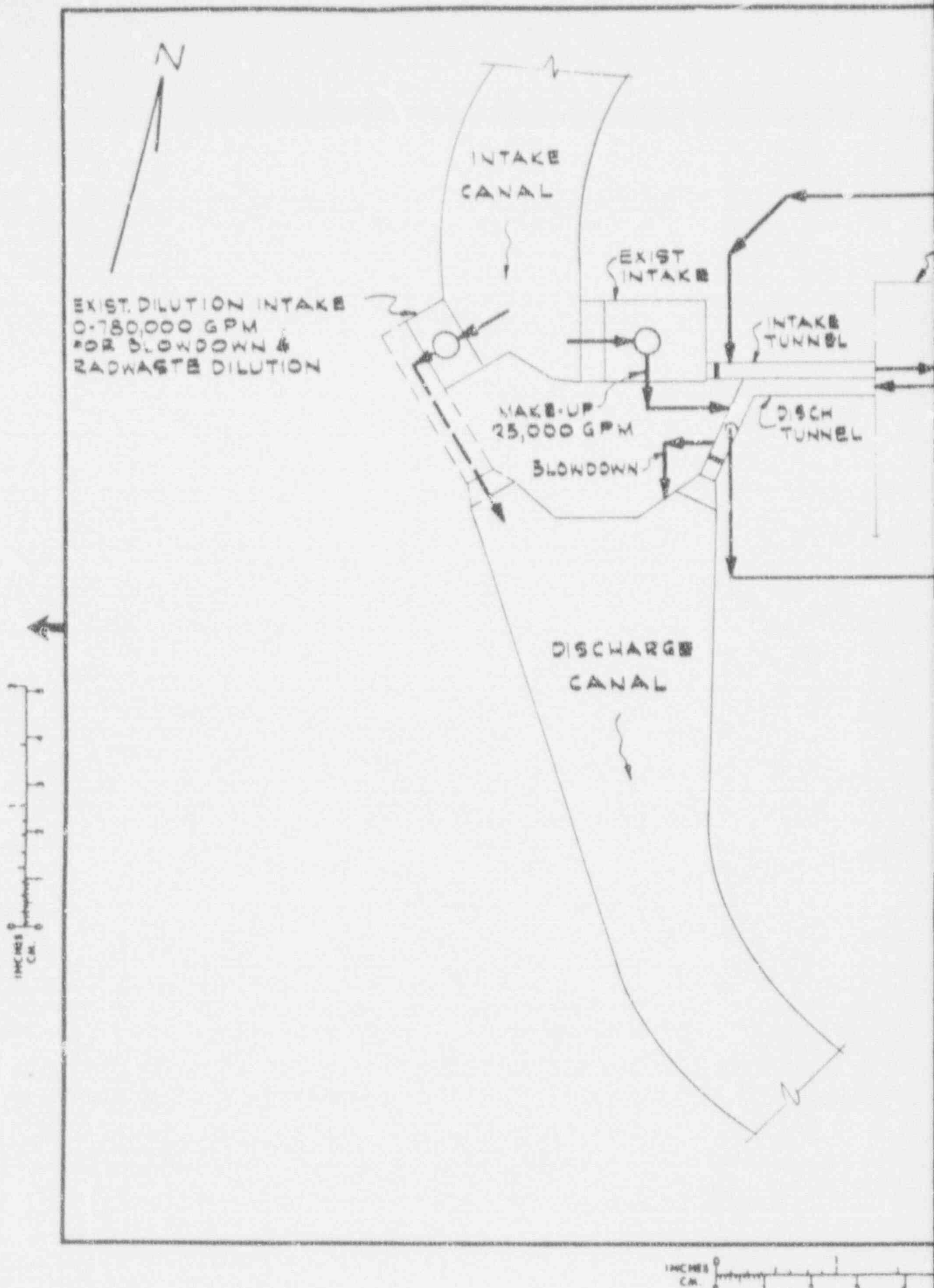
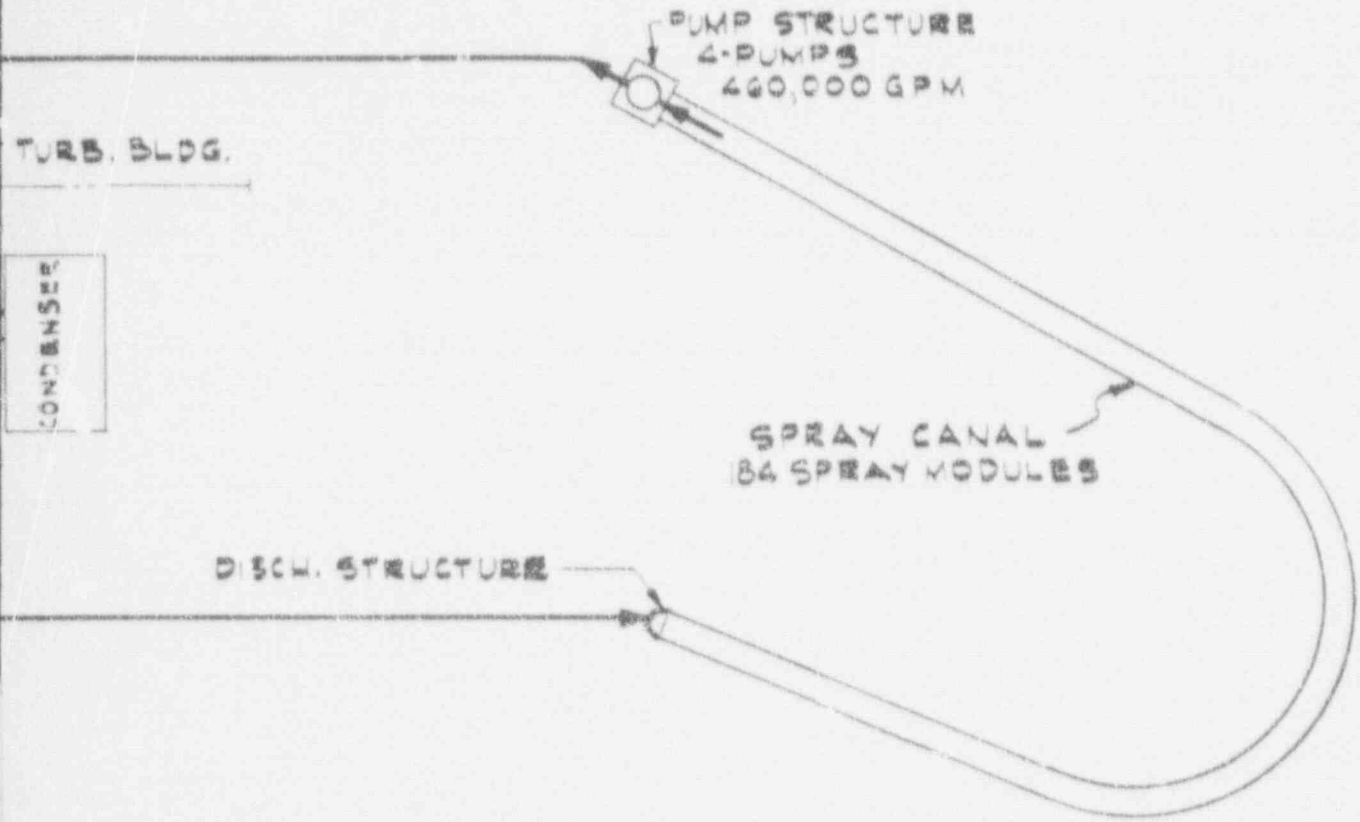

N
INTAKE CANAL
EXIST INTAKE
EXIST. DILUTION INTAKE
0-780,000 GPM
FOR BLOWDOWN &
RADWASTE DILUTION
INTAKE TUNNEL
MAKE-UP
25,000 GPM
DISCH TUNNEL
BLOWDOWN
DISCHARGE CANAL
INCHES
CM.

EXHIBIT 58



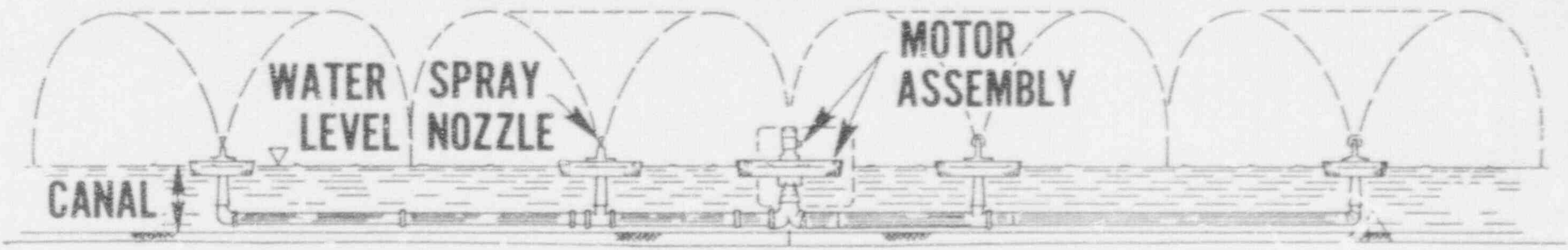
SI
APERTURE
CARD

Also Available On
Aperture Card

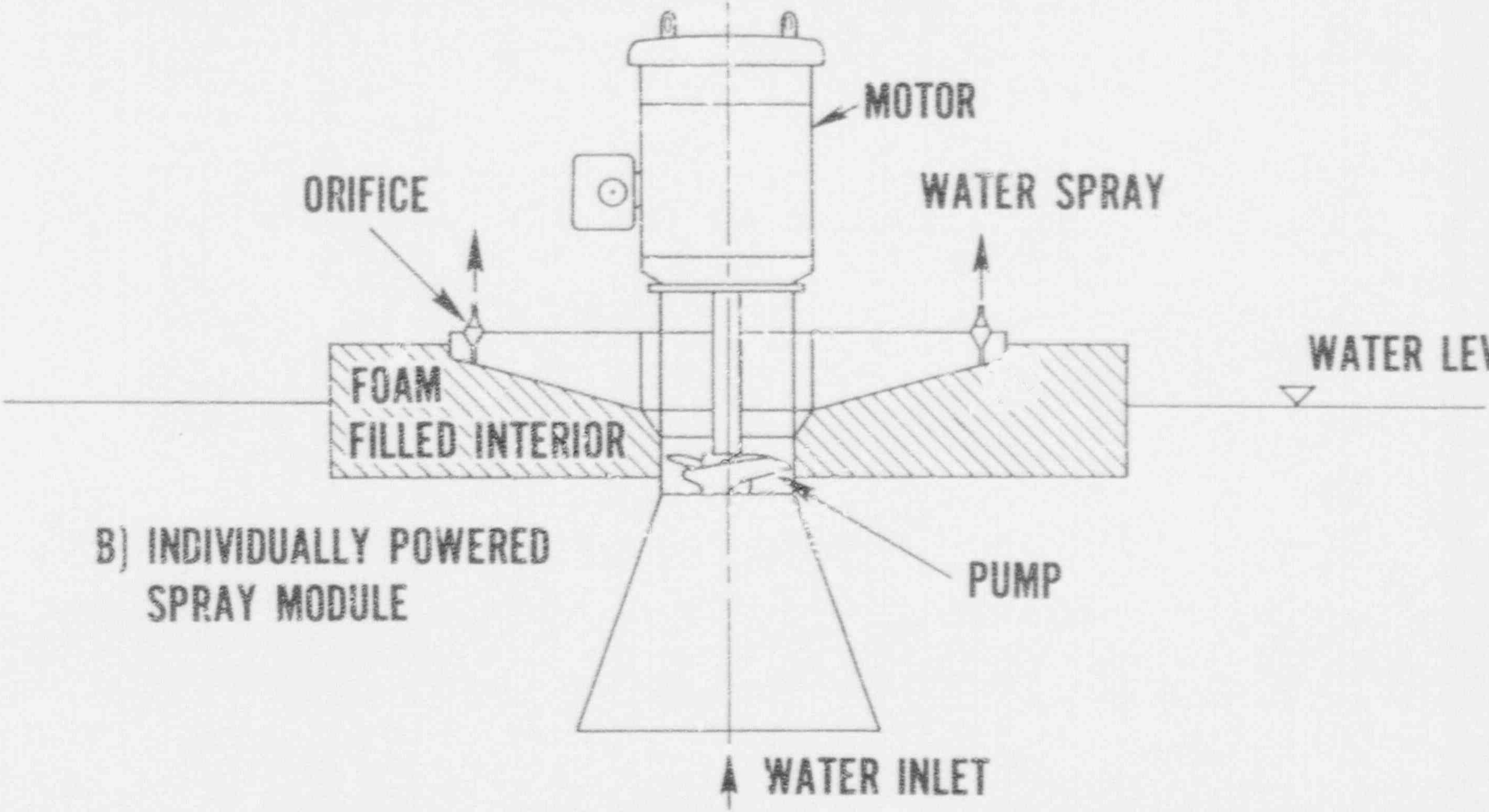
EBASCO SERVICES INCORPORATED		JERSEY CENTRAL POWER & LIGHT OYSTER CREEK NUCLEAR GEN. STATION	JCP-7037
DIV. CIVIL / DR. GA SCALE NTS / CH. DATE FEB 1977	APPROVED	ALTERNATIVE COOLING WATER SYS. STUDY SPRAY CANAL	EXHIBIT 58

9111110048 - 32

POWERED SPRAY MODULES

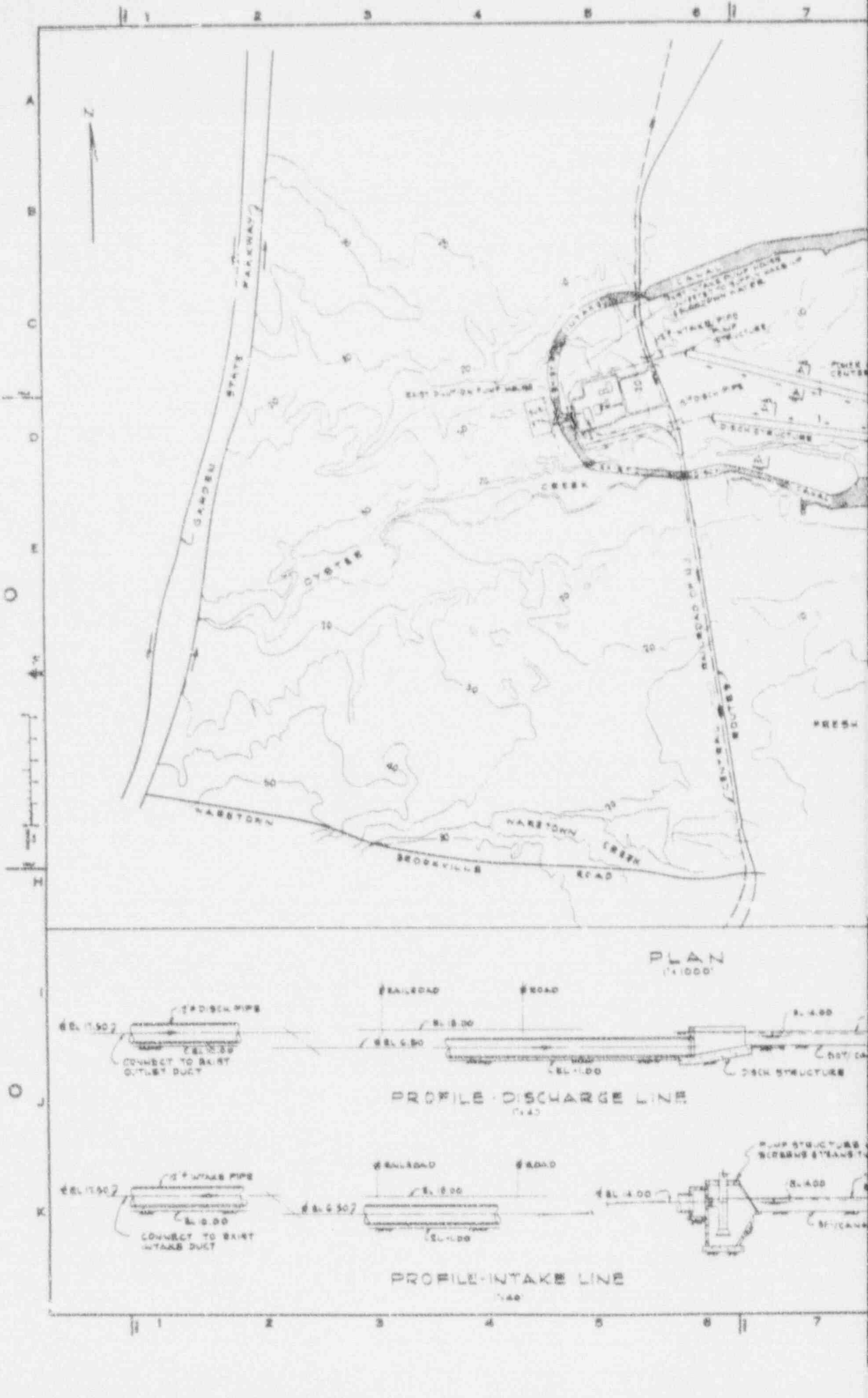


A) PUMP - GROUP SPRAY HEADS MODULE ASSEMBLY

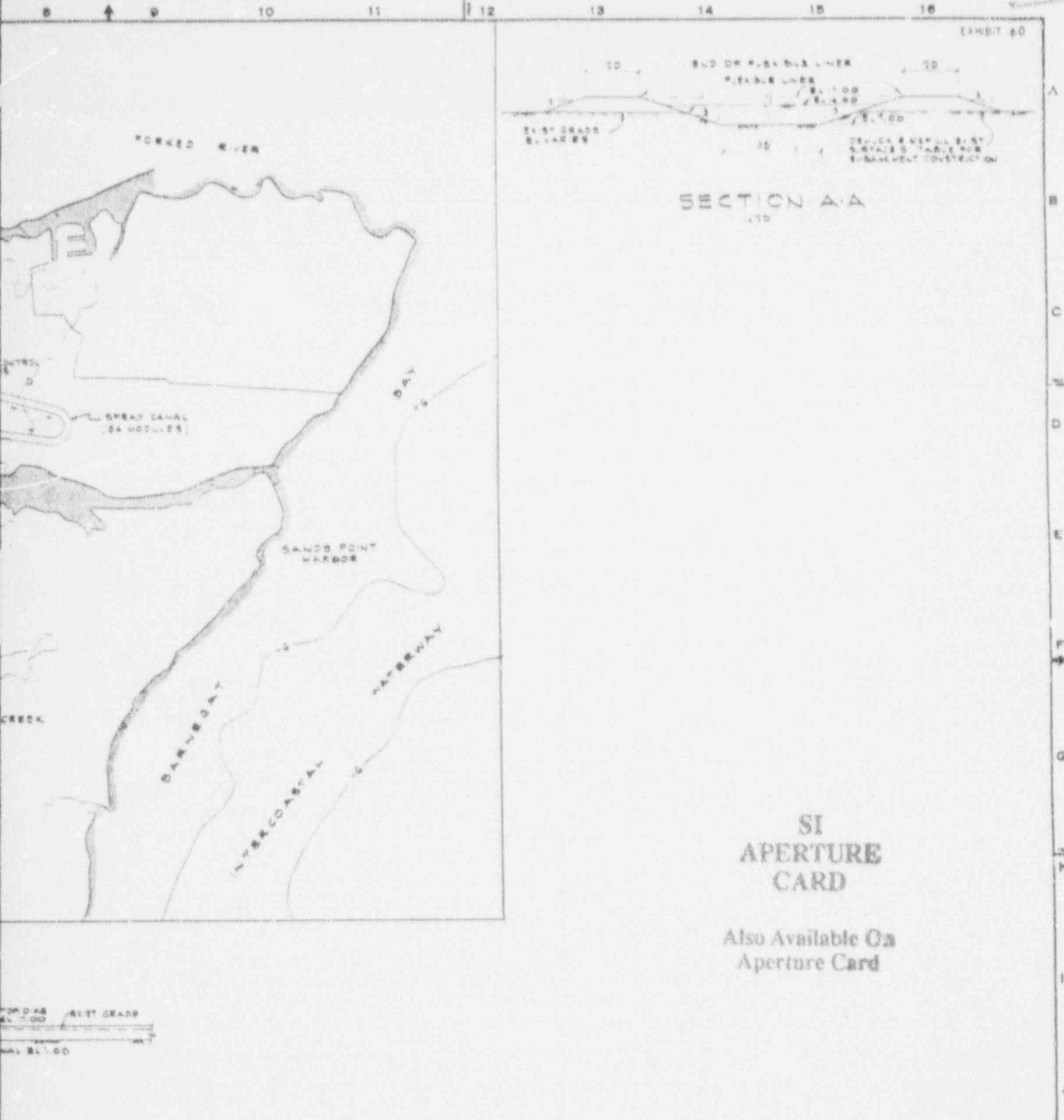


B) INDIVIDUALLY POWERED SPRAY MODULE

Exhibit 59



GARDEN STATE PARKWAY
CANAL
OYSTER CREEK
WARETOWN
WARETOWN CREEK
BROOKVILLE ROAD
CENTRAL RAILROAD OF N.J.
FRESH
DISCH. STRUCTURE
PLAN
PROFILE - DISCHARGE LINE
CONNECT TO EXIST OUTLET DUCT
DISCH. STRUCTURE
PROFILE - INTAKE LINE
CONNECT TO EXIST INTAKE DUCT



JERSEY CENTRAL POWER & LIGHT CO.
OYSTER CREEK NUCLEAR GENERATING STATION

ALTERNATIVE COOLING WATER SYSTEM STUDY
SPRAY CANAL

EBASCO SERVICES INCORPORATED

SCALE AS NOTED	APPROVED	FEB 1977
		JCP-7037
		EXHIBIT 60

NO	DATE	REVISION	BY	CK	APPROVED

SI
APERTURE
CARD

Also Available On
Aperture Card

9111110048 - 33

SPRAY COOLING MODULE SYSTEMS

Utility	Location	No. of Modules	Twb F	Approach F	Range F	Flow, gpm	Mode of Operation
Commonwealth Edison	Cordova, Ill Quad Cities	152*					Closed Cycle
Commonwealth Edison	Morris, Ill 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 New Hampshire	Merimack Sta, Bow, N H	56**	62	20.0	18.0	200 000	Helper System
Virginia Electric & Power Co	Chesterfield Sta, Chester, Va	40**	77.1	26.2	8.5	489 000	Helper System
Mississippi Power Co	Jack Watson Sta Gulfport, Miss	57**					Helper System
Commonwealth Edison	Cordova, Ill 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

Exhibit 61

JCP&L OYSTER CREEK NGS
ALTERNATIVE COOLING WATER SYSTEM STUDY
ONCE THROUGH, COOLING POND & SPRAY MODULE COOLING SYSTEMS

TECHNICAL SUMMARY

Cooling System Type	Existing System	Ocean Intake & Discharge: Single Pressure Condenser	Ocean Intake & Discharge: Multipressure Condenser	Discharge Canal to Bay	Discharge Pipes to Bay	1000 Acre Pond	500 Acre Pond	Spray Modules
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.

Exhibit 82
Sheet 1 of 2

JCP&L OYSTER CREEK NGS
ALTERNATIVE COOLING WATER SYSTEM STUDY
COOLING TOWER SYSTEM DESIGN PARAMETERS
TECHNICAL SUMMARY

	Natural Draft Cooling Tower	Fan Assisted Cooling Tower	Mechanical Draft Cooling Towers						
			Evaporative (Wet)		Wet/Dry		Helper Towers		Dry
			Round	Rectangular	Fresh Water	Salt Water			
Approach to T_{wb} = 74 F, 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, 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, ft x ft	-	-	-	70 x 540	70 x 512	64 x 432	70 x 540	64 x 432	340 x 1500
Cooling Tower Height, ft	540	390	69	55	60	60	55	60	126
No. of Fans per Cooling 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	790	122	446

Incremental Capability Charge Calculation

Year	Single Payment Present Worth Factor at R = 11.22%	Installed Capacity Charge $/MW-Day	Installed Capacity Present Worth $/MW-Day	Operating Capacity Charge $/MW-Period	Operating Capacity Charge $/MW-Period
1984	0.8991	104.0	93.5	23×1.07^8 = 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	0.1072	402.4	43.1	152.9	16.4
	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, Cloud Growth and Precipitation Augmentation
	Impact	Comment	Impact	Comment	Impact	Comment	Impact
Cooling Towers							
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/km² 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
Saltwater							
Wet/dry	Low	-	Low (1)	-	Moderate (3)	-	Moderate
Dry	Low	-	Low	-	Low	-	High
Cooling Pond	Low	-	Moderate	Fogging may extend ½ mile	Low	-	Low
Spray Canal		-	Moderate	Fogging may extend ½ mile	High	Drift may extend 2,000 ft or more from canal	Low
Canal-to-bay	Low	-	Low (2)	-	Low	-	Low (2)
Once-through-ocean	Low	-	Low	-	Low	-	Low
Helper Cooling Towers							
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 Summer	Average Winter	Average Spring
Round Mechanical Draft Towers			
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 (^{o} F) between Blowdown Flow and Receiving Water Temperature*	7.0	30.8	16.7
Draft Towers			
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 (^{o} F) between Blowdown Flow and Receiving Water Temperature*	7.9	31.8	17.8
Natural Draft Tower			
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)*	166.2	622.6	345.7
Temperature Differential (^{o} F) between Blowdown Flow and Receiving Water Temperature*	8.5	29.2	17.0
Floating Spray Modules			
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 (^{o} F) between Blowdown Flow and Receiving Water Temperature*	8.1	27.2	15.1

Exhibit 63 (Cont'd)

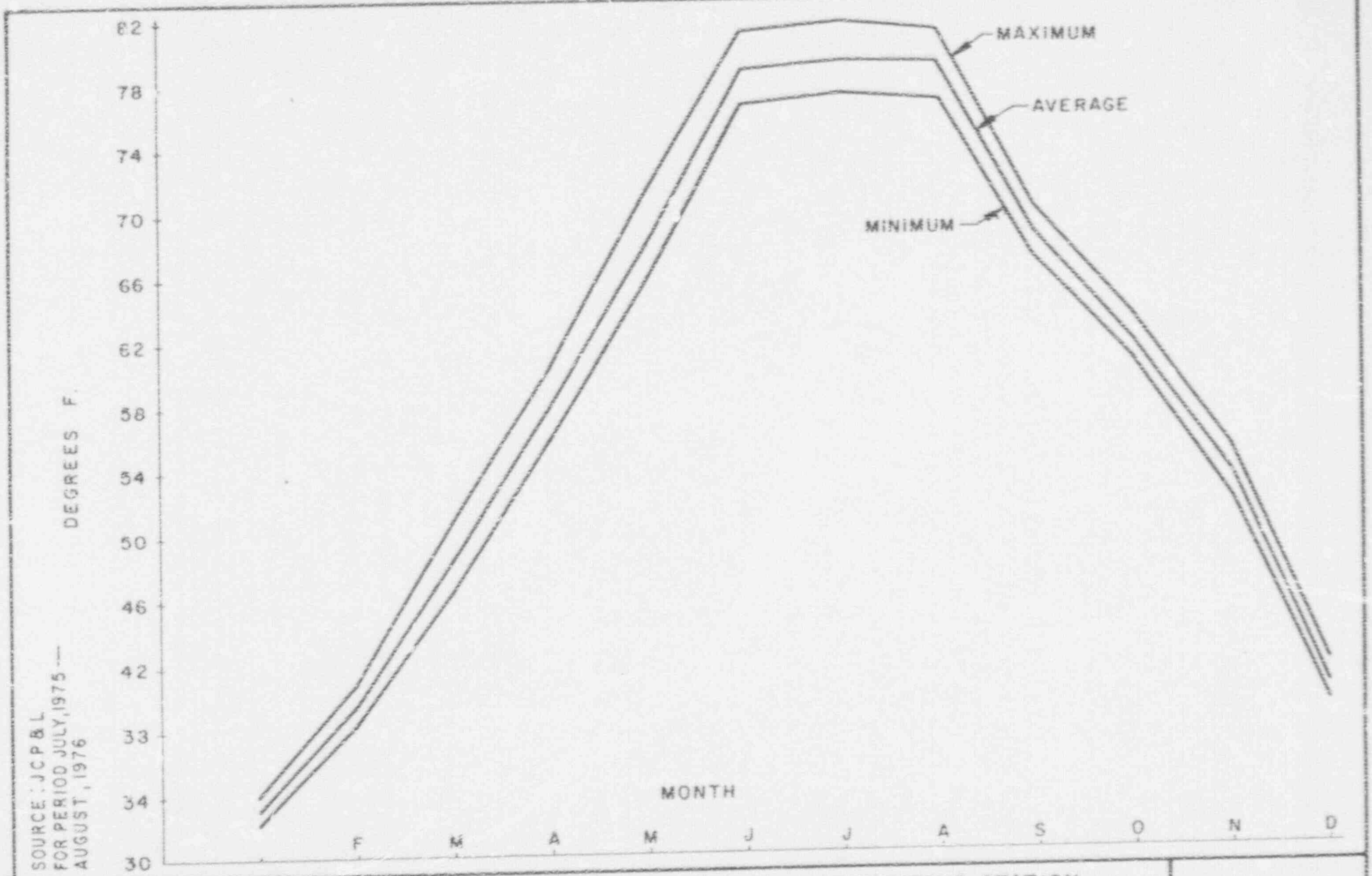
SUMMARY OF CLOSED-CYCLE COOLING SYSTEM

OPERATING CHARACTERISTICS

	Average Summer	Average Winter	Average Spring
Salt Water Wet/Dry Mechanical Draft Towers			
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 (° F) between Blowdown Flow and Receiving Water Temperature*	8.7	31.8	19.5
500-Acre Cooling Pond			
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 (° F) between Blowdown Flow and Receiving Water Temperature*	12.6	31.5	8.7
1,000-Acre Cooling Pond			
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 (° F) between Blowdown Flow and Receiving Water Temperature*	7.0	22.2	13.7
Fresh Water Wet/Dry Mechanical Draft Towers			
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 (° F) between Blowdown Flow and 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	1	2
Average Summer Temperature Rise (° F)	1.02	0.55
Average Summer Flow Rate (gpm)	298,960.	558,960.
Average Winter Temperature Rise (° F)	4.50	2.42
Average Winter Flow Rate (gpm)	302,860.	562,860.
Average Spring Temperature Rise (° F)	2.42	1.30
Average Spring Flow Rate (gpm)	300,990.	560,990.

Round Mechanical Draft Towers

No. Dilution Pumps Operating	1	2
Average Summer Temperature Rise (° F)	0.91	0.49
Average Summer Flow Rate (gpm)	298,960.	558,960.
Average Winter Temperature Rise (° F)	4.36	2.35
Average Winter Flow Rate (gpm)	302,860.	562,860.
Average Spring Temperature Rise (° 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	1	2
Average Summer Temperature Rise (° F)	1.10	0.59
Average Summer Flow Rate (gpm)	298,750.	558,750.
Average Winter Temperature Rise (° F)	4.12	2.21
Average Winter Flow Rate (gpm)	302,650.	562,650.
Average Spring Temperature Rise (° 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	1	2
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	1	2
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 ($^\circ$ F)	1.66	0.89
Average Summer Flow Rate (gpm)	299,510.	599,510.
Average Winter Temperature Rise ($^\circ$ F)	4.65	2.51
Average Winter Flow Rate (gpm)	304,958.	564,958.
Average Spring Temperature Rise ($^\circ$ F)	2.84	1.53
Average Spring Flow Rate (gpm)	302,114.	562,114.

1000 Acre Pond - 20° Rise

No. Dilution Pumps Operating		
Average Summer Temperature Rise ($^\circ$ F)	.97	.52
Average Summer Flow Rate (gpm)	302,059.	562,059.
Average Winter Temperature Rise ($^\circ$ F)	3.55	1.93
Average Winter Flow Rate (gpm)	309,626.	569,626.
Average Spring Temperature Rise ($^\circ$ 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

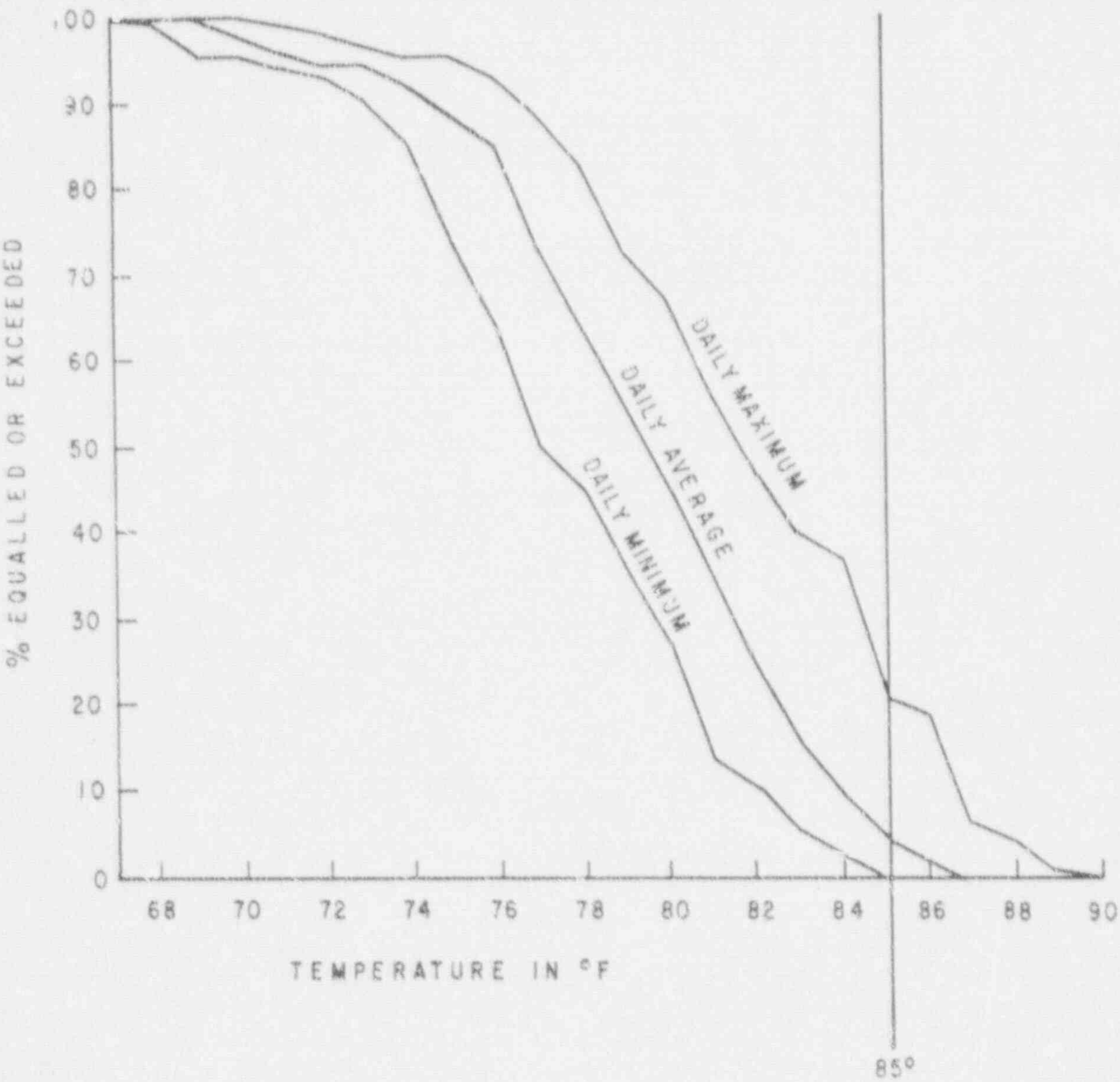
DISCHARGE FLOW RATES AND
TEMPERATURE RISE ABOVE AMBIENT

CLOSED-CYCLE SPRAY CANAL ALTERNATIVE

184 Floating Spray Modules

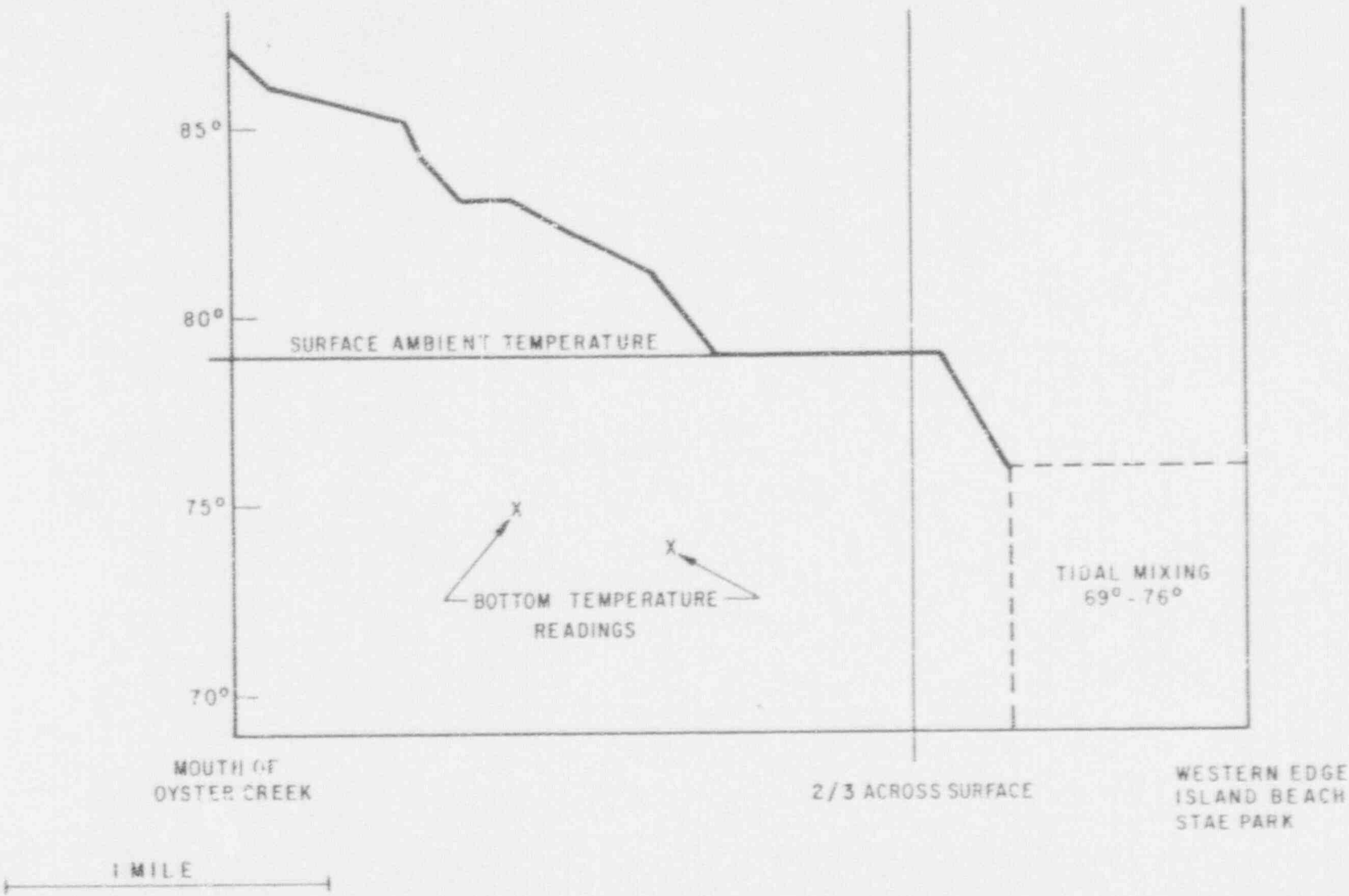
No. Dilution Pumps Operating	1	2
Average Summer Temperature Rise (° F)	1.08	0.58
Average Summer Flow Rate (gpm)	299,635.	559,635.
Average Winter Temperature Rise (° F)	3.92	2.11
Average Winter Flow Rate (gpm)	303,848.	563,848.
Average Spring Temperature Rise (° F)	2.10	1.13
Average Spring Flow Rate (gpm)	301,993.	561,993.

*Includes estimated Oyster Creek blowdown dischsrge plus Forked River blowdown discharge.

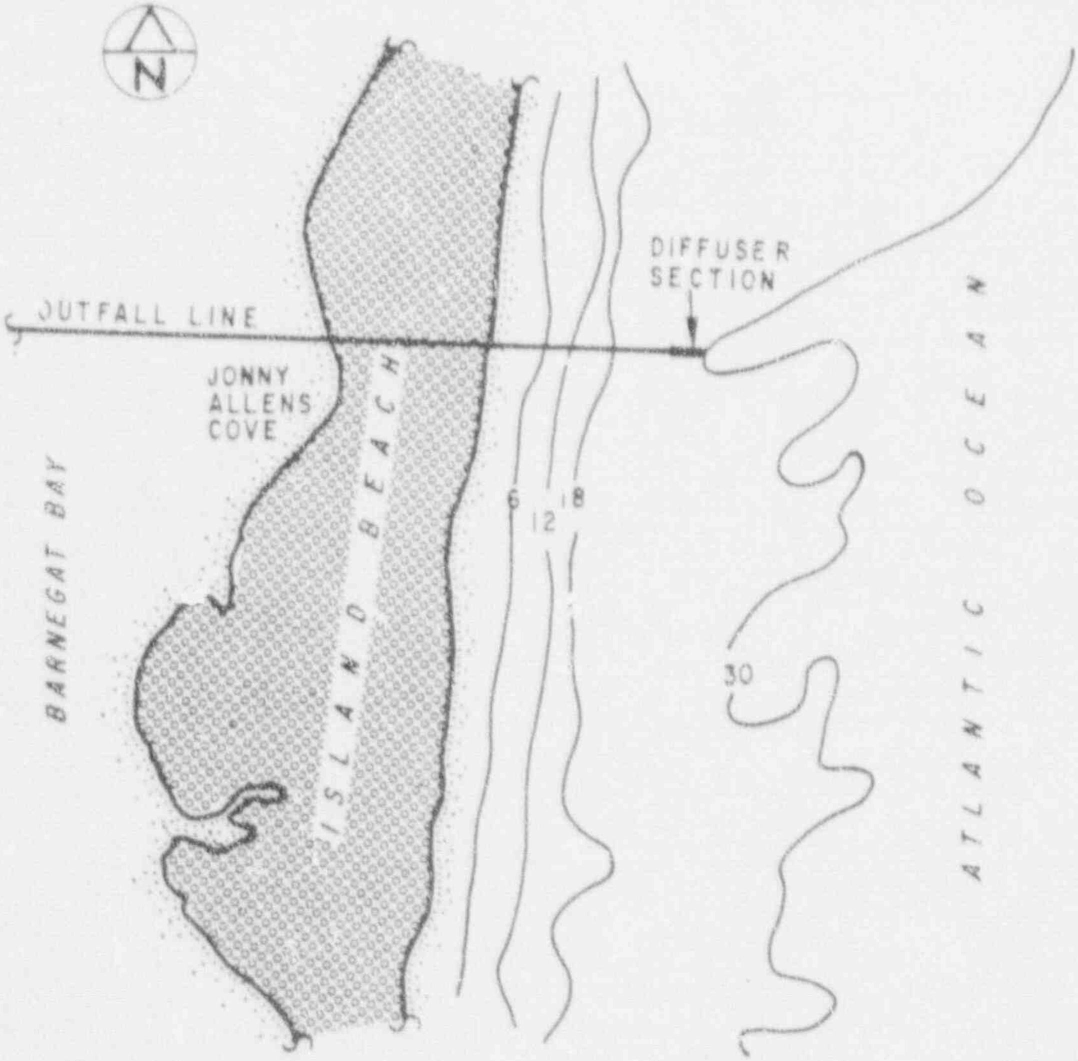


PERIOD OF RECORD:
JULY & AUGUST 1975
JUNE, JULY & AUGUST 1976
SOURCE: JCP & L

JERSEY CENTRAL POWER AND LIGHT COMPANY EBASCO SERVICES INCORPORATED New York	OYSTER CREEK SUMMER INTAKE WATER TEMPERATURE FREQUENCIES	EXHIBIT 70



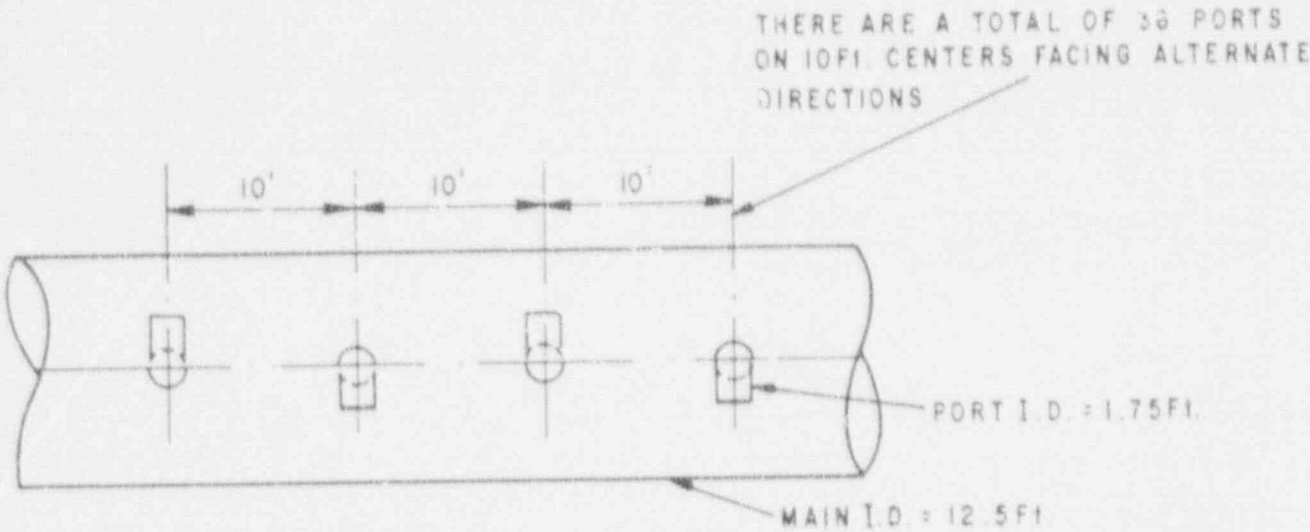
JERSEY CENTRAL POWER & LIGHT COMPANY EBASCO SERVICES INCORPORATED New York	THERMAL PLUME PROFILE AUGUST 6, 1974 FULL LOAD EBB TIDE	EXHIBIT 71



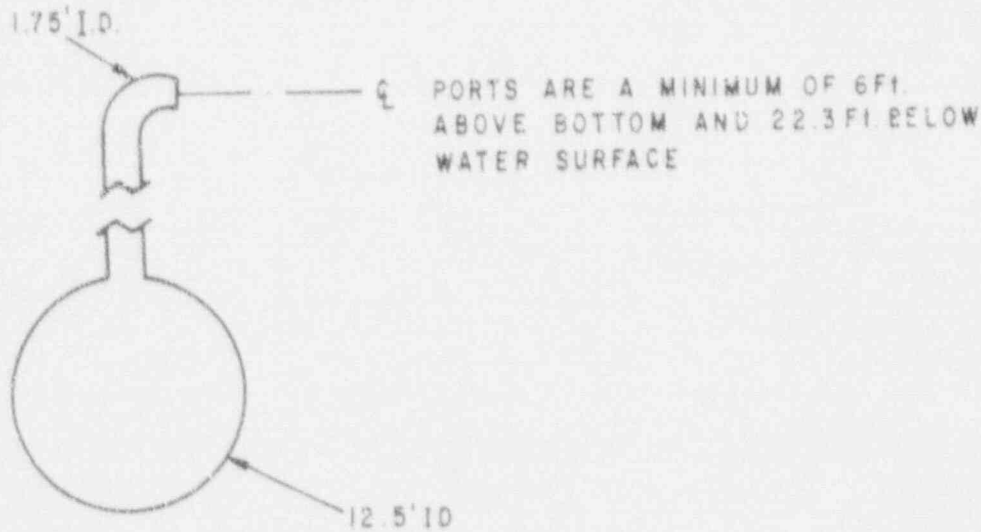
SCALE: 1" = 2000'

NOTE: DIFFUSER SECTION IS 350Ft. LONG FROM CENTER LINE OF FIRST PORT TO CENTER LINE OF LAST PORT

JERSEY CENTRAL POWER AND LIGHT COMPANY EBASCO SERVICES INCORPORATED New York	LOCATION OF DIFFUSER FOR SINGLE PRESSURE CONDENSER	EXHIBIT 72

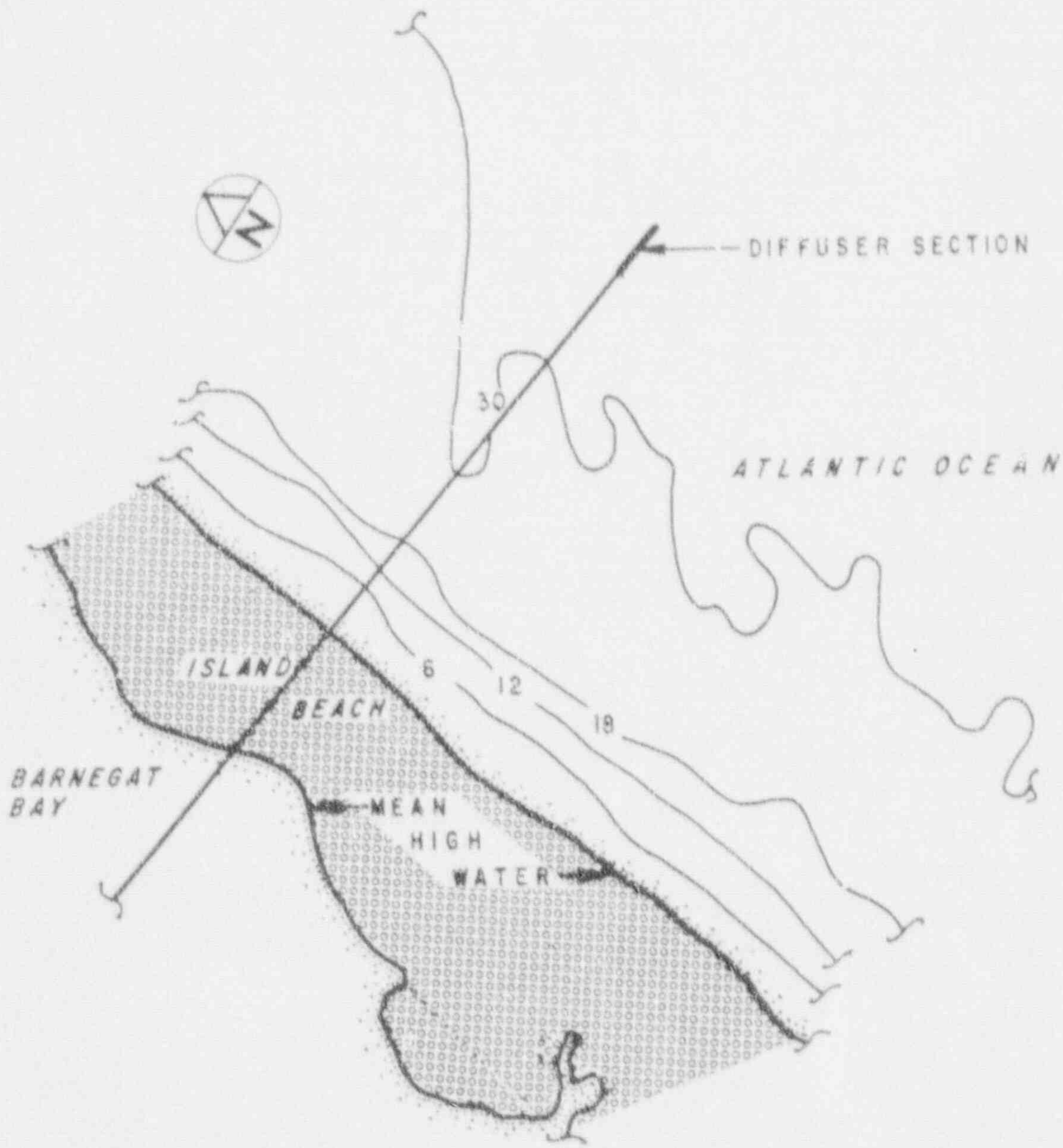


PLAN VIEW



TYPICAL SECTION

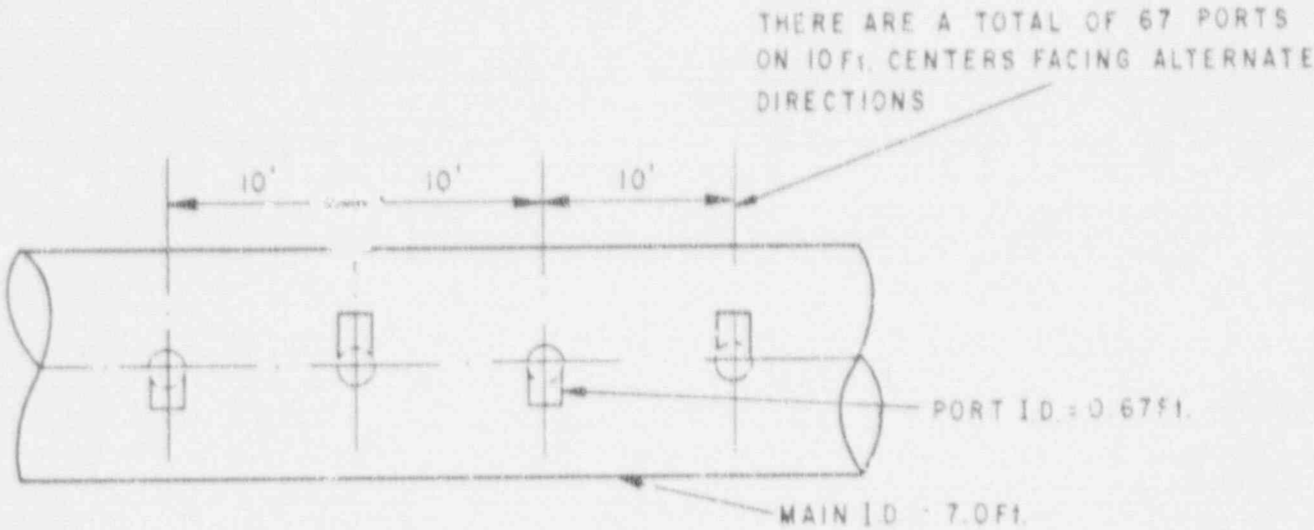
JERSEY CENTRAL POWER AND LIGHT COMPANY EBASCO SERVICES INCORPORATED New York	PLAN AND SECTION OF DIFFUSER FOR SINGLE PRESSURE CONDENSER	EXHIBIT 73



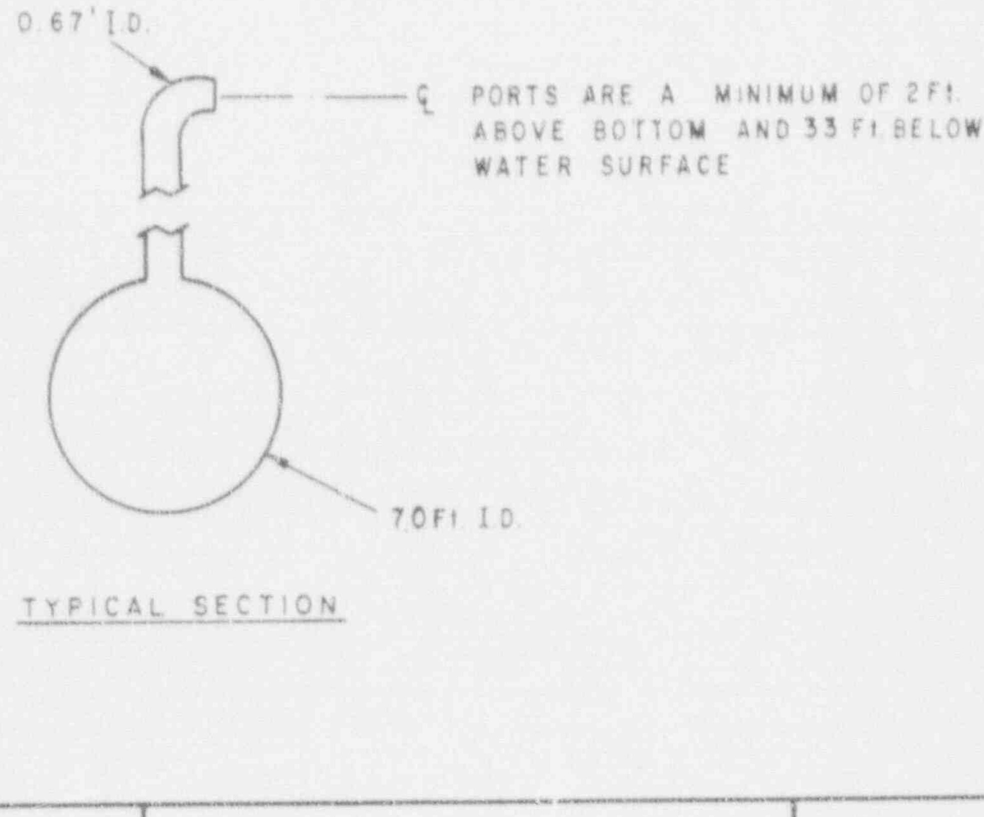
SCALE: 1" = 2000'

NOTE: DIFFUSER SECTION IS 660 Ft. LONG
FROM CENTER LINE OF FIRST PORT
TO CENTER LINE OF LAST PORT

JERSEY CENTRAL POWER AND LIGHT COMPANY EBASCO SERVICES INCORPORATED New York	LOCATION OF DIFFUSER FOR MULTI-PRESSURE CONDENSER	EXHIBIT 74



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.

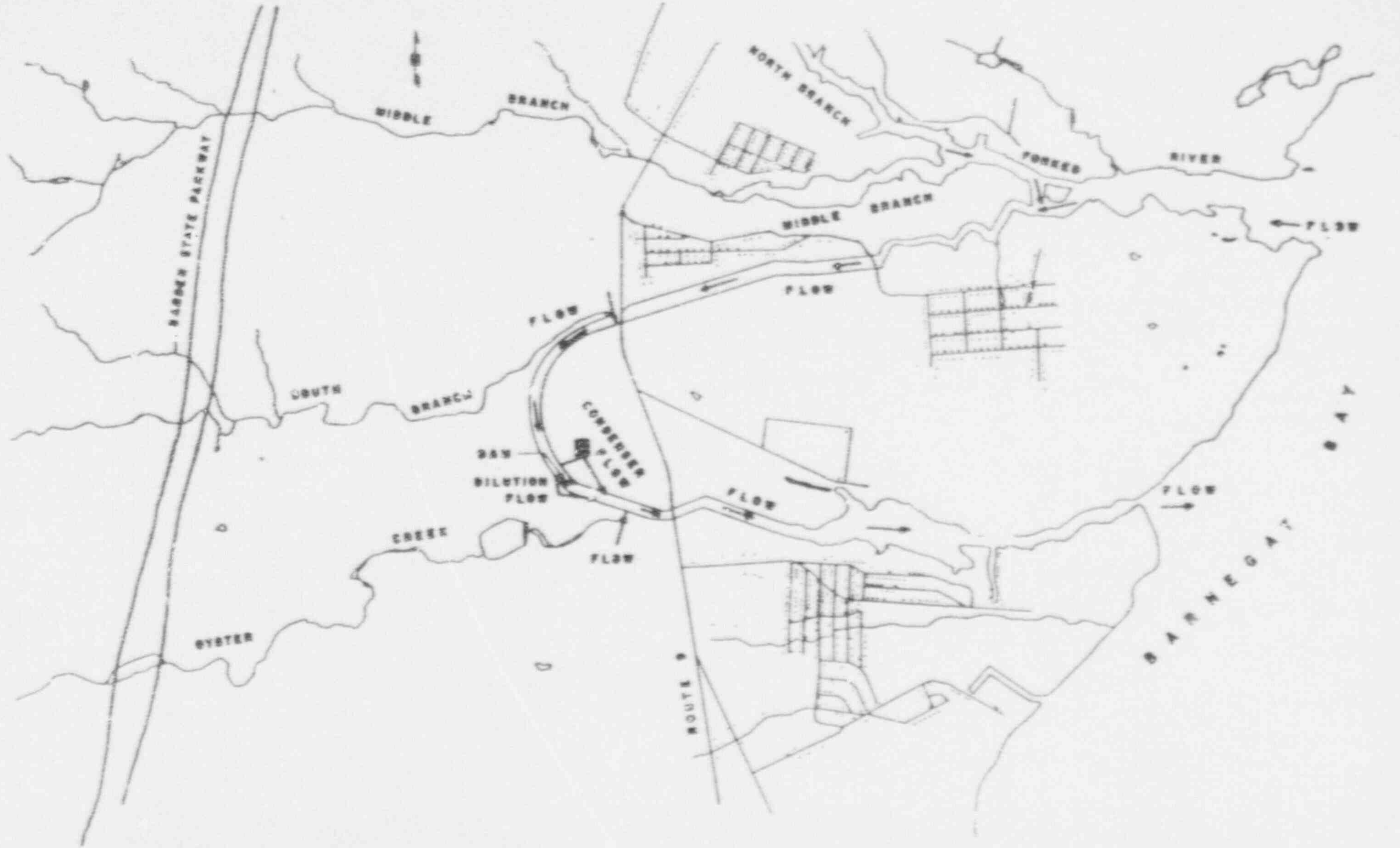
Exhibit 77

HIGH TEMPERATURE HELPER TOWER PERFORMANCE PREDICTIONS

AVERAGE CONDITIONS

	Summer	Winter	Spring	Fall
Wet Bulb Temperature (° 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)	82.5	49.5	64.3	68.0
Temperature Rise Above Ambient Before Dilution (° F)	3.7	12.0	6.3	7.0
Temperature Rise After Dilution with Two Pumps (° F)	1.7	5.6	3.0	3.3
Heat Load (Million Btu/Hour)	858	2784	1461	1624
Heat Load (% of existing 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 AND LIGHT COMPANY EBASCO SERVICES INCORPORATED New York	FLOW CHARACTERISTICS OF SURFACE WATER BODIES IN THE VICINITY OF THE OYSTER CREEK NGS	EXHIBIT 78

Exhibit 79

FLOW CHARACTERISTICS OF SURFACE WATER BODIES IN THE VICINITY OF THE OYSTER CREEK NUCLEAR GENERATING STATION

Surface Water Body	Average Flow (cfs)	Maximum Flow (cfs)	Minimum Flow (cfs)	Average Flow per Sq Mi of Drainage Area (cfs)
Oyster Creek[(1)] (near Brookville)	28.3	232	12	3.8
Forked River[(1)]				
North Branch	13.7	25.9	5.4	1.05
Middle Branch	2.6[(2)]	-	-	1.72
South Branch	3.7	5.4	1.3	2.8
Tom's River[(3)]	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

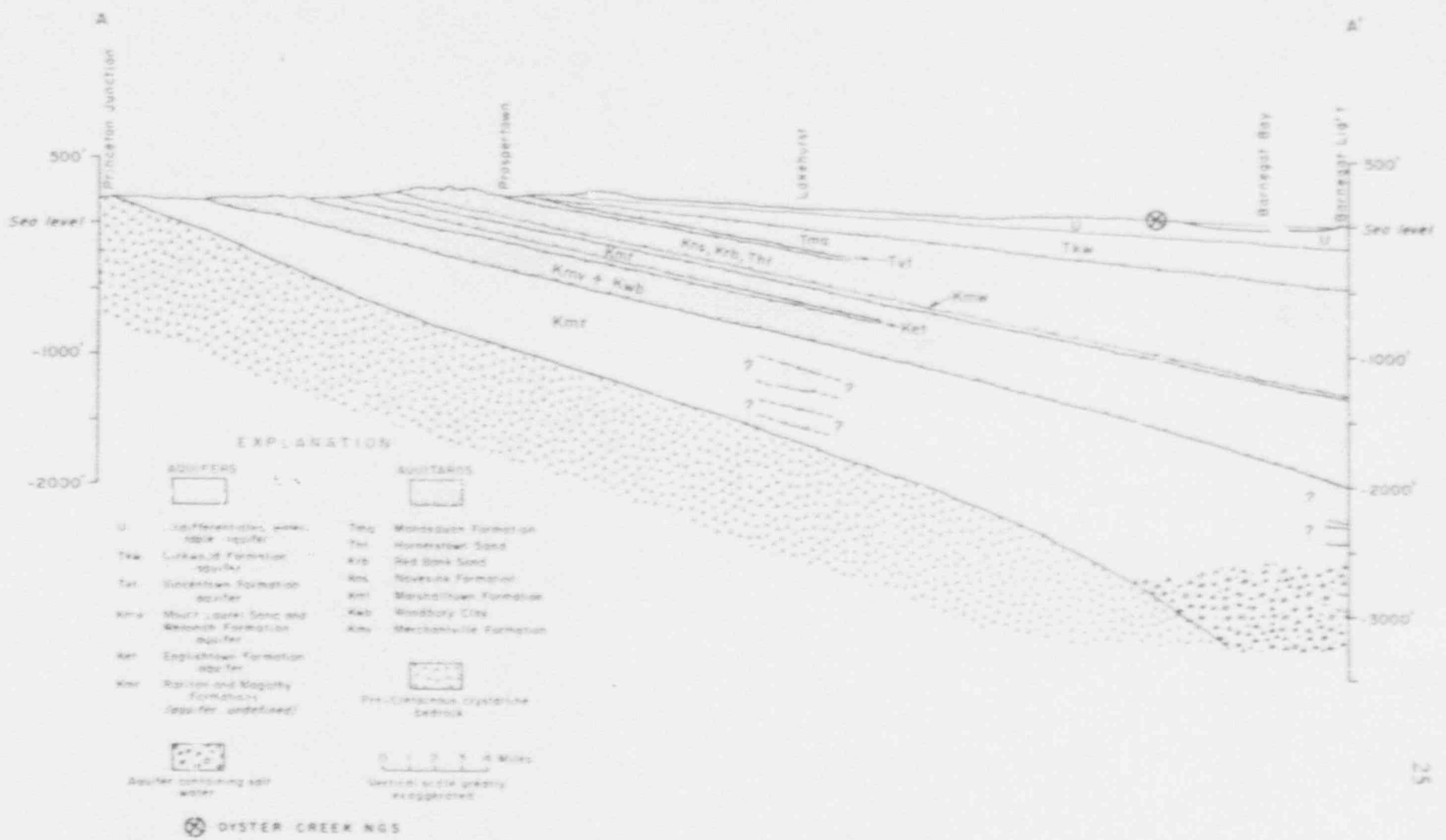
TYPICAL WATER QUALITY ANALYSIS
FOR SURFACE WATER BODIES IN THE VICINITY OF THE OYSTER CREEK NUCLEAR GENERATING STATION[1]

Parameter	Units	Oyster Creek	Forked River[2] North Branch	Forked River South Branch	Tom's River
Acidity, total	mg/l-$CaCO_3$	5.0	5.0	5.0	5.0
Alkalinity, total	mg/l-$CaCO_3$	2.8	2	2	0
Aluminum	mg/l	0.2	-	0.3	0.4
Bicarbonate	mg/l-$CaCO_3$	2	2	2	0
Calcium	mg/l	2.5	12	12	2.8
Carbon Dioxide	mg/l	8	-	-	-
Carbonate	mg/l-$CaCO_3$	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-$CaCO_3$	5	-	4	12
Total	mg/l-$CaCO_3$	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_4	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_2)	mg/l	3.5	5	5.2	4.4
Sodium	mg/l	3.2	-	4.8	5.0
Sulfate	mg/l-SO_4	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.

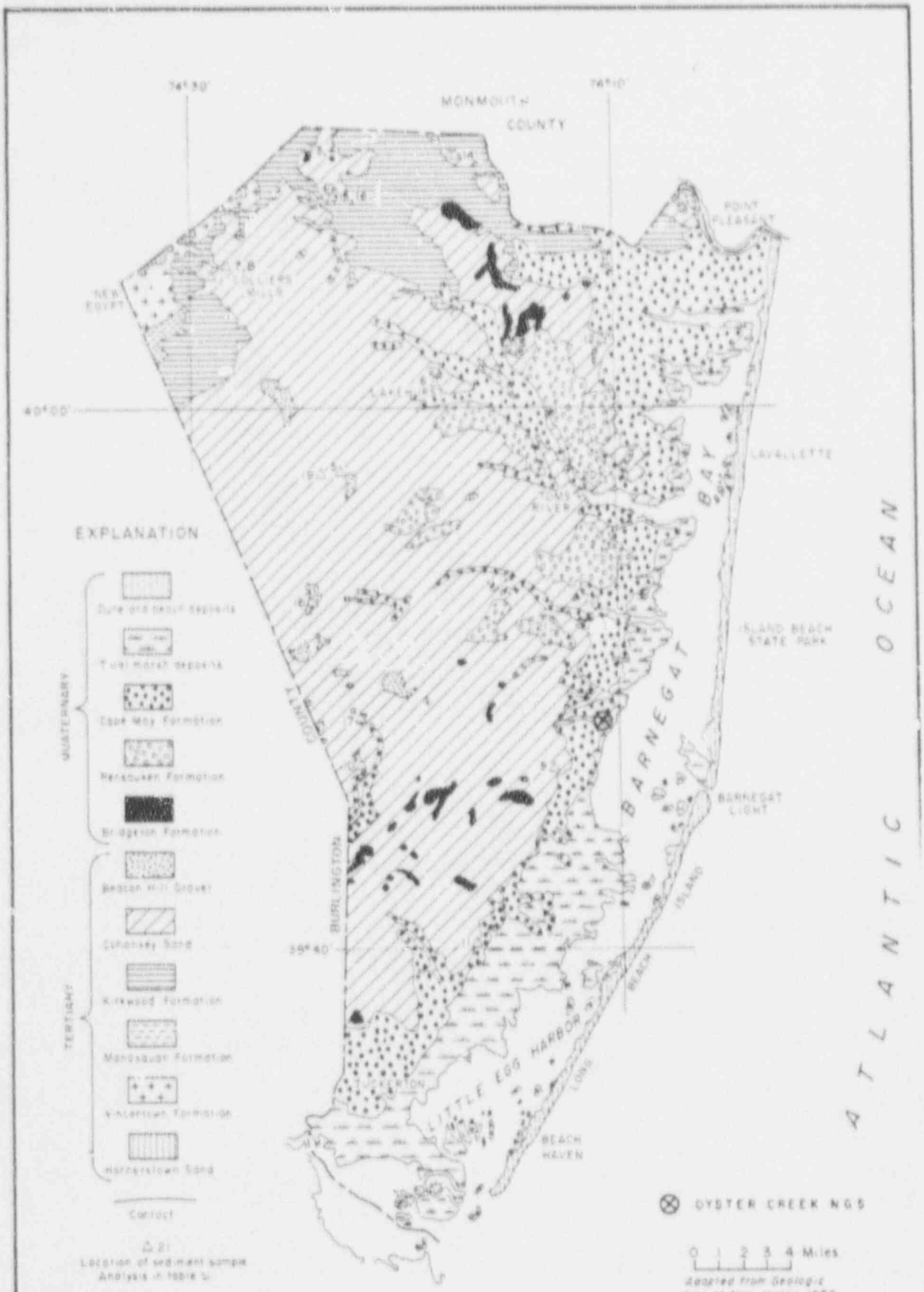
NOTE: REPRODUCED FROM REF. 2, PG. 21

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



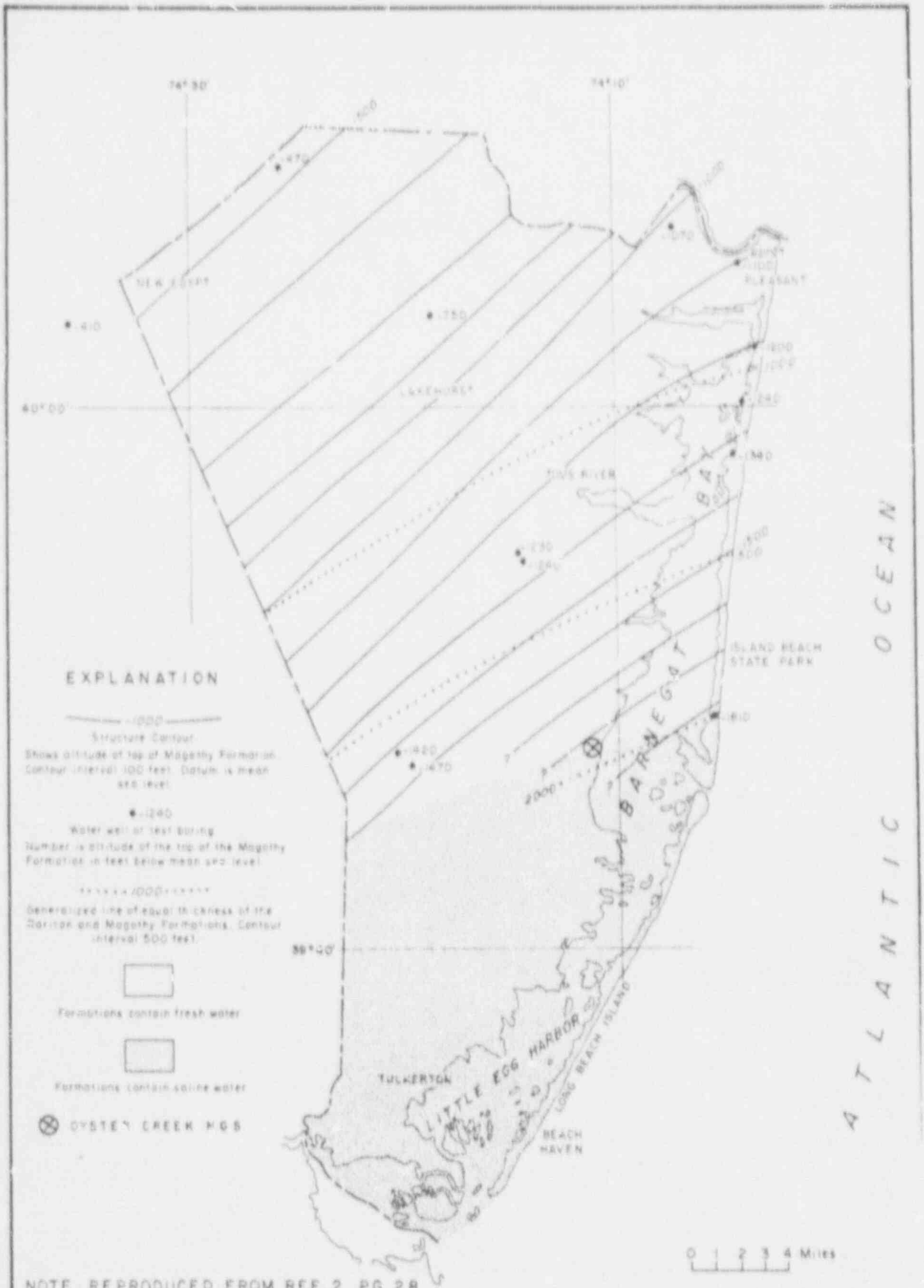
NOTE: REPRODUCED FROM REF. 2 PG. 25

JERSEY CENTRAL POWER AND LIG'" COMPANY EBASCO SERVICES INCORPORATED New York	GEOHYDROLOGIC SECTION, OCEAN COUNTY	EXHIBIT 82

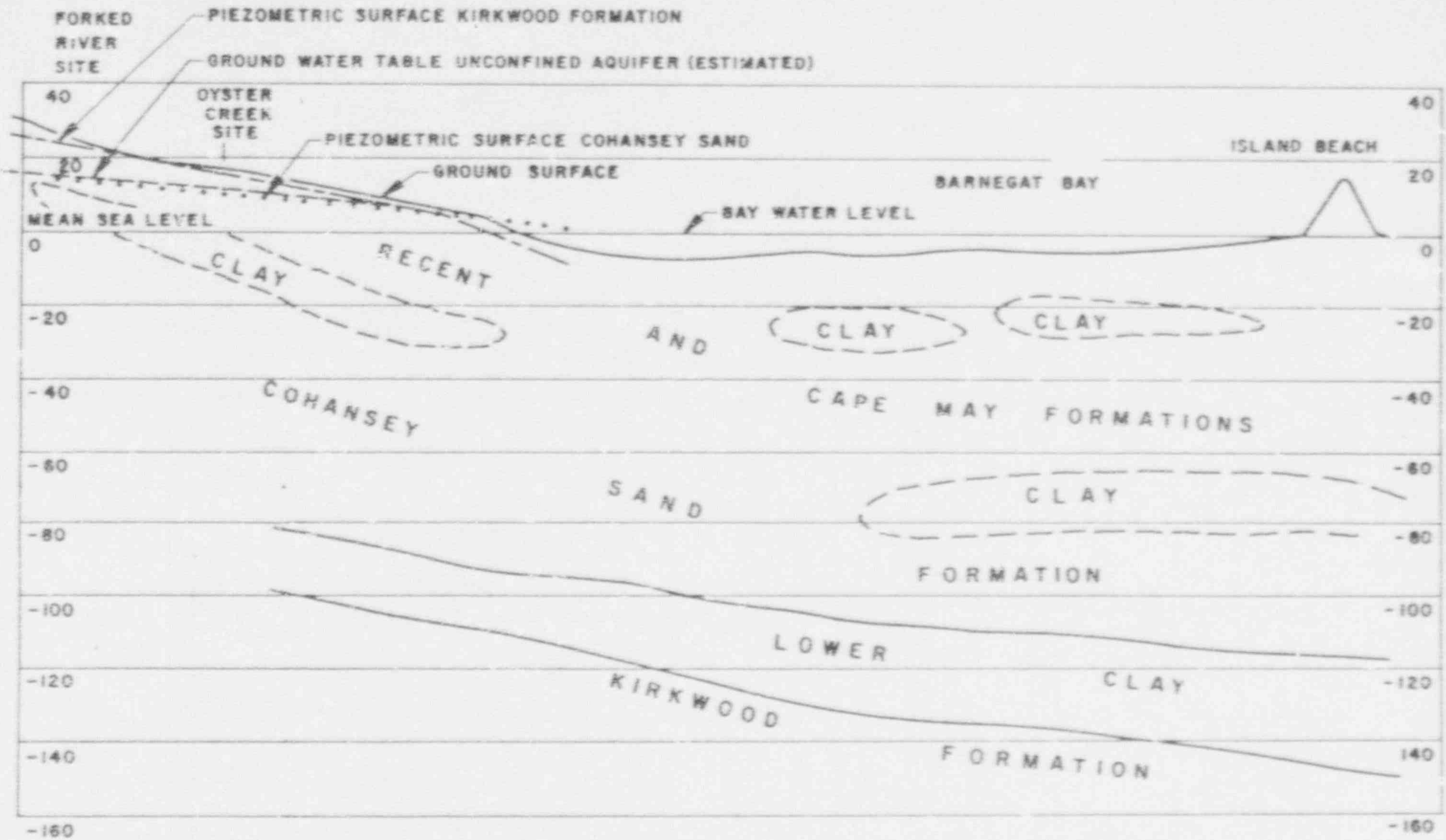


NOTE: REPRODUCED FROM REF. 2 PG. 24

JERSEY CENTRAL POWER AND LIGHT COMPANY EBASCO SERVICES INCORPORATED New York	GEOLOGIC MAP OF OCEAN COUNTY	EXHIBIT 83



JERSEY CENTRAL POWER AND LIGHT COMPANY 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	GEOHYDROLOGIC CROSS-SECTION AT OYSTER CREEK	EXHIBIT 85
EBASCO SERVICES INCORPORATED New York		

Exhibit 86

PHYSICAL PROPERTIES OF AQUIFERS NEAR OYSTER CREEK[(1)]

Aquifer	Average Thickness (feet)	Yield of Wells (gpm)	Permeability (gpd/ft^2)	Trans-missibility (gpd/ft)	Storage Coefficient
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	1×10^{-3}
Cohansey Sand	60	400 to 1200	100 to 2000	20000 to 70000	1×10^{-3}
Kirkwood Formation Upper Sand	50	300	100 to 1000	10000 to 40000	1×10^{-4}
Kirkwood Formation Lower Sand	90	500 to 1200	200 to 1200	20000 to 70000	1×10^{-4}

(1) 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]

Aquifer	Approximate Depth Range	Elevation (MSL) of Piezometric Surface
Upper confined	10 to 30 ±	+ 8 feet at Oyster Creek
Cohansey Sand	10 to 90 ±	+ 14 feet at Forked River Site + 10 feet at Oyster Creek Site + 4 feet at Barnegat Bay
Kirkwood Formation	90 to 300 ±	

[1] From Oyster Creek NGS Environmental Report, pg 2.5-13

Exhibit 88

CHEMICAL COMPOSITICN OF WATER IN THE MAJOR AQUIFERS IN THE OYSTER CREEK AREA[1]

Aquifer	Temperature (°F)	Iron (fe)	Calcium (Ca)	Magnesium (Mg)	Chloride (Cl)	Silica (SiO_2)	Total Dissolved Solids	pH
Unconfined, Recent Cape May Formation[3]	56 to 59	.2 to 10	12 to 300[2]	12 to 300[2]	15 to 44	-	-	6.1 to 8.4
Confined, Lower Cape May 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 Formation (Upper and Lower 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[5]	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/1.

Exhibit 89

OYSTER CREEK WELL WATER ANALYSIS[1]
(Kirkwood Formation)

Constituent	Parts per Million
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[2]
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 ($CaCO_3$)	26.6 (Ca, Mg & Fe)
Phenol Phthalein Alkalinity ($CaCO_3$)	0.0
Methyl Orange Alkalinity ($CaCO_3$)	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 50

ESTIMATED BARNEGAT BAY AND ATLANTIC OCEAN WATER QUALITY

Parameter	Barnegat Bay Average (mg/l)	Barnegat Bay Maximum (mg/l)	Atlantic Ocean[1] Average (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 $CaCO_3$	82	104	118
pH, units	7.7	8.3	8.3

(1) Based on information presented in References 8 and 9.

Exhibit 91

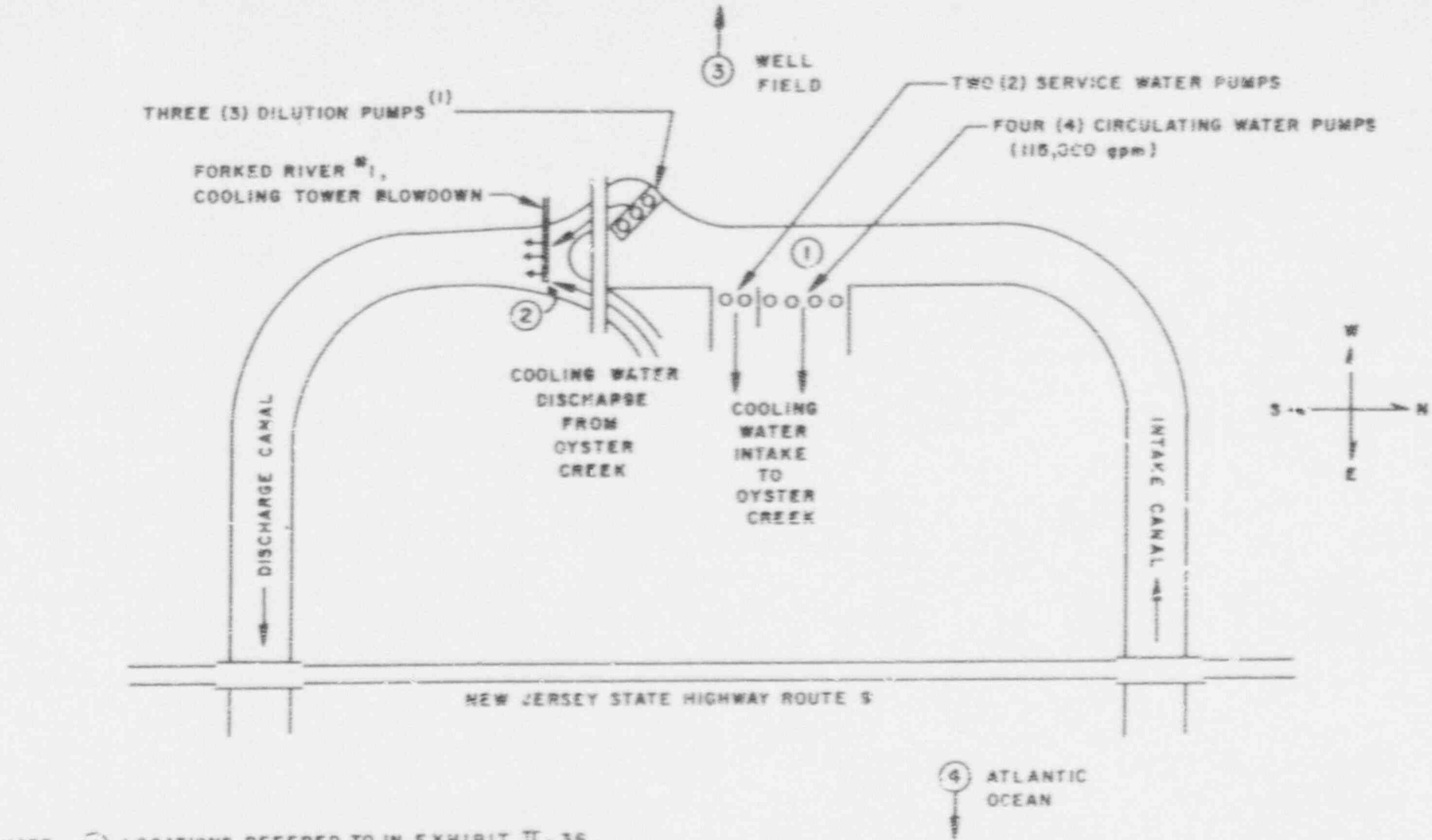
OYSTER CREEK NUCLEAR GENERATING STATION INTAKE WATER ANALYSIS

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 $CaCO_3$	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	SCHEMATIC DIAGRAM OF OYSTER CREEK AND FORKED RIVER NGS INTAKE AND DISCHARGE CANAL	EXHIBIT 92

Exhibit 93

SUMMARY OF CONDENSER COOLING WATER SYSTEM OPERATIONAL PARAMETERS[1]

System	Makeup Flow (gpm)	Blowdown Flow (gpm)	Evaporation Rate (gpm)	Cycle of Concentration	Makeup Location[2]	Discharge Location[2]
Mechanical Draft Cooling Tower	22,410	14,940	7,470	1.5	1	2
Natural Draft Cooling Tower	22,200	14,800	7,[illegible]	1.5	1	2
Cooling Pond 500 Acres	23,268	15,512	7,756	1.5	1	2
Cooling Pond 1000Acres	26,379	17,586	8,793	1.5	1	2
Spray Canal	23,403	15,602	7,801	1.5	1	2
Salt Water Wet/Dry Cooling System	21,000	14,000	7,000	1.5	1	2
Fresh Water Wet/Dry Cooling System	8,700	2,900	5,800	3	3	2
Helper Tower System	462,000	455,300	6,700	Once-Through	1	2
Ocean Once-Through 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] Wet/Dry Tower System
	Average	Maximum	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 $CaCO_3$	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

Parameter(2)	Natural & Mechanical Draft Towers		Cooling Po[nd] 500 Acres	
	Average	Maximum	Average	Maximu[m]
Calcium	299	377	299	377
Magnesium	912	1150	912	1150
Sodium	7119	8976	7119	8976
Potassium	265	334	265	334
Chloride	13,124	16,549	13,124	16,549
Sulphate	1,946	2,370	1,946	2,370
Nitrate	0.0	0.21	0.0	0.21
Phosphate	0.72	0.93	0.72	0.93
Bicarbonate	103	130	103	130
Silica	18.6	24	18.6	24
Iron	0.62	0.79	0.62	0.79
Manganese	0.01	0.013	0.01	0.013
Zinc	0.01	0.013	0.01	0.013
Salinity	23,805	30,015	23,805	30,015
Alkalinity, as $CaCO_3$	85	108	85	108
pH	7.5	8.3	7.5	8.3
Percent Increase above Ambient	3.5		3.5	

(1) Mixing of Oyster Creek NGS Cooling System Blowdown with the B[...]

(2) All water quality concentrations are expressed in mg/l except[...]

(3) Percent increase for most parameters; nutrients (5%) and iro[...]

Exhibit 95

SI APERTURE CARD

Also Available On Aperture Card

Exhibit 95

QUALITY CONCENTRATIONS IN RECEIVING WATER BODY AFTER MIXING

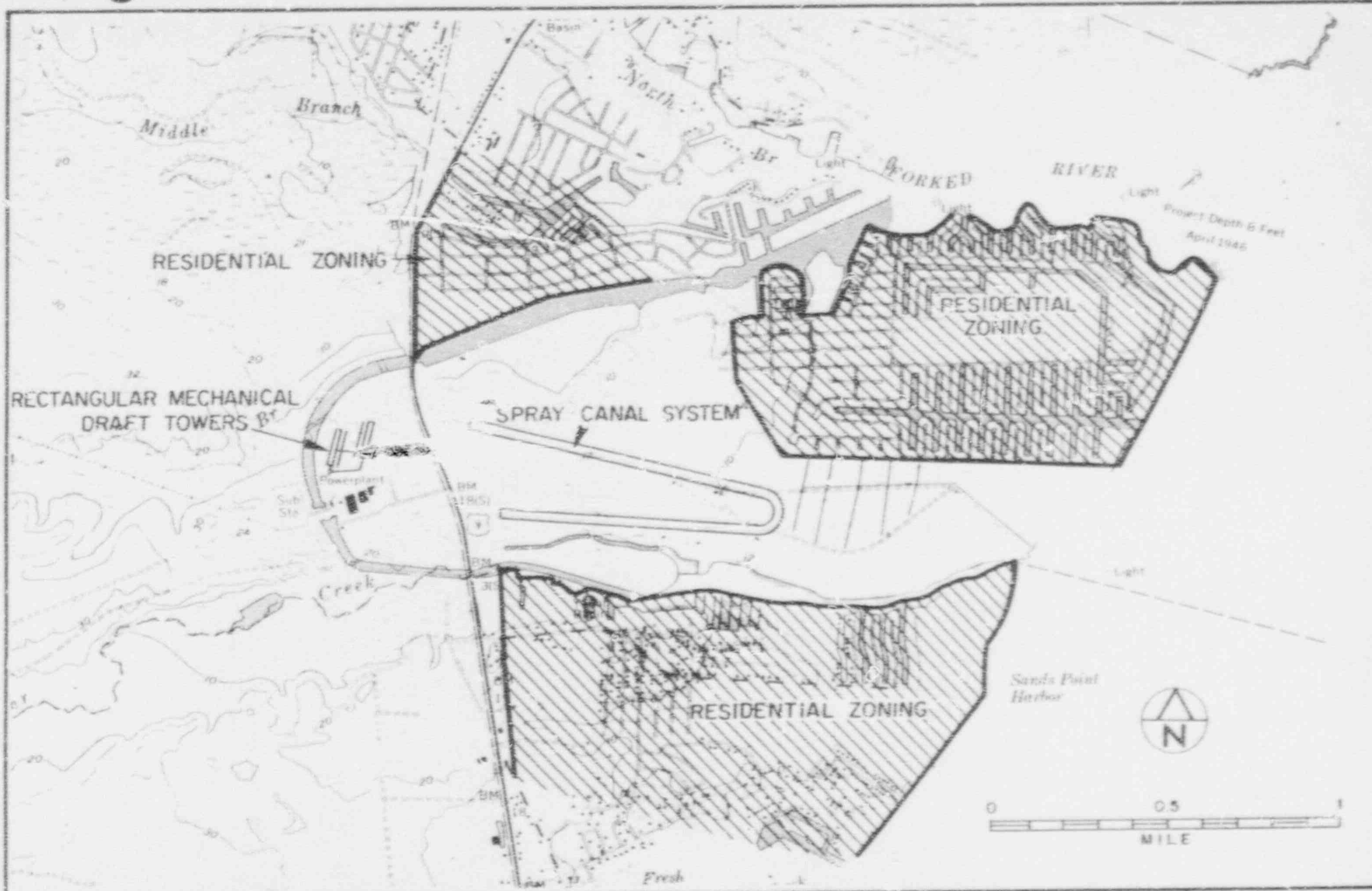
nd	Cooling Pond 1000 Acres		Salt Water Wet/Dry Tower System		Spray Canal		Freshwater Wet/Dry Tower System		Helper Tower System		Ocean Once-Through
	Average	Maximum	Average	Maximum	Average	Maximum	Average	Maximum	Average	Maximum	Average
	300	378	299	376	299	377	294	370	294	370	406
	914	1152	911	1149	912	1150	896	1130	897	1131	1292
	7132	9086	7112	8967	7119	8976	6993	8817	7002	8828	10,714
	265	335	265	334	265	334	-	-	261	329	385
	13,149	16,581	13,111	16,533	13,124	16,549	12,891	16,255	12,908	16,277	19,250
	1,950	2,375	1,878	2,368	1,946	2,370	1,846	2,328	1,849	2,331	2,688
	0.0	0.21	0.0	0.21	0.0	0.21	0.004	0.21	0.0	0.20	-
	0.73	0.93	0.72	0.93	0.72	0.93	0.74	0.95	0.71	0.92	0.12
	104	131	103	130	103	130	102	128	102	128	144
	18.7	24	18.6	24	18.6	24	18.5	23.6	18.3	23	3.2
	0.62	0.79	0.62	0.79	0.62	0.79	0.67	0.83	0.61	0.77	0.002
	0.01	0.013	0.01	0.013	0.01	0.013	0.01	0.013	0.01	0.013	0.005
	0.01	0.013	0.01	0.013	0.01	0.013	-	-	0.01	0.013	0.005
	23,851	30,073	23,782	29,986	23,805	30,015	23,384	29,484	23,414	29,522	35,000
	85	108	85	108	85	108	84	106	84	106	118
	7.5	8.3	7.5	8.3	7.5	8.3	7.5	8.3	7.5	8.3	8.3
	3.7		3.4		3.5		1.7(3)		1.8		0

low from Forked River NGS and Two Dilution Pumps.

pH which is in units.

(11%) exhibit more substantial increases.

9111110048 - 34



JERSEY CENTRAL POWER AND LIGHT COMPANY EBASCO SERVICES INCORPORATED New York	RESIDENTIALLY ZONED PROPERTIES IN THE SITE VICINITY	EXHIBIT 95

Exhibit 97

SUMMARY OF VISUAL/ESTHETIC IMPACTS

Cooling System	Permanent Loss of Vegetative Cover	Profile Impact	Visible Plume	Ground Fog
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 c 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 Atlantic County	Rank in New Jersey		Dollars	Rank in Atlantic 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, 984	9
Winter flounder	28, 710	10	18	White perch	7, 782	10
Butterfish	23, 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, 280	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		525, 621	
King mackerel	34	34	-			
	2, 129, 284					

Exhibit 99

Some major New Jersey Commercial fish landings for 12 months ending December 1971, 1972, 1973[a] (From Ichthyological Associates AGS 1974)

Species	1971 lbs.	1971 Dollars	1971 Rank in N.J. by lbs.	1972 lbs.	1972 Dollars	1972 Rank in N.J. by lbs.	1973 lbs.	1973 Dollars	1973 Rank in N.J. by lbs.
Atlantic menhaden	59,836,182	1,023,017	1	137,475,910	2,262,142	1	154,483,250	3,939,399	1
Silver hake (whiting)	3,948,096	374,689	2	5,439,740	452,744	2	6,449,617	868,295	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	678,981	3	2,970,040	772,910	4
Weakfish (grey sea trout)	3,080,730	254,474	3	3,178,790	332,642	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	6
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	1,116,494	87,990	8
Yellowtail flounder	1,297,064	97,110	7	867,103	89,640	8	1,052,966	122,512	9
Butterfish	1,245,450	103,465	8	492,327	92,735	11	1,029,938	157,503	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	210,877	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	630,925	263,863	14
American eel	103,601	28,065	15	262,214	57,763	15	230,678	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

a 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[a].

Fishes		1974	1973	1972	1971	1970	1969
Pomatomus saltatrix	Atlantic County	-	140				
(blue fish)	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	Atlantic County		432				
(summer flounder)	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	Atlantic County		59				
(red hake)	New Jersey	-	1 116	759	711	-	385
	Mid-Atlantic	1 113	1 454	1 161	997	893	644
Alosa spp	Atlantic County**		1				
(shad)	New Jersey	-	143	263	101	-	-
	Mid-Atlantic	-	308	375	222	314	342
Brevoortia turannus	Atlantic County	-					
(menhaden)	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	Atlantic County		163				
(porgy)	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[a].

Fishes		1974	1973	1972	1971	1970	1969
Cynoscion regalis	Atlantic County		238				
(weakfish)	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	Atlantic County		159				
(striped bass)	New Jersey	-	776	372	283	-	-
	Mid-Atlantic	2 233	3 093	1 457	1 513	1 615	1 888
Invertebrates							
Callinectes sapidus	Atlantic County		127	114			
(blue crab)	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	Atlantic County		4 743	1 403			
(surf clam)	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
Crassostria virginica	Atlantic County		7	10			
(oyster)	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	Atlantic County		56	72			
(sea scallop)	New Jersey		416	247	112	95	307
	Mid-Atlantic	534	569	468	514	635	912
Aequipecten irradians (bay scallop)	Mid-Atlantic	694	250	93	144	365	249

a 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	278
Total No. angler hours	247	568	1776	1802	2038	2072	1228	1572	1152	12455
Total No. of fishermen	47	73	229	231	257	263	162	213	165	1643
Atlantic cod	-	-	-	-	-	-	-	-	14	14
Red hake	-	-	31+	1	-	-	-	-	-	32+
Striped bass	-	6	11	-	1	-	-	86	202	306
Black sea bass	-	-	1120+	-	11	54	-	19	275	1430
Bluefish	-	-	5	131	310	1087	150	702	176	2561
Amber jack	-	-	-	-	-	1	-	-	-	1
Dolphin	-	-	-	-	-	1	-	-	-	1
Scup	-	-	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
Cunner	-	-	39	-	-	-	-	-	-	39
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	2235	748	122	10	6	5611
Winter flounder	420	-	33	-	-	-	-	-	-	453
Northern puffer	-	-	-	-	1	-	-	-	-	1
Total	420	5259	2491	2467	2751	2443	2079	1531	1031	29472+

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.[illegible]	5.3
Bluefish	-	-	5	131	310	1087	150	702	176	2561
% of total catch	-	-	6.2	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	175[illegible]	723	240	3250
% of total catch	-	-	0.2	+	-	21.1	84.[illegible]	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	7350
% 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	0.5	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	25.5

\+ Indicates less than 0.1.

EXHIBIT 103

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 Creek to & Including Forked River	Waretown Creek to & Including Oyster Creek	Northern Approach Barnegat 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
September - December			
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
Species Taken			
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)

	Cedar Creek to & Including Forked River	Waretown Creek to & Including Oyster Creek	Northern Approach Barnegat Inlet	Forked River	Oyster Creek
Temperature Range (C), Surface	8.5-20.0	8.1-21.0	6.2-20.2	4.5-21.5	4.5-26.0
Salinity Range (ppt), Surface	18.5-20.0	22.0-23.0	21.0-30.0	14.0-22.0	12.0-22.0
January - April					
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[a]	-	-	-	-	-
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
Species Taken					
American eel	-	1	1	-	-
Winter flounder	-	23	11	5	-
Total	0	24	12	5	0

[a]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)

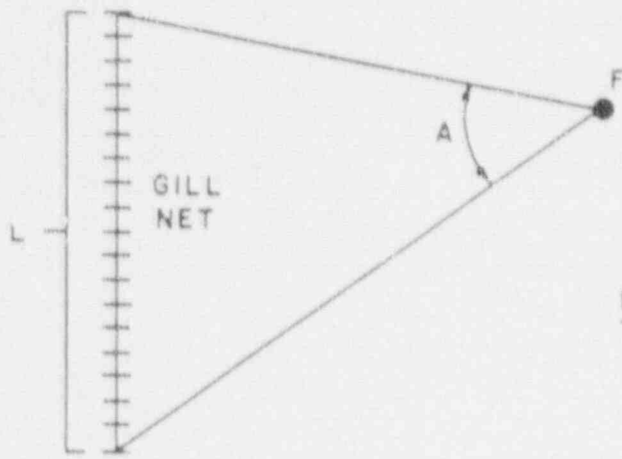
	September 1975			October 1975			November 1975			December 1975		
Species	lbs	Value ($)	Gear*	lbs	Value ($)	Gear	lbs	Value ($)	Gear	lbs	Value ($)	Gear
Blue crab	14,640	3,294	330	24,000	6,000	330	-	-	-	31,200	9,300	805
Americal eel	1,285	386	340	1,100	330	340	-	-	-	-	-	-
Northern quahog	3,020	3,174	845	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
	January 1976			February 1976			March 1976			April 1976		
Species	lbs	Value ($)	Gear	lbs	Value ($)	Gear	lbs	Value ($)	Gear	lbs	Value ($)	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 - ΔT
   a. At Different Dilutions
   b. By Season
2. Change in Salinity - ΔS
   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

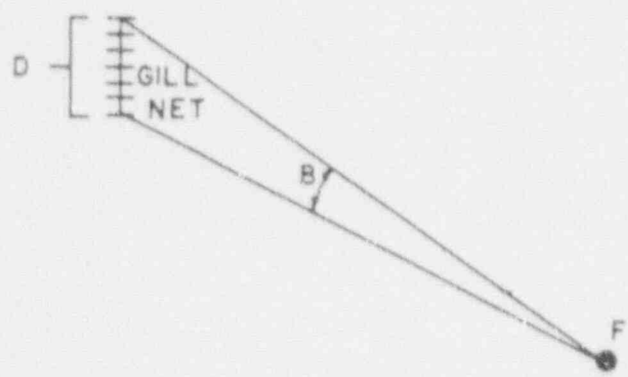
NOTES

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

Exhibit 107 Aquatic Ecological Differentiating Factors: Summer Operation, Phase 1 Estimates

	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			
Dilution Pumps	0	1	2	3	0	1	2	3	0	1	2	3
ΔT (F)[1]	20	13	9	7	20	13	9	7	0.7	0.5	0.4	0.3
ΔS (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
Impingement $\times 10^2$ /Wk	105	115	125	135	20	30	40	50	20	30	40	50
Entrainment[2] $\times 10^1$ /Min	14	16	18	20	14	16	18	20	14	16	18	20

[1]Estimates based on combined Oyster Creek and Forked River flows.

[2]Equivalent Adults

Exhibit 107

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
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
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
5	15	25	35	0	10	20	30	5	15	25	35	5	15	25	35
1	3	5	7	0	2	4	6	1	3	5	7	1	3	5	7

Exhibit 108 Aquatic Ecological Differentiating Factors: Winter Operation, Phase 1 Estimates

	Canal(Pipe)-to-Bay System or Existing System				Canal(Pipe)-to-Bay System or Existing System with Bucket Screens				"Low Temperat Helper Towe with Bucket Sc		
Dilution Pumps	0	1	2	3	0	1	2	3	0	1	2
ΔT (F)[1]	21	13	10	8	21	13	10	8	10	6	5
ΔS (0/00)	0.4	0.2	0.2	0.2	0.4	0.2	0.2	0.2	0.6	0.4	0.2
Impingement $\times 10^2$ /Wk	1900	1910	1920	1930	375	385	395	405	375	385	395
Entrainment[2] $\times 10^1$ /Min	42	52	62	72	42	52	62	72	42	52	62

[1]Estimates based on combined Oyster Creek and Forked River flows.

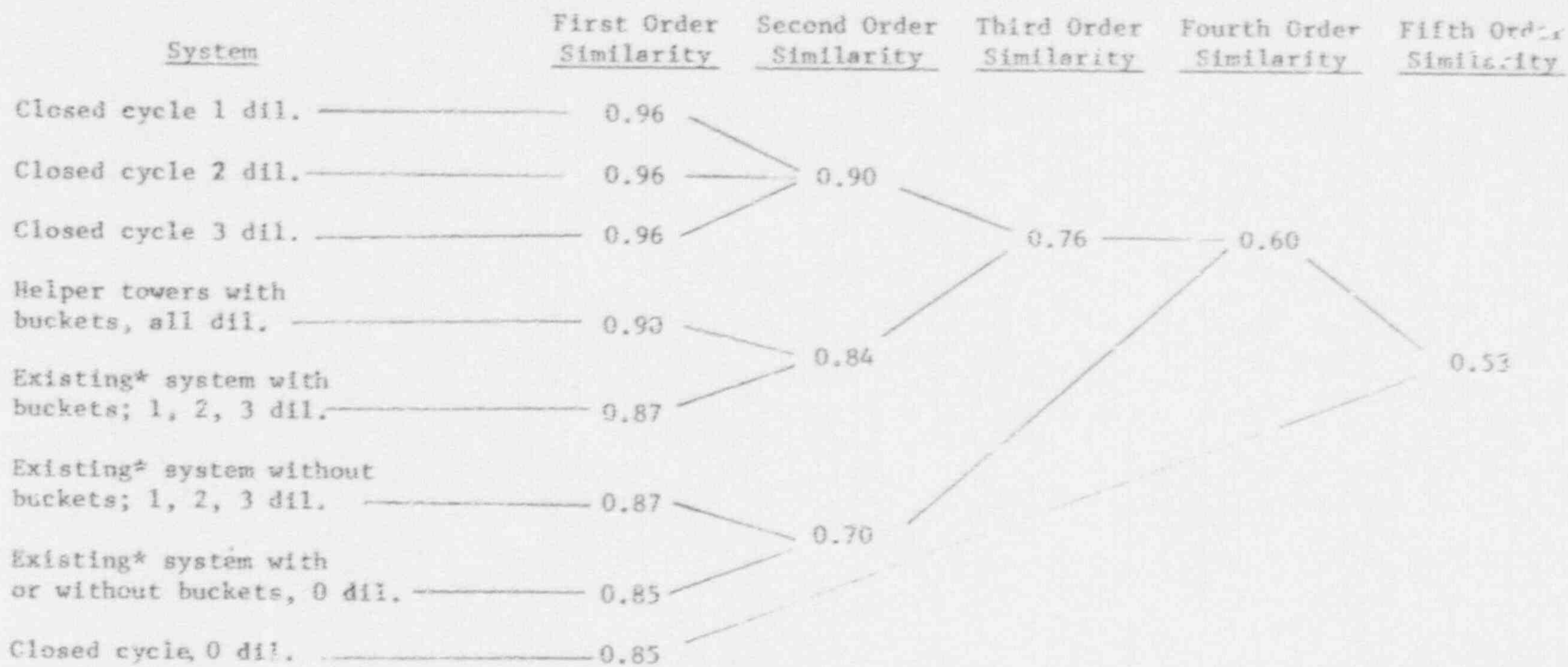
[2]Equivalent Adults

Exhibit 108

re" 's eens	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			
3	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3
4	30	4	2	2	27	3	2	1	32	3	3	2	22	4	2	1
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
405	90	100	110	120	0	10	20	30	90	100	110	120	90	100	110	120
72	2	12	22	32	0	10	20	30	2	12	22	32	2	12	22	32

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

Date	Species	Number[1]	Size Range	Probable Cause	Intake Temperature °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	Winter dilution pump operation and new shutdown procedures instituted
	Spot	---	---	Thermal Shock	
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		

[1] Source: Reintjes (1973 b, c.; 1974a)[34,35,36]; JCP&L (1973 a, 1973 b)[37,38]; AEC (1973)[39]; Younger (1974)[40].

[2] 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

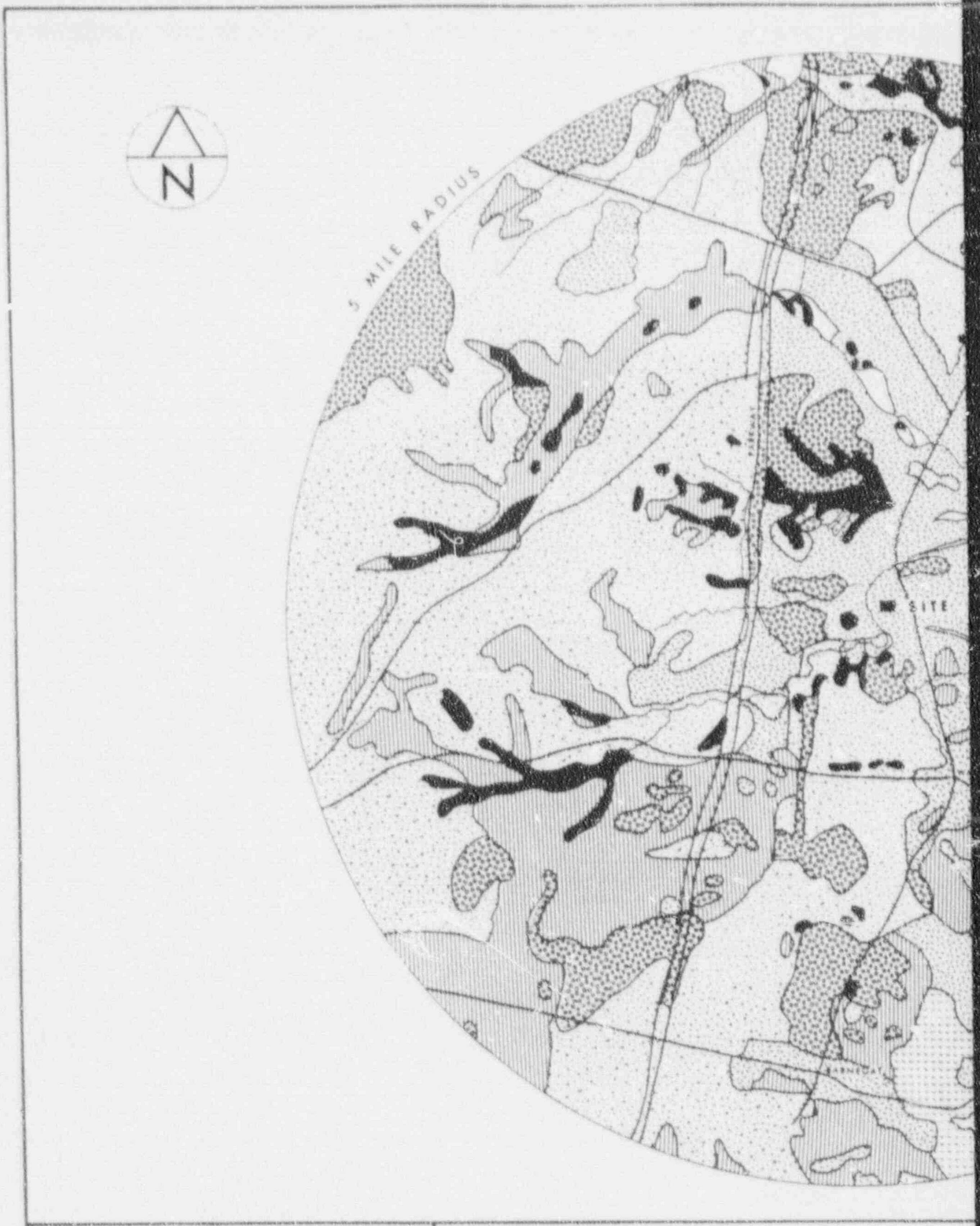
System	No. Dilution Pumps 0	1	2	3[1/]
Existing	No	No	No	Yes
Existing with Ristroph Bucket Screens	No	No	No	Yes
Canal-To-Bay	No	No	No	Yes
Saltwater Cooling Towers	Yes[2]	No	No	Yes
Freshwater Cooling Towers	Yes[2]	No	No	Yes
Helper Cooling Towers[4]	Yes	Yes	Yes	Yes
Cooling Ponds[3]	Yes[2]	Yes	Yes	Yes
Ocean Intake/Discharge System	No; however, this system has potentially high aquatic impacts relating to construction (i.e. dredging), entrainment, impingement and fouling.			

[1] Unnecessary entrainment/impingement increase per level of temperature reduction achieved.

[2] Significant increase in Oyster Creek salinity.

[3] High watershed losses.

[4] Helper towers offer no advantages over the other cooling tower systems and exhibit much greater impingement and entrainment losses.



JERSEY CENTRAL POWER AND LIGHT COMPANY	KEY TO VEG
EBASCO SERVICES INCORPORATED New York	

LEGEND

- HARDWOOD
- WHITE CEDAR
- MIXED HARDWOOD PINE
- PINE
- SALTWATER MARSH
- BAY
- NON - FORESTED

ETATION IN A 5 MILE RADIUS	EXHIBIT 112

CHARACTERIS

Alternative Cooling System

Closed Cycle Systems

Cooling Towers

1. Dry

2. Wet

a. Natural Draft (NDCT) (includes fan-assisted)

b. Mechanical Draft

i. Rectangular

ii. Round

iii. Wet-dry (salt and fresh water)

Cooling Ponds

1. 500 acre

2. 1,000 acre

Spray Canal

Open Cycle Systems

Canal (pipe)-to-Bay

Once-through Ocean System

Helper Cooling Towers (Rectangular Mechanical Draft)

SI APERTURE CARD

Also Available On Aperture Card

EXHIBIT 113

ICS OF ALTERNATIVE COOLING SYSTEMS AFFECTING TERRESTRIAL ECOSYSTEMS

Land Requirements		Fogging/Icing	Salt Deposition		Height of Structure (feet)
Acreage	Sensitive Areas Disturbed		Rate	Aereal Extent	
<10					120
<10			Less than 89 kg/ km^2/mo (maximum annual)	Max ESE near tower	550
<10			7 times NDCT	Max deposition near tower	55
<10			7 times NDCT	Max deposition near tower	70
<10			7 times NDCT (salt water tower)	Max deposition near tower (salt water tower)	60
500	Forested acreage				0
1,000	Forested acreage lost; including white cedar				0
<25		Icing within 2,000 feet	7 times NDCT	2,000 feet of canal	0
<25	Portion of salt marsh lost				0
<25	Barrier beach habitat lost				0
<10			7 times NDCT	Max deposition near tower	55

9111110048 - 38

	Land Requirements Impact
Alternative Cooling System	
Closed Cycle Systems	
Cooling Towers 1. Dry	Minimal habitat lost
2. Wet a. Natural Draft (NDCT) (includes fan-assisted)	Minimal habitat lost
b. Mechanical Draft i. Rectangular	Minimal habitat lost
ii. Round	Minimal habitat lost
iii. Wet-Dry (Salt and Fresh-water)	Minimal habitat lost
Cooling Ponds 1. 500 acre	Extensive habitat lost
2. 1000 acre	Extensive habitat lost, including sensitive areas
Spray Canal	Minimal habitat lost
Open-Cycle Systems Canal (Pipe)-to-Bay	Sensitive habitat lost
Once-Through Ocean System	Sensitive and rare habitat disrupted
Helper Cooling Towers (Rectangular Mechanical Draft)	Minimal habitat lost

*N/A - Not Applicable

EXHIBIT 114

RNATIVE COOLING SYSTEMS - TERRESTRIAL ECOLOGY

Fogging/Icing Impact	Salt Deposition Impact	Height of Structure Impact
N/A*	N/A	N/A
N/A	Potential effects on vegetation growth and distribution	Potential bird migration obstruction
N/A	Vegetation damage near tower	N/A
N/A	Vegetation damage near tower	N/A
N/A	Vegetation damage near tower (salt water)	N/A
N/A	N/A	N/A
N/A	N/A	N/A
egetation damage ithin 2,000 feet	Vegetation damage near spray canal.	
N/A	N/A	N/A
N/A	N/A	N/A
N/A	Vegetation damage near tower	N/A

	Plant Net Capabil[ity] MW
Existing Cooling System	608.8***
Ocean Intake & Discharge	622.6
Discharge Canal to the Bay	608.6
Discharge Pipelines to the Bay	608.6
Ocean Intake & Discharge with a Multipressure Condenser	603.1
Helper Cooling Towers (CT) with Tmin = 50 F	597.6
1000 Acre Cooling Pond	597.1
Helper CT with Tmin = 43 F	593.9
Mechanical Draft Rectangular CT	589.4
Fan Assisted CT	587.6
Mechanical Draft Round CT	588.8
Natural Draft CT	587.0
Spray Modules	585.4
Wet/Dry Salt Water CT	579.2
500 Acre Cooling Pond	576.0
Wet/Dry Fresh Water CT	574.1
Dry Cooling Tower	534.1

*At design Ambient Conditions (T_{wb} = 74 F, T_{db} = 89 F,

**At Reactor Thermal Output 1900 MWt.

***For Intake Cooling Water Temperature of 82 F.

Exhibit 115

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

ity at Design Conditions* Differential, MW	Plant Net Average Seasonal Capability, MW** Summer	Spring/Fall	Winter
Base	620.4	635.3	637.2
-13.8	624.2	627.0	627.5
1.4	618.8	633.8	635.7
1.4	616.5	633.8	635.7
5.7	607.1	619.4	623.6
11.2	608.9	623.8	625.9
11.7	614.0	631.6	634.8
14.9	605.3	620.1	622.2
19.4	599.7	616.5	621.3
21.2	597.1	615.2	622.3
20.0	600.0	615.3	620.1
21.8	599.1	621.4	628.5
23.4	599.0	619.3	624.5
29.6	590.6	605.3	615.7
32.8	600.5	622.4	630.7
34.7	583.8	604.8	569.3
74.7	570.1	598.4	603.9

wind speed 5 mph) and Reactor Thermal Output 1900 MWt.

EXH

SUMMARY OF ENVIRONMENTAL EFFECTS

Environmental Factors	Units	Natural Draft Cooling Tower	Fan-Assisted Natural Draft Tower	Round Mechanical Draft Towers	Dry Cooling Towers	Ocean Intake-Discharge Systems	[illegible]
1. Atmospheric Effects							
1.1 Elevated Visible Plumes	Qualitative	High	High	High	Low	Low	Low
1.2 Ground Level Fogging	Qualitative	Low	Low	Low	Low	Low	Low
1.3 Salt Deposition	Qualitative	Low	Low	Moderate	Low	Low	Low
1.4 Convective Instability	Qualitative	Moderate	Moderate	Moderate	High	Low	Low
2. Air Quality							
2.1 Particulate Emission Rate	% of Standard	353	336	336	-	-	-
3. Water Quality							
3.1 Construction Effects	Qualitative	Low	Low	Low	Low	High	Mode
3.2 Water Quality Concentrations	% Change	+3.5	+3.5	+3.5	0	0	0
4. Thermal Discharge Characteristics							
4.1 Heat Dissipation in Receiving Water (S/Winter)	Btu/hr X 10^6	164/622	164/622	135/660	-	4500	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
4.3 Area Affected by 1.5° F (Summer Max)	Acres	0	0	0	-	0	~ 230
5. Noise							
5.1 Noise Level		**	**	**	**	Low	63
6. Visual/Esthetic Effects							
6.1 Loss of Vegetative Cover	Qualitative	None	None	None	None	None	Low
6.2 Profile Impact	Qualitative	High	High	High	High	Low	Low
6.3 Elevated Visible Plumes	Qualitative	High	High	Moderate	None	None	None
6.4 Ground Fog	Qualitative	None	None	Low	None	None	Low

SI APERTURE CARD

Also Available On Aperture Card

Exhibit 116

[EXH]IBIT 116

[...] - ALTERNATIVE COOLING WATER SYSTEMS

Canal (Pipe)-[t]o Bay [S]ystem	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
	Low	Low	Low	Low	Low	Low	Low	
	Low	Low	High	High	Moderate	Moderate	Low	
	Low	Moderate	High	High	High	Low	Low	
	Moderate	Moderate	Moderate	Moderate	Low	Low	Low	
	<50	336	336	336	-	-	-	
[...]rate	Low	Low	Low	Low	Low	High	-	
	+1.7	+3.4	+1.8	+3.5	+3.5	+3.6	0	
	134/425	172/684	858/2784	153/681	161/596	500: 163/568 1000: 14[illegible]/549	4500	
	3.0/9.4	3.8/15.0	19/62	3.4/15.1	3.6/13.[illegible]	500: 5.5/15.7 1000: 3.3/12.2	100	
[...]0	0	0	437	0	0	0	~2300	Same as Existing System
	**	**	**	**	60-62	Low	Unavailable	
	None	None	None	None	Low	High	-	
	High	High	High	High	Low	Low	Moderate	
	None	None	Low	Low	Low	None	None	
	Low	Low	High	High	Moderate	Moderate	Low	

9111110048 - 41

SUMMARY OF ENVIRONMENTAL EF

Environmental Factors	Units	Natural Draft Cooling Tower	Fan-Assisted Natural Draft Tower	Round Mechanical Draft Towers	Dry Cooling Towers	Ocean Intake-Discharge Systems
7. Land Use						
7.1 Area Required	Acres	~10	~10	~10	~10	~25
8. Terrestrial Ecology						
8.1 Sensitive Land Requirements	Qualitative	Low	Low	Low	Low	Moderate
8.2 Fogging/Icing Effects on Vegetation	Qualitative	None	None	None	None	None
8.3 Salt Deposition Effects on Vegetation	Qualitative	Low	Low	Moderate	None	None
8.4 Bird Collision Effects	Qualitative	Moderate	Moderate	Low	None	None
9. Aquatic Ecology						
9.1 Impingement (Summer)	Qualitative	Low	Low	Low		Potentially High
9.2 Impingement (Winter)	Qualitative	Moderate	Moderate	Moderate		Potentially High
9.3 Entrainment (Summer)	Qualitative	Low	Low	Low		Potentially High
9.4 Entrainment (Winter)	Qualitative	Moderate	Moderate	Moderate		Potentially High
9.5 Wood Borers* Potential in Bay relative to Existing System (Base)	Qualitative	Lower	Lower	Lower		Lower
9.6 Cold Shock Potential in Bay relative to Existing System	Qualitative	Lower	Lower	Lower		-

*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 syst

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 syste

High - the impact is of sufficient magnitude to warrant serious considerations in the c

SI APERTURE CARD

Also Available On Aperture Card

Exhibit 116 (Cont'd)

EXHIBIT 116

ECTS - ALTERNATIVE COOLING WATER 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
~25	~10	~10	~10	~10	~25	1000/500	-	Same as Existing System
Moderate	Low	Low	Low	Low	Low	High	-	
None	None	None	None	None	Moderate	None	None	
None	None	Moderate	Moderate	Moderate	High	None	None	
None	None	None	None	None	None	None	None	
Moderate	Low	Low	Moderate	Low	Low	Low	Moderate	Low
High	Low	Moderate	High	Moderate	Moderate	Moderate	High	Moderate
Moderate	Low	Low	Moderate	Low	Low	Low	Moderate	Moderate
High	Moderate	Moderate	High	Moderate	Moderate	Moderate	High	High
Lower	Lower	Lower	Lower	Lower	Lower	Lower	Base	-
Lower	Lower	Lower	Lower	Lower	Lower	Lower	Base	-

ems would be expected to exceed noise criteria without noise reducing modifications.

m.

ooling elimination process.

9111110048 -42

Exhibit 117

COOLING TOWER CHARACTERISTICS USED IN SALT DRIFT ANALYSIS OYSTER CREEK STATION OYSTER CREEK NUCLEAR GENERATING STATION

	Natural Draft	Fan-Assisted Natural Draft	Round Mechanical Draft
Tower Geometry			
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
Design Conditions			
Circulating Water Flow Rate (gpm)(3)	433,300	458,500	433,300
Heat Load (BTU/hr)(3)	4.59×10^9	4.58×10^9	4.57×10^9
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[(1)]	Round Mechanical Draft[(1)]
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

Atmospheric Condition	No. of Groups	Group Classification
Wind Direction	16 Sectors	N, NNE, NE, ENE, E, ESE, SE, SSE, S, SSW, SW, WSW, W, WNW, NW, NNW
Wind Speed	8	0 - 3.0 mph 3.0 - 6.0 mph 6.0 - 9.0 mph 9.0 - 12.0 mph 12.0 - 18.0 mph 18.0 - 25.0 mph 25.0 - 32.0 mph >32.0 mph Wake Conditions for Winds 26 mph[(1)]
Stability Class	3	Pasquill Category C Pasquill Category D Pasquill Category E
Relative Humidity	2	>75% ≤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	90
			≤ 75	65
4-6	2.3	C, D, E	> 75	90
			≤ 75	65
7-9	3.5	C, D, E	> 75	90
			≤ 75	65
10-12	5.0	C, D, E	> 75	90
			≤ 75	65
13-18	7.0	D	> 75	90
			≤ 75	65
19-25	10.0	D	> 75	90
			≤ 75	65
26-32	13.0	D	> 75	90
			≤ 75	65
≥ 33	16.0	D	> 75	90
			≤ 75	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:

$$C = \text{Unstable}, \frac{\Delta T\ (F)}{100\ ft} \leq -0.8$$

$$D = \text{Neutral} \quad -0.8 < \frac{\Delta T\ (F)}{100\ ft} \leq -0.3$$

$$E = \text{Stable} \quad \frac{\Delta T\ (F)}{100\ ft} > -0.3$$

COLLECTION EFFICIENCY OF CYLINDRICAL AND RIBBON TYPE OBJECTS OF VARIOUS DIMENSIONS FOR DRIFT DROPS AS A FUNCTION OF DRIFT DROP DIAMETER AND WIND SPEED

Wind Speed Group (mph)	Obstacle Dimension (inches)	Collection Efficiency for Drop Diameter (um) 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	-	0.70	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

Month	Period of Record	Maximum Temperature (° F)	Average Temperature (° F)	Minimum Temperature (° 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

Source: JCP&L

Exhibit 123

EXTREME AND AVERAGE WET BULB AND WATER TEMPERATURES

DEGREES F

	Extreme Case		Average Case	
Month	Wet Bulb*	Intake Water	Wet Bulb*	Intake Water
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

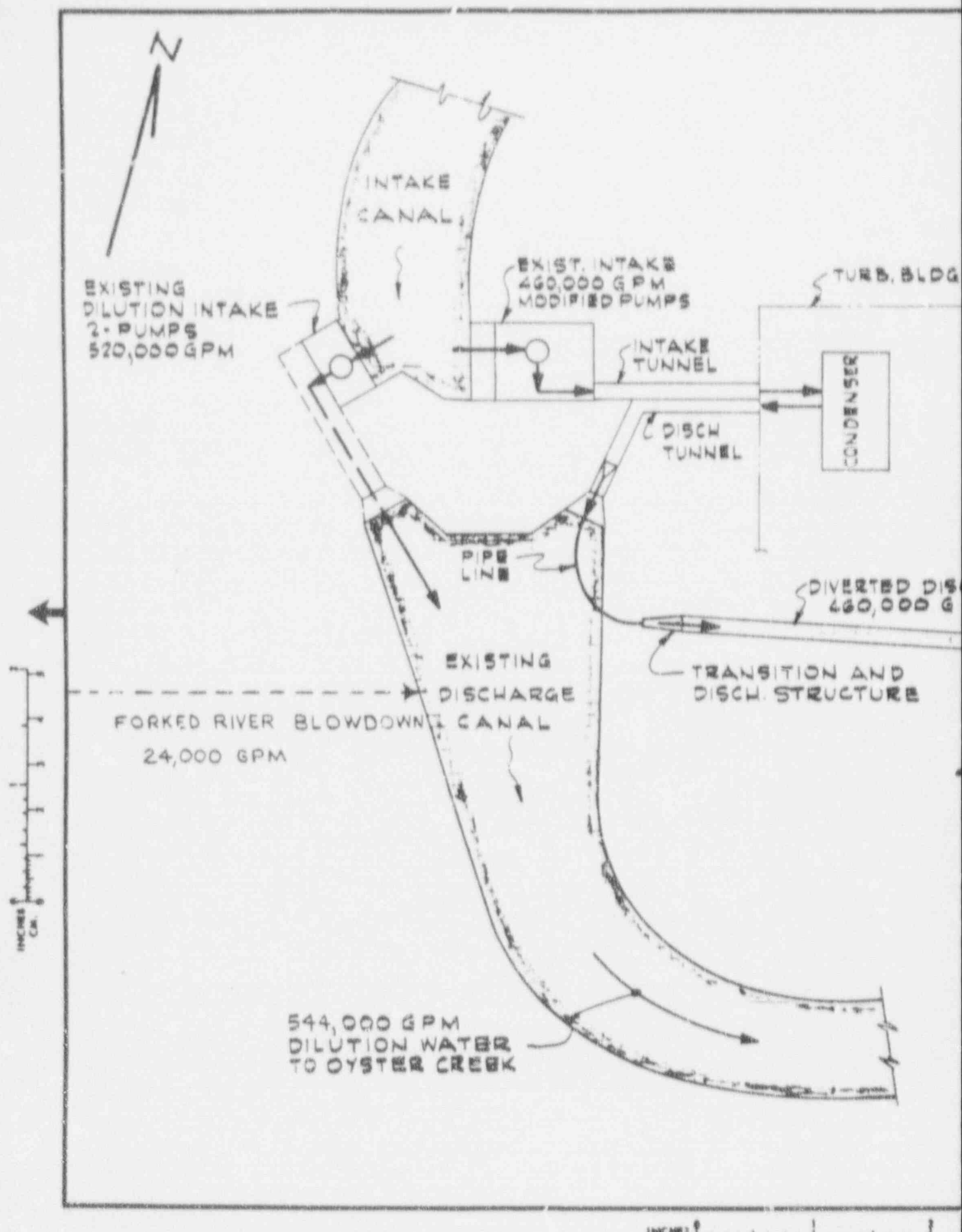
* Source: Atlantic City

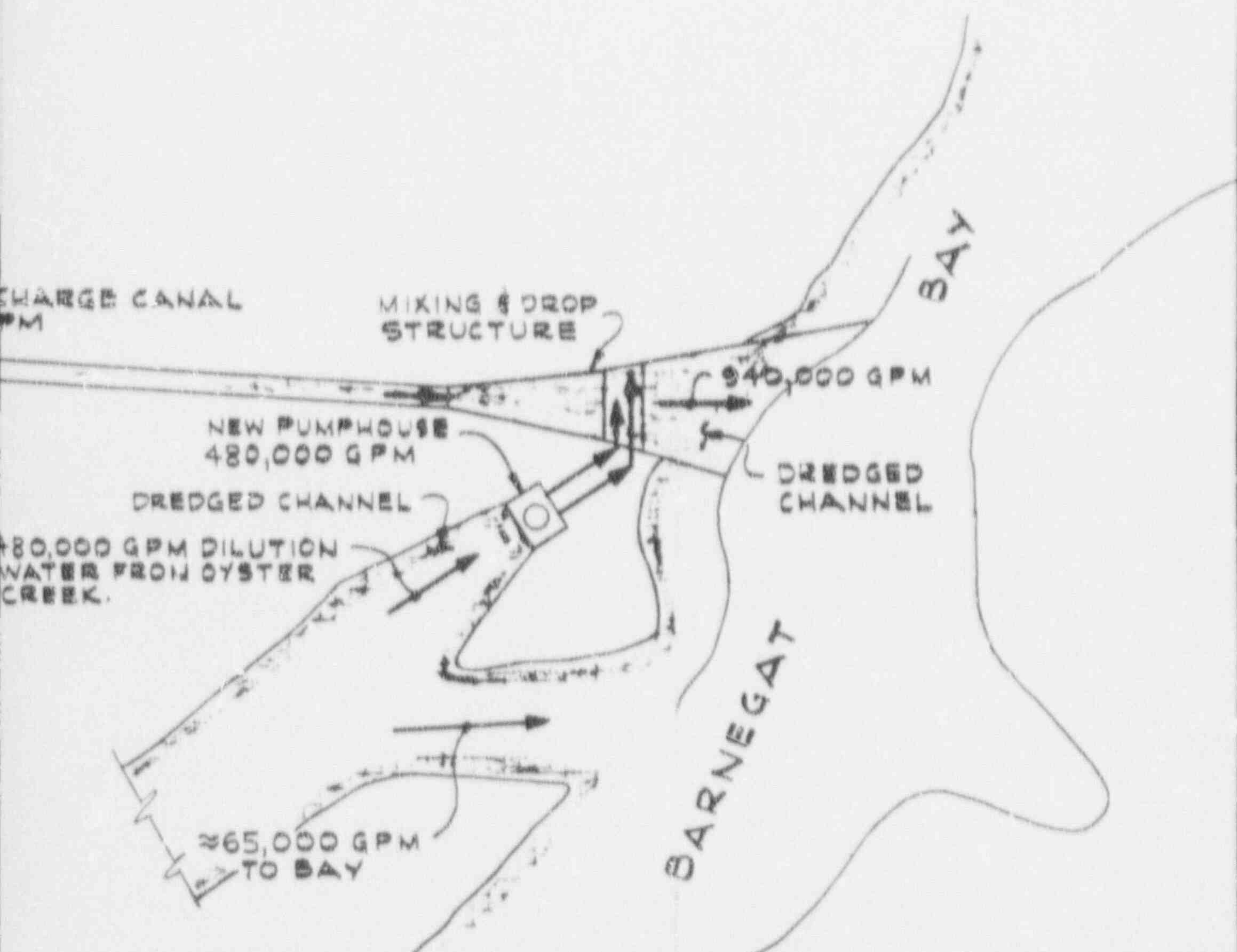
Exhibit 124

COOLING TOWER PERFORMANCE DATA

	Basin Water Temperature - °F			
Wet Bulb	Round Mech Draft Towers	Natural Draft Tower	Fan Assisted Towers	Forked River Station Tower
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

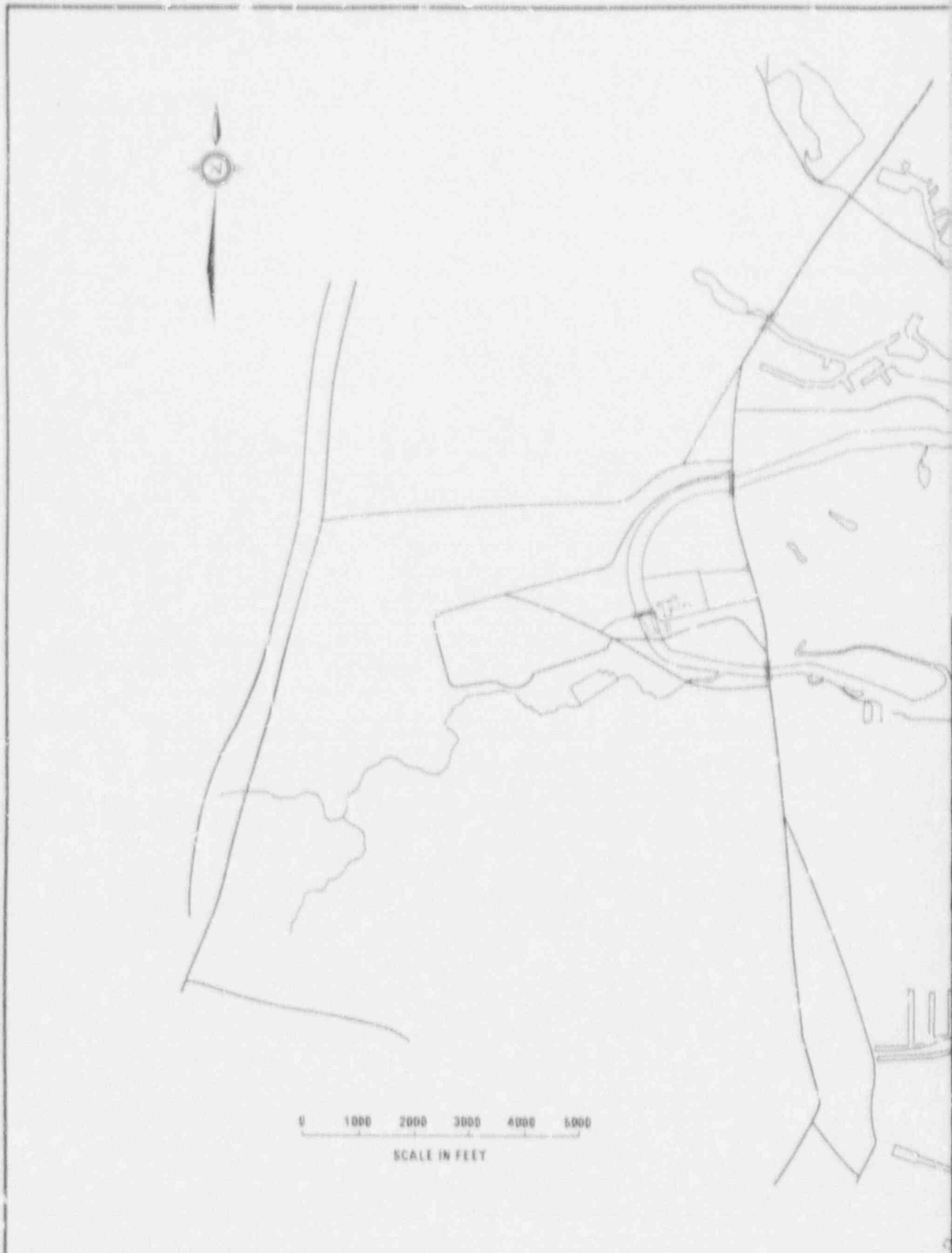
	Evaporation Rate - GPM			
30	4,800	5,000	5,000	9,800
46	5,700	5,700	5,800	11,100
65	6,550	6,550	6,600	12,000
74	7,000	7,000	7,100	13,000
78	7,400	7,400	7,[illegible]00	13,500


N
INTAKE CANAL
EXISTING DILUTION INTAKE 2-PUMPS 520,000 GPM
EXIST. INTAKES 460,000 GPM MODIFIED PUMPS
TURB. BLDG
INTAKE TUNNEL
CONDENSER
DISCH TUNNEL
PIPE LINE
DIVERTED DIS
460,000 G
TRANSITION AND DISCH. STRUCTURE
EXISTING DISCHARGE CANAL
FORKED RIVER BLOWDOWN
24,000 GPM
544,000 GPM DILUTION WATER TO OYSTER CREEK
INCHES
CM.



EBASCO SERVICES INCORPORATED		JERSEY CENTRAL POWER & LIGHT OYSTER CREEK NUCLEAR GEN. STATION ALTERNATIVE COOLING WATER SYS. STUDY DISCHARGE CANAL TO BAY FLOW DIAGRAM	JCP-7037 EXHIBIT 125
DIV. CIVIL DR. G.A. SCALE NTS CH. DATE	APPROVED		

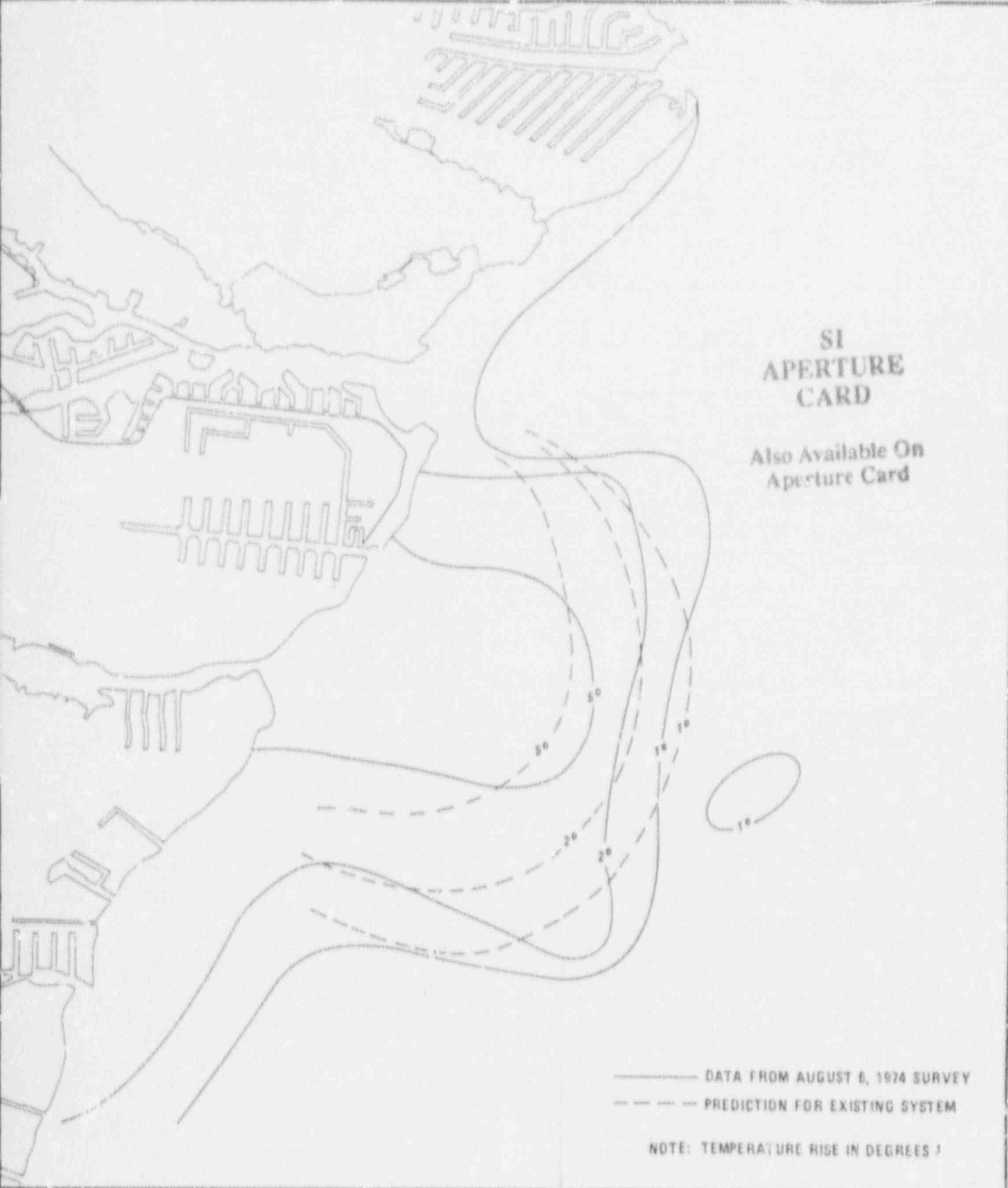
9111110048-43



JERSEY CENTRAL POWER
AND LIGHT COMPANY

EBASCO SERVICES INCORPORATED
New York

EXISTIN
MEASURED AND P



G OYSTER CREEK NGS COOLING SYSTEM
REDICTED SURFACE TEMPERATURE DISTRIBUTIONS

EXHIBIT
126

Exhibit 127

ESTIMATED CHEMICAL RELEASES TO THE CIRCULATING WATER DISCHARGE CANAL

Source	Compound	Average Addition[e] lb/day	Ionic Species	Normal Concentration in Cooling Water Inlet[e] mg/liter	Concentration Increase in Cooling Water[a] mg/liter: Average Release Rate	Concentration Increase in Cooling Water[a] mg/liter: Maximum Release Rate
Cooling Water Biocide	Chlorine	1,000	Chloride	12,680	0.18	0.36[b]
			Chlorine Residual	0	0.2	0.2[b]
Sewage Treatment	Chlorine	-	Chloride	12,680		
			Chlorine Residual	0		
Demineralizer Regenerant	Sulfuric Acid	68	Sulfate	1,820	0.012	0.82[c]
	Sodium Hydroxide	32	Sodium	7,130	0.0034	0.21[d]
			pH	6.95	6.95	6.88[c] 7.04[d]
Boiler Blowdown	Trisodium Phosphate	0.22	Sodium	7,130	-	0.02[f]
	Sodium Hydroxide	0.25	Sulfite	-	-	0.01[f]
	Sodium Sulfite	0.25	Phosphate	0.7	-	0.01[f]
Condenser Tube Corrosion Copper			Copper	0.02 - 0.10[e]	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

Distance From Tower, Feet	Unattenuated Sound Level, dB(A)
50	61.5
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

Distance From Tower, Feet	Unattenuated Sound Level, dB(A)
50	89
1,600	61.5

Unattenuated sound level at 1,800 feet from the towers:

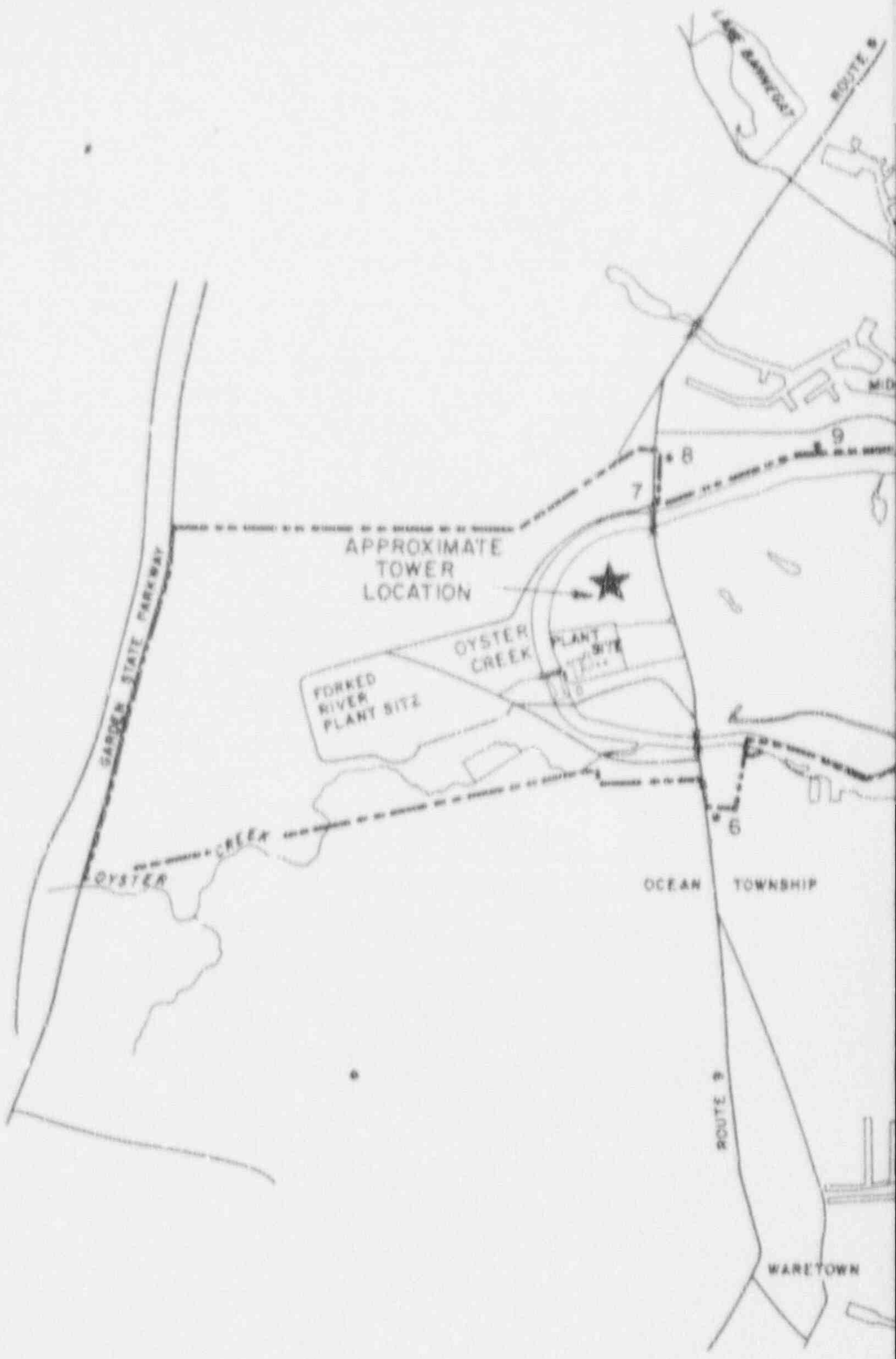
Octave Band Center Frequency (Hz)	31.5	63	125	250	500	1K	2K	4K	8K	A Scale
Sound Pressure Level (dB) Re-0.0002 Microbars	67	67.5	63.5	62.5	58	54.5	49.5	38.5	6.5	60

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

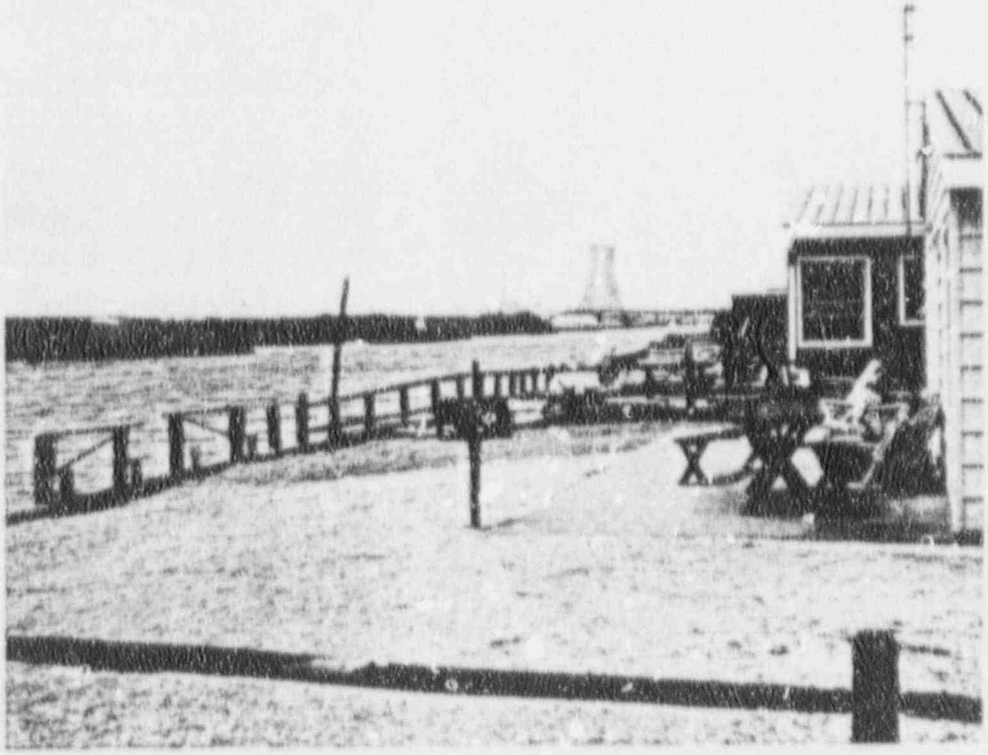
ROUND MECHANICAL DRAFT COOLING TOWERS

Distance From Tower, Feet	Unattenuated Sound Level, dB(A)
100	74
600	62



JERSEY CENTRAL POWER & LIGHT COMPANY	MAP FO NATURAL
EBASCO SERVICES INCORPORATED New York	

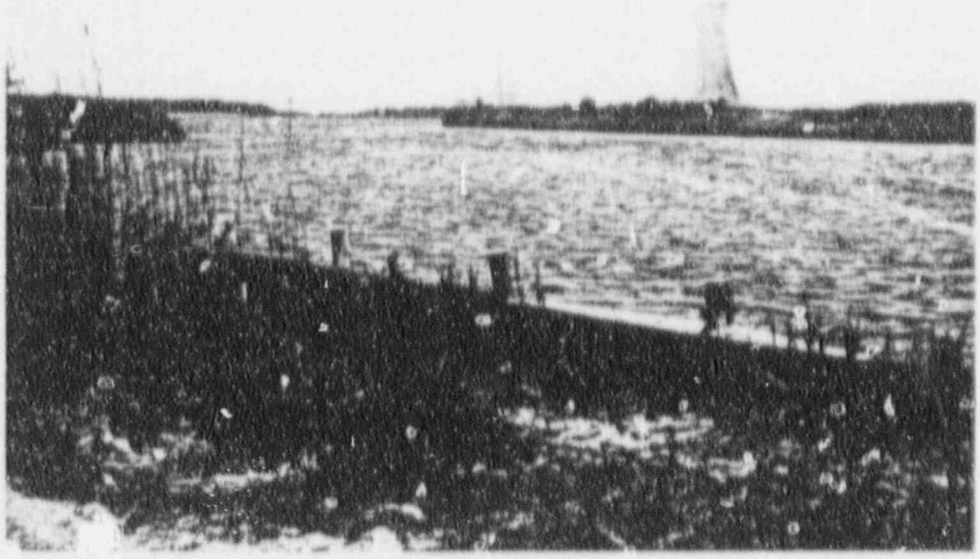
LOCATION No. 1 - VIEW FROM ABOUT 3/4 MILE FROM SHORE IN BARNEGAT BAY.



LOCATION No. 2 - VIEW FROM RESIDENCE AT BEACH BLVD. AND BINNACLE PT.

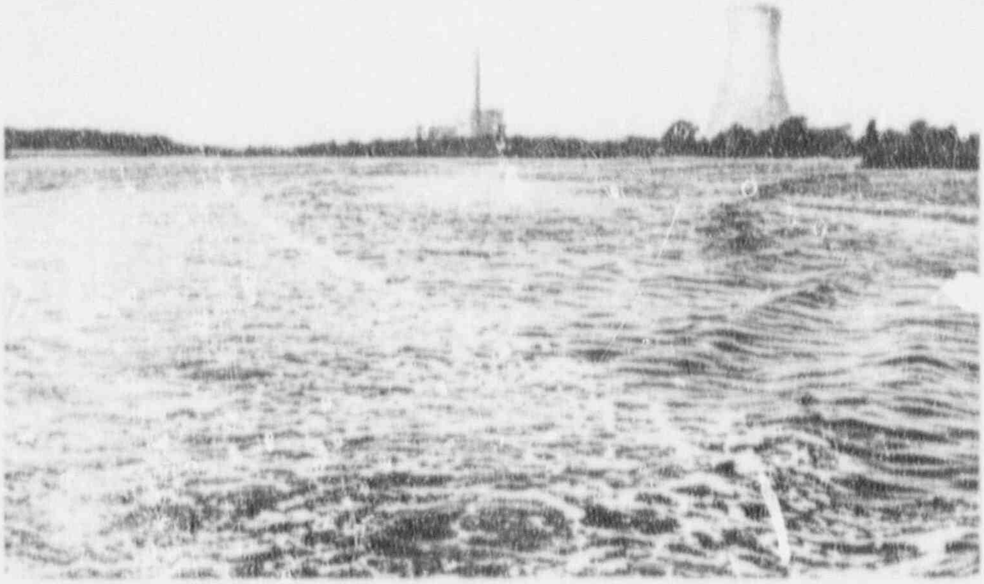
JERSEY CENTRAL POWER & LIGHT COMPANY EBASCO SERVICES INCORPORATED New York	PHOTOGRAPHIC ANALYSIS- NATURAL DRAFT COOLING TOWER VISUAL ASSESSMENT	EXHIBIT 130

LOCATION No. 3 - VIEW FROM RESIDENCE AT ORLANDO DRIVE AND PENGUIN, CT.

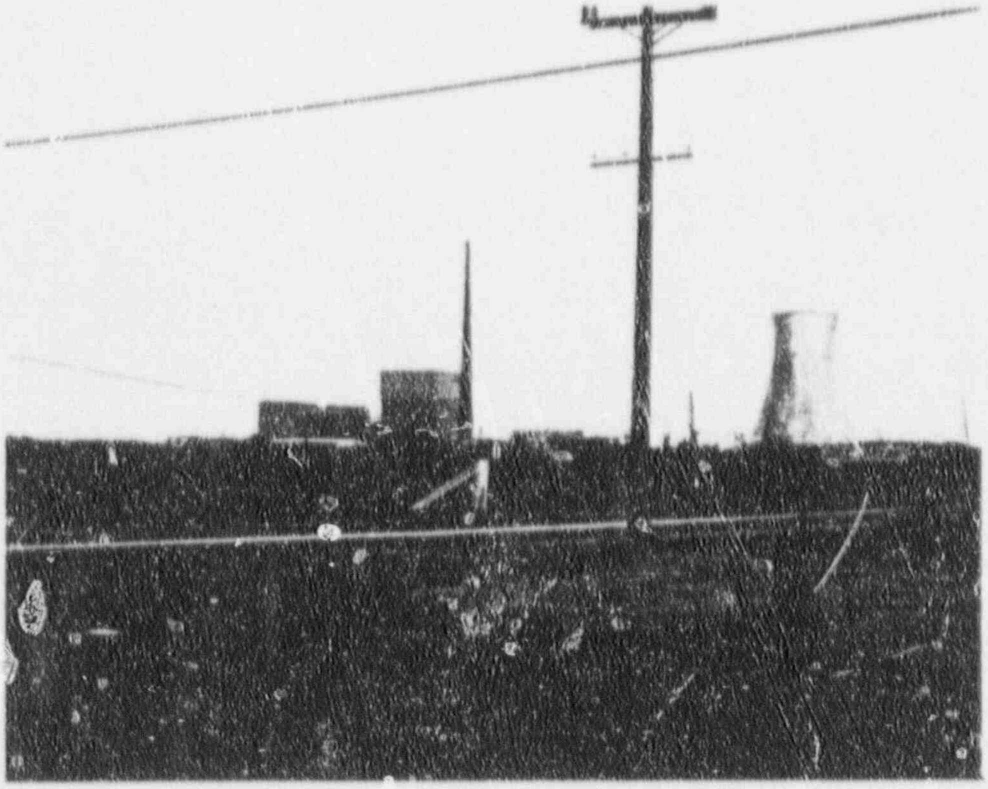


LOCATION No. 4 - VIEW FROM LAST RESIDENCE ON COMPASS RD. - LOOKING ACROSS OYSTER CREEK.

JERSEY CENTRAL POWER & LIGHT COMPANY	PHOTOGRAPHIC ANALYSIS- NATURAL DRAFT COOLING TOWER VISUAL ASSESSMENT	EXHIBIT 131
EBASCO SERVICES INCORPORATED New York		

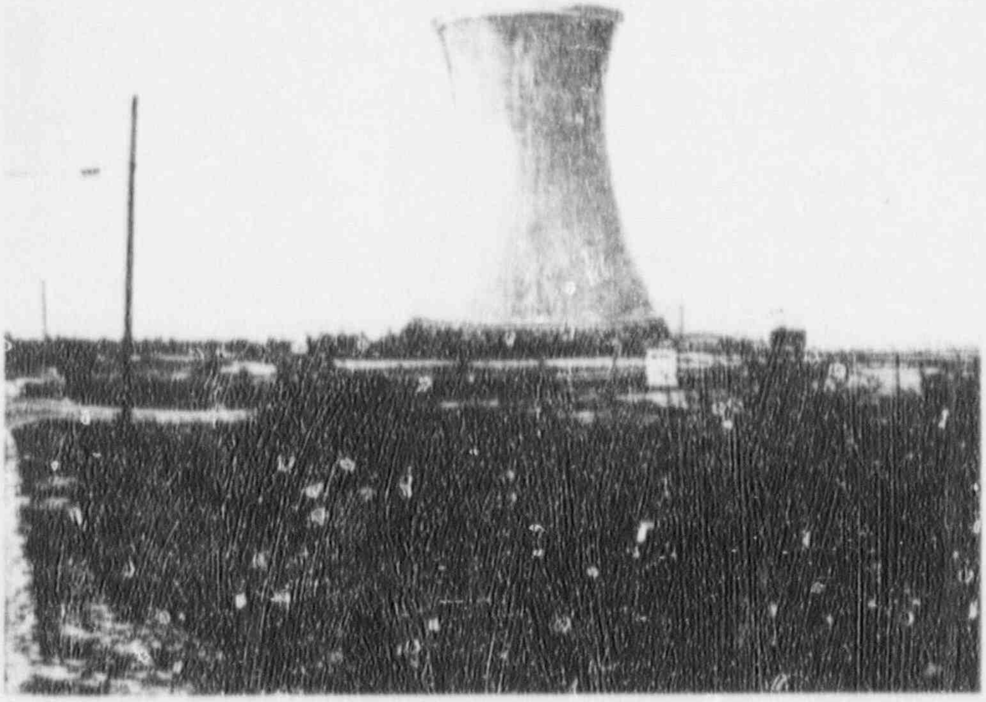


LOCATION No 5 - VIEW TAKEN FROM A BOAT IN OYSTER CREEK-
LOOKING WEST

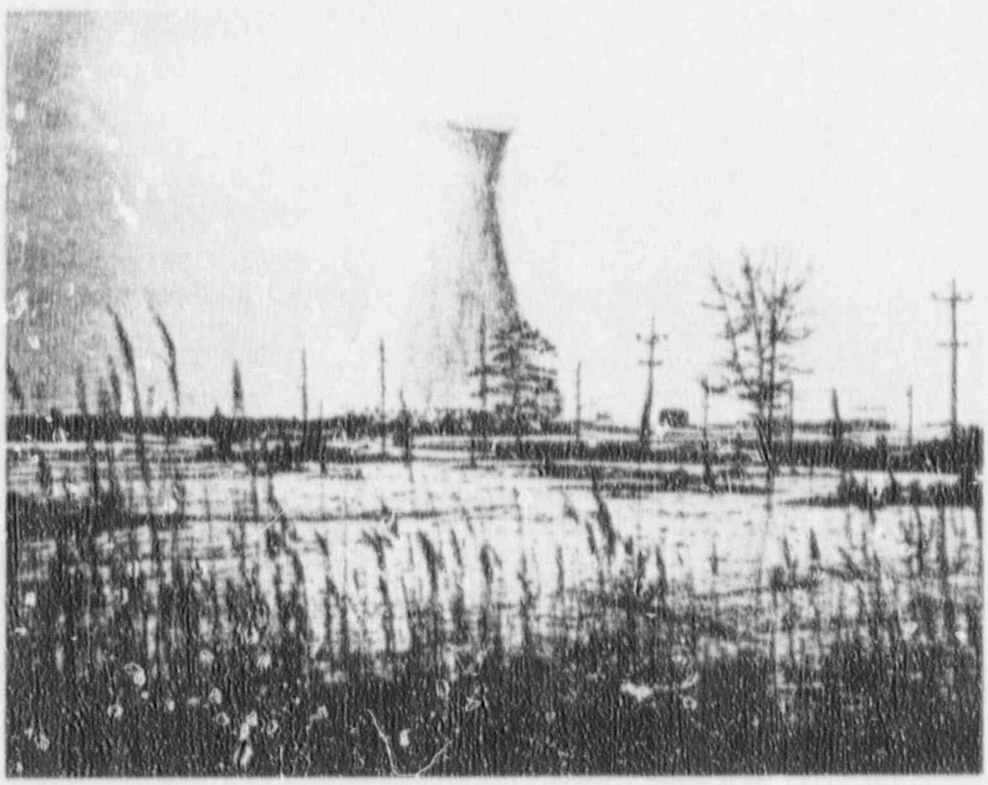


LOCATION No. 6 - VIEW TAKEN FROM NE CORNER OF BAY
PARKWAY AND ROUTE 9

JERSEY CENTRAL POWER & LIGHT COMPANY / EBASCO SERVICES INCORPORATED New York	PHOTOGRAPHIC ANALYSIS- NATURAL DRAFT COOLING TOWER VISUAL ASSESSMENT	EXHIBIT 132

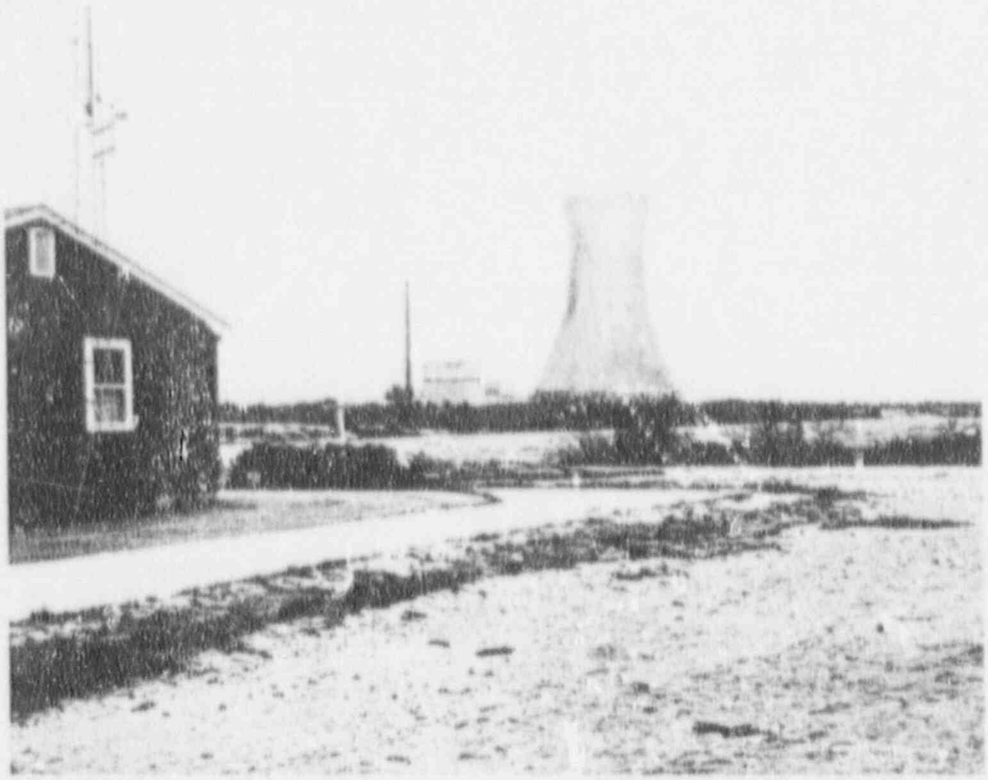


LOCATION No. 7 - VIEW FROM ROUTE 9 AT ABOUT 4/10 THS. MILE NORTH OF EX. PLANT



LOCATION No. 8 - VIEW FROM BACKYARD OF RESIDENCE AT NANTUCKET RD. AND BISCAYNE DR.

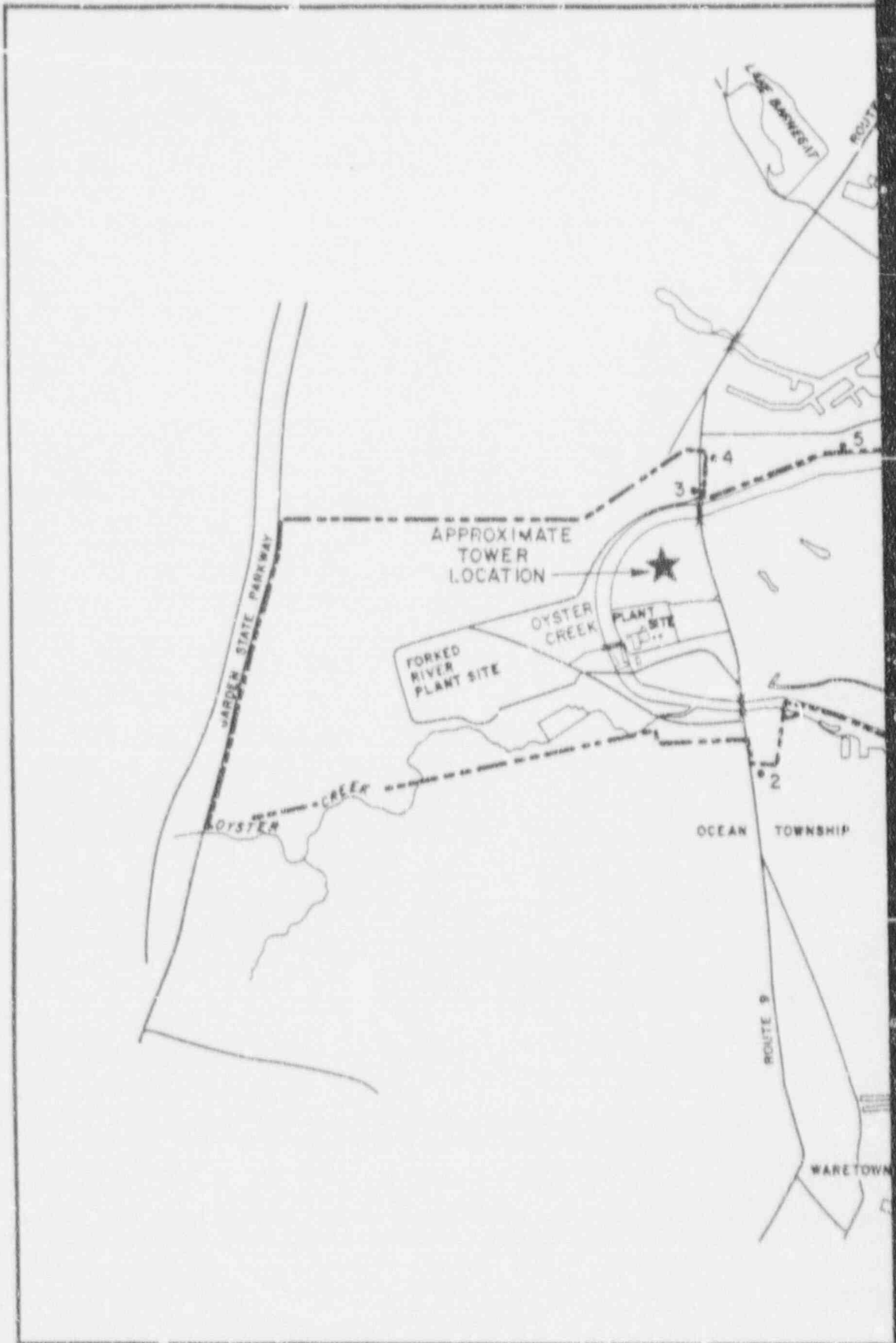
JERSEY CENTRAL POWER & LIGHT COMPANY	PHOTOGRAPHIC ANALYSIS- NATURAL DRAFT COOLING TOWER VISUAL ASSESSMENT	EXHIBIT 133
EBASCO SERVICES INCORPORATED New York		



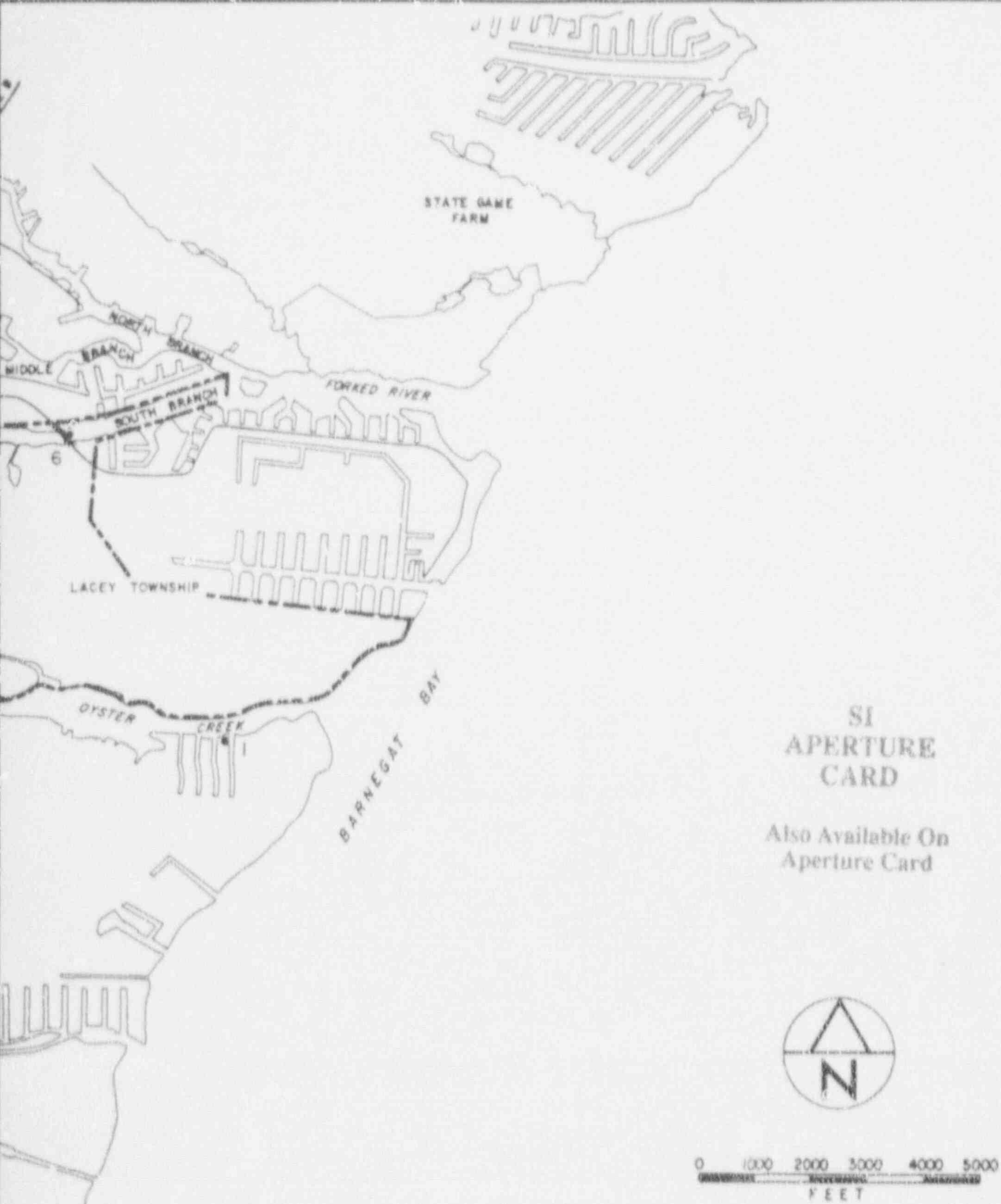
LOCATION No. 9 - VIEW FROM NANTUCKET AND BERMUDA DRIVES

LOCATION No 10 - VIEW FROM BEACH BLVD. BRIDGE OVER SOUTH BRANCH OF FORKED RIVER

JERSEY CENTRAL POWER & LIGHT COMPANY	PHOTOGRAPHIC ANALYSIS- NATURAL DRAFT COOLING TOWER VISUAL ASSESSMENT	EXHIBIT 134
EBASCO SERVICES INCORPORATED New York		

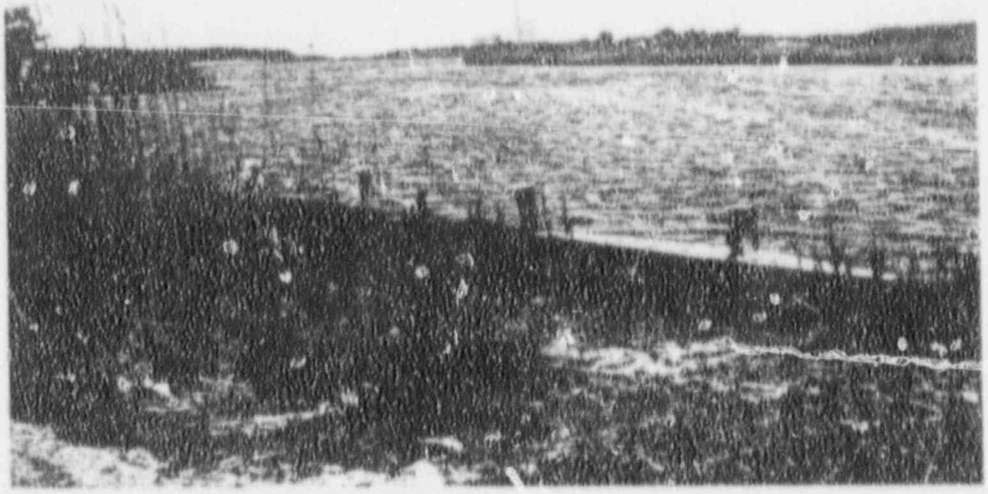


JERSEY CENTRAL POWER & LIGHT COMPANY	MA
EBASCO SERVICES INCORPORATED New York	ROUND

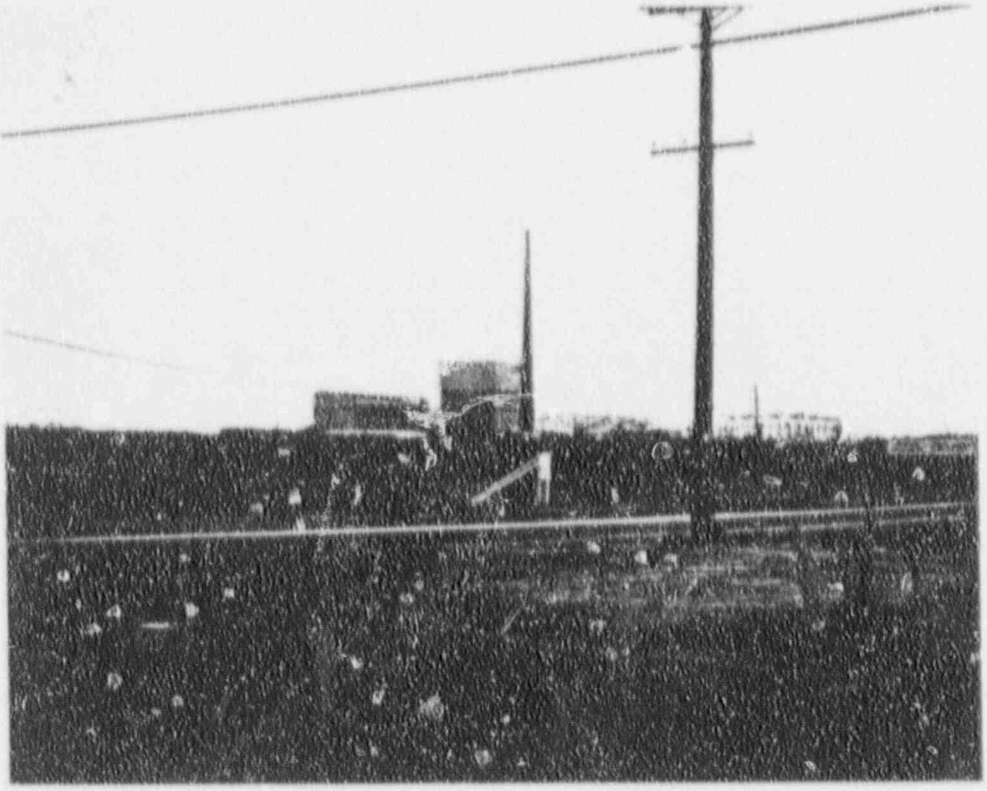


AP OF PHOTOGRAPH LOCATIONS
FOR VISUAL/ESTHETIC ANALYSIS
MECHANICAL DRAFT COOLING TOWERS

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

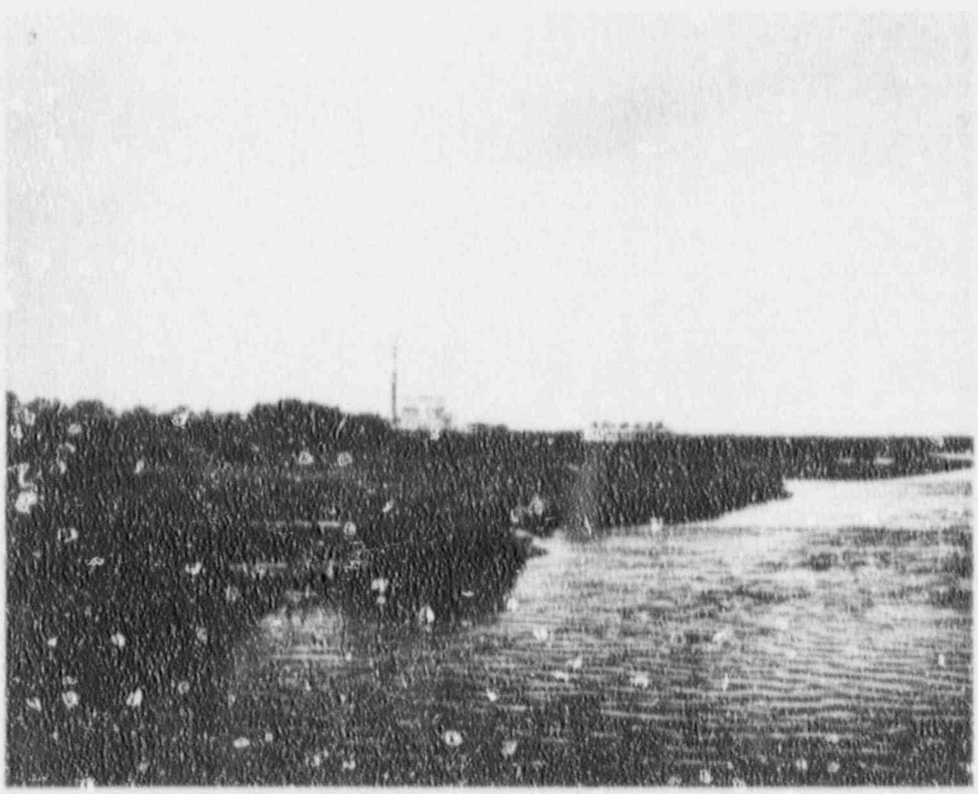
JERSEY CENTRAL POWER & LIGHT COMPANY	PHOTOGRAPHIC ANALYSIS- ROUND MECHANICAL COOLING TOWERS VISUAL ASSESSMENT	EXHIBIT 136
EBASCO SERVICES INCORPORATED New York		

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	PHOTOGRAPHIC ANALYSIS- ROUND MECHANICAL COOLING TOWERS VISUAL ASSESSMENT	EXHIBIT 137
EBASCO SERVICES INCORPORATED New York		

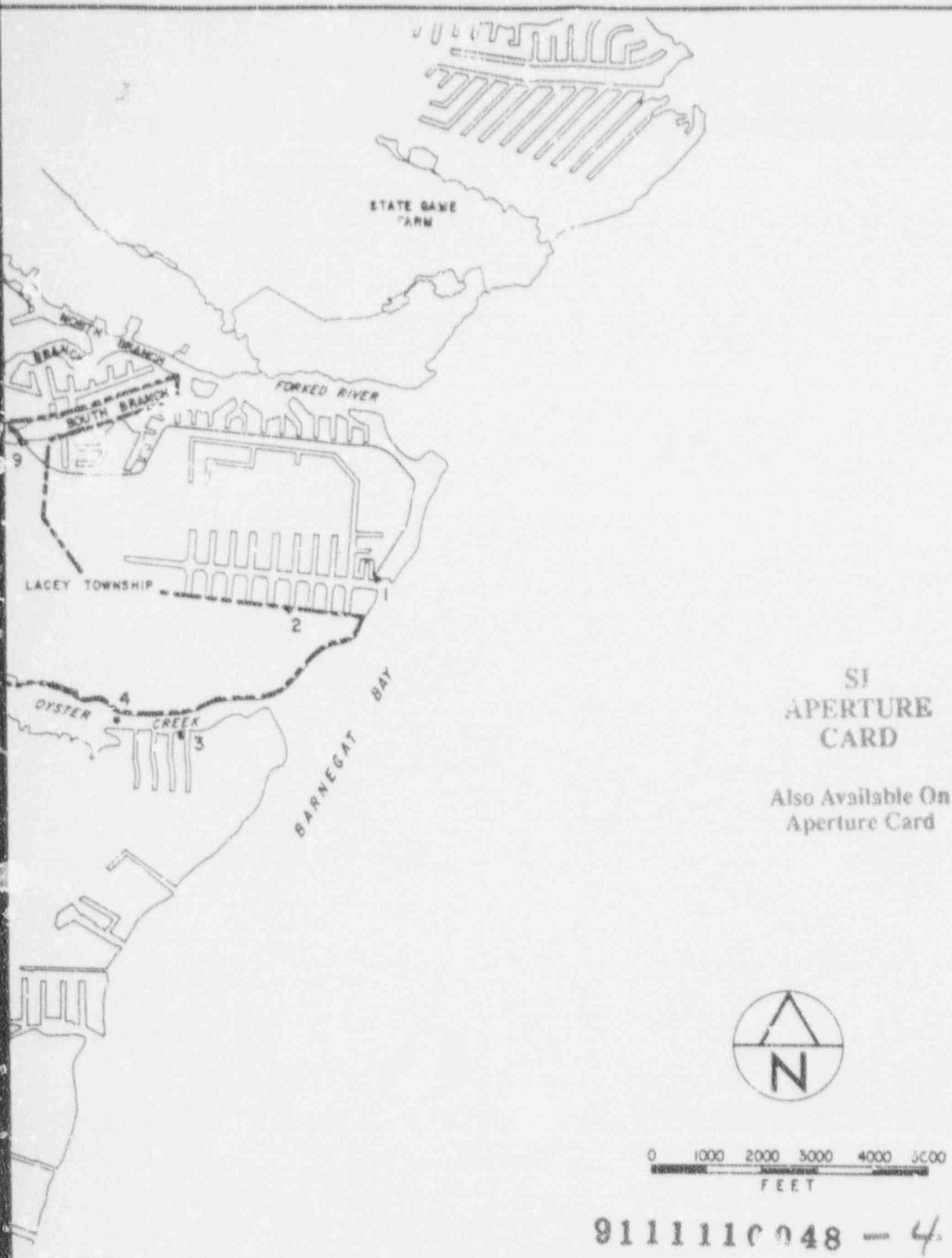
LOCATION No 5 - VIEW FROM NANTUCKET AND BERMUDA DRIVES



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	MAP FOR FAN-AS
EBASCO SERVICES INCORPORATED New York	



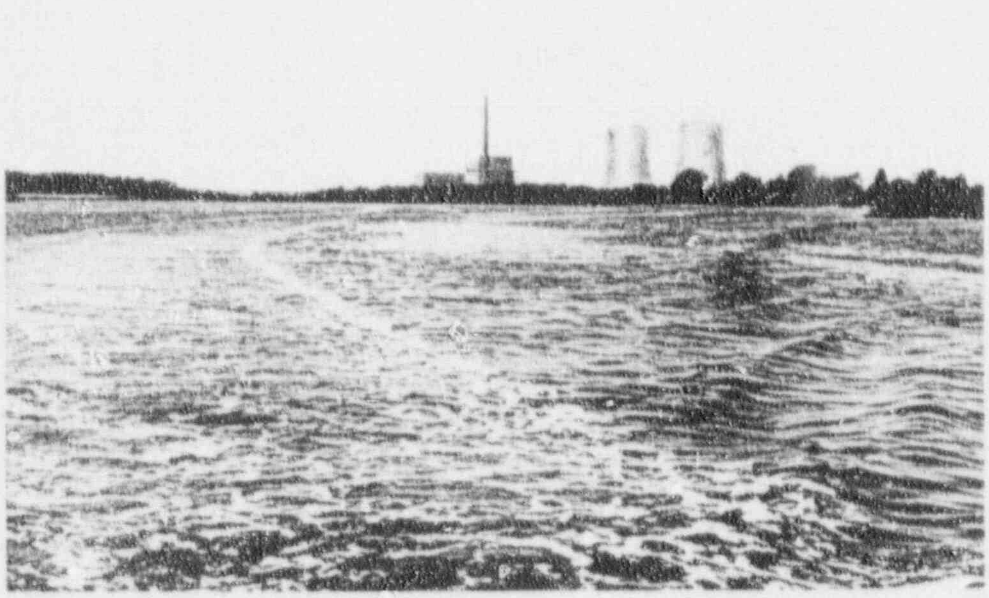
OF PHOTOGRAPH LOCATIONS VISUAL/ESTHETIC ANALYSIS SSISTED N. D. COOLING TOWERS	EXHIBIT 139

LOCATION No. 1 - VIEW FROM RESIDENCE AT BEACH BLVD. AND BINNACLE PT.

LOCATION No. 2 - VIEW FROM RESIDENCE AT ORLANDO DRIVE AND PENGUIN CT.

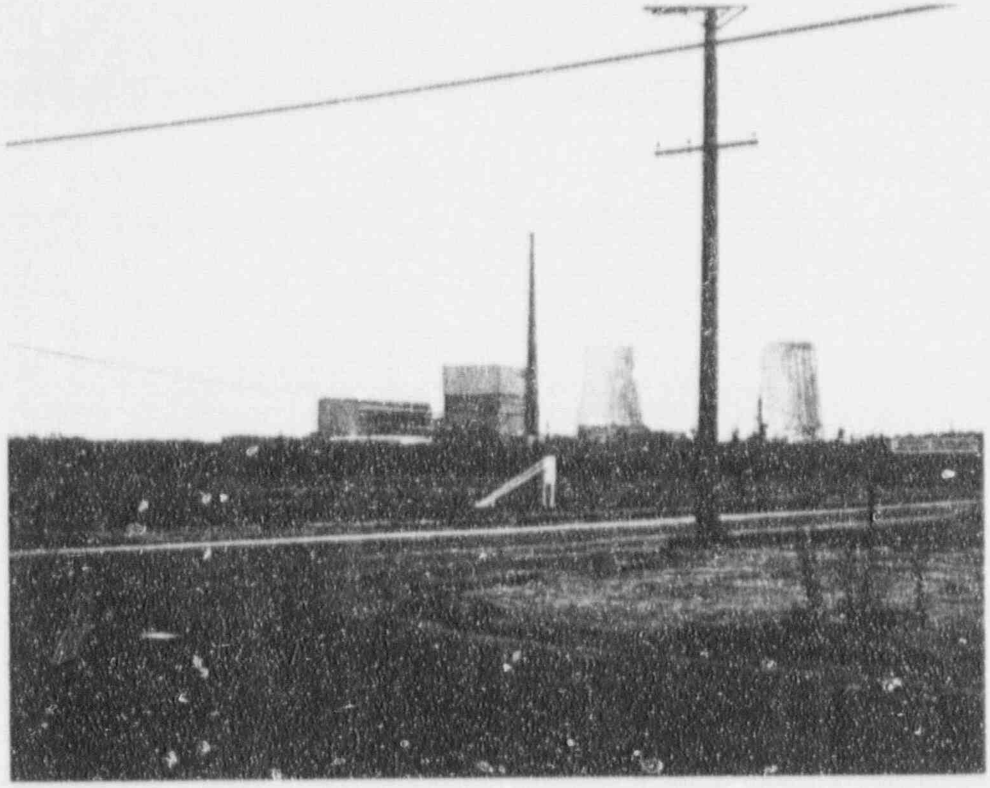
JERSEY CENTRAL POWER & LIGHT COMPANY EBASCO SERVICES INCORPORATED New York	PHOTOGRAPHIC ANALYSIS - FAN-ASSISTED NATURAL DRAFT COOLING TOWERS VISUAL ASSESSMENT	EXHIBIT 140

LOCATION No. 3 - VIEW FROM LAST RESIDENCE ON COMPASS RD.-
LOOKING ACROSS OYSTER CREEK

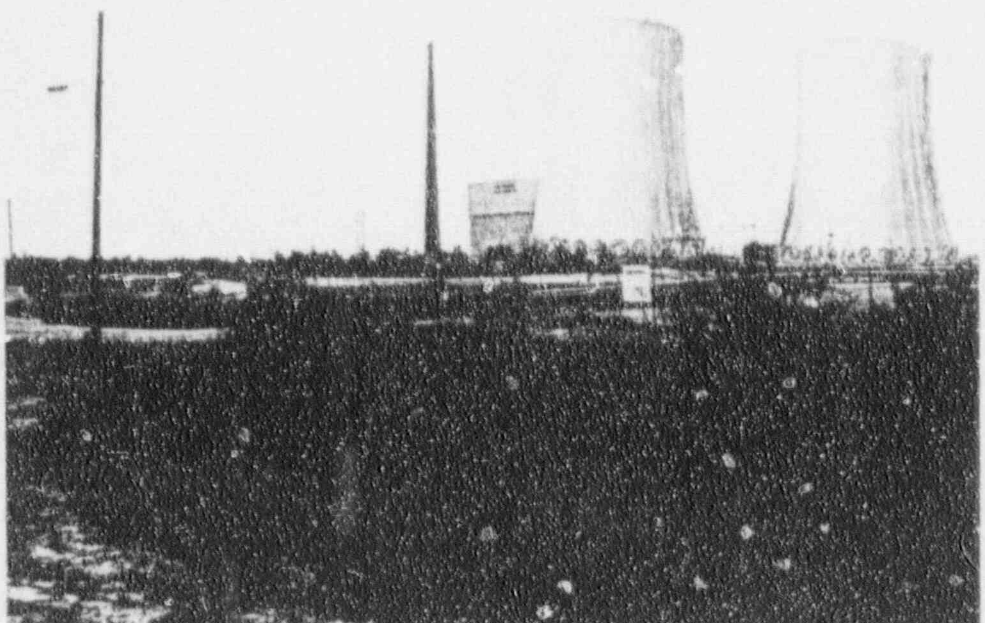


LOCATION No. 4 - VIEW TAKEN FROM A BOAT IN OYSTER CREEK-
LOOKING WEST

JERSEY CENTRAL POWER & LIGHT COMPANY	PHOTOGRAPHIC ANALYSIS - FAN-ASSISTED NATURAL DRAFT COOLING TOWERS VISUAL ASSESSMENT	EXHIBIT
EBASCO SERVICES INCORPORATED New York		141



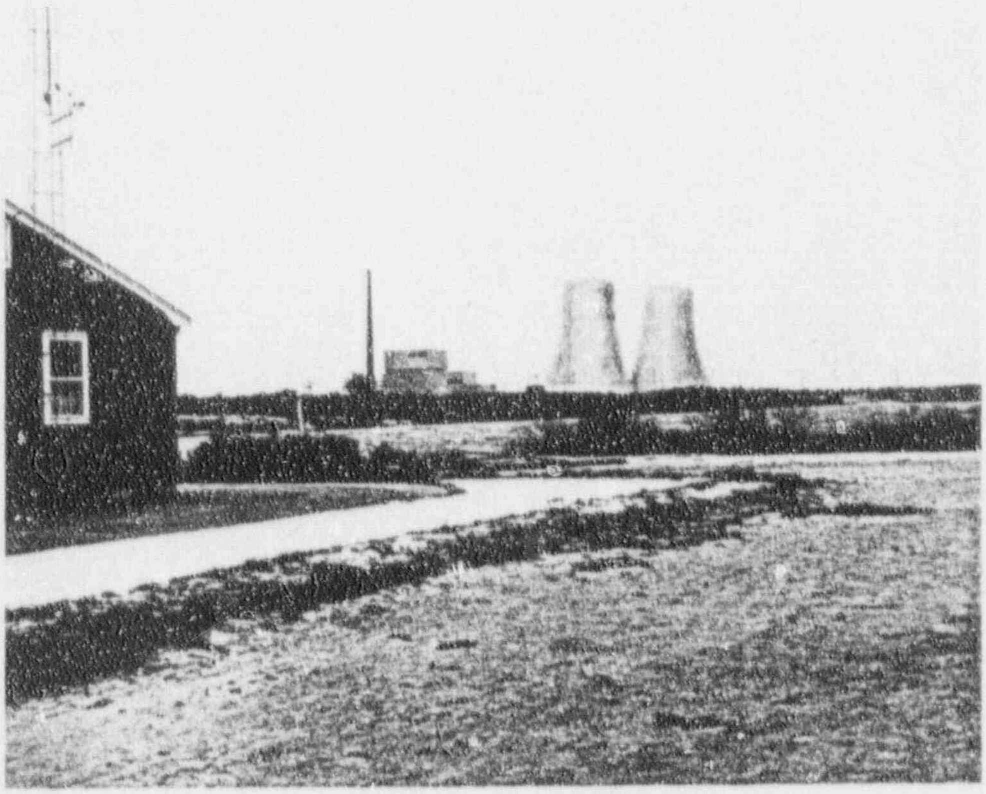
LOCATION No. 5 - VIEW TAKEN FROM NE CORNER OF BAY PARKWAY AND ROUTE 9



LOCATION No. 6 - VIEW FROM ROUTE 9 AT ABOUT 4/10 THS. MILE NORTH OF EX. PLANT

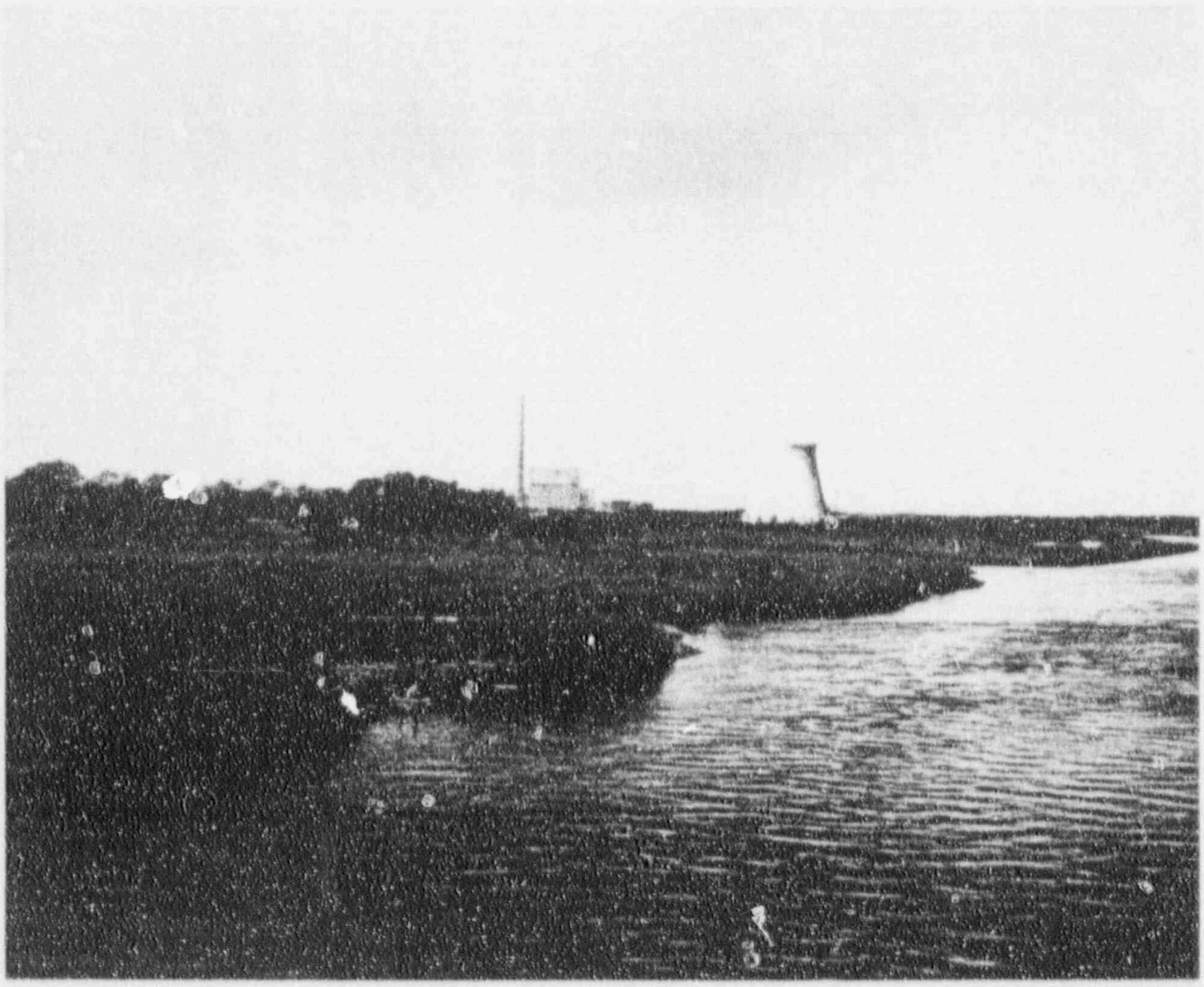
JERSEY CENTRAL POWER & LIGHT COMPANY EBASCO SERVICES INCORPORATED New York	PHOTOGRAPHIC ANALYSIS – FAN-ASSISTED NATURAL DRAFT COOLING TOWERS VISUAL ASSESSMENT	EXHIBIT 142

LOCATION No. 7 - VIEW FROM BACKYARD OF RESIDENCE AT NANTUCKET RD. AND BISCAYNE DR.



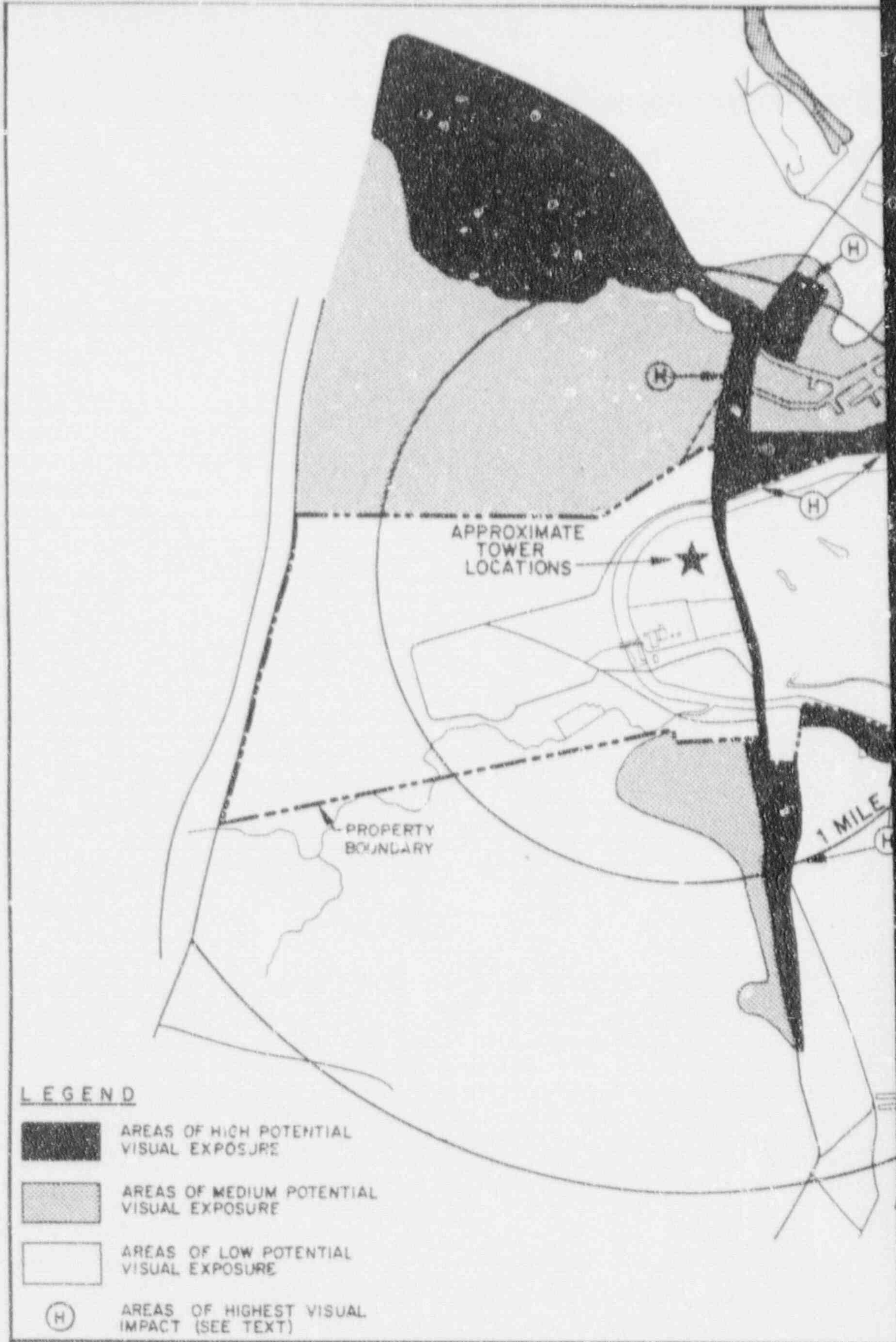
LOCATION No. 8 - VIEW FROM NANTUCKET AND BERMUDA DRIVES

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

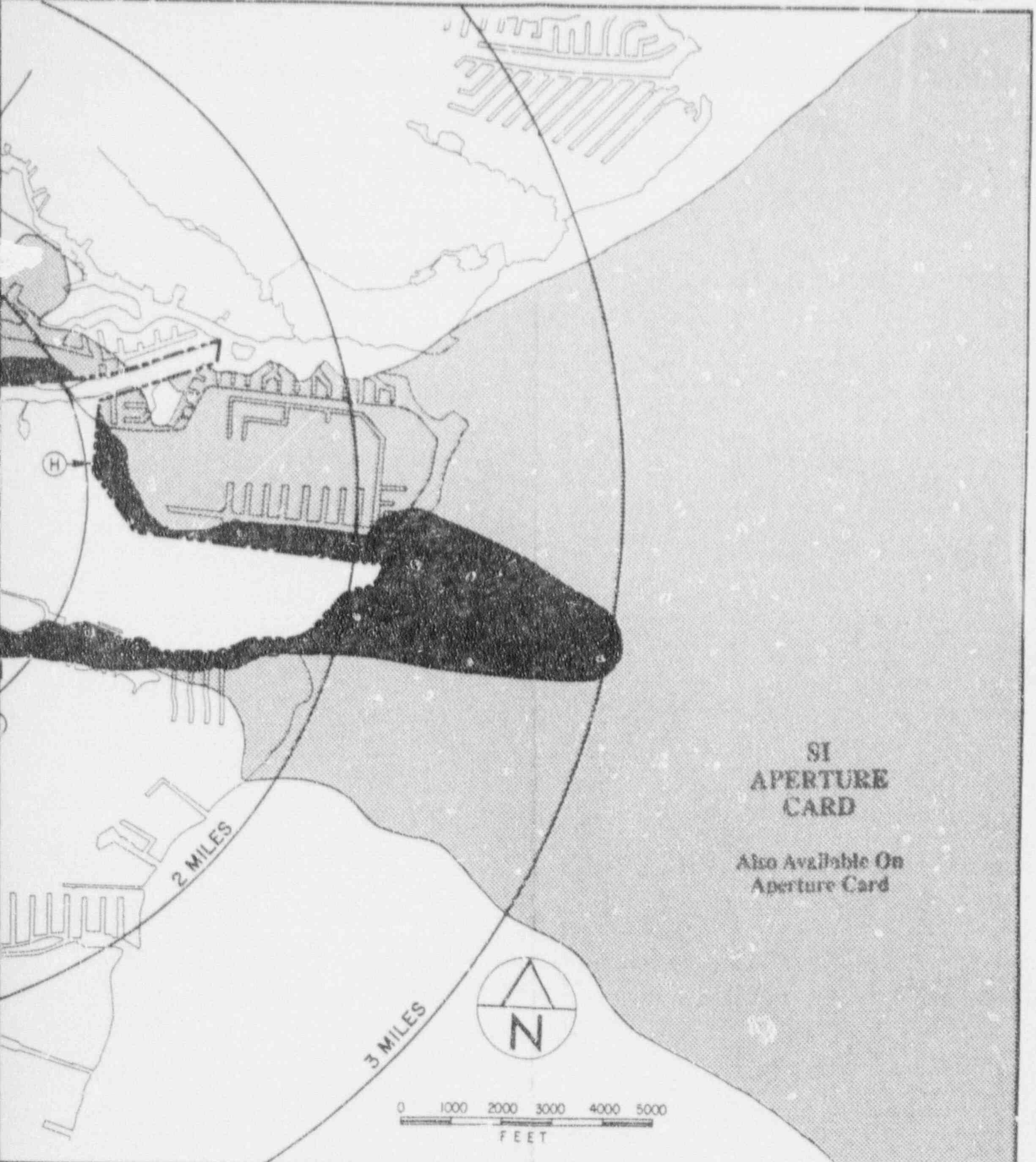
JERSEY CENTRAL POWER & LIGHT COMPANY EBASCO SERVICES INCORPORATED New York	PHOTOGRAPHIC ANALYSIS - FAN-ASSISTED NATURAL DRAFT COOLING TOWERS VISUAL ASSESSMENT	EXHIBIT 144



JERSEY CENTRAL POWER & LIGHT COMPANY

EBASCO SERVICES INCORPORATED
New York

ARE



AS OF POTENTIAL VISUAL EXPOSURE
TO POWER PLANT ELEMENTS

EXHIBIT
145

9111110048 -48

COMPARISON OF THE FOUR SPE

Species	Mode of Larval Development	Distribution in Barnegat Barnegat Bay	Tolerances: Adult: Salinity	Tolerances: Adult: Temperature	La... Gel...
Bankia gouldi	oviparous (T&J)	Most abundant species found throughout Barnegat Bay (T3)	10-35 ppt (T4); 9-30 ppt (S&T)	5-33 C (T4)	Sensi
Teredo navalis	larviparous (T&J)	Baywide, most common along eastern portion of bay where Gelbstoff in low conc. (T3)	5-32 ppt (B)	2-35 C (B)	Highl tive limit disper by pr settl
Teredo furcifera	larviparous (T&J)	Manihawkin area, Sedge Island, Oyster Creek, Forked River	(H,T&R;R,R,B&H(a);R,R,B&H(b);R,R,B		
Teredo bartschi	larviparous (C&K)	Oyster Creek only	(H,T&R;R,R,B&H(a);R,R,B&H(b);R,R,B		

Exhibit Source: Masnik (197)

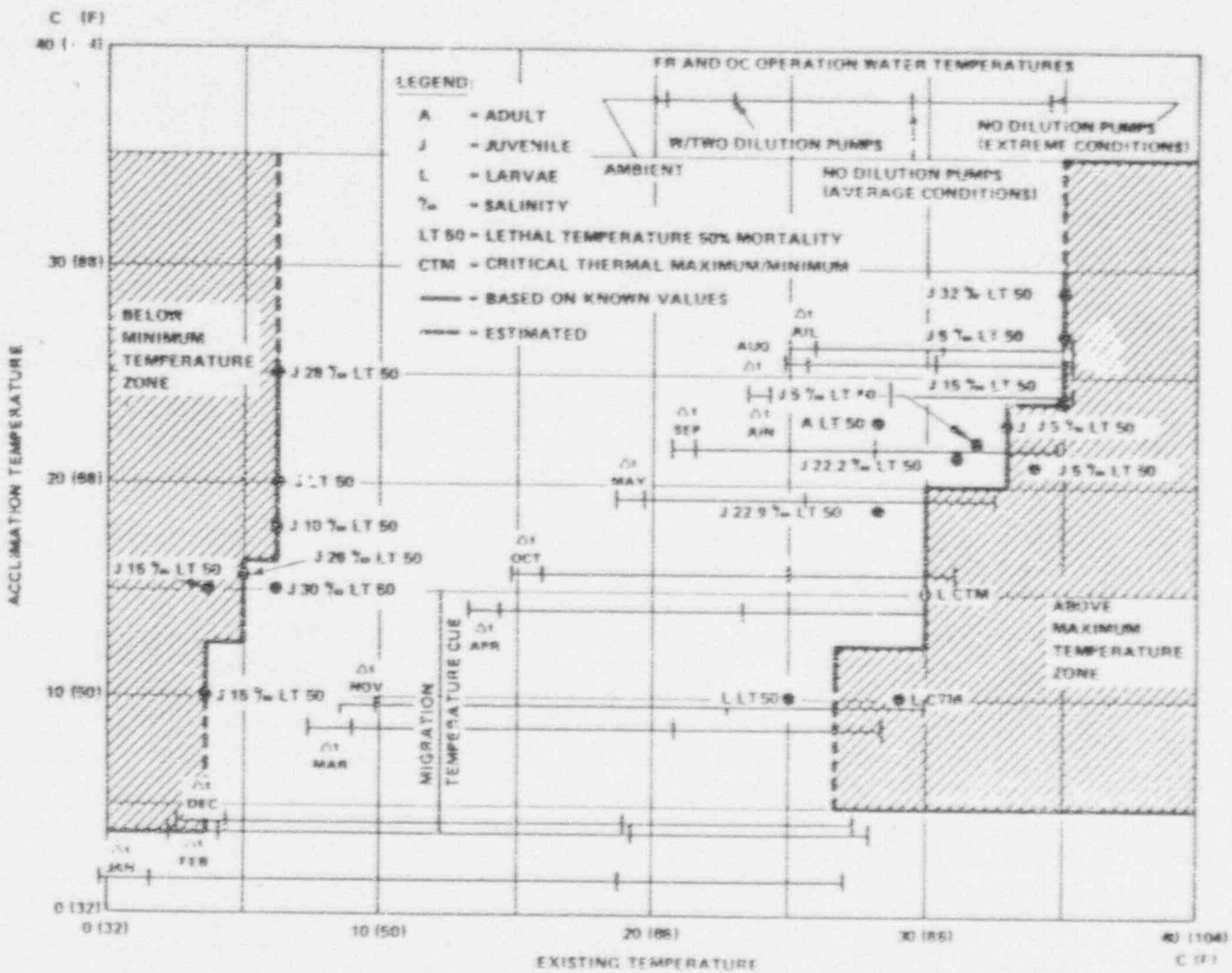
Sources: T&J: Turner and Johnson, 1971.
C&K: Clapp and Kenk, 1963.
T3: Turner, 1973.
H,T&R: Hoagland, Turner and Rochester (no date).
R,R,B&H(a): Richards, Rehm, Bellmore and Hillman, 1976a.
R,R,B&H(b): Richards, Rehm, Bellmore and Hillman, 1976b.
R,R,B&H(c): Richards, Rehm, Bellmore and Hillman, 1976c.

Exhibit 146

CIES OF TEREDINIDS KNOWN FROM BARNEGAT BAY

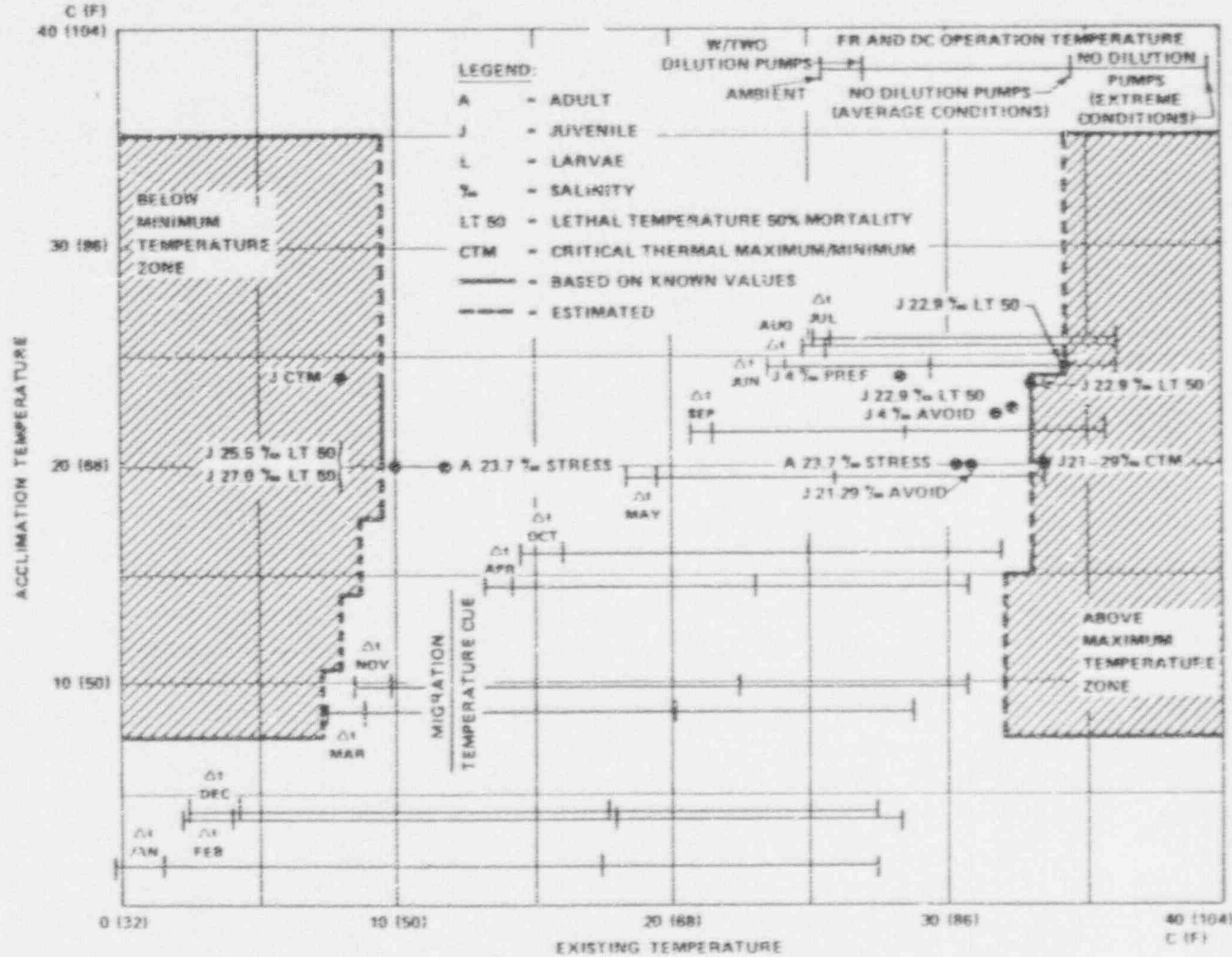
rvae ponse to stoff	Spawning	Development: Egg to Pediveliger Stage Planktonic Period	Salinity Optimum Growth	Temperature Greatest Settlement	Time from Settlement to Sexual Maturity	Generation Time
ive (C)	17.5-30 C at 30 ppt salinity (T4)	25 days @ 25 C 30 ppt salinity (T4)	Does well above 19 ppt, tolerates 10-35 ppt (T4)	24-27 C (R&N)	33 days at 22-25 C and 30 ppt salinity (T4)	2-3 months (T4)
sensi- nd may larval sion mature ng (C)	Young released at 13-30 C (B)	About 15 days at 25 C and 30 ppt salinity (T4)	Does well above 15 ppt, tolerated 10-32 ppt (T4)		33 days at 22-25 C (T4), 24 days at 27-30 C (P)	2-3 months (T4)
H (c)'		Up to 22 days (T&J)				
H (c)		Short ≈ 4 days (T&J)				

T4: Turner, 1974.
S&T: Scheltema and Truitt, 1954.
B: Blum, 1923.
C: Culliney, 1973.
R&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 Temp (°C)	Fish Stage	Salinity	Publ Source	Temperature Limits (C) High	Temperature Limits (C) Low
29	J	32	(L&H)	34.8 LT_{50}	
28					
27.2	J	3.2	(M&G)	32.2 Avoid temp	
27	J	5	(L&H)	35.0 LT_{50}	
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 LT_{50}
24	J	15	(L&H)	35.0 LT_{50}	
23	J	5	(L&H)	33.0 LT_{50}	
22.9	A		(P)	28.3 LT_{50}	
22.2	J	4	(M&G)	28.3 Avoid temp	
22	J	5	(L&H)	31.9 LT_{50}	
21.6	J	22.2	(P)	31.1 LT_{50}	
21.1	J	1	(M&G)	30.0 Avoid temp	
21	J	5	(L&H)	34.0 LT_{50}	
20.6	J	4	(M&G)	25.6 Avoid temp	
20	J	29	(W)		10.0 LT_{50}
19	J	22.9	(P)	28.2 LT_{50}	
18	J	10	(L&H)		6.0 LT_{50}
17					
16	J	26	(L&H)		5.0 LT_{50}
15	L		(H)	29.7	
	J	30	(L&H)		6.0 LT_{50}
	J	15	(L)		4.0 LT_{50}
	J	25.5	(W)		7.0 LT_{50}
14					
13					
12					
11					
10	J	15	(L)		4.0 LT_{50}
	L		(H)	25.0 LT_{50} 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 Temp (°C)	Fish Stage	Salinity	Publ Source	Temperature Limits (C) High	Low
29					
28					
27					
26					
25					
24.2	J	22.9	(P)	34.2 LT_{50}	
24	J		(M)		7.9 CTM
23.9	J	4	(M&G)	28.3 pref temp	
23.7	J	22.9	(P)	33.1 LT_{50}	
23					
22.5	J	22.9	(P)	32.3 LT_{50}	
22.2	J	4	(M&G)	31.7 Avoid temp	
22					
21					
20	A	23.7	(O&S)	(30.4 Stress)	(11.9 Stress)
	J	25.5	(W)		10.0 LT_{50}
	J	27	(W)	30.7 Avoid temp	10.0 LT_{50}
	J	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

LT_{50} = 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

Common Name	Scientific Name
Atlantic menhaden	*Brevoortia tyrannus*
Bay anchovy	*Anchoa mitchilli*
Atlantic silversides	*Menidia menidia*
Threespine stickleback	*Gasterosteus aculeatus*
Northern pipefish	*Syngnathus floridae*
Striped bass	*Morone saxatilis*
Bluefish	*Pomatomus saltatrix*
Weakfish	*Cynoscion regalis*
Northern kingfish	*Menticirrhus saxatilis*
Sand lance	*Ammodytes* sp.
Summer flounder	*Paralichthyes dentatus*
Winter flounder	*Pseudopleuronectes americanus*
Northern puffer	*Sphoeroides maculatus*

INVERTEBRATES

Common Name	Scientific Name
Shipworms	*Teredo navalis*
	Bankia gouldi
Cherrystone	*Mercenaria mercenaria*
Blue crab	*Callinectes sapidus*
Opossum shrimp (Mysids)	*Neomysis americana*
Sand shrimp	*Crangon septemspinosa*
Arrowworms	*Sagitta elegans*

SPECIES COM

Month	T-FR	S-FR	GN-FR	T-D
May	0	0	0	.0
June	.17	1.23	17.78	0
July	0	.39	4.00	.3
August	0	0	17.95	0
May	40.99	42.66	0	68.5
June	55.97	50.74	0	64.9
July	79.61	22.57	0	[illegible]
August	59.75	16.61	0	69.8
May	0	12.39	0	.2
June	0	24.02	0	0
July	.10	41.60	0	0
August	1.40	27.56	0	0
May	1.56	3.67	0	.6
June	.84	.49	0	2.6
July	.14	.26	0	0
August	.98	0	0	.6
May	.14	13.76	0	0
June	21.51	12.75	0	2.0
July	14.24	5.91	12.00	33.9
August	20.06	4.59	23.08	19.2
May	0	0	0	.0
June	0	0	0	2.0
July	0	.26	0	.1
August	.42	0	0	.2
May	28.79	6.88	0	25.7
June	5.38	0	0	15.7
July	.37	1.57	0	0
August	1.12	0	0	.2
May	28.09	20.64	7.69	4.5
June	15.80	10.29	35.56	12.1
July	4.19	8.92	72.00	8.7
August	11.08	43.11	41.03	7.6

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 Mou

- DP = Dilution Pumps
- IMP = Impingement Collections

Exhibit 152

POSITION (%) OF HAULS BY VARIOUS GEAR TYPES & LOCATIONS (1976)

	S-OC	GN-OC	T-IBW	S-BBW	T-BBCR	S-BBCR	BN-BBCR	DD	IMP
		Atlantic Menhaden							
7	0	0	0	0	0	0	79.37	1.43	.05
	0	75.00	0	0	0	0	61.64	1.73	.03
0	0	14.29	0	0	0	0	46.82	2.35	.43
	0	17.65	0	0	.62	0	26.35	1.99	.11
		Bay Anchovy							
7	8.37	0	94.03	57.22	91.15	0	0	59.66	27.08
9	41.43	0	95.61	79.03	80.16	2.33	0	6.71	1.64
4	7.87	0	91.09	24.03	87.17	5.54	0	.21	.57
0	7.63	0	75.84	30.76	85.21	13.47	0	0	1.08
		Atlantic Silverside							
2	41.87	0	.58	15.75	.55	40.48	0	.13	.21
	17.35	0	0	6.20	0	81.40	0	.22	.02
	57.69	0	0	46.75	.18	81.03	0	0	0
	22.76	0	0	39.88	2.11	25.60	0	0	0
		Northern Pipefish							
5	0	0	.58	2.62	.55	7.22	0	.13	.15
7	.41	0	.48	1.77	.26	0	0	0	.10
	.35	0	0	1.30	.27	.96	0	0	.04
6	0	0	0	2.20	.26	.17	0	0	.01
		Spot							
	2.46	0	0	.79	0	0	0	0	0
8	9.59	0	.81	6.35	8.78	3.94	0	11.47	1.60
8	13.99	10.71	4.46	14.55	6.37	2.87	25.91	20.58	.04
	1.71	29.41	8.72	2.00	2.64	2.13	16.97	10.61	.50
		Winter Flounder							
7	6.40	0	0	0	0	0	0	.65	.01
8	2.04	0	0	0	.18	.52	0	0	.08
5	1.75	0	.58	0	.18	.57	0	.11	.01
2	.66	0	2.01	.20	1.14	1.73	0	0	.01
		Sand Shrimp							
9	14.78	0	2.39	9.97	3.17	6.19	0	2.08	43.63
3	1.63	0	.81	1.03	.18	0	0	.43	16.42
	.52	0	0	.65	.27	.48	0	0	.25
2	47.76	0	0	12.02	1.23	24.53	0	0	0
		Blue Crab							
5	26.11	66.67	1.93	12.34	3.17	23.71	5.76	32.81	26.29
7	27.55	0	2.09	5.61	6.15	9.04	36.30	74.89	73.08
2	16.61	71.43	3.88	11.95	4.19	6.00	21.36	68.02	96.74
6	18.82	29.41	6.71	11.02	4.67	25.87	28.89	82.26	95.73

ns

EXHIBIT 153

POTENTIALLY INJURIOUS AIRBORNE SALT CONCENTRATIONS AND DEPOSITION RATES

- Threshold For Development of Toxic Soil Salinity *

THRESHOLD LEVEL	SOURCE	COMMENT
56,000 kg/km^2 Annual Average (4,670 kg/km^3/month)	University of Maryland (cited in John Hopkins University, 1972)	Conclusion derived from literature review, refers to soils of Chalk Point

- Thresholds For Occurrence of Direct Injury to Vegetation*

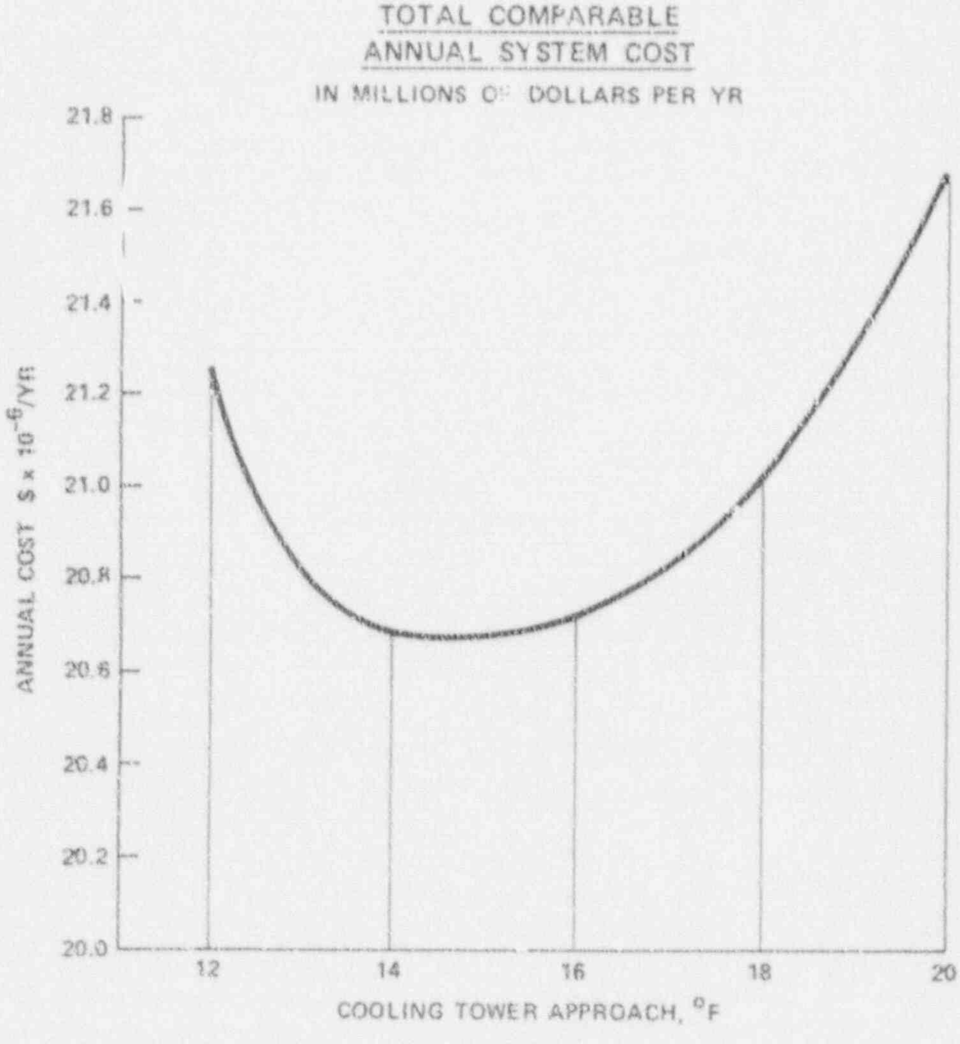
THRESHOLD LEVEL	SOURCE	COMMENT
Short-term Levels		
Less than 60 ug/m^3 for Several Hours	Rutgers University (Moser and Swain, 1971)	Level not likely to cause injury; suggested by B Moser, based primarily on one season's observations at Island Beach State Park (NJ)
100 ug/m^3 for Several Hours	Rutgers University (Moser and Swain, 1971)	Level at which injury to sensitive spp would be expected
387 kg/km^2 for 1 Hour	McCune et al., 1974	Occurrence of foliar lesions on bush bean growing under laboratory conditions
Monthly and Annual Levels		
40 ug/m^3/month	Rutgers University (Moser and Swain, 1971)	No visible injury observed on vegetation of Island Beach State Park, when summer month concentrations averaged this level (80 ug/m^3 at surf, 14 ug/m^3 at leaward side of island)

EXHIBIT 153
(Cont'd)

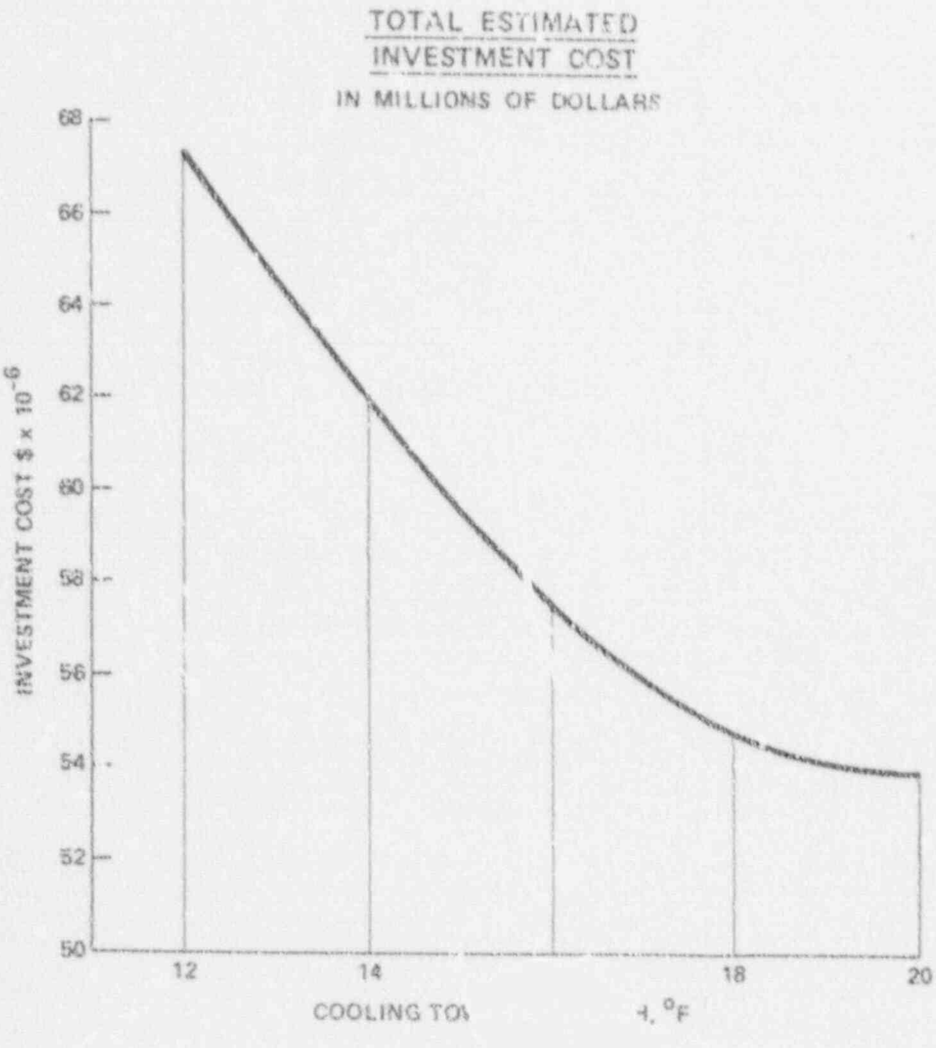
THRESHOLD LEVEL	SOURCE	COMMENT
3200 kg/km^2/month	Mulchi and Armbruster, 1975	Significant decrease in yield of soybean and corn, growing under field conditions after weekly application of spray solution for 8 weeks; corn may be effected at lower rates.
13,200 kg/km^2 Annual Average (1100 kg/km^2/month)	University of Maryland (cited in John Hopkins 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
OYSTER CREEK NUCLEAR GI
ALTERNATIVE COOLING WA
NATURAL DRAFT COOLIN
ECONOMICS FOR BEST CASES VERSUS



& LIGHT COMPANY
ENERATING STATION
ATER SYSTEM STUDY
G TOWER SYSTEM
S COOLING TOWER APPROACH



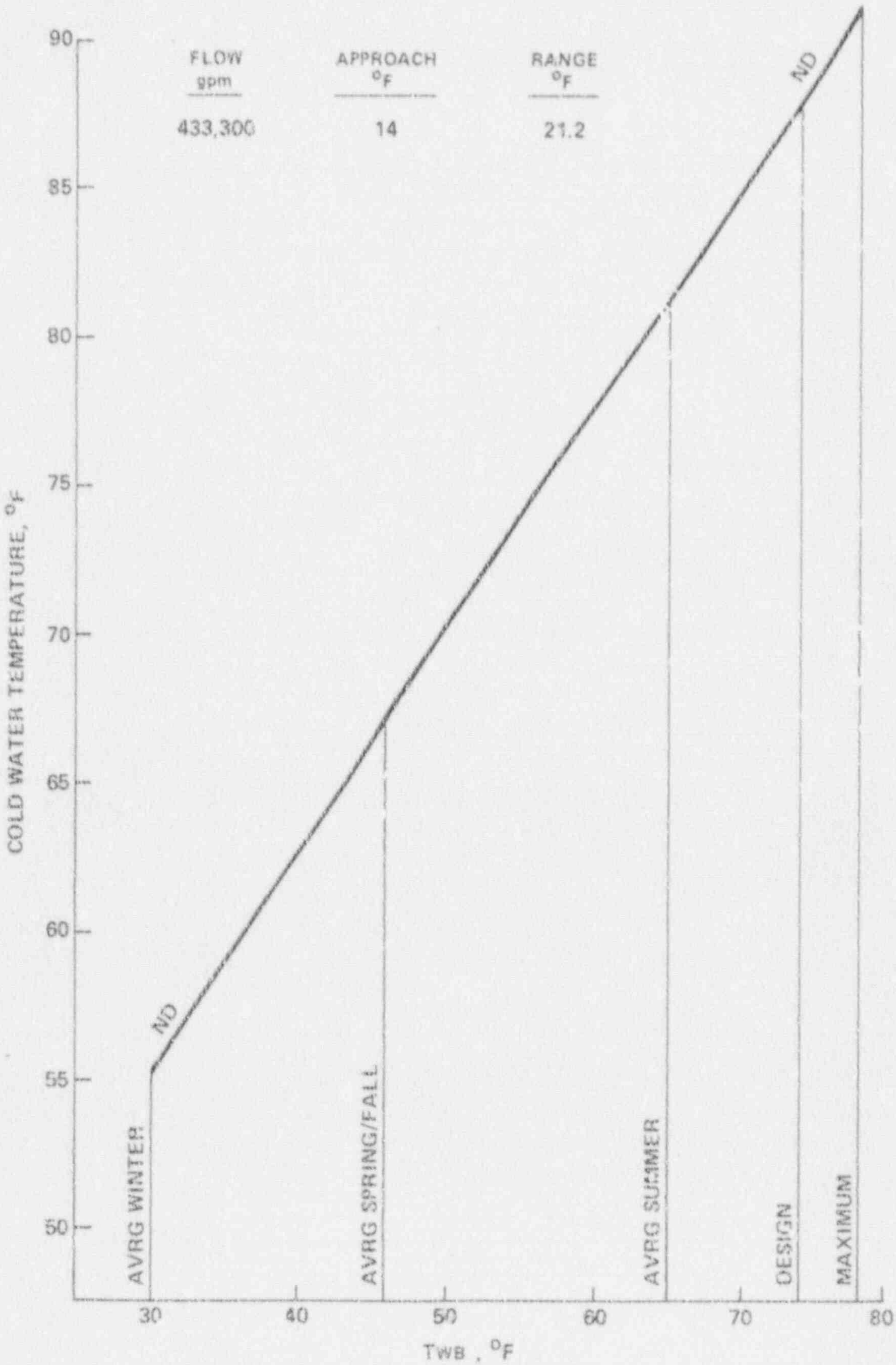
SI
APERTURE
CARD

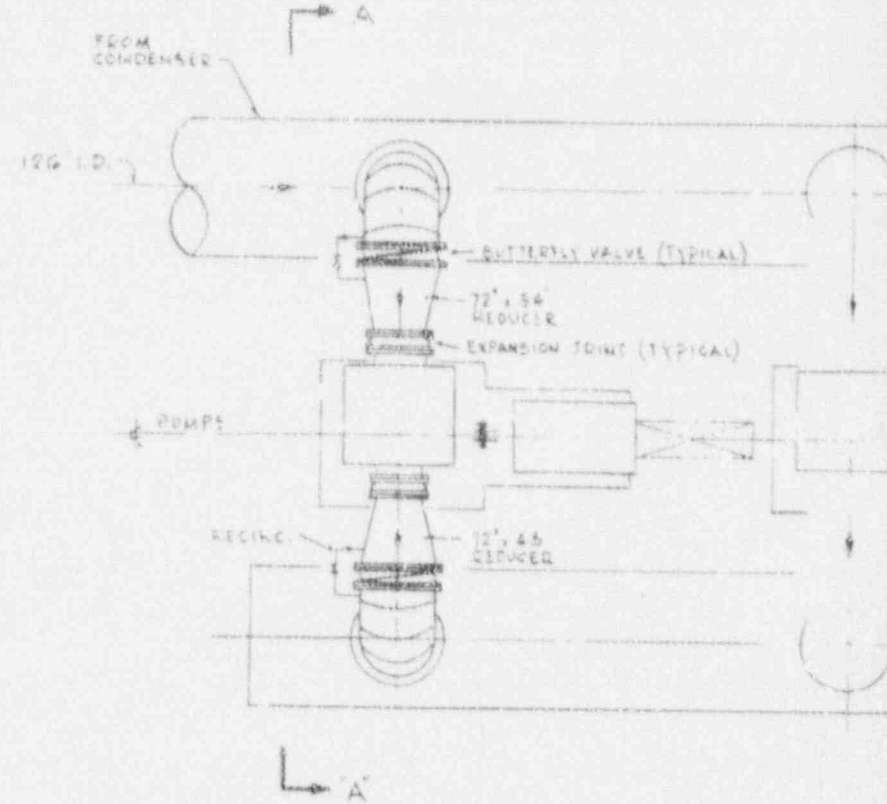
Also Available On
Aperture Card

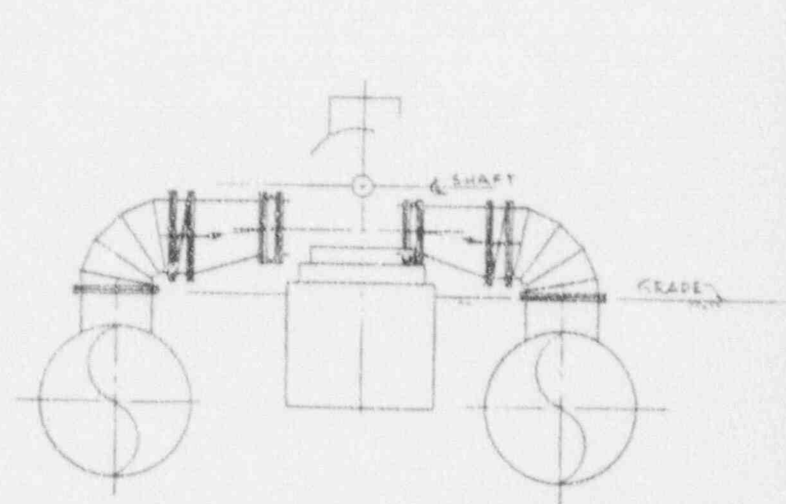
EXHIBIT 154

9111110048 - 51

JCP&L OYSTER CREEK NGS
NATURAL DRAFT COOLING TOWER THERMAL PERFORMANCE AT FULL LOAD OPERATION

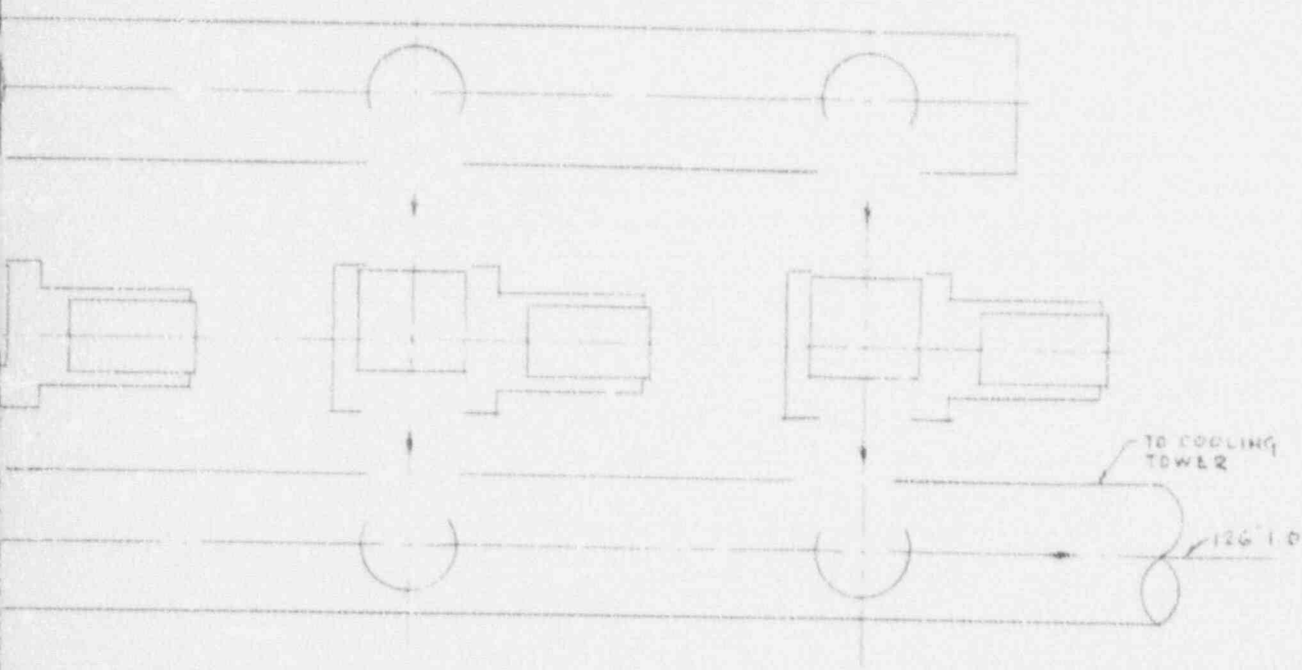






SECTION "A-A"

TYPICAL FOR FOUR PUMPS



PLAN

SCALE 1"=10'-0

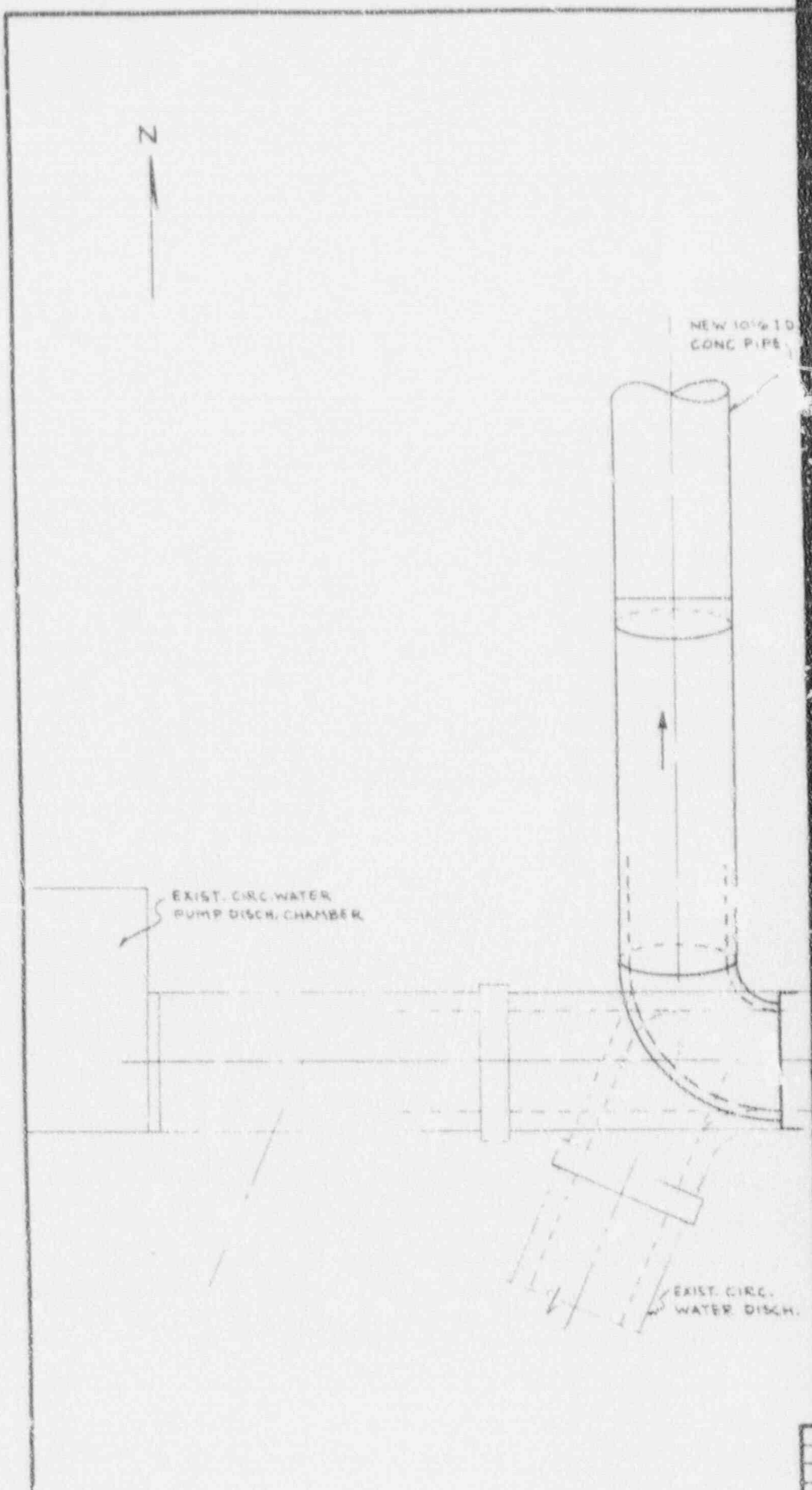
SI APERTURE CARD

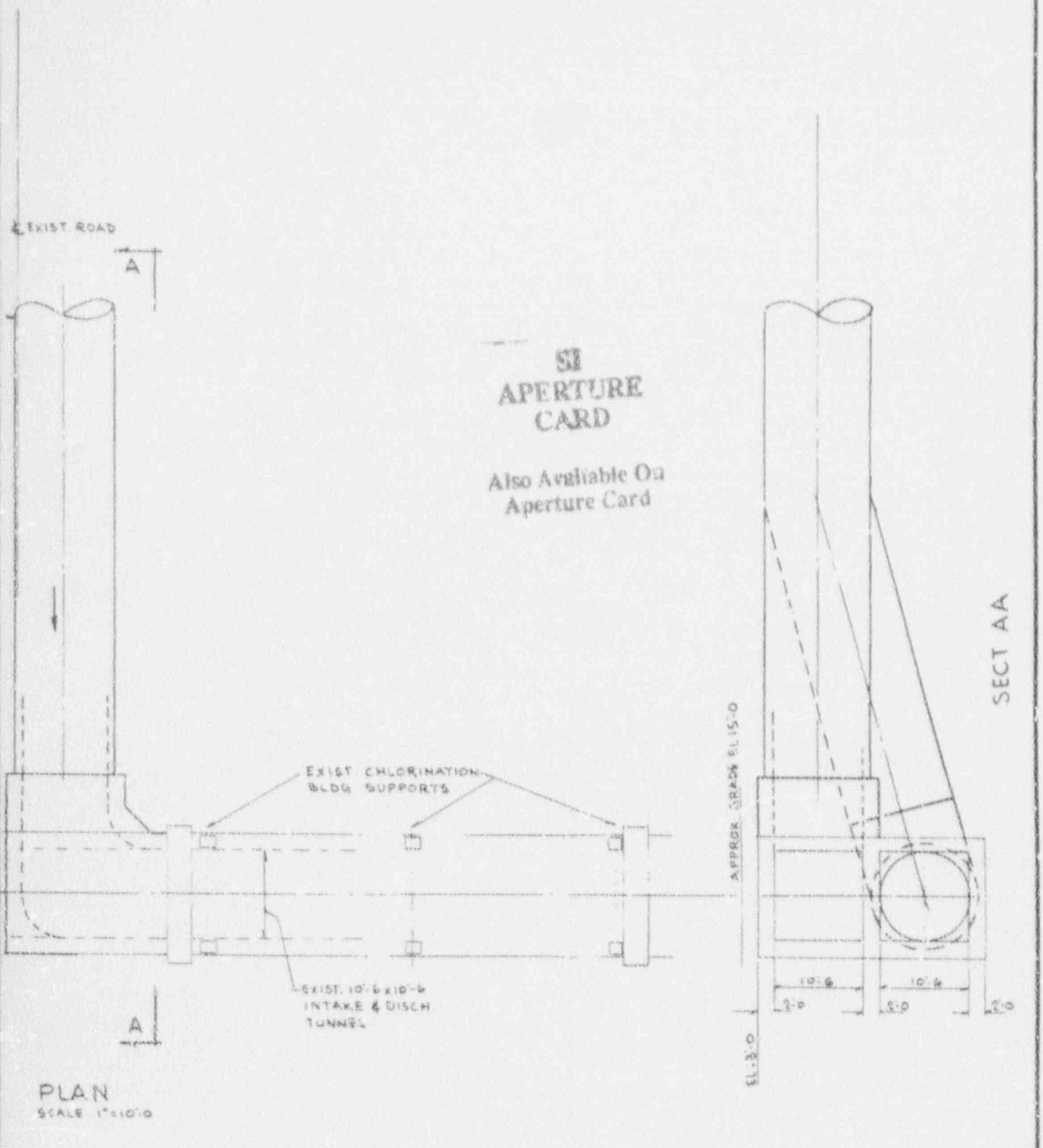
Also Available On Aperture Card

EBASCO SERVICES INCORPORATED	JERSEY CENTRAL POWER & LIGHT OYSTER CREEK NUCLEAR GENERATING STATION ALTERNATIVE COOLING WATER SYSTEM STUDY CIRC. WATER BOOSTER PUMP ARRANGEMENT	EXHIBIT 156
DIV. MECH. DR. RHP CH. DATE	APPROVED	

DATE	BY	APPROVED

9111110048 -52


N
CONC PIPE
EXIST. CIRC. WATER
PUMP DISCH. CHAMBER
EXIST. CIRC.
WATER DISCH.



EBASCO SERVICES INCORPORATED		JERSEY CENTRAL POWER & LIGHT OYSTER CREEK NUCLEAR GENERATING STATION ALTERNATIVE COOLING WATER SYSTEM STUDY INTERCONNECTION TO EXISTING CIRC. WATER SYSTEM
DIV MECH DR L.M.O CH DATE	APPROVED	EXHIBIT 157

DATE	BY	APPROVED

JERSEY CENTRAL PO[W
OYSTER CREEK NUCLE[A
ONE NATURAL DR[A
ENGINEERING & CON[

MONTHS:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
I ENGINEERING																
A – COOLING TOWER																
B – CIRCULATING WATER PUMPS																
C – TUBE CLEANING SYSTEM AMERTAP																
D – CONCRETE HYDRAULIC																
E – MECHANICAL																
F – ELECTRICAL & I&C																
II CONSTRUCTION																
A – SITE PREPARATION, PILE DRIVING, GRADING & ROADS																
B – PRECAST SHELL COLUMNS																
C – POUR RING FOOTINGS & PLINTHS																
D – SHELL COLUMN ERECTION																
E – SHELL CONSTRUCTION																
F – BASIN POUR																
G – INTAKE STRUCTURE																
H – FILL STRUCTURE ERECTION																
I – INTERNALS INSTALLATION																
J – BOOSTER PUMP FOUNDATIONS																
K – MECHANICAL & ELECTRICAL EQUIPMENT INSTALLATION																
L – TUBE CLEANING SYSTEM (AMERTAP)																
M – CONDUIT, CABLE & WIRING INSTALLATION																
N – PIPING INSTALLATION																
O – PREPARATION WORK FOR OUTAGE																
P – OUTAGE – FINAL PIPE CONNECTIONS																

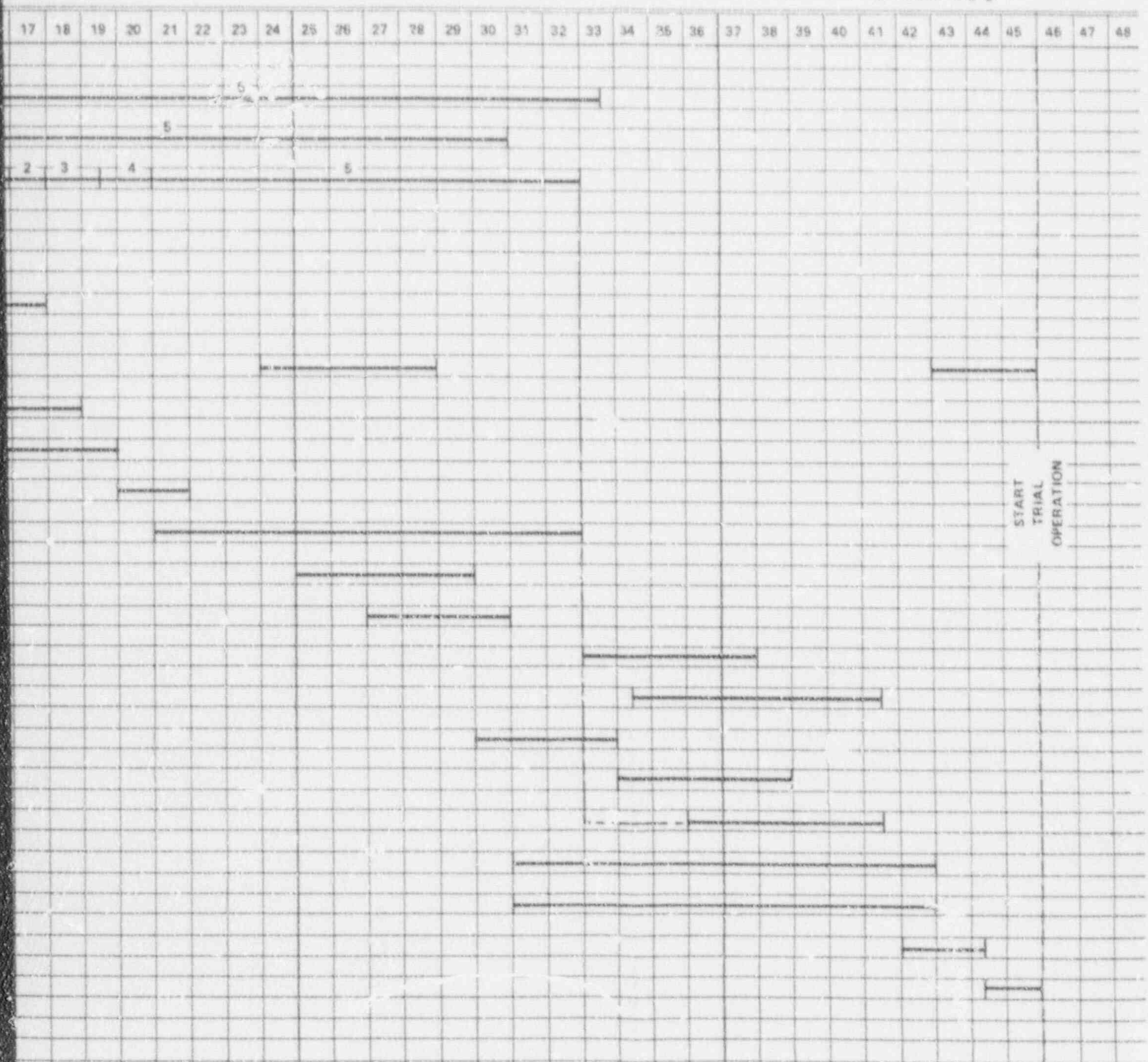
LEGEND:
1 – ENGINEERING
2 – SPECIFICATION
3 – BID PROPOSAL
4 – EVALUATE & PURCHASE
5 – DESIGN & FABRICATE

WER & LIGHT COMPANY
AR GENERATING STATION
AFT COOLING TOWER
STRUCTION SCHEDULE

SI
APERTURE
CARD

Also Available On
Aperture Card

EXHIBIT 15 8



9111110048 -54

E B A S C O S E

THE FOLLOWING APPLIES TO ALL CONDENSING SYSTEM

UNIT: BASED ON GE-TC6F-38"LSB RATED 6__MW * 1

CONDENSER:
 TUBE MATERIAL TIT
 TUBE GAUGE
 TUBE CLEANLINESS FACTOR 0.
 SINGLE OR MULTI BACK PRESSURE SIN
 NO. OF CONDENSER SHELLS

 NO. OF PUMPS
 TYPE OF PUMPS VE

ECONOMIC FACTORS
 RATE OF RETURN (%) 0
 FIXED CHARGE RATE (%) 22

TYPE OF COOLING
 DESIGN WET BULB
 DESIGN DRY BULB
 DESIGN APPROACH

USER'S SELECTED
 MAX. CONDENSER
 MAX. TEMPERATUR

CASES NUMBERED , TO 1
PLUS OR MINUS 0.25 IN

THE OTHER CASES ARE W
OF THE FOLLOWING AVER

AVERAGE DESIGN BACK PRESSURE
2.50
3.00
3.50
4.00
4.50

CASES NUMBERED 6001 T
AND TUBE VELOCITY FOR
COST INCLUDING CAPABI

*** FOR ZERO RATE OF RETURN IF MORE THA
ANNUAL FUEL COST IS THE AVERAGE OF ALL

CASES:

.0"HGA

	SELECTED BASE FOR COOLING SYSTEM DIFFERENTIAL CALCULATIONS	
N	CONDENSER TUBE O.D. (IN)	0.875
.22	CONDENSER TUBE LENGTH (FT)	42.5
00	NO. OF CONDENSER TUBES	14562
LE	COOLING TOWER FANS KW	0
3	CIRCULATING WATER PUMPS KW	2666
	ESTIMATED AUX. POWER REQUIREMENT EXCL. CW SYSTEM	17.50
	TURBINE GENERATOR CAPABILITY (MW)	670.0
4	UNIT NET CAPABILITY (MW)	620.00
T.	CAPABILITY ADJUSTMENT ($/KW)	0.0
	UNIT NET ANNUAL GENERATION (MWH/YR)	3539729
	GENERATION ADJUSTMENT (BTU/KWH)	10400

.00
.25

YSTEM: NATURAL DRAFT COOLING TOWER SYSTEM

TEMP. (F)	74.00
TEMP. (F)	88.90
TEMP. (F)	14.00

YSTEM LIMITATIONS

ACK PRESS. (IN.HGA)	5.00
RISE (F)	25.0

00 SHOW CONDENSING SYSTEMS WITHIN A RANGE OF
HGA OF AN AVERAGE BACK PRESSURE OF 2.00 IN.HGA

THIN A RANGE OF PLUS OR MINUS 0.25 IN.HGA
GE DESIGN BACK PRESSURES:

CASES

1001 TO 2000
2001 TO 3000
3001 TO 4000
4001 TO 5000
5001 TO 6000

6075 SHOW SMALLER VARIATIONS OF SURFACE AREA
THE PREVIOUS THREE BEST CASES BASED ON ANNUAL
ITY AND GENERATION ADJUSTMENTS

ONE LINE IS FILLED IN UNDER LOADING PERIOD DATA THEN
HE YEARS' FUEL COSTS

SORT IN ASCENDING ORDER OF ANNUAL

CASE NO	ANNUAL SYSTEM COSTS WITHOUT ADJUSTMNTS	ANNUAL SYSTEM COSTS INCLUDES ADJUSTMNTS	INVESTMENT COSTS INITIAL + ESCAL	INVESTMENT COSTS TOTAL	PREFD U CON TG CAPAB (MW)
1	14409	20368	38941	60602	613.

COST INCLUDING CAPABILITY & GENERATION ADJUSTMENTS

AAP DEPT A J MUSTO 11/10/77

RMANCE AT ESIGN DITIONS	SURFACE CONDENSER AND CONDENSER TUBES							PERFORMANCE AT PEAK LOAD CONDITION WATER TEMP	
IL.	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
74	3.61	823000	21.2	423.3	5.90	43	0.875	580.92	3.86

SI APERTURE CARD

Also Available On Aperture Card

9111110048-56

SPECIFICATIONS FOR CASE NO. 1 NATURAL DRAFT C
CW INLET DESIGN TEMPERATURE (F) 88.00 PERFORM
CONDENSER TEMPERATURE RISE (F) 21.18 TG CA
TUBE DIAMETER (INCHES)/GAUGE 0.875/22 AVG C
TOTAL TUBE LENGTH (FT/SHELL) 42.50
NO. OF: TUBES PER SHELL/SHELLS 14562/3
NO. OF: TUBE PASSES/PRESS ZONES 1/1 PERFORM
TOTAL SURFACE AREA (SQ FT) 423000 TG CA
CIRCULATING WATER FLOW (GPM) 423300 AVG C
TUBE VEL. AT ABOVE CW FLOW (FPS) 5.90

AVG SFA

E S T I M A T E D I

ACCOUNT CODE	INITIAL INVESTMENT COST ITEMS
	MAJOR SITE DEVELOPMENT
1.11	LOCAL IMPROVEMENT TO SITE-CLEARING
2.1	LOCAL GRADING
2.5	PILING
3.42	INTAKE STRUCTURE
3.2	CIRCULATING WATER CONDUIT: MAIN
3.2	BRANCHES
3.32	DISCHARGE STRUCTURE
3.41	COOLING TOWER BASIN
3.44	COOLING TOWER SUPERSTRUCTURE
5.1	TG BUILDING (DIFFERENTIAL)
4.18	TG PEDESTAL (DIFFERENTIAL)
7.1	TG & ACCESSORIES (DIFFERENTIAL)
10.211	CONDENSER SHELL
10.213	CONDENSER TUBE (TITAN)
10.221	CIRCULATING WATER PUMP
15.4	CIRCULATING WATER PUMP MOTOR
14.1	INSTRUMENTATION & CONTROL
15.11	START-UP & STANDBY TRANSFORMER (DIFFERENT
15.12	UNIT AUXILIARY TRANSFORMER (DIFFERENTIAL)
15.21	CIRCULATING WATER SWITCHGEAR
15.6	WIRING FOR CIRCULATING WATER SYSTEM
15.1	UNIT MAIN POWER TRANSFORMER (DIFFERENTIAL
15.23	FAN MOTOR POWER CENTER + REQ'D SWGR & FEE

TOTAL

TOTAL DIRECT ESCALATED COST: MATERIA
INDIRECT CONSTRUCTION COST INCLUDING
CONTINGENCY (14.00% OF DIRECT PLUS I
UTILITY'S EXPENSES, INTEREST DURING

TOTAL ESTIMATED I

E S T I M A T E D C O M P A R A B L

UNIT NET CAPABILITY W/SF/S/P (MW) 627.5 620.9 59
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$)

OOLING TOWER SYSTEM | A&C DEPT A J MS10 11/10/77 PAGE 7

ANCE AT DESIGN CONDITIONS:
PABILITY (MW) 613.74
ONDENSER PRESSURE (IN.HGA) 3.61

ANCE AT MAX SUMMER TEMPERATURE
PABILITY (MW) 608.64
ONDENSER PRESSURE (IN.HGA) 3.86

SONAL COND PRESS (IN.HGA) 1.52 2.03 3.02

NO. OF COOLING TOWERS-CT	1
NO. OF CELLS PER CT	0
CT DESIGN APPROACH TEMP (F)	14.00
TOTAL CT FAN MOTOR INPUT KW	0
TOTAL CW PUMP MOTOR INPUT KW	9221
CW PUMP MOTOR RATING (HP)	3000
CW SYSTEM TDH (FT)	69.38
CW MAIN CONDUIT DIAM (FT)	10.00
NO. OF CW PUMPS	4
TOTAL DILUTION PUMP INPUT KW	1000

NITIAL INVESTMENT COST

	TODAY'S MATERIAL COST UNIT	TOTAL 1000$	TODAY'S INSTALLATION COST UNIT	TOTAL 1000$	ESCALATION 1000$ MATERIAL	INSTALLATION
	***************	4820	***************	1635	1630	767
	***************		1$/ACRE	0		0
	***************		2.50$/CU YD	103		37
	1.45$/SQ FT	209	1.00$/SQ FT	144	55	52
	4.10$/CU FT	480	10.75$/CU FT	1260	162	739
	320$/LIN FT	691	2.00$/LIN FT	487	234	286
	0.00$/LIN FT	0	.00$/LIN FT	0	0	0
	0.00$/CU FT	0	0.00$/CU FT	0	0	0
	0.80$/SQ FT	116	8.20$/SQ FT	1184	39	556
	5638031$/EACH	5638	[illegible]$/EACH	6891	2360	4044
	0.00$/CU FT	0	0.00$/CU FT	0	0	0
	0$/FT HT	0	0$/FT HT	0	0	0
	0.00$/KVA	0	0.00$/KVA	0	0	0
	0$/EACH	0	0$/EACH	0	0	0
	0.0000$/FT	0	0.0000$/FT	0	0	0
	245280$/EACH	981	24528$/EACH	98	332	58
	206375$/EACH	826	8255$/EACH	33	279	19
	2500.00$/EACH	10	1200.00$/EACH	5	3	3
IAL)	0$/MVA	0	0$/MVA	0	0	0
	6700$/MVA	49	1200$/MVA	9	17	5
	43000$/PUMP	172	18000$/PUMP	72	58	42
	23059$/MVA	236	57525$/MVA	589	80	346
)	0$/MVA	0	0$/MVA	0	0	0
DER	0$/CENTER	0	0$/CENTER	0	0	0
		14228		12510	5249	6954

PLUS 0.00% SALES/USE TAX PLUS INSTALLATION	38941
PROFESSIONAL SERVICES	6035
NDIRECT COST)	6297
CONSTRUCTION, & LAND	9330
	******
NVESTMENT COST 1000$	60602

SI
APERTURE
CARD

Also Available On
Aperture Card

E INVESTMENT & ANNUAL COSTS

		1000$/YR	MILLS/KWH
.1 580.9	CW SYSTEM FUEL COST (BASE VALUE)	163	
39.09	ANNUAL FIXED CHARGES (AT RATE 0.2225)	13484	
	WATER COST (AT 0.00$/MILLION GALLONS + CHEMICALS)	156	
3444835	MAINTENANCE (1.00% OF TOTAL INV + 0$/FAN)	606	
94894	SUBTOTAL ANNUAL COST	14409	
	NET PRODUCTION COST		4.183
6234			
	ADJUSTMENT FOR DIFFERENTIAL CAPABILITY	857	
	ADJUSTMENT FOR DIFFERENTIAL NET ANNUAL GENERATION	5102	
23981	TOTAL COMPARABLE ANNUAL COST INCLUDING ADJUSTMENTS FOR EQUALIZED CAPABILITY & NET ANNUAL GENERATION	20368	
64455	COMPARABLE NET PRODUCTION COST INCL. ADJUSTMENTS		5.754

9111110048 - 57

Exhibit 160

JERSEY CENTRAL POWER & LIGHT COMPANY
OYSTER CREEK NUCLEAR GENERATING STATION
TIME AND FEE REQUIREMENTS TO OBTAIN NECESSARY PERMITS
FOR PREFERRED COOLING SYSTEMS

	PREFERRED COOLING TOWER SYSTEMS		CANAL-TO-BAY SYSTEM	
ACTIVITY	TIME (MONTHS)(4)	FEES ($)	TIME (MONTHS)(4)	FEES ($)
NRC-EIS Process	24	N. A.	24	N. A.
NPDES Permit	6	N. A.	6	$100.
Section 401 Certification	6	N. A.	6	N. A.
Corps of Engrs Sect 404 Permit	N.A.(1)	N. A.	3-6(2)	$100.
Corps of Engrs Sect 10 Permit	N.A.	N. A.	3-6(2)	$100.
N J CAFRA Permit	4	$1,000. + $10/Acre to be developed	4	$1,000. + $10/Acre to be developed
Riparian Permit	N.A.	N. A.	3-4(3)	½ of 1% of construction cost min. $100.
Wetlands Permit	N.A.	N. A.	3-4(3)	½ of 1% of construction cost min. $300.
Stream Encroachment Permit	N.A.	N. A.	3-4(3)	$400. for each structure outside canal + $400. for each 1,000 ft. of canal affected by major activities in canal
Soil Erosion & Sediment Control Certification	1	Fees set by Soil Conservation District based on cost	1	Fees set by Soil Conservation District based on cost
N J Wastewater 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

Characteristic	Natural Draft	Fan-Assisted Natural Draft	Round Mechanical Draft
Height (ft)	540	300	69
Base Diameter (ft)	430	230	237
Exit Diameter (ft)	230	170	122 (2)
Circulating Water Flow (gpm) (1)	433,300	229,250	216,650
Unit Rating (mw)	640	320	320
No. of Towers	1	2	2
Heat Load (Btu/mw-hour) (1)	6.94×10^6	6.94×10^6	6.94×10^6
Exit Air Velocity (fpm)	720	700	1,317
Exit Fan Volume (ft^3/hour) (1)	0.0	4.68×10^8	1.17×10^9
No. of Fans (1)	-	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 1

ANNUAL FREQUENCY OF ELEVATED PLUMES FROM NATURAL DRAFT TOWER
OYSTER CREEK NUCLEAR GENERATING STATION

Plume Lengths (ft)	Hours per Year for Given Direction from Towers															
	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
0 - 500	207	89	83	156	218	250	102	97	92	55	53	48	53	39	52	98
500 - 1,000	204	109	104	123	247	268	187	147	85	70	57	72	63	54	21	85
1,000 - 1,500	131	89	83	97	142	128	86	84	100	62	51	48	53	50	24	61
1,500 - 2,000	62	62	37	55	70	72	35	44	61	57	35	37	41	43	20	38
2,000 - 2,500	31	33	37	38	48	45	20	21	27	26	25	26	36	14	13	20
2,500 - 3,000	18	12	17	19	23	11	14	13	9	17	16	11	8	8	5	12
3,000 - 3,500	3	7	7	2	12	9	9	11	6	5	11	18	2	5	0	8
3,500 - 4,000	18	1	4	7	7	8	4	7	1	6	5	2	3	6	3	11
4,000 - 4,500	13	2	0	4	5	1	1	7	2	1	3	3	7	6	4	1
4,500 - 5,000	9	5	3	2	7	2	3	1	2	2	1	1	5	10	1	4
5,000 - 5,500	5	4	4	3	4	0	1	2	1	1	1	6	3	2	1	3
5,500 - 6,000	5	5	2	3	2	1	0	3	3	1	2	1	1	6	1	1
6,000 - 6,500	3	2	4	1	3	1	0	2	3	1	1	2	2	2	0	5
6,500 - 7,000	1	1	1	0	0	1	0	1	0	0	0	0	0	0	3	1
7,000 - 7,500	1	0	0	2	1	0	0	2	0	0	0	1	0	0	2	0
7,500 - 8,000	2	0	0	1	1	0	0	0	0	1	0	0	0	2	0	1
8,000 - 8,500	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	1
8,500 - 9,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9,000 - 9,500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9,500 - 10,000	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
10,000 - 10,500	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
10,500 - 11,000	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
11,000 - 11,500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11,500 - 12,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12,000 - 12,500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12,500 - 13,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13,000 - 13,500	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
13,500 - 14,000	0	0	0	4	0	0	0	0	0	0	0	0	0	0	6	0

EXHIBIT 162

OYSTER CREEK NUCLEAR GENERATING STATION NATURAL DRAFT TOWER IMPACTS

TABLE 2

PREDICTED MAXIMUM PEAK SHORT-TERM NEAR GROUND AIRBORNE CONCENTRATION (ug/m^3) OF SALT RESULTING FROM OPERATION OF ONE NATURAL DRAFT COOLING TOWER AT THE OYSTER CREEK NUCLEAR GENERATING STATION

Month	Hours of Persistence	Direction[a]	Distance (miles)	Near Ground Airborne Concentration (ug/m^3)
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	S	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

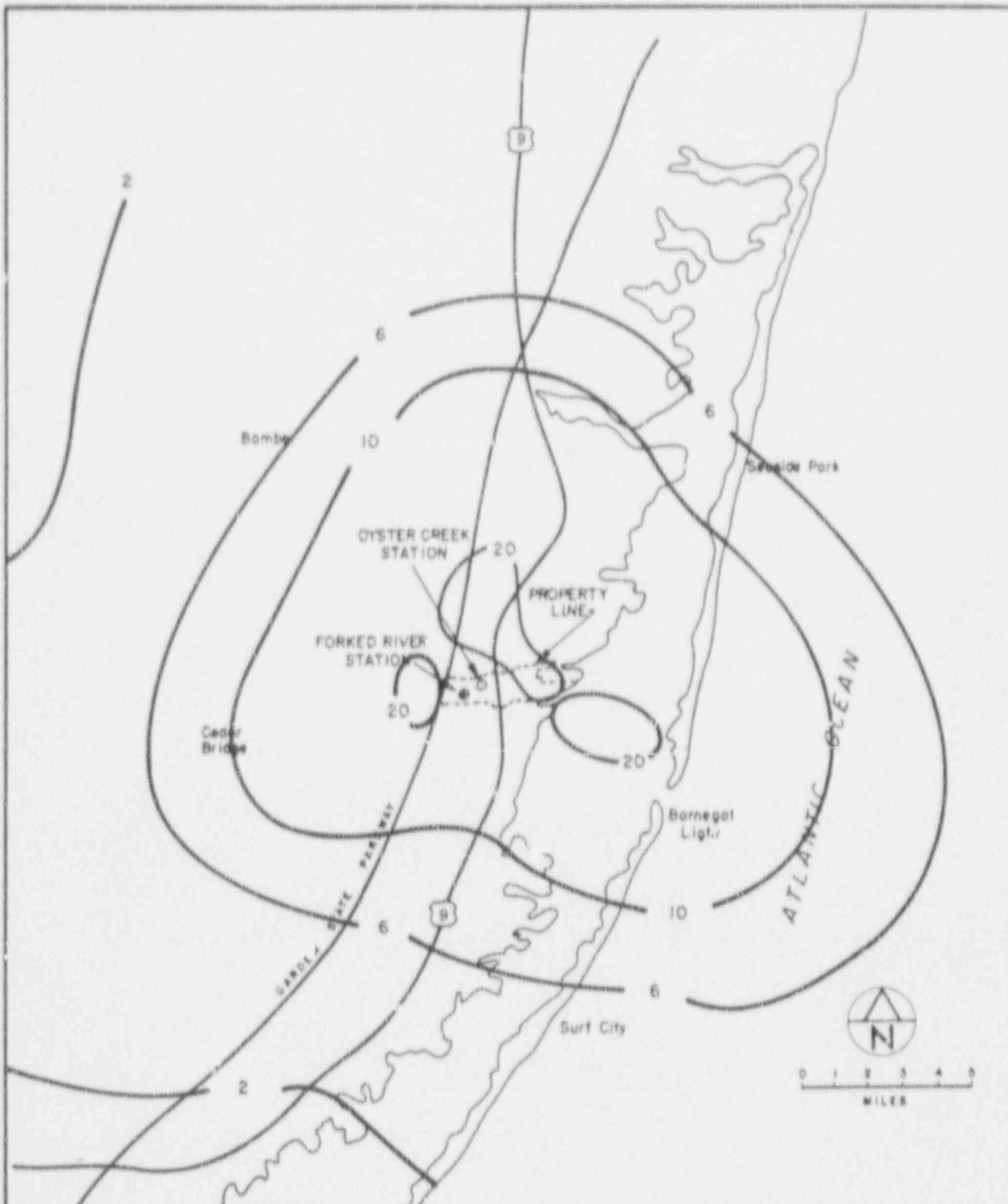
TABLE 3

PREDICTED MAXIMUM PEAK SHORT-TERM NEAR GROUND AIRBORNE CONCENTRATION (ug/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

Month	Hours of Persistence	Direction(*)	Distance (miles)	Near Ground Airborne Concentration (ug/m^3)
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	[illegible].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

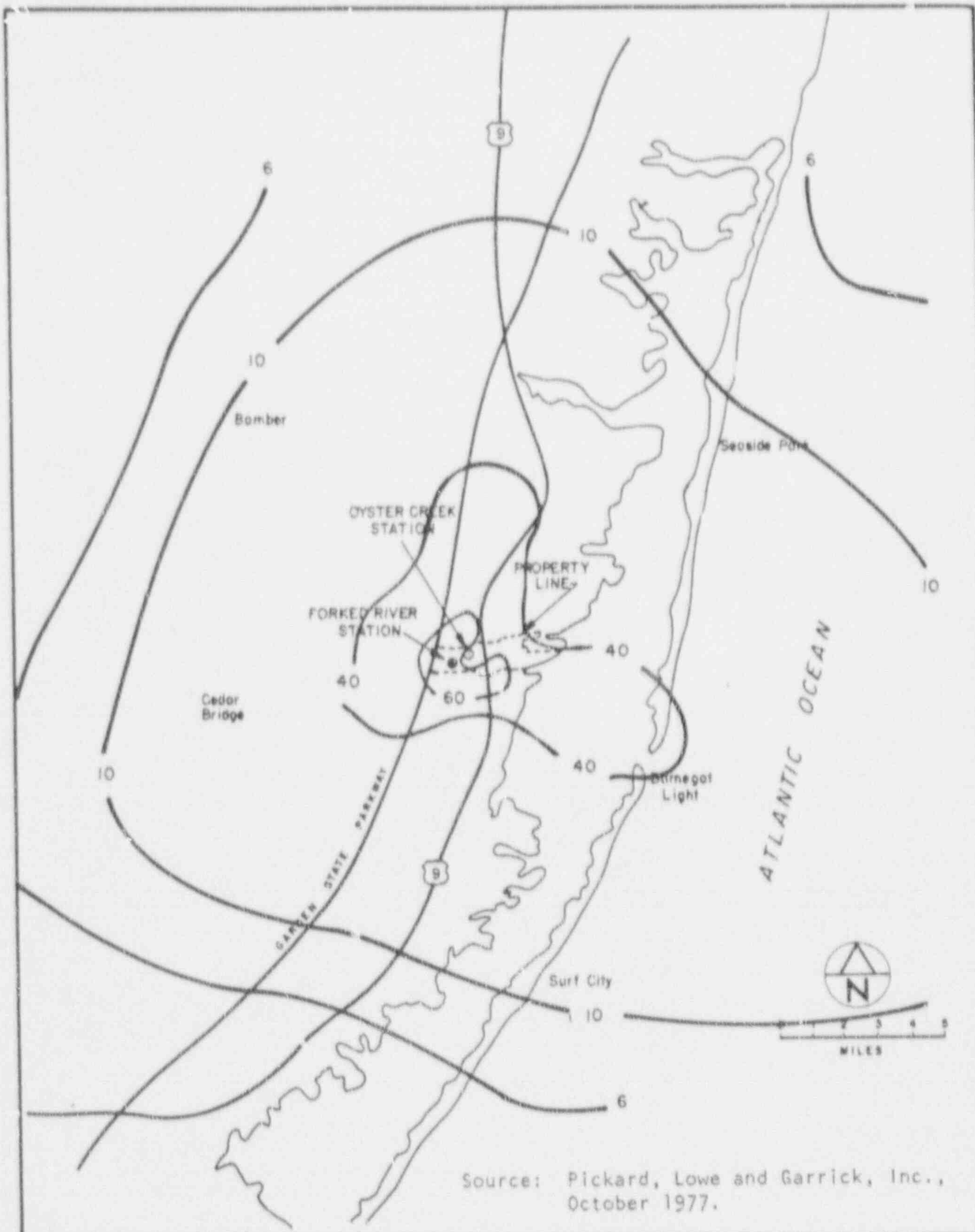
(*) Indicates direction where salt is deposited - winds come from opposite direction

Source: Pickard, Lowe and Garrick, Inc.,
October 1977.



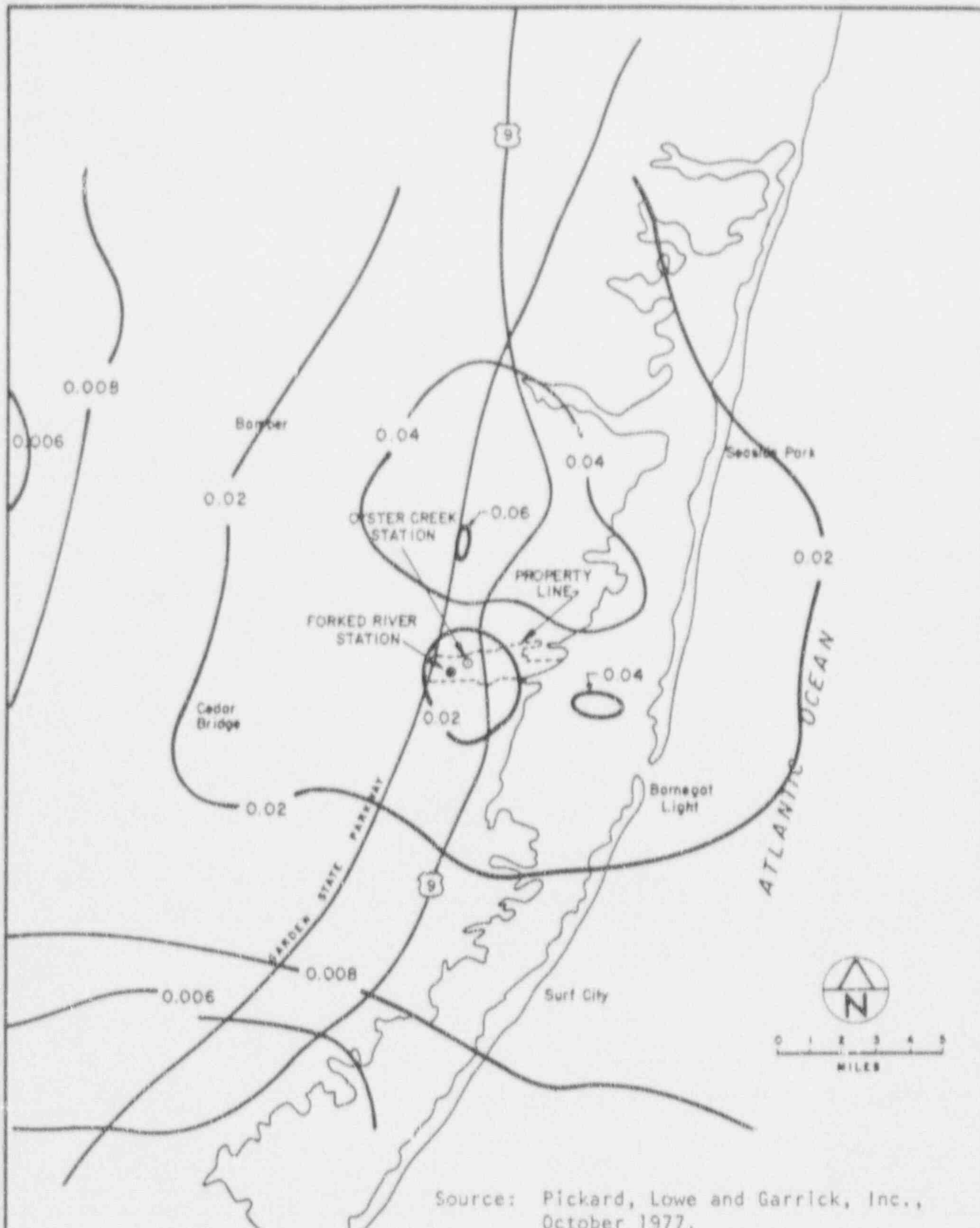
Source: Pickard, Lowe and Garrick, Inc., October 1977.

JERSEY CENTRAL POWER & LIGHT COMPANY EBASCO SERVICES INCORPORATED New York	ANNUAL AVERAGE SALT DEPOSITION RATE (Kg/Km2-Month) FROM ONE NATURAL DRAFT TOWER AT THE OYSTER CREEK SITE (0-15 MILES)	EXHIBIT 163



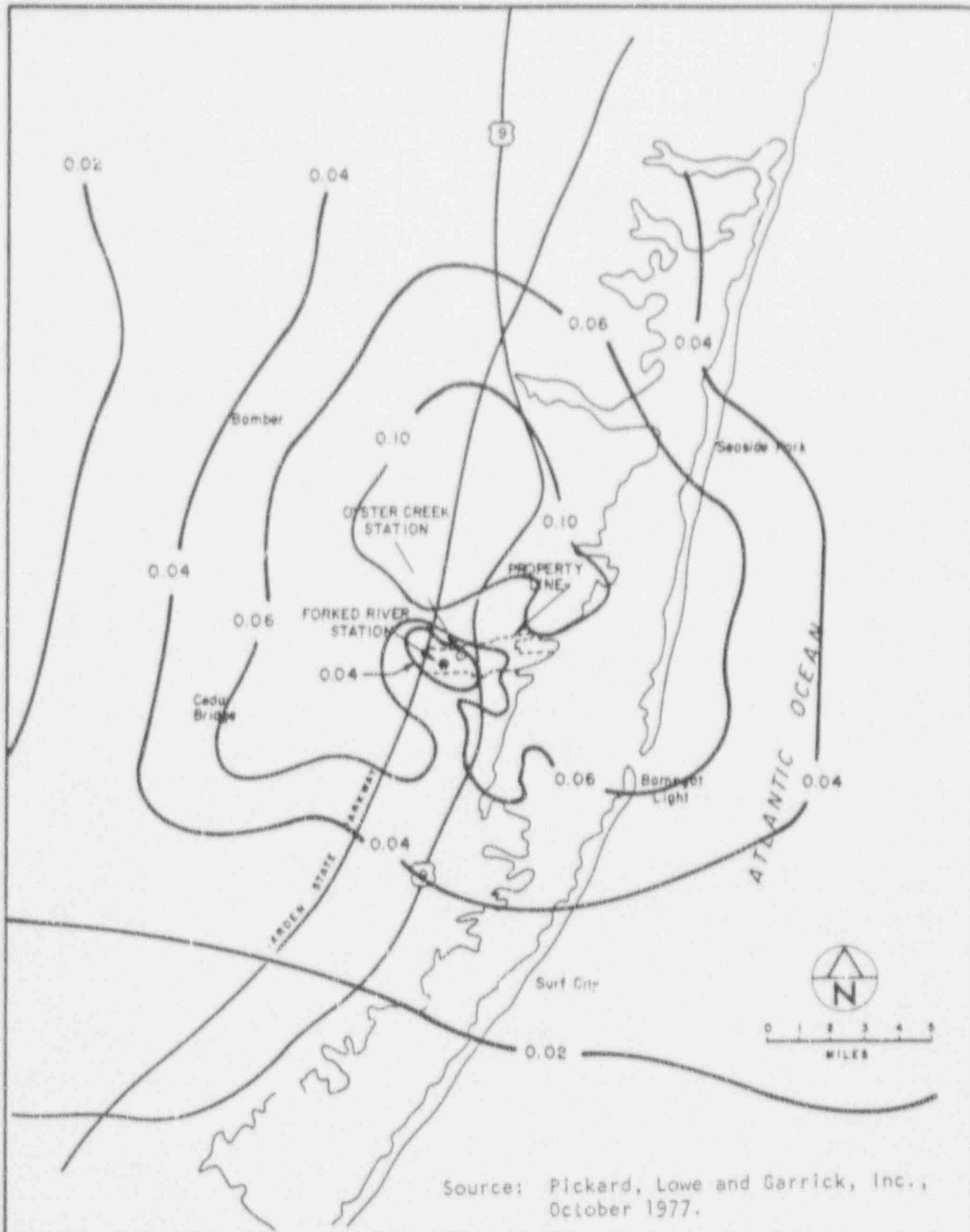
Source: Pickard, Lowe and Garrick, Inc., October 1977.

JERSEY CENTRAL POWER & LIGHT COMPANY EBASCO SERVICES INCORPORATED New York	ANNUAL AVERAGE SALT DEPOSITION RATE (Kg/Km2-Month) FROM ONE NATURAL DRAFT TOWER AT OYSTER CREEK SITE AND ONE NATURAL DRAFT TOWER AT FORKED RIVER SITE (0-15 MILES)	EXHIBIT 164



Source: Pickard, Lowe and Garrick, Inc., October 1977.

JERSEY CENTRAL POWER & LIGHT COMPANY EBASCO SERVICES INCORPORATED New York	AVERAGE SUMMER AIRBORNE SALT CONCENTRATIONS (ug/m3) FROM ONE NATURAL DRAFT TOWER AT THE OYSTER CREEK SITE (0 - 15 MILES)	EXHIBIT 165



Source: Pickard, Lowe and Garrick, Inc., October 1977.

JERSEY CENTRAL POWER & LIGHT COMPANY EBASCO SERVICES INCORPORATED New York	AVERAGE SUMMER AIRBONE SALT CONCENTRATIONS (μg/m3) FROM ONE NATURAL DRAFT TOWER AT THE OYSTER CREEK SITE AND ONE NATURAL DRAFT TOWER AT THE FORKED RIVER SITE (0 - 15 MILES)	EXHIBIT 166

Exhibit 167

DISCHARGE PARAMETERS UNDER AVERAGE CONDITIONS

NATURAL DRAFT TOWER

Month	Oyster Creek NGS Discharge Flow GPM	Forked River NGS Discharge Flow GPM	Required* Dilution Flow GPM	Combined Flow to Oyster Creek GPM	Combined Temperature Rise in Oyster Creek Deg F
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	[illegible].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 [illegible]

DISCHARGE PARAMETERS UNDER EXTREME CONDITIONS

NATURAL DRAFT TOWER

Month	Oyster Creek NGS Discharge Flow GPM	Forked River NGS Discharge Flow GPM	Required* Dilution Flow GPM	Combined Flow to Oyster Creek GPM	Combined Temperature Rise in Oyster Creek Deg F
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(1) (CCCS)

			Evaporation Loss (gpm)		Concentration Factor		Discharge Flow (gpm)	
Mode	Month	Pumps	Avg(2)	Max(3)	Avg(2)	Max(3)	Avg(2)	Max(3)
Oyster Creek NGS 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)

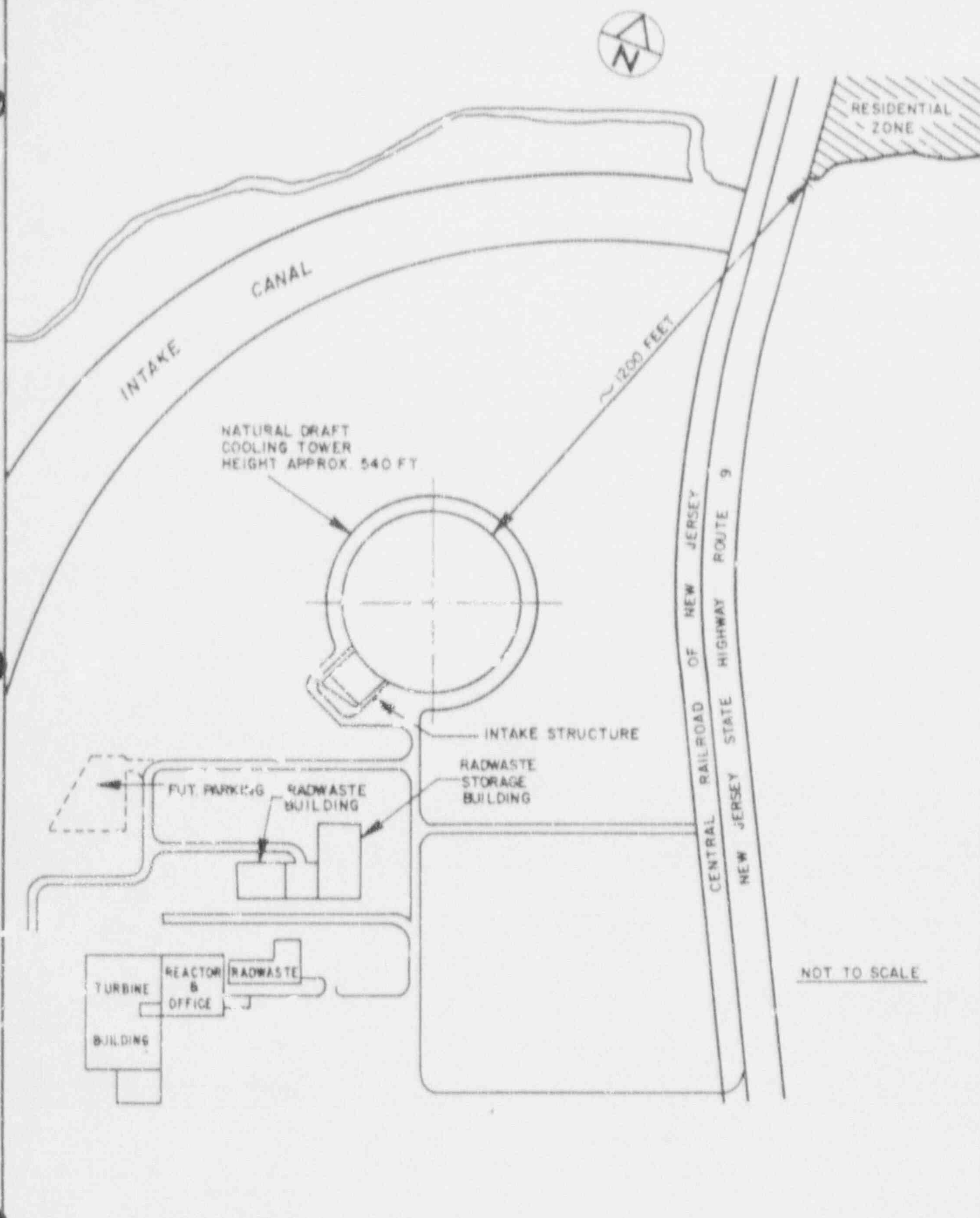
MONTHLY DISCHARGE FLOWS, EVAPORATION LOSSES AND CONCENTRATION FACTORS FOR THE CLOSED CYCLE COOLING SYSTEMS[1] (CCCS)

Mode	Month	No. Pumps	Evaporation Loss (gpm) Avg[2]	Evaporation Loss (gpm) Max[3]	Concentration Factor Avg[2]	Concentration Factor Max[3]	Discharge Flow (gpm) Avg[2]	Discharge Flow (gpm) Max[3]
Oyster Creek NGS & Forked River 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
	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

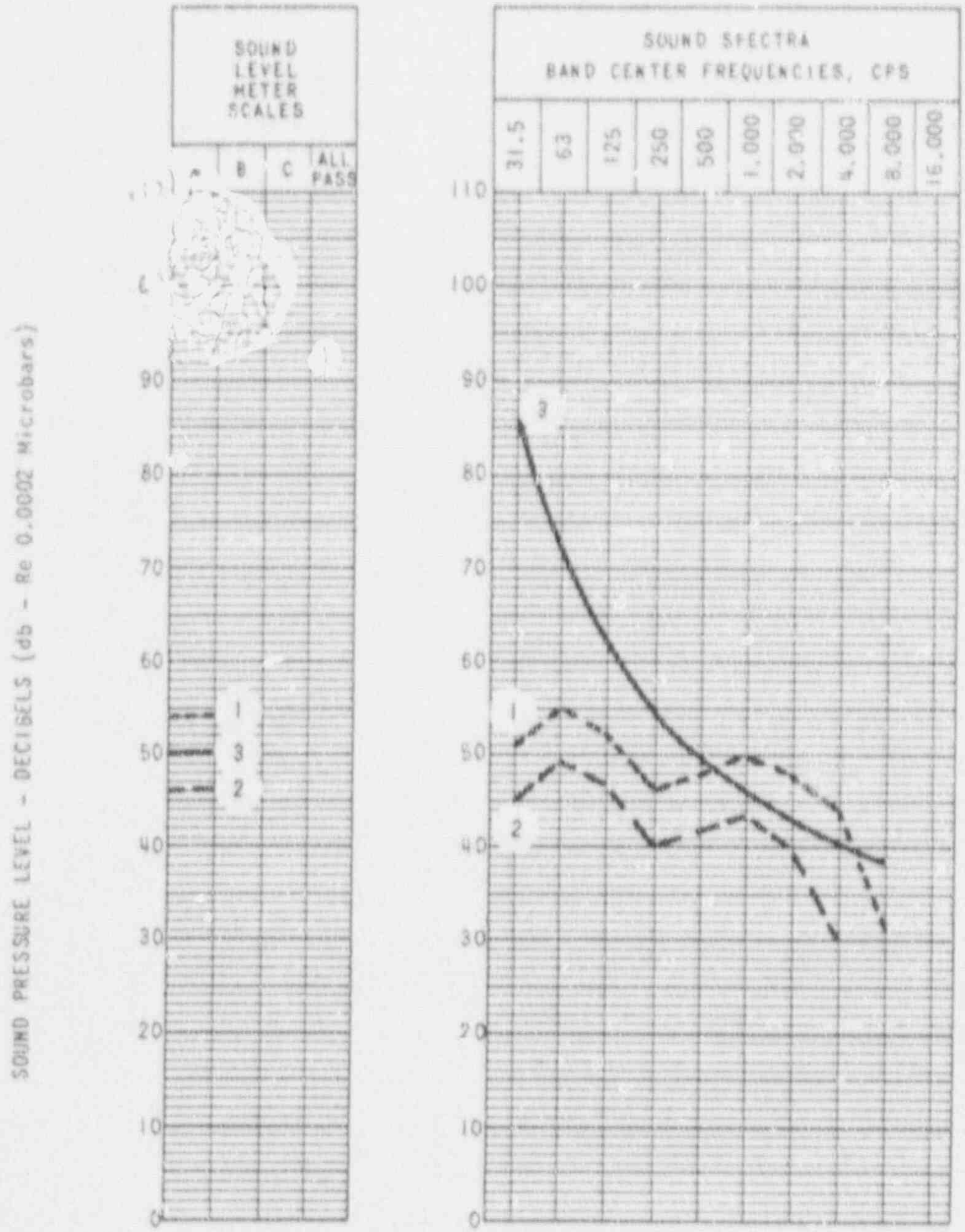
Notes: (1) The CCCS include the natural draft, round mechanical draft and fan-assisted natural draft cooling towers with saltwater makeup.

(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.

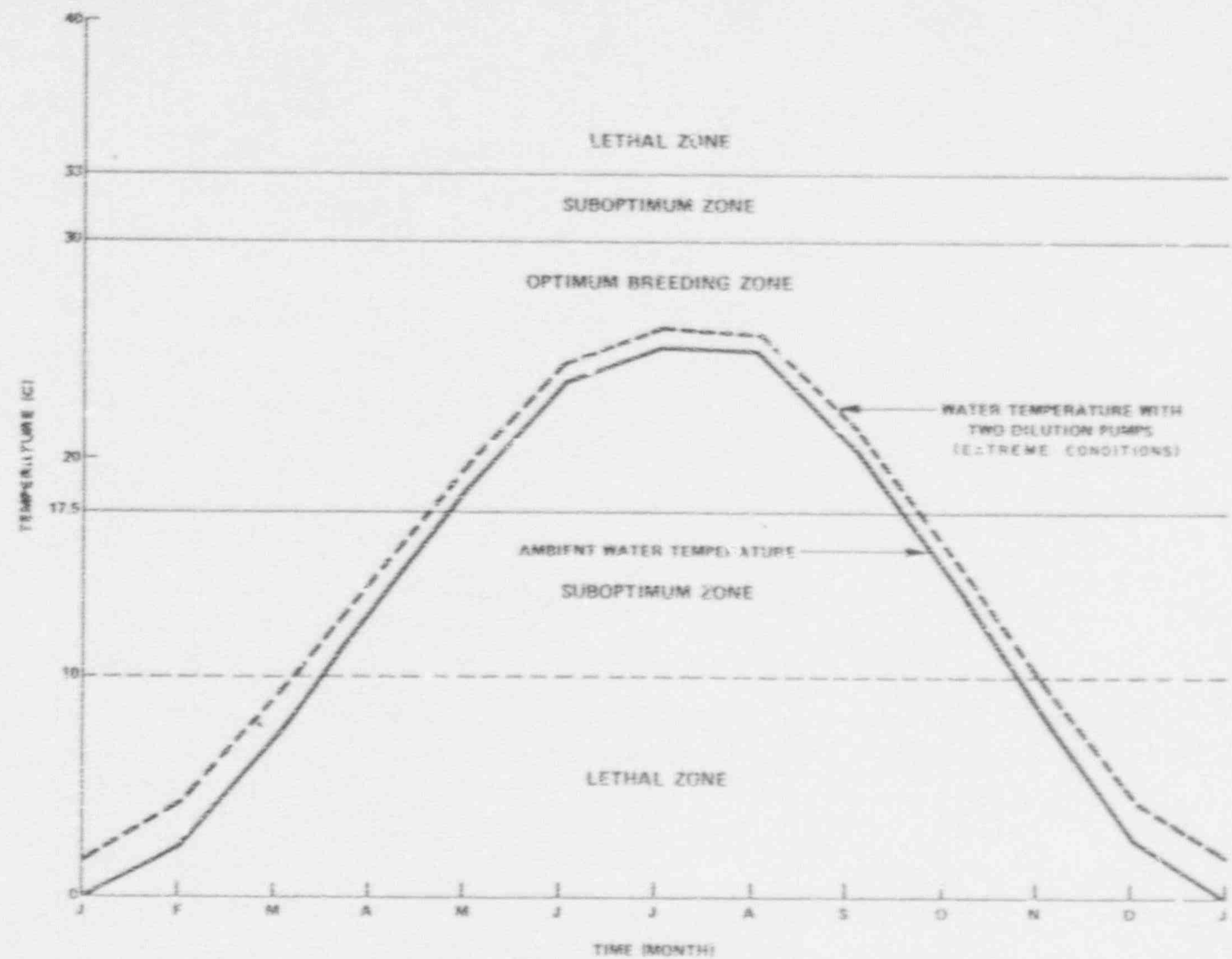


JERSEY CENTRAL POWER & LIGHT COMPANY	LOCATION OF NATURAL DRAFT COOLING TOWER WITH RESPECT TO NEAREST RESIDENTIAL ZONE	EXHIBIT 170
EBASCO SERVICES INCORPORATED New York		

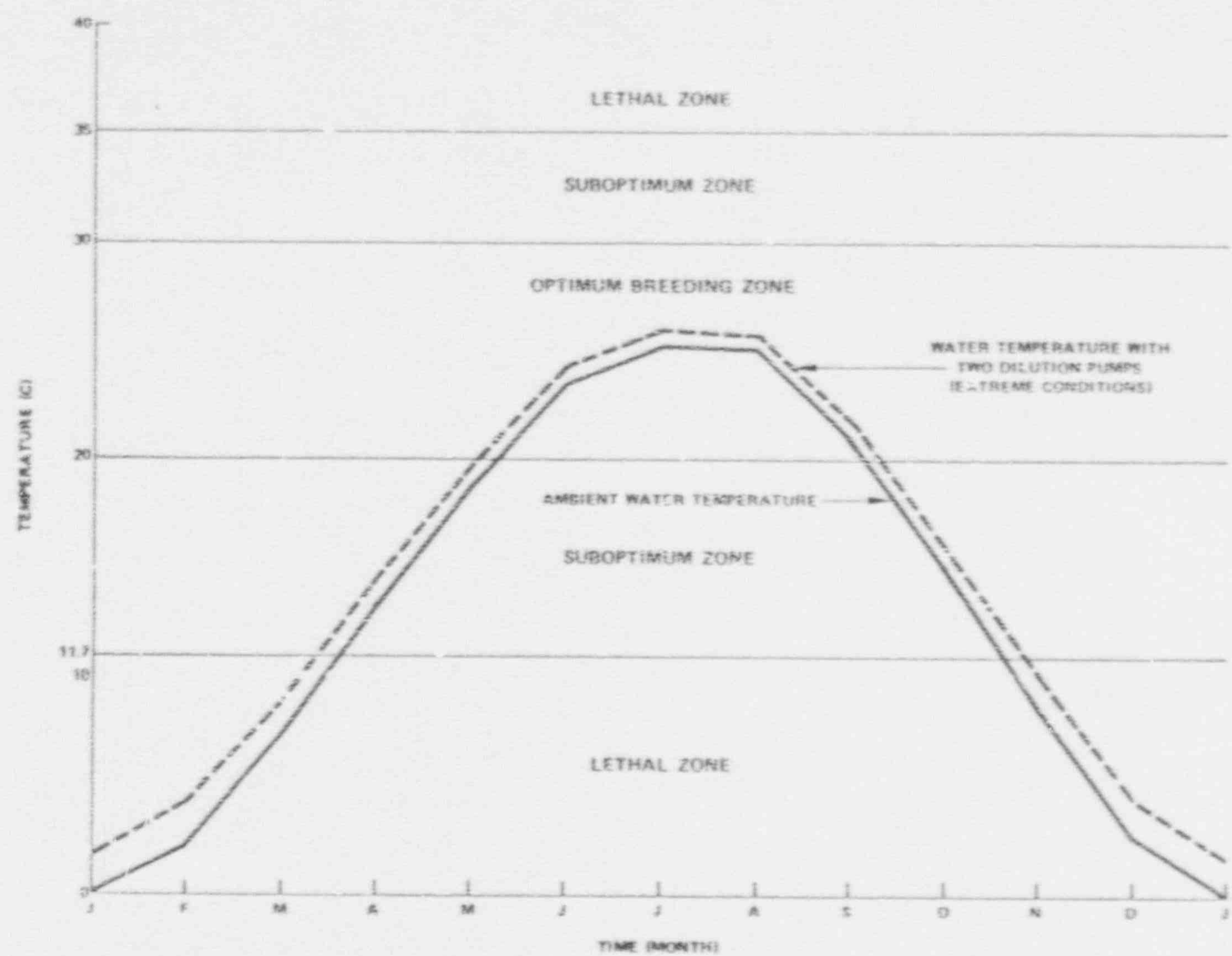


1. UNATTENUATED SPL AT A DISTANCE OF ABOUT 1200 FT FROM THE TOWER
2. UNATTENUATED SPL AT A DISTANCE OF ABOUT 2500 FT FROM THE TOWER
3. NEW JERSEY NIGHTTIME CRITERION

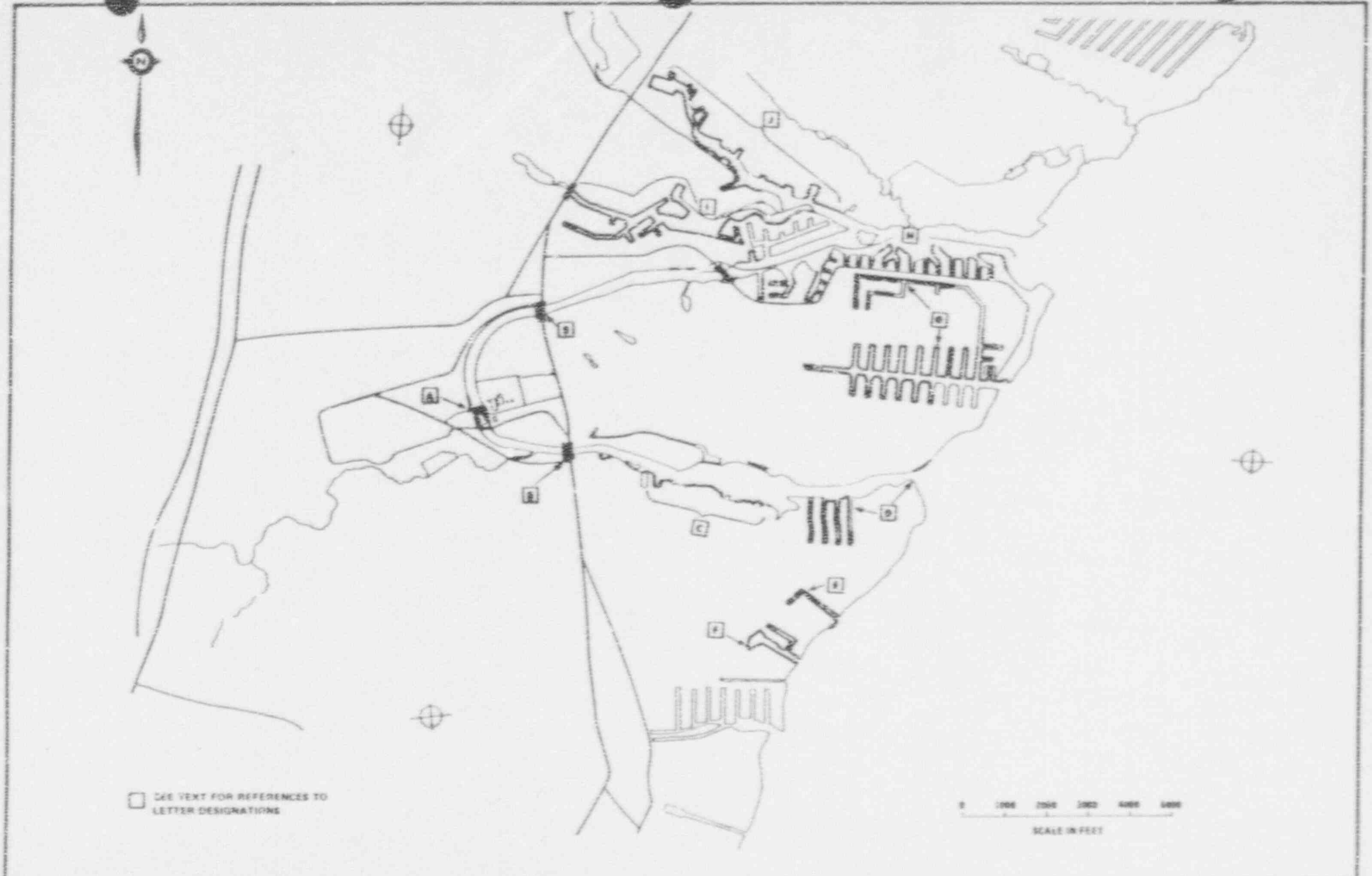
JERSEY CENTRAL POWER & LIGHT COMPANY EBASCO SERVICES INCORPORATED New York	NATURAL DRAFT COOLING TOWER NOISE DATA	171



JERSEY CENTRAL POWER & LIGHT COMPANY	OPTIMUM BREEDING AND LETHAL WATER TEMPERATURE ZONES FOR BANKIA GOULDI (PREFERRED COOLING TOWER SYSTEMS)	EXHIBIT 172
EBASCO SERVICES INCORPORATED New York		



JERSEY CENTRAL POWER & LIGHT COMPANY EBASCO SERVICES INCORPORATED New York	OPTIMUM BREEDING AND LETHAL WATER TEMPERATURE ZONES FOR *TEREDO NAVALIS* (PREFERRED COOLING TOWER SYSTEMS)	EXHIBIT 173



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

EXH

ENTRAINMENT ESTIMATES FOR CONDENS

for *Mercenaria mercen*

Month 1975-1976	Circulating Water (gpm x 10^3)	Sample Days per Month[1]	Daily[2] Sample Entrainment	Condenser Mortality Rate	Sample Condenser Mortality	Projected Daily Entrain: Canal-Bay/[3] Existing System	C
	Data for Existing System						
Sep	[illegible]5	21/30	-	No	-	-	
Oct	345	29/31	-	Determinations	-	-	
Nov	345 0	24/30 5/30	-		-	-	
Dec	345 0	23/31 3/31	4.47×10^9		-	5.95×10^9	2.
Jan	345	23/30	-		-	-	
Feb	345	25/29			-	-	
Mar	460 345 0	15/31 8/31 3/31	-		-	-	
Apr	460	30/30	6.11×10^{11}		-	6.11×10^{11}	2.
May	460	29/31	1.99×10^{10}		-	1.99×10^{10}	9.
Jun	460	26/30	1.06×10^{10}		-	1.06×10^{10}	4.
Jul	460	31/31	-		-	-	
Aug	460	31/31	5.7×10^{10}		-	5.7×10^{10}	2.

(1) Unaccounted for days showed variable daily flow

(2) Based on IA, 1977, Table 7-CWS discharge sample basis

(3) Assumes circulating water flow at 460 x

(4) Assumes 100% mortality

(5) Entrainment halved with operation of on

IBIT 175

ER CIRCUL.TING WATER AND DILUTION WATER

aria-umbo and hinge stages

ment ooling Towers	Projected Daily Mortality Canal-Bay/ Existing System	Cooling[4] Towers	Dilution Water (gpm x 10^3)	Sample Days[1] per Month	Mean Density in No/m^3 Station 11[2]	Actual Dilution Water Daily Entrainment	Daily Entrainment[5] Through Two Dilution Pumps (560 x 10^6 gpm)
-	-	-	250	25/30	-	-	-
-	-	-	500	11/31	-	-	-
			250	14/31			
-	-	-	500	24/30	-	-	-
72 x 10^8	-	2.72 x 10^8	500	25/31	9	6.48 x 10^6	6.48 x 10^6
-	-	-	500	24/31	-	-	-
-	-	-	500	25/29	-	-	-
-	-	-	500	18/31	-	-	-
			250	11/31			
79 x 10^{10}	-	2.79 x 10^{10}	500	23/30	923	5.87 x 10^8	6.65 x 10^8
			250	7/30			
08 x 10^8	-	9.08 x 10^8	250	25/31	30	1.08 x 10^7	2.16 x 10^7
84 x 10^8	-	4.84 x 10^8	500	19/30	16	9.95 x 10^6	1.15 x 10^7
			250	7/30			
-	-	-	500	25/31	-	-	-
			250	4/31			
6 x 10^9	-	2.6 x 10^9	500	25/31	86	6.19 x 10^7	6.19 x 10^7

x 10^6 gpm

e dilution pump at 260 x 10^6 gpm

EXHIBI

ENTRAINMENT ESTIMATES FOR CONDENSER

for Tered

Month 1975-1976	Circulating Water (gpm x 10³)	Sample Days(1) per Month	Daily(2) Sample Entrainment	Condenser Mortality Rate	Sample Condenser Mortality	Projected Daily Entrainmen: Canal-Bay/(3) Existing System	Coo To
	Data for Existing System						
Jun	345	21/30	0	No	0	0	0
Jul	345	29/31	3.40×10^9	Determinations	-	4.52×10^9	2.06
Aug	345 0	24/30 5/30	8.45×10^7		-	1.12×10^8	5.11
Sep	345 0	23/31 3/31	0		0	0	0
Oct	345	23/30	9.99×10^8		-	1.33×10^9	6.07
Nov	345	25/29	0		0	0	0
Dec	345	26/31	0		0	0	0
Jan	500	30/30	-		-	-	-
Feb	500	29/31	-		-	-	-
Mar	460 345 0	26/30	0		0	0	0
Apr	460	31/31	0		0	0	
May	460	31/31	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 1

(4) Assumes 100% mortality

(5) Entrainment halved with operation of one

T 175

CIRCULATING WATER AND DILUTION WATER

nid-larvae

t ing ers	Projected Daily Mortality Canal-Bay/ Existing System	Cooling Towers(4)	Dilution Water (gpm x 10^3)	Sample Days(1) per Month	Mean Density in No/m^3 Station B(2)	Actual Dilution Water Daily Entrainment	Daily Entrainment(5) Through Two Dilution Pumps (560 x 10^6 gpm)
	0	0	-		0	0	0
x 10^3	-	2.06 x 10^8	500	11/31	6.84	4.92 x 10^9	4.92 x 10^9
x 10^6	-	5.11 x 10^6	500 250	26/31 5/31	0.17	1.22 x 10^8	1.22 x 10^8
	0	0	250	26/31	0	0	0
x 10^7	-	6.07 x 10^7	500 250	11/31 14/31	2.01	1.09 x 10^9	1.45 x 10^9
	0	0	500	24/30	0	0	0
	0	0	500	25/31	0	0	0
	-	-	500	24/31	-	-	-
	-	-	500	25/29	-	-	-
	0	0	500 250	18/31 11/31	0	0	0
	0	0	500 250	23/30 7/30		0	0
	0	0	250	25/31	0	0	0

^{6} gpm

ilution pump at 260 x 10^6 gpm

SI
APERTURE
CARD

Also Available On
Aperture Card

9111110048 - 59

EXHIBI

ENTRAINMENT ESTIMATES FOR CONDENSER

for Neomysis

Month 1975-1976	Circulating Water (gpm x 10^3)	Sample Days[(1)] per Month	Daily[(2)] Sample Entrainment	Condenser Mortality Rate	Sample Condenser Mortality	Projected Daily Entrainment: Canal-Bay/[(3)] Existing System	Cool Tow
Sep	345	21/30	3.95×10^9	.665	2.63×10^9	5.25×10^9	2.4 x
Oct	345	29/31	6.24×10^9	.007	4.37×10^7	8.30×10^9	3.79
Nov		24/30 5/30	8.88×10^9	.066	5.56×10^8	1.18×10^{10}	5.39
Dec	343 0	23/31 3/31	1.41×10^{10}	.183	2.58×10^9	1.88×10^{10}	8.58
Jan	345	23/30	2.50×10^9	-	-	3.33×10^9	1.52
Feb	345	25/29	8.28×10^9	-	-	1.10×10^{10}	5.02
Mar	460 345 0	15/31 8/31 3/31	4.12×10^{10}	.01	4.12×10^8	3.61×10^{10}	1.65
Apr	460	30/30	5.49×10^9	.01	5.49×10^7	5.49×10^9	2.51
May	460	29/31	3.75×10^9	.02	7.5×10^7	3.75×10^9	1.71
Jun	460	26/30	2.37×10^{10}	.22	5.21×10^9	2.37×10^{10}	1.08
Jul	460	31/31	1.37×10^{10}	.67	9.18×10^9	1.37×10^{10}	6.25
Aug	460	31/31	2.65×10^{10}	.81	2.15×10^{10}	2.65×10^{10}	1.21

(1) Unaccounted for days showed variable daily flow

(2) Based on IA, 1977, Table 13 - discharge sample basis

(3) Assumes circulating water flow at 460 x 10

(4) Assumes 100% mortality

(5) Entrainm[illegible] halved with operation of one

r 175

CIRCULATING WATER AND DILUTION WATER

americana

t ... ing ... ers	Projected Daily Mortality: Canal-Bay/ Existing System	Projected Daily Mortality: Cooling Towers (4)	Dilution Water (gpm x 10^3)	Sample Days (1) per Month	Mean Density Station 11 (2) (in No./1000 m^3)	Actual Dilution Water Daily Entrainment	Daily Entrainment (5) Through Two Dilution Pumps (560 x 10^6 gpm)
10^8	3.49×10^9	2.4×10^8	250	26/30	8,030	2.89×10^9	5.78×10^9
x 10^8	5.81×10^7	3.79×10^8	500 250	11/31 14/31	12,793	6.91×10^9	9.21×10^9
x 10^8	7.79×10^8	3.39×10^8	500	24/30	17,987	1.30×10^{10}	1.30×10^{10}
x 10^8	3.44×10^9	8.58×10^8	500	25/31	28,419	2.05×10^{10}	2.05×10^{10}
x 10^8	-	1.52×10^8	500	24/31	7,332	5.28×10^9	5.28×10^9
x 10^8	-	5.02×10^8	500	25/29	24,180	1.74×10^{10}	1.74×10^{10}
x 10^9	3.61×10^8	1.65×10^9	500 250	18/31 11/31	70,080	3.79×10^{10}	5.05×10^{10}
x 10^8	5.49×10^7	2.51×10^8	500 250	23/30 7/30	8,431	5.[illegible]6 x 10^9	6.07×10^9
x 10^8	7.5×10^7	1.71×10^8	250	25/31	5,737	2.07×10^9	4.13×10^9
x 10^9	5.21×10^9	1.08×10^9	500 250	19/30 7/30	36,340	2.27×10^{10}	2.62×10^{10}
x 10^8	9.18×10^9	6.25×10^8	500 250	25/31 4/31	1,368	1.54×10^{10}	1.54×10^{10}
x 10^9	2.15×10^{10}	1.21×10^9	500	25/31	41,453	2.98×10^{10}	2.98×10^{10}

^{6} gpm

ilution pump at 250 x 10^6 gpm

EXHIBIT

ENTRAINMENT ESTIMATES FOR CONDENSER

for Mysids and

Month 1975-1976	Circulating Water (gpm x 10^3)	Sample Days per Month (1)	Daily (2) Sample Entrainment	Condenser Mortality Rate	Sample Condenser Mortality	Projected Daily Entrainment: Canal-Bay/ (3) Existing System	Projected Daily Entrainment: Cool Tow
	Data for Existing Systems						
Sep	345	[illegible]	2.07×10^7	.665 +	1.38×10^7	2.75×10^7	1.26 x
Oct	345	29/31	2.8×10^7	.007 +	1.96×10^5	3.72×10^7	1.70 x
Nov	345 0	24/30 5/30	3.2×10^7	.066 +	2.11×10^6	4.26×10^7	1.94 x
Dec	345 0	23/31 [illegible]/31	3.9×10^7	.183 +	7.14×10^6	5.19×10^7	2.37 x
Jan	345	23/30	1.80×10^7	-	-	2.39×10^7	1.09 x
Feb	345	25/29	5.48×10^7	-	-	7.29×10^7	3.33 x
Mar	460 345 0	15/31 8/31 3/31	1.22×10^8	.01 ++	1.22×10^6	1.22×10^8	5.57 x
Apr	460	30/30	1.42×10^7	.01 ++	1.42×10^5	1.42×10^7	6.48 x
May	460	29/31	9.62×10^6	.02 ++	1.92×10^5	9.62×10^6	4.39 x
Jun	460	26/30	5.54×10^7	.22 ++	1.22×10^7	5.54×10^7	2.53 x
Jul	460	31/31	4.21×10^7	.67 ++	2.82×10^7	4.21×10^7	1.92 x
Aug	460	31/31	7.73×10^7	.81 ++	6.26×10^7	7.73×10^7	3.53 x

(1) Unaccounted for days showed variable daily flow

(2) Based on IA, 1977, Table 17 - Annual basis

\+ Based on IA, 1975, Table 5

++ Based on IA, 1977, Table 1b

(3) Assu[illegible]ing water flow at 460 x 10

(4) Assumes 100% mortality

t 175

CIRCULATING WATER AND DILUTION WATER

gravid Mysids

t	Projected Daily Mortality						
ing ers	Canal-Bay/ Existing System	Cooling[(4)] Towers	Dilution Water (gpm x 10^3)	Sample Days[(1)] per Month	Mean Density in No/m^3 Station	Actual Dilution Water Daily Entrainment	Daily Entrainment Through Two Dilution Pumps (360 x 10^6 gpm)
10^6	1.83×10^7	1.26×10^6					
10^6	2.6×10^5	1.7×10^6					
10^6	2.81×10^6	1.94×10^6					
10^6	9.5×10^6	2.37×10^6					
10^6	-	1.09×10^6					
10^6	-	3.33×10^6					
10^6	1.22×10^6	5.57×10^6					
10^5	1.42×10^5	6.48×10^5					
10^5	1.92×10^5	4.39×10^5					
10^7	1.22×10^7	2.53×10^7					
10^6	..82 x 10^7	1.92×10^6					
10^6	6.26×10^7	3.53×10^6					

6 gpm

SI
APERTURE
CARD

Also Available On
Aperture Card

9111110048 - 61

EXHIBI

ENTRAINMENT ESTIMATES FOR CONDENSER

for Coro

Month 1975-1976	Data for Existing System: Circulating Water (gpm x 10^3)	Sample Days[1] per Month	Daily[2] Sample Entrainment	Condenser Mortality Rate	Sample Condenser Mortality	Projected Daily Entrainmen: Canal-Bay/[3] Existing System	Cool Tow
Sep	345	21/30	6.46×10^6	-	-	8.59×10^6	3.92
Oct	345	29/31	3.48×10^6	-	-	4.63×10^6	2.11
Nov	345 0	24/30 5/30	5.66×10^7	-	-	7.53×10^7	3.44
Dec	345 0	23/31 3/31	3.67×10^8	-	-	4.88×10^8	2.23
Jan	345	23/30	2.68×10^7	-	-	2.47×10^7	1.13
Feb	345	25/29	1.64×10^7	-	-	1.51×10^7	6.89
Mar	460 345 0	15/31 8/31 3/31	-	-	-	-	
Apr	460	30/30	1.64×10^7	-	-	1.64×10^7	7.49
May	460	29/31	1.13×10^9	-	-	1.13×10^9	5.16
Jun	460	26/30	1.69×10^9	-	-	1.69×10^9	7.72
Jul	460	31/31	7.73×10^8	-	-	7.73×10^8	3.53
Aug	460	31/31	3.70×10^8	-	-	3.70×10^8	1.69

(1) Unaccounted for days showed variable daily flow

(2) Based on IA, 1977, Table 13 - discharge density basis

(3) Assumes circulating water flow at 460 x 10

(4) Assumes 100% mortality

(5) Entrainment halved with operation of one

t 175

CIRCULATING WATER AND DILUTION WATER

phium sp

(Projected Daily Mortality) ...ing ...ers	Projected Daily Mortality: Canal-Bay/ Existing System	Projected Daily Mortality: Cooling Towers(4)	Dilution Water (gpm x 10^3)	Sample Days(1) per Month	Mean Density Station 11(2) (in No. /1000 m^3)	Actual Dilution Water Daily Entrainment	Daily Entrainment(5) Through Two Dilution Pumps (560 x 10^6 gpm)
x 10^5	-	3.92 x 10^5	250	26/30	13	4.68 x 10^6	9.36 x 10^6
x 10^5	-	2.11 x 10^5	500 250	11/31 14/31	7	3.78 x 10^6	5.04 x 10^6
x 10^6	-	3.44 x 10^6	500	24/30	114	8.21 x 10^7	8.21 x 10^7
x 10^7	-	2.23 x 10^7	500	25/31	739	5.32 x 10^8	5.32 x 10^8
x 10^6	-	1.13 x 10^6	500	24/31	54	3.89 x 10^7	3.89 x 10^7
x 10^5	-	6.89 x 10^5	500	25/29	33	2.38 x 10^7	2.38 x 10^7
	-	-	500 250	18/31 11/31	-	-	-
x 10^5	-	7.49 x 10^5	500 250	23/30 7/30	33	2.06 x 10^7	2.38 x 10^7
x 10^5	-	5.16 x 10^5	250	25/31	2,279	8.2 x 10^8	1.64 x 10^9
x 10^7	-	7.72 x 10^7	500 250	19/30 7/30	3,402	2.12 x 10^9	2.45 x 10^9
x 10^8	-	3.53 x 10^8	500 250	25/31 4/31	1,560	1.12 x 10^9	1.12 x 10^9
x 10^9	-	1.69 x 10^9	500	25/31	745	5.36 x 10^8	5.36 x 10^8

^{6} gpm

ilution pump at 260 x 10^6 gpm

EXHIBIT

ENTRAINMENT ESTIMATES FOR CONDENSER C

for Crangon septemspin

	Data for Existing Systems					Projected Daily Entrainment	
Month 1975-1976	Circulating Water (gpm x 10^3)	Sample Days per Month[1]	Daily[2] Sample Entrainment	Condenser Mortality Rate	Sample Condenser Mortality	Canal-Bay/[3] Existing System	Cooli Towe
Sep	345	21/30	6.77×10^4	-	-	9×10^4	4.11 x
Oct	345	29/31	0	-	0	0	0
Nov	345 0	24/30 5/30	0	-	0	0	0
Dec	345 0	23/31 3/31	4.36×10^5	-	-	5.8×10^5	2.6
Jan	345	23/30	6.33×10^5	-	-	8.42×10^5	3.84 x
Feb	345	25/29	6.15×10^5	-	-	8.18×10^5	3.73 x
Mar	460 345 0	15/31 8/31 3/31	1.39×10^6	-	-	1.85×10^6	8.45 x
Apr	460	30/30	1.69×10^5	.295	4.99×10^4	1.69×10^5	7.72 x
May	460	29/31	2.43×10^5	.128	3.11×10^4	2.43×10^5	1.11 x
Jun	460	26/30	2.16×10^5	.64	1.38×10^5	2.16×10^5	9.86 x
Jul	460	31/31	3.04×10^5	.75	2.28×10^5	3.04×10^5	1.04 x
Aug	460	31/31	1.02×10^6	.50	5.1×10^5	1.02×10^6	4.66 x

(1) Unaccounted for days showed variable daily flow

(2) Based on IA, 1977, Table 17-day and night discharge samples

(3) Assumes circulating water flow at 460×10^6

(4) Assumes 100% mortality

175

IRCULATING WATER AND DILUTION WATER

sa-adults/juveniles

ng rs	Projected Daily Mortality Canal-Bay/ Existing System	Cooling[(4)] Towers	Dilution Water (gpm x 10^3)	Sample Days[(1)] per Month	Mean Density in No/m^3 Station 11	[illegible]	Daily [illegible] nment ough Two [illegible] Pumps
10^3	-	4.11×10^3					
	0	0					
	0	0					
10^4	-	2.65×10^4					
10^4	-	3.84×10^4					
10^4	-	3.73×10^4					
10^4	-	8.45×10^4					
10^3	4.99×10^4	7.72×10^3					
10^4	3.11×10^4	1.11×10^4					
10^3	1.38×10^5	9.86×10^3					
10^4	2.28×10^5	1.04×10^4					
10^4	5.1×10^5	4.66×10^4					

gpm

SI
APERTURE
CARD

Also Available On
Aperture Card

9111110048 -G3

EX

ENTRAINMENT ESTIMATES FOR CONDEN

for Crangon sept

	Data for Existing Systems					Projected Daily Entrai
Month 1975-1976	Circulating Water (gpm x 10^3)	Sample Days(1) per Month	Daily(2) Sample Entrainment	Condenser Mortality Rate	Sample Condenser Mortality	Canal-bay/(3) Existing System
Sep						
Oct						
Nov						
Dec						
Jan						
Feb						
Mar						
Apr						
May						
Jun						
Jul						
Aug						

(1) Unaccounted for days showed variable daily flow

(2) Based on IA, 1977, Table 10-day and night samples

(3) Entrainment halved with operation of o

HIBIT 175

SER CIRCULATING WATER AND DILUTION WATER

emspinosa-macroplankton

d nment Cooling Towers	Projected Daily Mortality Canal-Bay/ Existing System	Projected Daily Mortality Cooling Towers	Dilution Water (gpm x 10^3)	Sample Days[(1)] per Month	Mean Density Station 7[(2)] (in No. /1000 m^3)	Actual Dilution Water Daily Entrainment	Daily Entrainment[(3)] Through Two Dilution Pumps (560 x 10^6 gpm)
			250	26/30	62	2.23×10^7	4.46×10^7
			500 250	11/31 14/31	-	-	-
			500	24/30	14	1×10^7	1×10^7
			500	25/31	147	1.06×10^8	1.06×10^8
			500	24/31	289	2.08×10^8	2.08×10^8
			500	23/29	298	2.15×10^8	2.15×10^8
			500 250	18/31 11/31	1,475	7.95×10^8	1.06×10^9
			500 250	23/30 7/30	89	5.66×10^7	6.41×10^7
			250	25/31	98	3.53×10^7	7.06×10^7
			500 250	19/30 7/30	96	5.98×10^7	6.91×10^7
			500 250	25/31 4/31	153	1.10×10^8	1.10×10^8
			500	25/31	349	2.51×10^8	2.51×10^8

e dilution pump at 260 x 10^6 gpm

EXHI

ENTRAINMENT ESTIMATES FOR CONDENSE

for Crangon s

Month 1975-1976	Data for Existing System: Circulating Water (gpm x 10^3)	Sample Days[1] per Month	Daily[2] Sample Entrainment	Condenser Mortality Rate	Sample Condenser Mortality	Projected Daily Entrainm: Canal-Bay/[3] Existing System	Co T
Sep	345	[illegible]	3.76×10^3	No	-	5×10^3	2.2
Oct	345	[illegible]	4.18×10^5	Determinations	-	5.56×10^5	2.5
Nov	345 0	[illegible]	[illegible] $\times 10^5$		-	3.50×10^5	1.6
Dec	345 0	[illegible] 3/3	[illegible]		-	3.82×10^6	1.7
Jan	345	23/30	[illegible]		-	3.76×10^5	1.7
Feb	345	25/29	1.45×10^6		-	1.93×10^6	8.8
Mar	460 345 0	15/31 8/31 3/31	8.32×10^6		-	9.65×10^6	4.4
Apr	460	30/30	7.35×10^7		-	7.35×10^7	3.36
May	460	29/31	1.80×10^8		-	1.80×10^8	3.2
Jun	460	26/30	5.15×10^7		-	5.15×10^7	2.35
Jul	460	31/31	3.24×10^6		-	3.24×10^6	1.48
Aug	460	31/31	3.18×10^5		-	3.18×10^5	1.45

(1) Unaccounted for days showed variable daily flow

(2) Based on IA, 1977, Table 17 - day and night intake samples

(3) Assumes circulating water flow at 460 x 1

(4) Assumes 100% mortality

(5) Based on IA, 1977, Table 10 - day and nig

RIT 175

R CIRCULATING WATER AND DILUTION WATER

eptemspinosa-zoea

ent oling owers	Projected Daily Mortality Canal-Bay/ Existing System	Cooling(4) Towers	Dilution Water (gpm × 10³)	Sample Days(1) per Month	Mean Density Station 7 (in No./1000 m³)	Actual Dilution Water Daily Entrainment	Daily Entrainment(6) Through Two Dilution Pumps (560 × 10⁶ gpm)
× 10²	-	2.28 × 10²	250	26/30	2	7.2 × 10⁵	1.44 × 10⁶
× 10⁴	-	2.54 × 10⁴	500 250	11/31 14/31	249	1.34 × 10⁸	1.79 × 10⁸
× 10⁴	-	1.60 × 10⁴	500	24/30	120	8.€. × 10⁷	8.64 × 10⁷
× 10⁵	-	1.74 × 10⁵	500	25/31	1,379	9.93 × 10⁸	9.93 × 10⁸
× 10⁵	-	1.72 × 10⁴	500	24/31	124	8.93 × 10⁷	8.93 × 10⁷
× 10⁴	-	8.81 × 10⁴	500	25/29	629	4.53 × 10⁸	4.53 × 10⁸
× 10⁵	-	4.41 × 10⁵	500 250	18/31 11/31	3,928	2.12 × 10⁹	2.83 × 10⁹
× 10⁶	-	3.36 × 10⁶	500 250	23/30 7/30	29,478	1.87 × 10¹⁰	2.12 × 10¹⁰
× 10⁶	-	8.2 × 10⁶	250	25/31	82,501	2.97 × 10¹⁰	5.94 × 10¹⁰
× 10⁶	-	2.3? × 10⁶	500 250	19/30 7/30	27,076	1.69 × 10¹⁰	1.95 × 10¹⁰
× 10⁵	-	1.48 × 10⁵	500 250	25/31 4/31	885	6.37 × 10⁸	6.37 × 10⁸
× 10⁴	-	1.45 × 10⁴	500	25/31	165	1.19 × 10⁸	1.19 × 10⁸

6 gpm

(6) Entrainment halved with operation of one dilution pump at 260 × 10⁶ gpm

samples

SI
APERTURE
CARD

Also Available On
Aperture Card

9111110048 -65

EXHI

ENTRAINMENT ESTIMATES FOR CONDENSE

for Callinecte

	Data for Existing Systems					Projected Daily Entrainm	
Month 1975-1976	Circulating Water (gpm x 10^3)	Sample Days per Month(1)	Daily(2) Sample Entrainment	Condenser Mortality Rate	Sample Condenser Mortality	Canal-Bay/(3) Existing System	Co T
Sep	345	21/30	1.88×10^6	0	0	2.5×10^6	1.1
Oct	345	29/31	2.15×10^5	0	0	2.86×10^5	1.3
Nov	345 0	24/30 5/30	0	-	0	0	
Dec	345 0	23/31 3/31	0	-	0	0	
Jan	345	23/30	0	-	0	0	
Feb	345	25/29	0	0	0	0	
Mar	460 345 0	15/31 8/31 3/31	0	-	0	0	
Apr	460	30/30	0	-	0	0	
May	460	29/31	0	-	0	0	
Jun	460	26/30	0	-	0	0	
Jul	460	31/31	0	-	0	0	
Aug	460	31/31	7.38×10^4	0	0	7.38×10^4	3.3

(1) Unaccounted for days showed variable daily flow

(2) Based on IA, 1977, Table 17 - condenser discharge samples

(3) Assumes circulating water flow at 460 x

(4) Assumes 100% mortality

...BIT 175

...R CIRCULATING WATER AND DILUTION WATER

...s sapidus-megalopa

...ent	Projected Daily Mortality						
...oling ...owers	Canal-Bay/ Existing System	Cooling[4] Towers	Dilution W... (gm... [illegible])	Sample Days[1] per Month	Mean Density in No/m^3 Station	Actual Dilution Water Daily Entrainment	Daily Entrainment Through Two Dilution Pumps (560 x 10^6 gpm)
...4 x 10^5	0	1.14 x 10^5					
...1 x 10^4	0	1.31 x 10^4					
0	0	0					
0	0	0					
0	0	0					
0	0	0					
0	0	0					
0	0	0					
0	0	0					
0	0	0					
0	0	0					
... x 10^3	0	3.37 x 10^3					

...10^6 gpm

ENTRAINMENT ESTIMATES FOR COND

for Callinectes

	Data for Existing Systems					Projec Daily Entr
Month 1975-1976	Circulating Water (gpm x 10^3)	Sample Days[(1)] per Month	Daily[(2)] Sample Entrainment	Condenser Mortality Rate	Sample Condenser Mortality	Canal-Bay/[(3)] Existing System
Sep	345	21/30	1.04×10^9	0	0	1.38×10^9
Oct	345	29/31	1.40×10^8	0	0	1.86×10^8
Nov	345 0	24/30 5/30	4.47×10^6	0	0	5.95×10^6
Dec	345 0	23/31 3/31	-	-	-	-
Jan	345	23/30	-	-	-	-
Feb	345	25/29	-	-	-	-
Mar	460 345 0	15/31 8/31 3/31	-	-	-	-
Apr	460	30/30	7.95×10^6	0	0	7.95×10^6
May	460	29/31	2.78×10^7	0	0	2.78×10^7
Jun	460	26/30	1.13×10^8	0	0	1.13×10^8
Jul	460	31/31	1.94×10^7	0	0	1.94×10^7
Aug	460	31/31	9.44×10^7	0	0	9.44×10^7

(1) Unaccounted for days showed variable daily flow

(2) Based on IA, 1977, Table 10 - Station 7 densities

(3) Assumes circulating water flow at 460

(4) Assumes 100% mortality

XHIBIT 175

ENSER CIRCULATING WATER AND DILUTION WATER

sapidus-larvae and juveniles

ted inment	Projected Daily Mortality						
Cooling Towers	Canal-Bay/ Existing System	Cooling Towers(4)	Dilution Water ($gpm \times 10^3$)	Sample Days(1) per Month	Mean Density in No/m^3 Station	Actual Dilution Water Daily Entrainment	Daily Entrainment Through Two Dilution Pumps (560×10^6 gpm)
6.3×10^7	0	6.3×10^7					
8.49×10^6	0	8.49×10^6					
2.72×10^5	0	2.72×10^5					
-	-	-					
-	-	-					
-	-	-					
-	-	-					
$.63 \times 10^5$	0	3.63×10^5					
$..7 \times 10^6$	0	1.27×10^6					
$.16 \times 10^6$	0	5.16×10^6					
$.86 \times 10^5$	0	8.86×10^5					
$.31 \times 10^6$	0	4.31×10^6					

$\times 10^6$ gpm

EXH

ENTRAINMENT ESTIMATES FOR CONDENS

for Callinectes sapid

Month 1975-1976	Data for Existing Systems					Projected Daily Entrain	
	Circulating Water (gpm x 10^3)	Sample Days(1) per Month	Daily(2) Sample Entrainment	Condenser Mortality Rate	Sample Condenser Mortality	Canal-Bay/(3) Existing System	C
Sep							
Oct							
Nov							
Dec							
Jan							
Feb							
Mar							
Apr							
May							
Jun							
Jul							
Aug							

(1) Unaccounted for days showed variable daily flow

(2) Based on IA, 1977, Table 10-day and night samples

(3) Entrainment halved with operation of one

IBIT 17b

ER CIRCULATING WATER AND DILUTION WATER

us-megalopa, juvenile, zoea

ment ooling Towers	Projected Daily Mortality Canal-Bay/ Existing System	Cooling Towers	Dilution Water (gpm x 10^3)	Sample Days(1) per Month	Mean Density Station 7 (in No./1000 m^3)	Actual Dilution Water Daily Entrainment	Daily Entrainment(3) Through Two Dilution Pumps (560 x 10^6 gpm)
			250	26/30	2,102	7.57×10^8	1.51×10^9
			500 250	11/31 14/31	281	1.52×10^8	2.02×10^8
			500	24/30	9	6.48×10^6	6.48×10^6
			500	25/31	-	-	-
			500	24/31	-	-	-
			500	25/29	-	-	-
			500 250	18/31 11/31	-	-	-
			500 250	23/30 7/30	16	1.02×10^7	1.15×10^7
			250	25/31	56	2.02×10^7	4.04×10^7
			500 250	19/30 7/30	228	1.42×10^8	1.64×10^8
			500 250	25/31 4/31	39	2.81×10^7	2.81×10^7
			500	25/31	190	1.37×10^8	1.37×10^8

dilution pump at 260 x 10^6 gpm

EXHI

ENTRAINMENT ESTIMATES FOR CONDENSER

for Sagit

Month 1975-1976	Data for Existing System: Circulating Water (gpm x 10^3)	Sample Days[1] per Month	Daily[2] Sample Entrainment	Condenser Mortality Rate	Sample Condenser Mortality	Projected Daily Entrainme…: Canal-Bay/[3] Existing System	Co… T…
Sep	345	21/3C	0	No	0	0	
Oct	345	29/31	0	Determinations	0	0	
Nov	345 0	24/30 5/30	0		0	0	
Dec	345 0	23/31 3/31	5.28×10^5		-	7.02×10^5	3.2
Jan	345	23/30	1.24×10^7		-	1.65×10^7	7.5
Feb	345	25/29	4.19×10^7		-	5.57×10^7	2.54
Mar	460 3'5 0	15/31 8/31 3/31	2.32×10^7		-	3.09×10^7	1.41
Apr	460	30/30	1.2×10^5		-	1.2×10^5	5.48
May	460	29/31	0		0	0	
Jun	460	26/30	0		0	0	
Jul	460	3:/31	0		0	0	
Aug	463	31/31	0		0	0	

(1) Unaccounted for days showed variable daily flow

(2) Based on IA, 1977, Table 17 - day and night samples

(3) Assumes circulating water flow at 460 x

(4) Assumes 100% mortality

(5) Based on IA, 1977, Table 10 - day and nig

IT 175

CIRCULATING WATER AND DILUTION WATER

ta elegans

nt ling wers	Projected Daily Mortality Canal-Bay/ Existing System	Cooling Towers(4)	Dilution Water (gpm x 10^3)	Sample Days(1) per Month	Mean Density Station 7(5) (in No. /1000 m^3)	Actual Dilution Water Daily Entrainment	Daily Entrainment(6) Through Two Dilution Pumps (560 x 10^6 gpm)
0	0	0	250	26/30	-	-	-
0	0	0	500 250	11/31 14/31	-	-	-
0	0	0	500	24/30	14	1.01×10^7	1.01×10^7
x 10^4	-	3.2×10^4	500	25/31	238	1.71×10^8	1.71×10^8
x 10^5	-	7.53×10^5	500	24/31	8,079	5.82×10^9	5.82×10^9
x 10^6	-	2.54×10^6	500	25/29	15,835	1.14×10^{10}	1.14×10^{10}
x 10^6	-	1.41×10^6	500 250	18/31 11/31	14,742	7.96×10^9	1.06×10^{10}
x 10^3	-	5.48×10^3	500 250	23/30 7/30	-	-	-
0	0	0	250	25/31	-	-	-
0	0	0	500 250	19/30 7/30	-	-	-
0	0	0	500 250	25/31 4/31	-	-	-
0	0	0	500	25/31	-	-	-

0^6 gpm

(6) Entrainment halved with operation of one dilution pump at 260 x 10^6 gpm

ht samples

SI APERTURE CARD

Also Available On Aperture Card

9111110048 - 69

EX

ENTRAINMENT ESTIMATES FOR CONDENS

for Brevoort

	Data for Existing Systems					Projecte Daily Entrai
Month 1975-1976	Circulating Water ($gpm \times 10^3$)	Sample Days[1] per Month	Daily[2] Sample Entrainment	Condenser Mortality Rate	Sample Condenser Mortality	Canal-Bay/[3] Existing System
Sep						
Oct						
Nov						
Dec						
Jan						
Feb						
Mar						
Apr						
May						
Jun						
Jul						
Aug						

(1) Unaccounted for days showed variable daily flow

(2) Based on IA, 1977, Table 21

(3) Entrainment halved with operation of on

HIBIT 175

EEN CIRCULATING WATER AND DILUTION WATER

ia tyrannus-larvae

...ment Cooling Towers	Projected Daily Mortality Canal-Bay/ Existing System	Projected Daily Mortality Cooling Towers	Dilution Water (gpm x 10^3)	Sample Days(1) per Month	Mean Density in No/m^3 Station 7(2)	Actual Dilution Water Daily Entrainment	Daily Entrainment(3) Through Two Dilution Pumps (560 x 10^6 gpm)
			250	26/30	-	-	-
			500 250	11/31 14/31	0.003	1.62×10^6	2.16×10^6
			500	24/30	0.002	1.44×10^6	1.44×10^6
			500	25/31	0.021	1.51×10^7	1.51×10^7
			500	24/31	-	-	-
			500	25/29	-	-	-
			500 250	18/31 11/31	-	-	-
			500 250	23/30 7/30	0.002	1.27×10^6	1.44×10^6
			250	25/31	0.002	7.2×10^5	1.44×10^6
			500 250	19/30 7/30	-	-	-
			500 250	25/31 4/31	-	-	-
			500	25/31	-	-	-

e dilution pump at 260 x 10^6 gpm

SI
APERTURE
CARD

Also Available On
Aperture Card

9111110048 - 70

EX

ENTRAINMENT ESTIMATES FOR CONDEN

for Ancho

Month 1975-1976	Data for Existing System: Circulating Water (gpm x 10^3)	Sample Days[(1)] per Month	Daily[(2)] Sample Entrainment	Condenser Mortality Rate	Sample Condenser Mortality	Projected Daily Entrai: Canal-Bay/[(3)] Existing System	
Sep	345	21/30	0	No	0	0	
Oct	345	29/31	0	Determinations	0	0	
Nov	345 0	24/30 5/30	0		0	0	
Dec	345 0	23/31 3/31	0		0	0	
Jan	345	23/30	0		0	0	
Feb	345	25/29	0		0	0	
Mar	460 345 0	15/31 8/31 3/31	0		0	0	
Apr	460	30/30	8.14×10^4		-	8.14×10^4	3.
May	460	29/31	8.15×10^7		-	8.15×10^7	3.
Jun	460	26/30	3.38×10^8		-	3.38×10^8	1.
Jul	460	31/31	2.8×10^8		-	2.8×10^8	1.
Aug	460	31/31	2.47×10^7		-	2.47×10^7	1.

(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

(4) Assumes 100% mortality

(5) Based on IA, 1977, Table 21 - day and n

HIBIT 175

SER CIRCULATING WATER AND DILUTION WATER

a mitchilli-eggs

ment	Projected Daily Mortality						
Cooling Towers	Canal-Bay/ Existing System	Cooling(4) Towers	Dilution Water (gpm x 10^3)	Sample Days(1) per Month	Mean Density in No/m^3(5) Station 7	Actual Dilution Water Daily Entrainment	Daily Entrainment(6) Through Two Dilution Pumps (560 x 10^6 gpm)
0	0	0	250	26/30	-	-	-
0	0	0	500 250	11/31 14/31	-	-	-
0	0	0	500	24/30	-	-	-
0	0	0	500	25/31	-	-	-
0	0	0	500	24/31	-	-	-
0	0	0	500	25/29	-	-	-
0	0	0	500 250	18/31 11/31	-	-	-
72 x 10^3	-	3.72 x 10^3	500 250	23/30 7/30	0.034	8.19 x 10^4	9.27 x 10^4
72 x 10^6	-	3.72 x 10^6	250	25/31	38.682	5.27 x 10^7	1.05 x 10^8
54 x 10^7	-	1.54 x 10^7	500 250	19/30 7/30	168.274	3.96 x 10^8	4.58 x 10^8
28 x 10^7	-	1.28 x 10^7	500 250	25/31 4/31	106.213	2.89 x 10^8	2.89 x 10^8
13 x 10^6	-	1.13 x 10^6	500	25/31	14.409	3.93 x 10^7	3.93 x 10^7

10^6 gpm

(6) Entrainment halved with operation of one dilution pump at 260 x 10^6 gpm

ight samples

ENTRAINMENT ESTIMATES FOR CONDE[illegible]

for Anch[illegible]

Month 1975-1976	Data for Existing System: Circulating Water (gpm x 10^3)	Sample Days[1] per Month	Daily[2] Sample Entrainment	Condenser Mortality Rate	Sample Condenser Mortality	Projec[illegible] Daily Entra[illegible]: Canal-Bay/[3] Existing System
Sep	345	21/30	1.66×10^6	.646	1.07×10^6	2.21×10^6
Oct	345	29/31	1.29×10^5	.134	1.73×10^4	1.72×10^5
Nov	345 0	24/30 5/30	5.12×10^4	0	0	6.8×10^4
Dec	345 0	23/31 3/31	1.11×10^4	0	0	1.5×10^4
Jan	345	23/30	0	-	0	0
Feb	345	25/29	0	-	0	0
Mar	460 345 0	15/31 8/31 3/31	0	-	0	0
Apr	460	30/30	0	-	0	0
May	460	29/31	3.83×10^4	1.0	3.83×10^4	3.8×10^4
Jun	460	26/30	5.75×10^6	.01	5.75×10^4	5.75×10^6
Jul	460	31/31	1.64×10^7	.029	4.76×10^5	1.64×10^7
Aug	460	31/31	6.74×10^6	.257	1.73×10^6	5.74×10^6

(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

(4) Assumes 100% mortality

(5) Based on IA, 1977, Table 21 - day and

XHIBIT 175

NSER CIRCULATING WATER AND DILUTION WATER

a mitchilli-larvae

ted ainment Cooling Towers	Projected Daily Mortality Canal-Bay/ Existing System	Cooling Towers(4)	Dilution Water (gpm x 10^3)	Sample Days(1) per Month	Mean Density in No/m^3(5) Station 7	Actual Dilution Water Daily Entrainment	Daily Entrainment(6) Through Two Dilution Pumps (560 x 10^6 gpm)
1.01×10^5	1.43×10^6	1.01×10^5	250	26/30	1.89	2.58×10^6	5.16×10^6
7.85×10^3	2.3×10^4	7.85×10^3	500 250	11/31 14/31	0.248	5.07×10^5	6.76×10^5
3.1×10^3	0	3.1×10^3	500	24/30	0.039	7.9×10^4	7.9×10^4
6.85×10^2	0	6.85×10^2	500	25/31	0.009	2.45×10^4	2.45×10^4
0	0	0	500	24/31	-	-	-
0	0	0	500	25/29	-	-	-
0	0	0	500 250	18/31 11/31	-	-	-
0	0	0	500 250	23/30 7/30	-	-	-
$.73 \times 10^3$	3.8×10^4	1.73×10^3	250	25/31	-	-	-
$.62 \times 10^5$	5.8×10^4	2.62×10^5	500 250	19/30 7/30	3.586	8.46×10^6	9.77×10^6
$.49 \times 10^5$	4.8×10^5	7.49×10^5	500 250	25/31 4/31	10.171	2.77×10^7	2.77×10^7
$.08 \times 10^5$	1.7×10^6	3.08×10^5	500	25/31	4.056	1.11×10^7	1.11×10^7

x 10^6 gpm

(6) Entrainment halved with operation of one dilution pump at 260 x 10^6 gpm

night samples

E[illegible]

ENTRAINMENT ESTIMATES FOR CONDEN[illegible]

for Syngnathu[illegible]

	Data for Existing System					Projecte[illegible] Daily Entrai[illegible]	
Month 1975-1976	Circulating Water (gpm x 10^3)	Sample Days[1] per Month	Daily[2] Sample Entrainment	Condenser Mortality Rate	Sample Condenser Mortality	Canal-Bay/[3] Existing System	
Sep	345	21/30	4.19×10^4	.133	5.57×10^3	5.58×10^4	2
Oct	345	29/31	9.56×10^3	0	0	1.27×10^4	5
Nov	345 0	24/30 5/30	0	-	0	0	
Dec	345 0	23/31 3/31	0	-	0	0	
Jan	345	23/30	0	-	0	0	
Feb	345	25/29	0	-	0	0	
Mar	460 345 0	15/31 8/31 3/31	0	-	0	0	
Apr	460	30/30	1.63×10^4	0	0	1.63×10^4	7.
May	460	29/31	3.04×10^5	.394	1.2×10^5	3.04×10^5	.
Jun	460	26/30	7.87×10^5	.334	2.63×10^5	7.87×10^5	3.
Jul	460	31/31	4.0×10^5	.641	2.56×10^5	4.0×10^5	1.
Aug	460	31/31	5.37×10^4	.444	2.38×10^4	5.37×10^4	2.

(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 [illegible]

(4) Assumes 100% mortality

(5) Based on IA, 1977, Table 21 - day and n[illegible]

HIBIT 175

SER CIRCULATING WATER AND DILUTION WATER

fuscus-juveniles

d nment Cooling Towers	Projected Daily Mortality Canal-Bay/ Existing System	Cooling Towers (4)	Dilution Water (gpm x 10^3)	Sample Days (1) per Month	Mean Density in No/m^3 Station 7 (5)	Actual Dilution Water Daily Entrainment	Daily Entrainment (6) Through Two Dilution Pumps (560×10^6 gpm)
.55 x 10^3	7.42 x 10^8	2.55 x 10^3	250	26/30	0.025	559	1,118
.80 x 10^2	0	5.80 x 10^2	500	11/31	0.006	202	269
			250	14/31			
0	0	0	500	24/30	-	-	-
0	0	0	500	25/31	-	-	-
0	0	0	500	24/31	-	-	-
0	0	0	500	25/29	-	-	-
0	0	0	500	18/31	-	-	-
			250	11/31			
44 x 10^2	0	7.44 x 10^2	500	23/30	-	-	-
			250	7/30			
39 x 10^4	1.2 x 10^5	1.39 x 10^4	250	25/31	0.199	4.45 x 10^3	8.9 x 10^3
59 x 10^4	2.63 x 10^5	3.59 x 10^4	500	19/30	0.573	1.35 x 10^6	1.56 x 10^6
			250	7/30			
83 x 10^4	2.56 x 10^5	1.83 x 10^4	500	25/31	0.132	3.6 x 10^5	1.8 x 10^5
			250	4/31			
45 x 10^3	2.38 x 10^4	2.45 x 10^3	500	25/31	0.102	2.78 x 10^5	2.78 x 10^5

10^6 gpm

(6) Entrainment halved with operation of one dilution pump at 260×10^6 gpm

ight samples

SI APERTURE CARD

Also Available On Aperture Card

9111110048 - 73

TA[illegible]

ENTRAINMENT ESTIMATES FOR CONDEN[illegible]

for Pseudopleuron[illegible]

Month 1975-1976	Circulating Water (gpm x 10^3)	Sample Days[1] per Month	Daily[2] Sample Entrainment	Condenser Mortality Rate	Sample Condenser Mortality	Projected Daily Entra[illegible]: Canal-Bay/[3] Existing System
	Data for Existing Systems					
Sep	345	21/30	0	-	0	0
Oct	345	29/31	0	-	0	0
Nov	345 0	24/30 5/30	0	-	0	0
Dec	345 0	23/31 3/31	0	-	0	0
Jan	[illegible]	23/30	0	-	0	0
[illegible]	345	25/29	6.49×10^5	-	-	8.63×10^5
[illegible]	460 345 0	15/31 8/31 3/31	4.49×10^6	.058	2.6×10^5	5.97×10^6
Apr	460	30/30	1.39×10^5	.325	4.5×10^4	1.39×10^5
May	460	29/31	0	-	0	0
Jun	460	26/30	0	-	0	0
Jul	460	31/31	0	-	0	0
Aug	460	31/31	0	-	0	0

(1) Unaccounted for days showed variable daily flow

(2) Based on LA, 1977, Table 22-day and night samples

(3) Assumes circulating water flow at 460[illegible]

(4) Assumes 100% mortality

HIBIT 175

SER CIRCULATING WATER AND DILUTION WATER

ectes americanus-larvae

d inment Cooling Towers	Projected Daily Mortality Canal-Bay/ Existing System	Cooling(4) Towers	Dilution Water (gpm x 10^3)	Sample Days(1) per Month	Mean Density in No/m^3 Station	Actual Dilution Water Daily Entrainment	Daily Entrainment Through Two Dilution Pumps (560 x 10^6 gpm)
0	0	0					
0	0	0					
0	0	0					
0	0	0					
0	0	0					
.94 x 10^4	0	3.94 x 10^4					
.73 x 10^5	3.46 x 10^5	2.73 x 10^5					
.35 x 10^3	4.5 x 10^4	6.35 x 10^3					
0	0	0					
0	0	0					
0	0	0					
0	0	0					

x 10^6 gpm

E

ENTRAINMENT ESTIMATES FOR CONDE

for total

Month 1975-1976	Data for Existing Systems: Circulating Water (gpm x 10^3)	Sample Days[1] per Month	Daily[2] Sample Entrainment	Condenser Mortality Rate	Sample Condenser Mortality	Projected Daily Entrai: Canal-Bay/[3] Existing System	
Sep	345	21/30	3.10×10^6	Not	-	4.12×10^6	1
Oct	345	29/31	2.65×10^5	Quantified	-	3.52×10^5	1
Nov	345 0	24/30 5/30	6.93×10^4		-	9.2×10^4	4
Dec	345 0	23/31 3/31	3.14×10^4		-	4.2×10^4	1
Jan	345	23/30	3.50×10^6		-	4.66×10^6	2
Feb	345	25/29	2.92×10^6		-	3.88×10^6	1
Mar	460 345 0	15/31 8/31 3/31	5.92×10^6		-	7.87×10^6	3
Apr	460	30/30	4.81×10^5		-	4.81×10^5	2
May	460	29/31	6.9×10^5		-	6.9×10^5	3
Jun	460	26/30	1.72×10^7		-	1.72×10^7	7
Jul	460	31/31	2.66×10^7		-	2.66×10^7	1
Aug	460	31/31	1×10^7		-	1×10^7	4

(1) Uncounted for days showed variable daily flow

(2) Based on IA, 1977, Table 22 - day and night samples

(3) Assumes circulating water flow at 460

(4) Assumes 100% mortality

HIBIT 175

SER CIRCULATING WATER AND DILUTION WATER

fish-larvae

d nment Cooling Towers	Projected Daily Mortality Canal-Bay/ Existing System	Cooling Towers (4)	Dilution Water (gpm x 10^3)	Sample Days (1) per Month	Mean Density in No/m^3 Station	Actual Dilution Water Daily Entrainment	Daily Entrainment Through Two Dilution Pumps (560 x 10^6 gpm)
.88 x 10^5	-	1.88 x 10^5					
.61 x 10^4	-	1.61 x 10^4					
.20 x 10^3	-	4.20 x 10^3					
.92 x 10^3	-	1.92 x 10^3					
.13 x 10^5	-	2.13 x 10^5					
.77 x 10^5	-	1.77 x 10^5					
59 x 10^5	-	3.59 x 10^5					
2 x 10^4	-	2.2 x 10^4					
15 x 10^4	-	3.14 x 10^4					
85 x 10^5	-	7.85 x 10^5					
21 x 10^6	-	1.21 x 10^6					
57 x 10^5	-	4.57 x 10^5					

x 10^6 gpm

SI
APERTURE
CARD

Also Available On
Aperture Card

9111110048 - 75

ENTRAINMENT ESTIMATES FOR COND

for Cynosc

	Data for Existing Systems					Projec Daily Entr
Month 1975-1976	Circulating Water (gpm x 10^5)	Sample Days[(1)] per Month	Daily[(2)] Sample Entrainment	Condenser Mortality Rate	Sample Condenser Mortality	Canal-Bay/[(3)] Existing System
Sep						
Oct						
Nov						
Dec						
Jan						
Feb						
Mar						
Apr						
May						
Jun						
Jul						
Aug						

(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 10^6 gpm

XHIBIT 173

NSER CIRCULATING WATER AND DILUTION WATER

on regalis-larvae

ed inment Cooling Towers	Projected Daily Mortality Canal-Bay/ Existing System	Cooling Towers	Dilution Water (gpm x 10^3)	Sample Days[1] per Month	Mean Density in No/m^3 Station 7[2]	Actual Dilution Water Daily Entrainment	Daily Entrainment[3] Through Two Dilution Pumps (560 x 10^6 gpm)
			250	26/30	-	-	-
			500 250	11/31 14/31	-	-	-
			500	24/30	-	-	-
			500	25/31	-	-	-
			500	24/31	-	-	
			500	25/29	-	-	-
			500 250	18/31 11/31	-	-	-
			500 250	23/30 7/30	-	-	-
			250	25/31	-	-	-
			500 250	19/30 7/30	-	-	-
			500 250	25/31 4/31	0.006	4.02×10^6	4.32×10^6
			500	25/31	0.004	2.88×10^6	2.88×10^6

SI
APERTURE
CARD

Also Available On
Aperture Card

9111110048 - 76

ENTRAINMENT ESTIMATES FOR CONDE

for Taut

	Data for Existing Systems					Project Daily Entr
Month 1975-1976	Circulating Water (gpm x 10^3)	Sample Days[1] per Month	Daily[2] Sample Entrainment	Condenser Mortality Rate	Sample Condenser Mortality	Canal-Bay/[3] Existing System
Sep						
Oct						
Nov						
Dec						
Jan						
Feb						
Mar						
Apr						
May						
Jun						
Jul						
Aug						

(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 10^6 gpm

XHIBIT 175

NSER CIRCULATING WATER AND DILUTION WATER

ega onitis-eggs

ed inment Cooling Towers	Projected Daily Mortality Canal+Bay/ Existing System	Projected Daily Mortality Cooling Towers	Dilution Water (gpm x 10³)	Sample Days[1] per Month	Mean Density in No/m³ Station 7[2]	Act·al Dilution Water Daily Entrainment	Daily Entrainment[3] Through Two Dilution Pumps (560 x 10⁶ gpm)
			250	26/30	-	-	-
			500 250	11/31 14/31	-	-	-
			500	24/30	-	-	-
			500	25/31	-	-	-
			500	24/31	-	-	-
			500	25/29	-	-	-
			500 250	18/31 11/31	-	-	-
			500 250	23/30 7/30	0.283	1.80×10^8	2.04×10^8
			250	25/31	0.271	8.2×10^8	1.64×10^9
			500 250	19/30 7/30	0.152	9.43×10^7	1.09×10^8
			500 250	25/31 4/31	0.044	3.17×10^7	3.17×10^7
			500	25/31	0.005	3.6×10^6	3.6×10^6

ENTRAINMENT ESTIMATES FOR COND

for Ammodyte

Month 1975-1976	Data for Existing Systems: Circulating Water (gpm x 10^3)	Sample Days[1] per Month	Daily[2] Sample Entrainment	Condenser Mortality Rate	Sample Condenser Mortality	Projec Daily Entr: Canal-Bay/[3] Existing System
Sep						
Oct						
Nov						
Dec						
Jan						
Feb						
Mar						
Apr						
May						
Jun						
Jul						
Aug						

(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 10^6 gpm

XHIBIT 175

NSER CIRCULATING WATER AND DILUTION WATER

 sp - eggs and larvae

ed inment Cooling Towers	Projected Daily Mortality Canal-Bay/ Existing System	Projected Daily Mortality Cooling Towers	Dilution Water (gpm x 10^3)	Sample Days(1) per Month	Mean Density in No/m^3 Station 7(2)	Actual Dilution Water Daily Entrainment	Daily Entrainment Through Two Dilution Pumps (560 x 10^6 gpm)
			250	26/30	-	-	-
			500 250	11/31 14/31	-	-	-
			500	24/30	-	-	-
			500	25/31	-	-	-
			500	24/31	1.853	1.33×10^9	1.33×10^9
			500	25/29	1.003	7.22×10^8	7.22×10^8
			500 250	18/31 11/31	0.256	1.49×10^8	1.84×10^8
			500 250	23/30 7/30	0.024	1.53×10^7	1.73×10^7
			250	25/31	-	-	-
			500 250	19/30 7/30	-	-	-
			500 250	25/31 4/31	-	-	-
			500	25/31	-	-	-

SI
APERTURE
CARD

Also Available On
Aperture Card

9111110048 - 78

ENTRAINMENT ESTIMATES FOR COND

for Pseudopl

	Data for Existing Systems					Projec Daily Entr
Month 1975-1976	Circulating Water (gpm x 10^3)	Sample Days(1) per Month	Daily(2) Sample Entrainment	Condenser Mortality Rate	Sample Condenser Mortality	Canal-Bay/(3) Existing System
Sep						
Oct						
Nov						
Dec						
Jan						
Feb						
Mar						
Apr						
May						
Jun						
Jul						
Aug						

(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 260×10^6 gpm

EXHIBIT 172

ENSER CIRCULATING WATER AND DILUTION WATER

uronect s sp - larvae

ted ainment Cooling Towers	Projected Daily Mortality Canal-Bay/ Existing System	Cooling Towers	Dilution Water (gpm x 10^3)	Sample Days(1) per Month	Mean Density in No/m^3 Station 7(2)	Actual Dilution Water Daily Entrainment	Daily Entrainment(3) Through Two Dilution Pumps (560 x 10^6 gpm)
			250	26/30	-	-	-
			500 250	11/31 14/31	-	-	-
			500	24/30	-	-	-
			500	25/31	-	-	-
			500	24/31	-	-	-
			500	25/29	0.298	8.12×10^5	8.12×10^5
			500 250	18/31 11/31	1.645	4.48×10^6	4.48×10^6
			500 250	23/30 7/30	0.079	2.15×10^5	2.15×10^5
			250	25/31	-	-	-
			500 250	19/30 7/30	-	-	-
			500 250	25/31 4/31	-	-	-
			500	25/31	-	-	-

SI
APERTURE
CARD

Also Available On
Aperture Card

9111110048 - 79

E

ENTRAINMENT ESTIMATES FOR CONDE

for [illegible]

	Data for Existing Systems					Projecte Daily Entra
Month 1975-1976	Circulating Water (gpm x 10^3)	Sample Days(1) per Month	Daily(2) Sample Entrainment	Condenser Mortality Rate	Sample Condenser Mortality	Canal-Bay/(3) Existing System
Sep						
Oct						
Nov						
Dec						
Jan						
Feb						
Mar						
Apr						
May						
Jun						
Jul						
Aug						

(1) Unaccounted for days showed variable daily flow

(2) Based on IA, 1977, Table 21

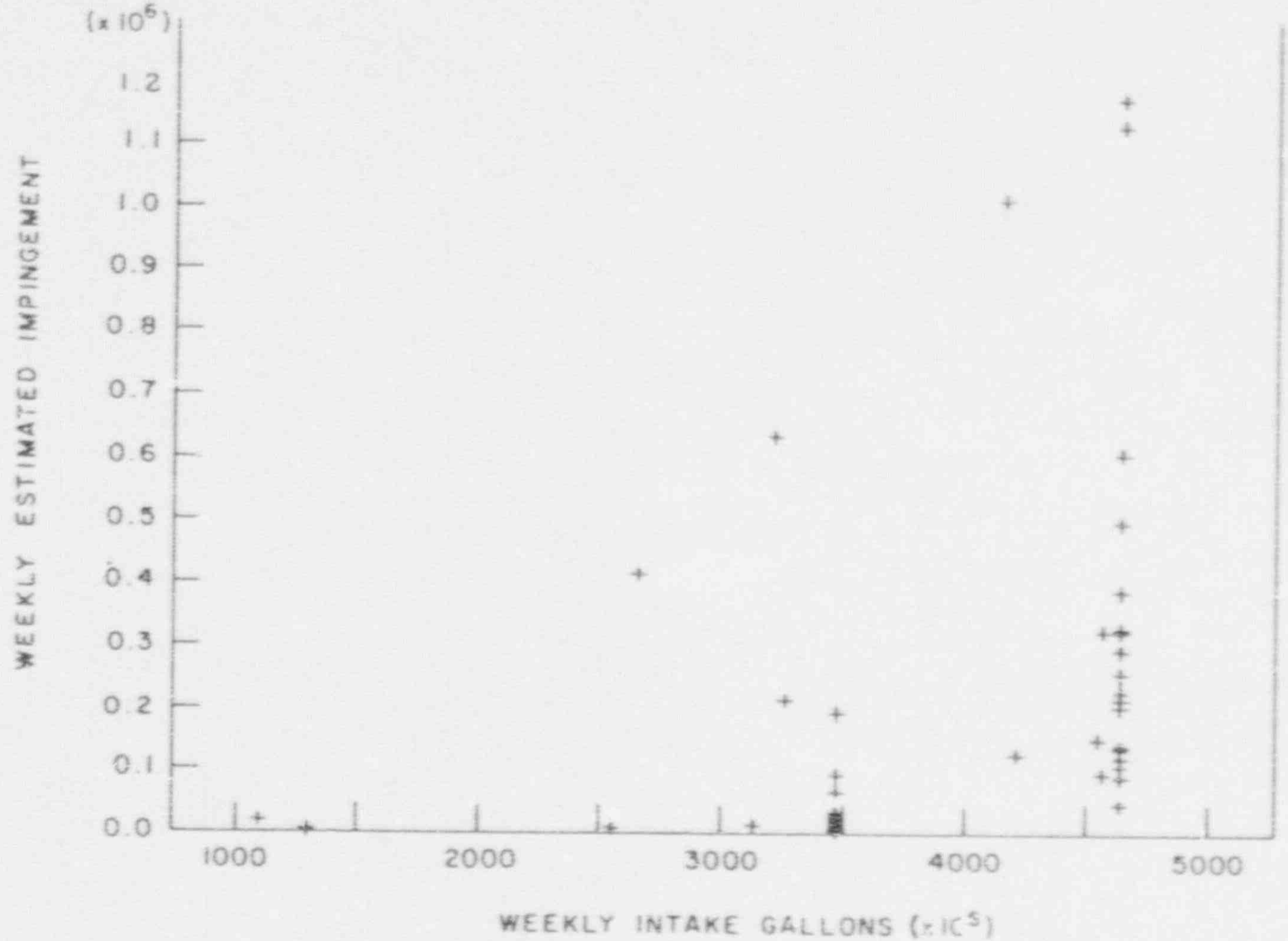
(3) Entrainment halved with operation of one dilution pump at 260×10^6 gpm

XHIBIT 175

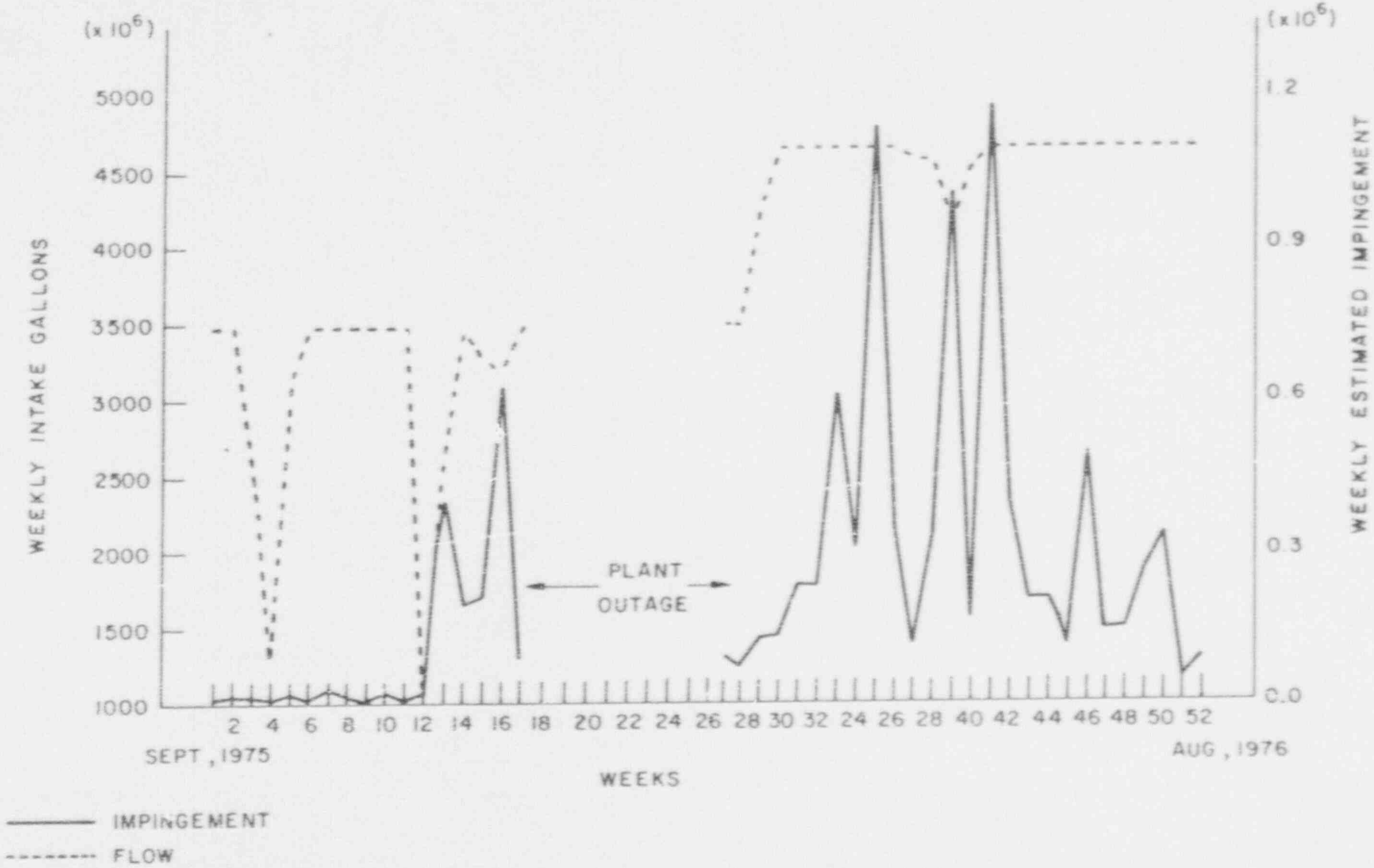
SSER CIRCULATING WATER AND DILUTION WATER

s maculatus-larvae

ed ...inment Cooling Towers	Projected Daily Mortality Canal-Bay/ Existing System	Projected Daily Mortality Cooling Towers	Dilution Water (gpm x 10^3)	Sample Days[(1)] per Month	Mean Density in No/m^3 Station 7[(2)]	Actual Dilution Water Daily Entrainment	Daily Entrainment[(3)] Through Two Dilution Pumps (560 x 10^6 gpm)
			250	26/30	-	-	-
			500 250	11/31 14/31	-	-	-
			500	24/30	-	-	-
			500	25/31	-	-	-
			500	24/31	-	-	-
			500	25/29	-	-	-
			500 250	18/31 11/31	-	-	-
			500 250	2?/30 7/30	-	-	-
			250	25/31	0.041	1.48 x 10^7	2.96 x 10^7
			500 250	19/30 7/30	0.042	2.61 x 10^7	3.02 x 10^7
			500 250	25/31 4/31	-	-	-
			500	25/31	-	-	-



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	IMPINGEMENT AND FLOW AT OCNGS FROM SEPTEMBER, 1975 TO SEPTEMBER, 1976	EXHIBIT 177
EBASCO SERVICES INCORPORATED New York		

Exhibit 178

COEFFICIENTS OF THE ANNUAL IMPINGEMENT REGRESSION EQUATIONS*, BY SPECIES

	Water Temperature	Salinity	DO	pH	Time of Day	Wind Speed	Wind Direction	No. of Screens	Water 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 MORTALIT

Atlantic menhaden (*Brevoortia tyrannus*)

I - Screen mortality rate: 31%
II - Screen mortality rate with Ri

Existing and Canal-to-Bay Systems	Jan	Feb	Mar
No. Impinged			1
No. Killed (I)			
No. Killed (II)			
Cooling Tower Systems			
No. Impinged			
No. Killed (I)			
No. Killed (II)			

Exhibit 179

' AND IMPINGEMENT ESTIMATES FOR OCNGS ALTERNATE COOLING SYSTEMS, BY SPECIES

stroph buckets: 7%

	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	10 Month Total
05	923	976	577	4,233	881	27	21	214	11,646	18,100
33	286	303	179	1,312	273	8	7	66	3,610	5,611
7	65	68	40	296	62	2	1	15	815	1,267
98	861	911	538	3,949	822	25	20	200	10,866	16,889
30	267	282	167	1,224	255	8	6	62	3,368	5,235
7	60	64	38	276	58	2	1	14	760	1,182

MONTHLY MORTALITY AND

Atlantic silverside (*Menidia menidia*)

I - Screen mortality rate: 40%
II - Screen mortality rate with Ristroph

Existing and Canal-to-Bay Systems	Jan	Feb	Mar
No. Impinged			26,513
No. Killed (I)			10,605
No. Killed (II)			1,591
Cooling Tower Systems			
No. Impinged			25,373
No. Killed (I)			10,149
No. Killed (II)			1,522

Exhibit 179 (Con't)

IMPINGEMENT ESTIMATES FOR OCNGS ALTERNATE COOLING SYSTEMS, BY SPECIES

buckets: 6%

Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	10 Month Total
4,070	4,696	321	2	1	3	37	977	24,705	58,138
1,628	1,878	128	1	0	1	15	391	8,607	23,255
244	282	19	0	0	0	2	59	1,291	3,488
3,895	4,029	307	2	1	3	35	935	23,643	55,172
1,558	1,612	123	1	0	1	14	374	9,457	22,069
234	242	18	0	0	0	2	56	1,418	3,310

SI
APERTURE
CARD

Also Available On
Aperture Card

9111110048 — 82

MONTHLY MORTALITY AND

Bay anchovy (*Anchoa mitchilli*)

I - Screen mortality rate: 77%
II - Screen mortality rate with Ristroph

Existing and Canal-to-Bay Systems	Jan	Feb	Mar	A
No. Impinged			45,744	94
No. Killed (I)			35,223	72
No. Killed (II)			9,149	18
Cooling Tower Systems				
No. Impinged			35,497	73
No. Killed (I)			27,333	56
No. Killed (II)			7,099	14

IMPINC[illegible]NT ESTIMA[illegible]S FOR OCNGS ALTERNATE COOLING SYSTEMS, BY SPECIES

buckets: 20%

[illegible]r	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	10 Month Total
[illegible],067	583,726	33,119	7,158	10,420	2,584	11,440	2,231	773	1,640,262
[illegible],162	449,469	25,502	5,512	8,023	1,990	8,809	1,718	595	1,263,002
[illegible],613	116,745	6,624	1,432	2,084	517	2,288	446	155	328,052
[illegible],820	29,186	27,886	5,555	8,086	1,318	8,877	1,731	600	850,556
[illegible],501	22,473	21,472	4,277	6,226	1,015	6,835	1,333	462	654,927
[illegible],364	5,837	5,577	1,111	1,617	264	1,775	346	120	170,110

MONTHLY MORTALITY AN

Blue crab (Callinectes sapidus)

I - Screen mortality rate: 8%
II - Screen mortality rate with Ristroph

Existing and Canal-to-Bay Systems	Jan	Feb	Mar	
No. Impinged			84,479	1
No. Killed (I)			6,758	
No. Killed (II)				
Cooling Tower Systems				
No. Impinged			75,355	1
No. Killed (I)			6,028	
No. Killed (II)				

Exhibit 179 (Con't)

) IMPINGEMENT ESTIMATES FOR OCNGS ALTERNATE COOLING SYSTEMS, BY SPECIES

bucket:

Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	10 Month Total
41,758	690,721	1,789,678	1,003,826	784,931	35,450	44,189	23,396	6,893	4,627,007
11,341	55,258	143,174	80,306	62,794	2,836	3,535	1,872	551	370,160
26,448	53,186	5,369	895,413	700,158	11,202	39,417	20,869	6,145	,930,490
10,116	4,255	430	71,633	56,013	896	3,153	1,670	492	154,440

MONTHLY MORTALITY AND IMPINGEM

Bluefish (*Pomatomus saltatrix*)

I - Screen mortality rate: 61%
II - Screen mortality rate with Ristroph buckets:

Existing and Canal-to-Bay Systems	Jan	Feb	Mar	Apr
No. Impinged				
No. Killed (I)				
No. Killed (II)				
Cooling Tower Systems				
No. Impinged				
No. Killed (I)				
No. Killed (II)				

NT ESTIMATES FOR OCNGS ALTERNATE COOLING SYSTEMS, BY SPECIES

11%

May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	10 Month Total
3,704	6,697	659	793	145				11,998
2,259	4,085	402	483	88				7,319
778	1,406	138	166	30				2,519
3,485	6,302	620	746	140				11,293
2,126	3,844	378	455	85				6,888
732	1,323	130	156	29				2,370

MONTHLY MORTALITY AND

Northern pipefish (*Sygnathus fuscus*)

I - Screen mortality rate: 4%
II - Screen mortality rate with Ristroph b

Existing and Canal-to-Bay Systems	Jan	Feb	Mar	Ap
No. Impinged			9,986	4
No. Killed (I)			399	
No. Killed (II)				
Cooling Tower Systems				
No. Impinged			9,786	4
No. Killed (I)			391	
No. Killed (II)				

IMPINGEMENT ESTIMATES FOR OCNGS ALTERNATE COOLING SYSTEMS, BY SPECIES

uckate: -

r	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	10 Month Month
414	3,678	2,446	415	78	46	118	4,687	12,463	34,791
177	147	98	17	3	2	5	187	498	1,392
326	3,550	2,407	407	76	45	116	4,593	12,214	34,095
17[illegible]	142	96	16	3	2	5	184	488	1,364

MONTHLY MORTALITY AND IMPINGEMENT

Sand shrimp (*Crangon septemspinosa*)

I - Screen mortality rate: 13%

II - Screen mortality rate with Ristroph buckets: -

Existing and Canal-to-Bay Systems	Jan	Feb	Mar	Apr	May
No. Impinged			203,489	254,715	874,1
No. Killed (I)			26,453	33,113	113,6
No. Killed (II)					
Cooling Tower Systems					
No. Impinged			188,024	235,357	48,0
No. Killed (I)			24,443	30,596	6,2
No. Killed (II)					

ESTIMATES FOR OCNGS ALTERNATE COOLING SYSTEMS, BY SPECIES

	Jun	Jul	Aug	Sep	Oct	Nov	Dec	10 Month Total
32	551,759	5,815	17	0	300	66,734	1,475,703	3,202,867
37	71,729	756	2	0	39	8,675	191,841	416,372
77	509,825	5,373	16	0	277	61,662	1,363,550	2,199,828
50	66,277	698	2	0	36	8,016	177,262	285,976

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.

PLANT CHARACTERIS

Utility	Plant	Water Body	MWe	Max Fl
JCP&L (N J)	Oyster Creek	Barnegat Bay	620	460,00
LILCO (N Y)	Far Rockaway	Jamaica Bay	115	57,00
	E F Barret	Great South Bay	190 1	102,00
			190 2	102,00
	Port Jefferson	Port Jefferson Harbor	98 392	80,00 204,00
	Glenwood	Hempstead Harbor	113.5 113.5	62,00
JCP&L (N J)	Sayreville	Raritan River	376	150,00 for 4 &
Con Ed (N Y)	Indian Point Unit 1	Hudson River	265	280,00
	Indian Point Unit 2	Hudson River	873	840,00
	Indian Point Unit 3	Hudson River	1,033	840,00
Northeast Utilities (Conn)	Devon	Housatonic River - L I Sound	475	20,13
	Norwalk Harbor	L I Sound	338	150,00
	Monteville 5 & 6	Thames R I/ L I Sound	75 410	39,02 124,79
	Millstone 1 & 2	Niantic Bay - L I Sound	652 830	419,65 547,57
Boston Edison	Pilgrim	Cape Cod Bay	655	319,99
Delmarva Pwr	Edge Moor 1&2 3&4	Delaware River	391	144,00 185,00
	5		400	396,00
Maine Yankee	Maine Yankee	Montsweag Bay	830	403,92
Central Maine	William F Wyman 1, 2 & 3	Casco Bay	224	48,00 25,00 25,00

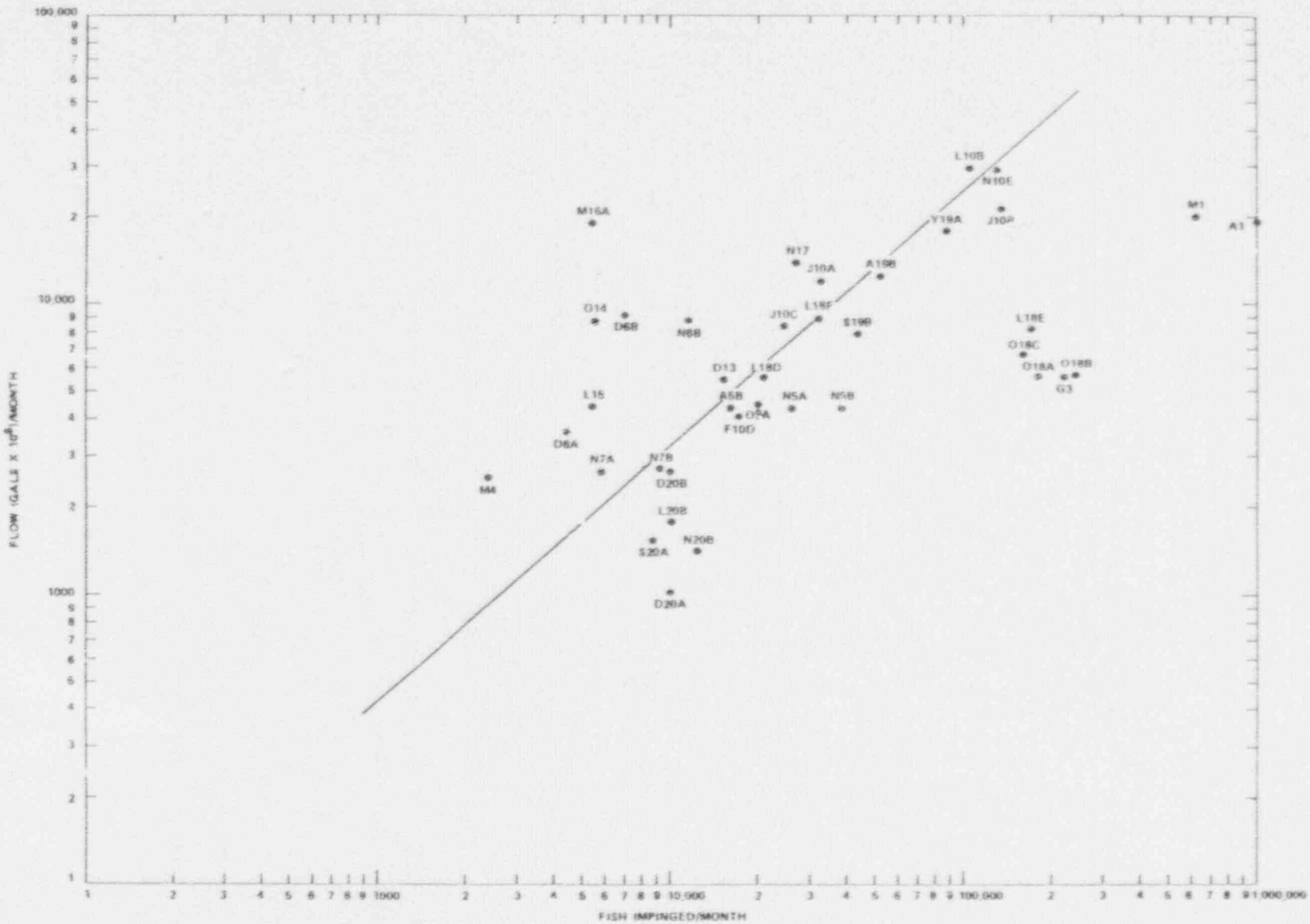
SI APERTURE CARD

Also Available On Aperture Card

Exhibit 181

...ICS OF INTAKES ALONG NORTH ATLANTIC ESTUARIES

...mum ...ow	Intake	Imp Sampling	Frequency	Comments
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.
gpm	Shoreline	35 samples, 1976	96 hrs/mo	Unit 4 only. No peaks.
gpm	Shoreline	33 samples, 1976	96 hrs/mo	Units 1 & 2 monitored separately. November peaks, April sub-peak.
gpm	Shoreline	33 samples, 1976	96 hrs/mo	
gpm	Shoreline	62 samples, 1976	96 hrs/mo	Units 1, 2 and 3, 4 monitored separately
gpm	Shoreline			Units 4 & 5 monitored separately
gpm	Shoreline	50 samples, 1976	96 hrs/mo	Killifish/silversides/no real period/ or abundance. November peak.
gpm ...nits ...6	Shoreline	Aug - Nov 1976 8 samples 3 - 6 hr intervals	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.
gpm	Shoreline	6/72 - 1975	Daily	Continuous sampling done due to extreme impingement rates - reduced pumping in effect. June peaks for all 3 units.
gpm	Shoreline	6/72 - 1975	Daily	
gpm	Shoreline	6/72 - 1975	Daily	
gpm	Shoreline	8/75 - 8/76 39 samples	2 - 4 days/mo	24 hr samples weekly from Apr to Sep & bimonthly Oct to Mar; Jan, June peaks.
gpm	Canal	8/75 - 8/76	2 - 4 days/mo	24 hr samples weekly (Apr - Sep) & biweekly (Oct - Mar) - winter flounder most abundant. Octob[illegible] peak.
gpm	Canal	8/75 - 8/76	2 - 4 days/mo	24 hr samples week[illegible] (Apr - Sep) & biweekly (Oct - Mar[illegible] - tomcod most abundant. July, Oct peak.
gpm	Canal			
gpm	Shoreline	1/76 - 9/76	Daily	Intakes include shoreline continuity, cutoff walls extending below normal low water & minimal approach velocities. May peak.
gpm	Shoreline	1/76 - 9/76	Daily	
gpm	Canal	9/72 - 9/76	48 hrs/wk	November peak, Aug sub-peak
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.
gpm	Shoreline			
gpm	Shoreline			24 hr samples; invertebrates counted. June peak, 1975.
gpm	Shoreline	44 samples, '75 48 samples, '76	1 day/wk	(1) 24 hr sample; 4 screens washed continuously. Jan peak, Apr sub-peak
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.
gpm	Shoreline	37 samples, '76		
gpm	Shoreline			



- 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 182
INTAKE FLOW VS IMPINGEMENT
AT NORTH ATLANTIC INTAKES
DURING MONTHS OF MAXIMUM
IMPINGEMENT

CODE	DESCRIPTION
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 1, 2 & 3
O5A	October - Long Island Lighting Co. - E. F. Barret Unit 1
O14	October - Northeast Utilities Service Co. - Norwalk Harbor
O18A	October - Delmarva Power Co. - Edge Moor Units 1 & 2
O18B	October - Delmarva Power Co. - Edge Moor Units 3 & 4
O18C	October - Delmarva Power Co. - Edge Moor Units 5
N5A	November - Long Island Lighting Co. - E. F. Barret Unit 1

Legend For Exhibit ... cont'd

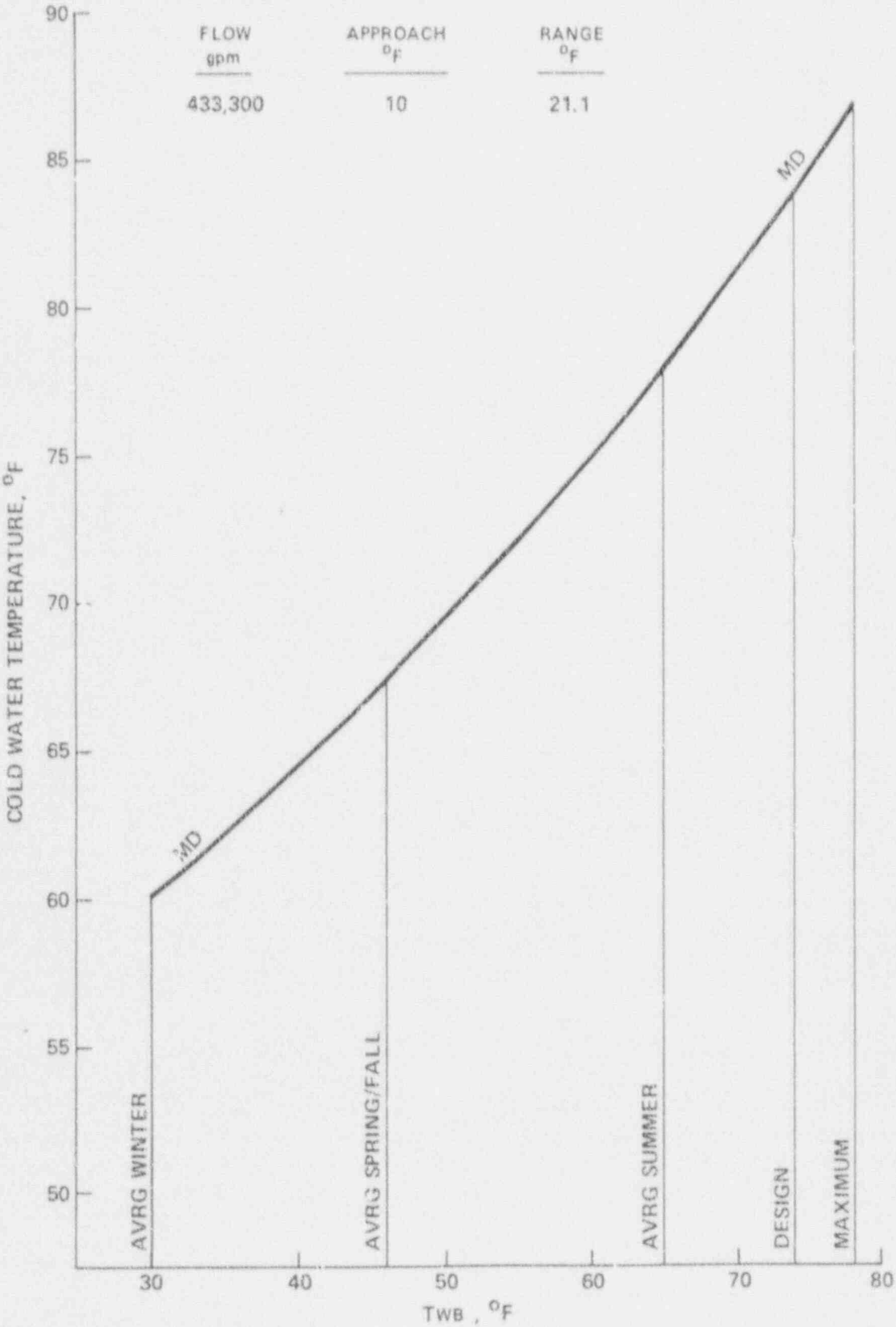
CODE	DESCRIPTION
N5B	November - Long Island Lighting Co. - E. F. Barret Unit 2
N6B	November - Long Island Lighting Co. - Port Jefferson Units 1 & 2
N7A	November - Long Island Lighting Co. - Glenwood Unit 4
N7B	November - Long Island Lighting Co. - Glenwood Unit 5
N10E	November - Consolidated Eidson - Indian Point Unit 2
N17	November - Boston Edison - Pilgrim Plant
N20B	November - Central Maine Power Company - W. F. Wyman Units 1, 2 & 3
D6A	December - Long Island Lighting Co. - Port Jefferson Units 1 & 2
D6B	December - Long Island Lighting Co. - Port Jefferson Units 3 & 4
D13	December - Northeast Utilities Service Co. - Devon Plant
D20A	December - Central Maine Power Company - W. F. Wyman Units 1, 2 & 3
D20B	December - Central Maine Power Company - W. F. Wyman 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

Month	Slope	Correlation Coefficient
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
ROUND MECHANICAL DRAFT COOLING TOWER THERMAL PERFORMANCE AT FULL LOAD OPERATION



FORM 543-42

JERSEY CENTRA
OYSTER CREEK NU
TWO ROUND MECHA
ENGINEERING &

		MONTHS:	1	2	3	4	5	6	7	8	9	10	1
I	ENGINEERING & PURCHASING												
	A – OPTIMIZATION ENGINEERING												
	B – TOWER: SPECIFY (1), BID (2), EVALUATE (3) & PURCHASE (4)				1	2	3	4					
	C – SYSTEM DESIGN & PURCHASE OF AUXILIARY EQUIPMENT												
	D – COOLING TOWER DESIGN (1) & FABRICATING & SHIPPING (2)												1
	E – DESIGN & PURCHASE TUBE CLEANING SYSTEM												
II	CONSTRUCTION												
	A – SITE PREPARATION, GRADING & ROADS												
	B – EXCAVATION & BACKFILL												
	C – FOUNDATIONS & BASIN	UNIT I											
	FOUNDATIONS & BASIN	UNIT II											
	D – INTAKE STRUCTURE												
	E – BOOSTER PUMP FOUNDATIONS												
	F – COOLING TOWER STRUCTURE	UNIT I											
	COOLING TOWER STRUCTURE	UNIT II											
	G – FILL STRUCTURE AND INTERNALS	UNIT I											
	FILL STRUCTURE AND INTERNALS	UNIT II											
	H – MECHANICAL EQUIPMENT												
	I – ELECTRICAL EQUIPMENT												
	J – PIPING INSTALLATION												
	K – TUBE CLEANING SYSTEM												
	L – CONDUIT, DUCT, WIRE & CABLE INSTALLATION												
	M – PREPARATION WORK FOR OUTAGE												
	N – OUTAGE – FINAL PIPE CONNECTIONS												

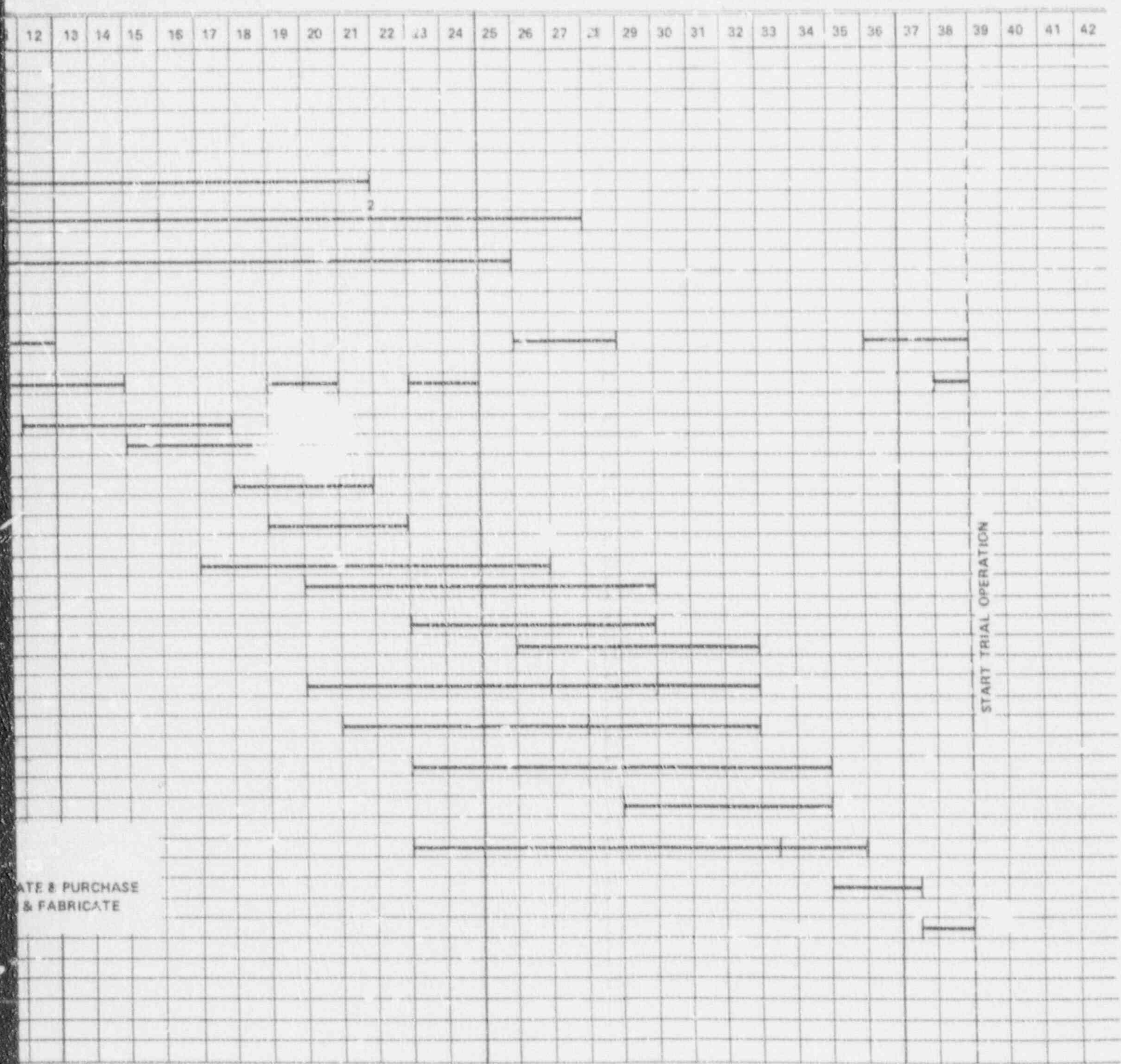
LEGEND:
1 – ENGINEERING
2 – SPECIFICATION
3 – BID PROPOSAL
4 – EVALU
5 – DESIGN

SI
APERTURE
CARD

Also Available On
Aperture Card

L POWER & LIGHT COMPANY
CLEAR GENERATING STATION
NICAL DRAFT COOLING TOWERS
CONSTRUCTION SCHEDULE

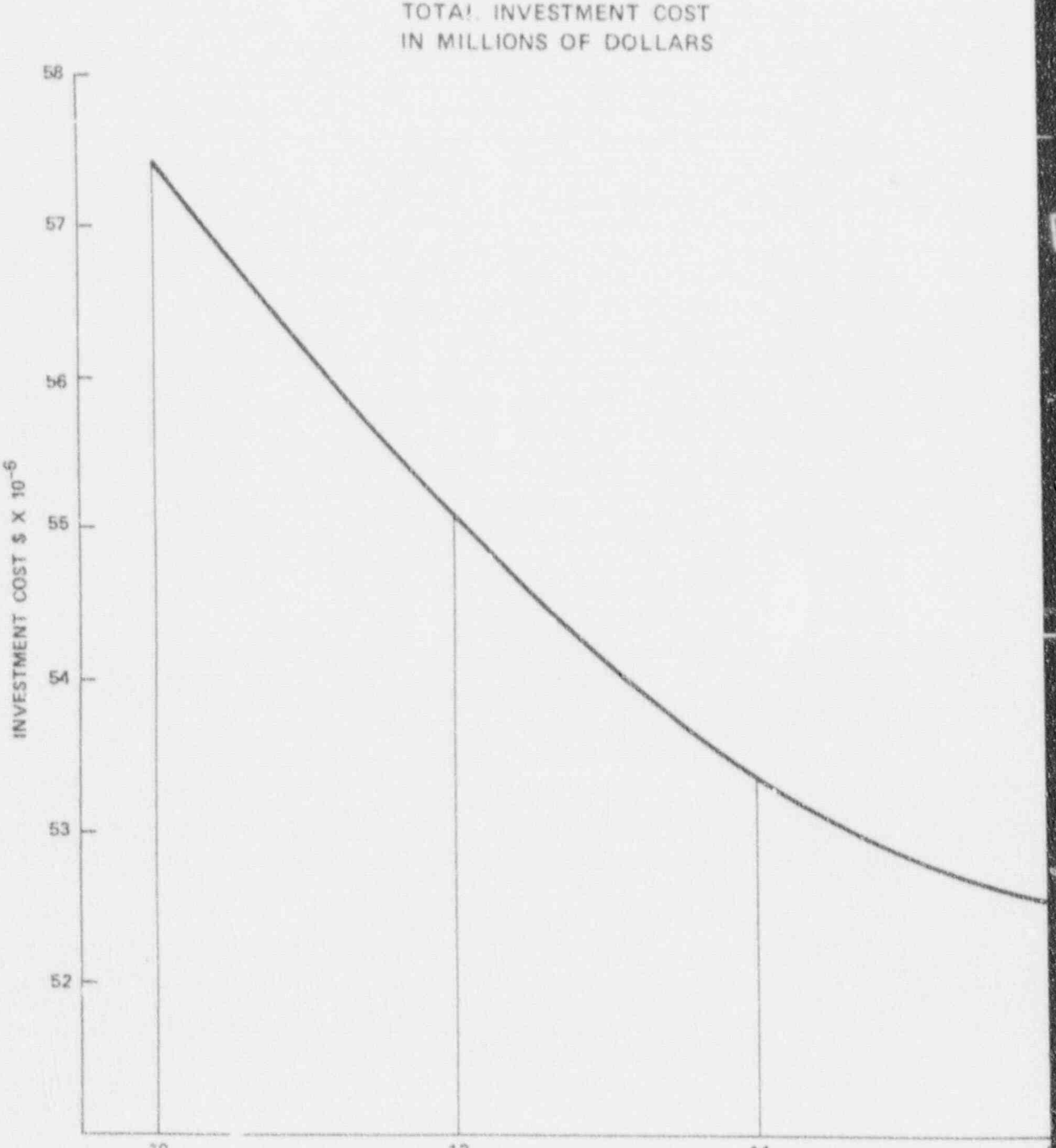
EXHIBIT 186



9111110048-89

JCP&L OYSTER CREEK N
ALTERNATIVE COOLI

OPTIMUM MECHANICAL DRAF
ECO



UCLEAR GENERATING STATION
NG WATER SYSTEM STUDY

T ROUND COOLING TOWER SYSTEM
ONOMICS

TOTAL COMPARABLE ANNUAL COST
IN MILLIONS OF DOLLARS PER YEAR

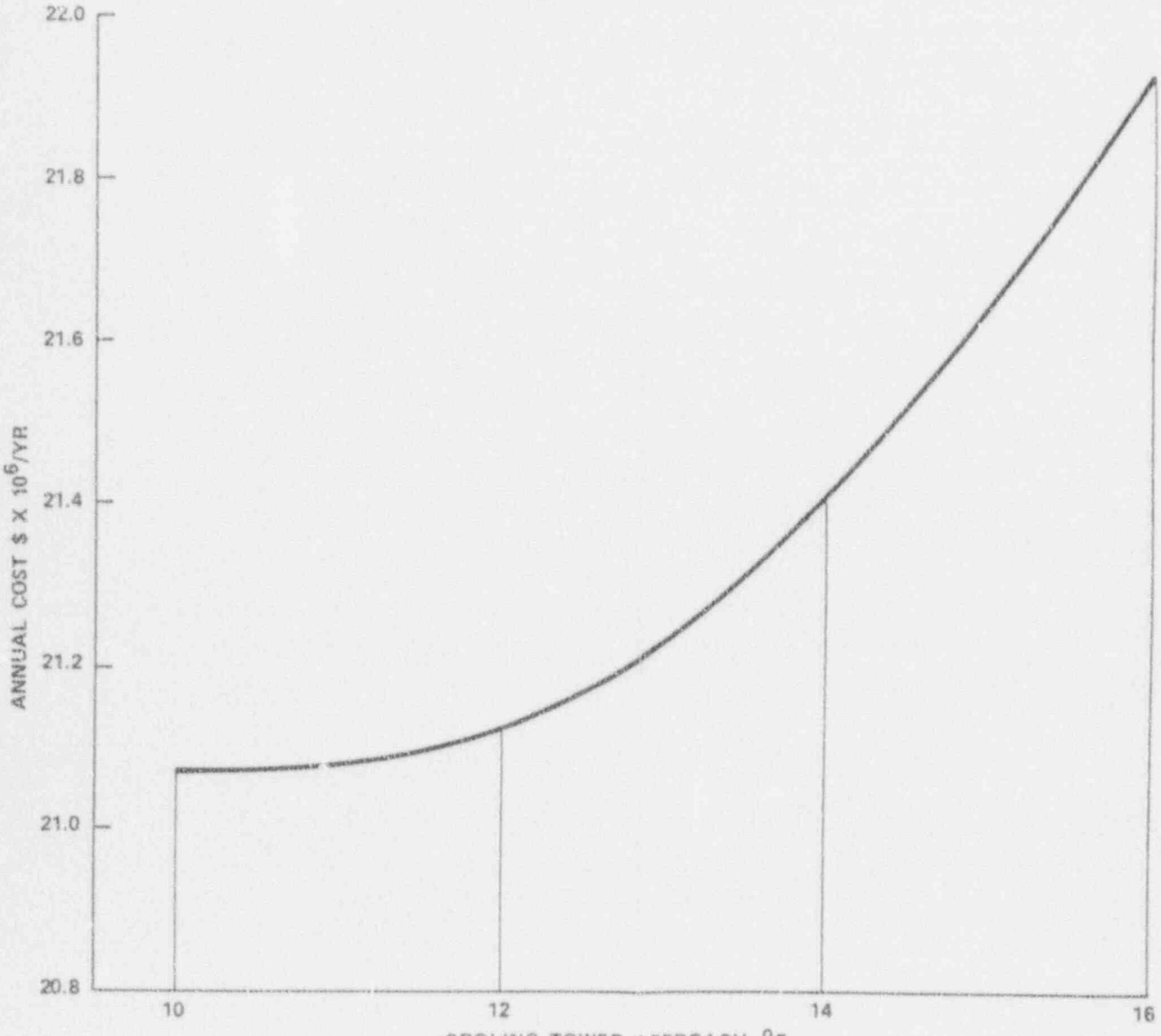


EXHIBIT 187

E B A S C O S E

THE FOLLOWING APPLIES TO ALL CONDENSING SYSTE

UNIT: BASED ON GE-TC6F-38"LSB RATED 640MW * 1

CONDENSER:
TUBE MATERIAL TIT
TUBE GAUGE
TUBE CLEANLINESS FACTOR 0.
SINGLE OR MULTI BACK PRESSURE SIN
NO. OF CONDENSER SHELLS

NO. OF PUMPS
TYPE OF PUMPS VE

ECONOMIC FACTORS
RATE OF RETURN (%) 9
FIXED CHARGE RATE (%) 22

TYPE OF COOLING
DESIGN WET BULB
DESIGN DRY BULB
DESIGN APPROACH

USER'S SELECTED
MAX. CONDENSER
MAX. TEMPERATUR

CASES NUMBERED 1 TO 1
PLUS OR MINUS 0.25 IN

THE OTHER CASES ARE
OF THE FOLLOWING AVER

AVERAGE DESIGN BACK PRESSURE
2.50
3.00
3.50
4.00
4.50

CASES NUMBERED 6001 T
AND TUBE VELOCITY FOR
COST INCLUDING CAPABI

*** FOR ZERO RATE OF RETURN IF MORE THA
ANNUAL FUEL COST IS THE AVERAGE OF ALL

CASES:

.0"HGA

AN		CONDENSER TUBE O.D. (IN)	0.875
22		CONDENSER TUBE LENGTH (FT)	42.5
000		NO. OF CONDENSER TUBES	14562
LE		COOLING TOWER FANS KW	0
3		CIRCULATING WATER PUMPS KW	2666
		ESTIMATED AUX. POWER REQUIREMENT EXCL. CW SYSTEM	17.50
		TURBINE GENERATOR CAPABILITY (MW)	670.0
4		UNIT NET CAPABILITY (MW)	620.00
PT.		CAPABILITY ADJUSTMENT ($/KW)	0.0
		UNIT NET ANNUAL GENERATION (MWH/YR)	3539729
		GENERATION ADJUSTMENT (BTU/KWH)	10400

SELECTED BASE FOR COOLING SYSTEM DIFFERENTIAL CALCULATIONS

.00
.25

SYSTEM: MECHANICAL DRAFT ROUND CT SYSTEM

TEMP. (F)	74.00
TEMP. (F)	68.90
TEMP. (F)	10.00

SYSTEM LIMITATIONS

BACK PRESS. (IN.HGA)	5.00
E RISE (F)	25.0

000 SHOW CONDENSING SYSTEMS WITHIN A RANGE OF
.HGA OF AN AVERAGE BACK PRESSURE OF 2.00 IN.HGA

ITHIN A RANGE OF PLUS OR MINUS 0.25 IN.HGA
AGE DESIGN BACK PRESSURES:

CASES

1001 TO 2000
2001 TO 3000
3001 TO 4000
4001 TO 5000
5001 TO 6000

D 6075 SHOW SMALLER VARIATIONS OF SURFACE AREA
THE PREVIOUS THREE BEST CASES BASED ON ANNUAL
LITY AND GENERATION ADJUSTMENTS

N ONE LINE IS FILLED IN UNDER LOADING PERIOD DATA THEN
THE YEARS' FUEL COSTS

SORT IN ASCENDING ORDER OF ANNUAL CO

	ANNUAL SYSTEM COSTS		INVESTMENT COSTS		PERFORMANCE DESIGN CONDITI
CASE NO	WITHOUT ADJUSTMNTS	INCLUDES ADJUSTMNTS	INITIAL + ESCAL	TOTAL	TG CAPABIL. (MW)
1	13529	20808	36105	56015	621.42

CE AT N ONS	SURFACE CONDENSER AND CONDENSER TUBES						PERFORMANCE AT PEAK LOAD CONDITION WATER TEMP	
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
3.23	423000	21.1	423.3	5.90	43	0.875	584.04	3.41

SI
APERTURE
CARD

Also Available On
Aperture Card

9111110048 - 92

SI APERTURE CARD

Also Available On Aperture Card

```
 SPECIFICATIONS FOR CASE NO.       1 MECHANICAL DRAF
CW INLET DESIGN TEMPERATURE (F)      80.00  PERFORM
CONDENSER TEMPERATURE RISE (F)       21.05    TG CA
TUBE DIAMETER (INCHES)/GAUGE       0.875/22   AVG C
TOTAL TUBE LENGTH (FT/SHELL)         42.50
NO. OF: TUBES PER SHELL/SHELLS     10562/3
NO. OF: TUBE PASSES/PRESS ZONES        1/1  PERFORM
TOTAL SURFACE AREA (SQ FT)          423000    TG CA
CIRCULATING WATER FLOW (GPM)        423300    AVG C
TUBE VEL. AT ABOVE CW FLOW (FPS)      5.90
                                            AVG SFA
                               E S T I M A T E D   I

ACCOUNT
 CODE            INITIAL  INVESTMENT  COST  ITEMS
          MAJOR SITE DEVELOPMENT
 1.11     LOCAL IMPROVEMENT TO SITE-CLEARING
 2.1      LOCAL GRADING
 2.5      PILING
 3.42     INTAKE STRUCTURE
 3.2      CIRCULATING WATER CONDUIT: MAIN
 3.2                                 BRANCHES
 3.32     DISCHARGE STRUCTURE
 3.41     COOLING TOWER BASIN
 3.44     COOLING TOWER SUPERSTRUCTURE
 5.1      TG BUILDING (DIFFERENTIAL)
 4.18     TG PEDESTAL (DIFFERENTIAL)
 7.1      TG & ACCESSORIES (DIFFERENTIAL)
10.211    CONDENSER SHELL
10.213    CONDENSER TUBE (TITAN)
10.221    CIRCULATING WATER PUMP
15.3      CIRCULATING WATER PUMP MOTOR
14.1      INSTRUMENTATION & CONTROL
15.11     START-UP & STANDBY TRANSFORMER (DIFFERENT
15.12     UNIT AUXILIARY TRANSFORMER (DIFFERENTIAL)
15.21     CIRCULATING WATER SWITCHGEAR
15.6      WIRING FOR CIRCULATING WATER SYSTEM
15.1      UNIT MAIN POWER TRANSFORMER (DIFFERENTIAL
15.23     FAN MOTOR POWER CENTER + REQ'D SWGR & FEE

                    TOTAL

            TOTAL DIRECT ESCALATED COST: MATERIA
            INDIRECT CONSTRUCTION COST INCLUDING
            CONTINGENCY (14.00% OF DIRECT PLUS I
            UTILITY'S EXPENSES, INTEREST DURING

                        TOTAL   ESTIMATED   I

             E S T I M A T E D   C O M P A R A B L
UNIT NET CAPABILITY W/SF/S/P (MW)   619.1 614.8 59
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$)
```

```
T FOUND  CT SYSTEM                                  ARC ATHT A J MOSTC 11/07/77 PAGE    7
ANCE AT DESIGN CONDITIONS:                           NO. OF COOLING TOWERS-CT           2
PABILITY (MW)                       621.42           NO. OF CELLS PER CT               19
NDENSER PRESSURE (IN.HGA)             3.23           CT DESIGN APPROACH TEMP (F)   10.00
                                                     TOTAL CT FAN MOTOR INPUT KW    6343
                                                     TOTAL CW PUMP MOTOR INPUT KW   8757
ANCE AT MAX SUMMER TEMPERATURE                       CW PUMP MOTOR RATING (HP)      3000
PABILITY (MW)                       617.64           CW SYSTEM TDH (FT)            84.89
NDENSER PRESSURE (IN.HGA)             3.41           CW MAIN CONDUIT DIAM (FT)     10.00
                                                     NO. OF CW PUMPS                   4
SONAL COND PRESS (IN.HGA) 1.70 2.04 2.73             TOTAL DILUTION PUMP INPUT KW   1000
N I T I A L   I N V E S T M E N T   C O S T
```

	TODAY'S MATERIAL COST		TODAY'S INSTALLATION COST		ESCALATION 1000$	
	UNIT	TOTAL 1000$	UNIT	TOTAL 1000$	MATERIAL	INSTALLATION
	---------------	4080	---------------	1600	1380	751
	---------------		0$/ACRE	0		0
	---------------		2.50$/CU YD	27		10
	0.00$/SQ FT	0	0.00$/SQ FT	0	0	0
	4.10$/CU FT	480	10.75$/CU FT	1260	162	739
	329$/LIN FT	526	232.00$/LIN FT	371	178	218
	65.00$/LIN FT	156	65.21$/LIN FT	157	53	92
	0.00$/CU FT	0	0.00$/CU FT	0	0	0
	0.80$/SQ FT	69	6.20$/SQ FT	704	23	331
	2653050$/EACH	5306	2170677$/EACH	4341	2221	2548
	0.00$/CU FT	0	0.00$/CU FT	0	0	0
	0$/FT HT	0	0$/FT HT	0	0	0
	0.00$/KVA	0	0.00$/KVA	0	0	0
	0$/EACH	0	0$/EACH	0	0	0
	0.0000$/FT	0	0.0000$/FT	0	0	0
	245280$/EACH	981	24528$/EACH	98	332	58
	206375$/EACH	826	8255$/EACH	33	279	19
	1504.76$/EACH	63	1019.05$/EACH	43	21	25
IAL)	0$/MVA	0	0$/MVA	0	0	0
	6700$/MVA	93	1200$/MVA	17	31	10
	43000$/PUMP	172	18000$/PUMP	72	58	42
	39687$/MVA	669	113812$/MVA	1910	226	1121
)	0$/MVA	0	0$/MVA	0	0	0
DER	166000$/CENTER	664	37000$/CENTER	148	225	87
		14065		10780	5190	6050

```
L PLUS  0.00% SALES/USE TAX PLUS INSTALLATION     36105
 PROFESSIONAL SERVICES                             5462
NDIRECT COST)                                      5619
CONSTRUCTION, & LAND                               8629
                                                 ------
NVESTMENT   COST   1000$                          56015
```

9111110048-93

F I N V E S T M E N T & A N N U A L C O S T S		1000$/YR	MILLS/KWH
9.0 584.0	CW SYSTEM FUEL COST (BASE VALUE)	163	
35.96	ANNUAL FIXED CHARGES (AT RATE 0.2225)	12463	
	WATER COST (AT 0.00$/MILLION GALLONS + CHEMICALS)	155	
3423282	MAINTENANCE (1.20% OF TOTAL INV + 2000$/FAN)	748	
116447	SUBTOTAL ANNUAL COST	13529	
	NET PRODUCTION COST		3.952
6192			
	ADJUSTMENT FOR DIFFERENTIAL CAPABILITY	1017	
	ADJUSTMENT FOR DIFFERENTIAL NET ANNUAL GENERATION	6261	
23981	TOTAL COMPARABLE ANNUAL COST INCLUDING ADJUSTMENTS FOR EQUALIZED CAPABILITY & NET ANNUAL GENERATION	20808	
60587	COMPARABLE NET PRODUCTION COST INCL. ADJUSTMENTS		5.878

Exhibit 189

OYSTER CREEK ROUND MECHANICAL

DRAFT TOWER IMPACTS

TABLE 1

ANNUAL FREQUENCY OF ELEVATED PLUMES FROM ROUND TOWERS
OYSTER CREEK STATION

Plume Lengths (ft)	Hours per Year for Given Direction from Towers															
	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
0 - 500	197	75	74	126	133	141	54	74	69	36	40	64	49	57	49	100
500 - 1,000	201	104	90	141	270	287	153	130	82	73	49	43	52	54	32	95
1,000 - 1,500	159	94	88	104	180	197	135	113	83	59	59	67	59	51	21	62
1,500 - 2,000	89	72	62	67	102	102	73	57	93	53	40	39	46	41	24	51
2,000 - 2,500	40	49	30	47	65	60	25	39	44	40	23	29	29	31	14	33
2,500 - 3,000	30	27	29	36	30	38	23	15	23	19	24	25	27	7	8	10
3,000 - 3,500	20	6	16	13	24	11	8	13	7	20	12	12	7	8	5	12
3,500 - 4,000	9	8	8	3	11	6	9	10	6	5	10	11	4	9	1	9
4,000 - 4,500	11	2	2	5	11	5	5	9	2	5	6	3	8	7	3	8
4,500 - 5,000	10	5	3	5	5	6	2	5	1	3	3	7	2	11	4	5
5,000 - 5,500	9	4	3	5	9	1	0	4	4	2	4	5	4	4	3	3
5,500 - 6,000	9	7	5	5	5	1	2	4	4	1	1	1	3	4	0	4
6,000 - 6,500	0	1	3	0	0	1	0	1	0	0	0	1	1	1	2	4
6,500 - 7,000	1	1	1	1	1	1	0	3	0	0	0	1	0	0	3	0
7,000 - 7,500	3	0	1	2	1	0	0	0	2	0	1	0	0	2	0	1
7,500 - 8,000	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0	1
8,000 - 8,500	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
8,500 - 9,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9,000 - 9,500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9,500 - 10,000	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
10,000 - 10,500	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
10,500 - 11,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11,000 - 11,500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11,500 - 12,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12,000 - 12,500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12,500 - 13,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Exhibit 189

OYSTER CREEK ROUND MECHANICAL

DRAFT TOWER IMPACTS

TABLE 2

PREDICTED MAXIMUM PEAK SHORT-TERM NEAR GROUND AIRBORNE CONCENTRATION ($\mu g/m^3$) OF SALT RESULTING FROM OPERATION OF TWO ROUND MECHANICAL DRAFT COOLING TOWERS AT THE OYSTER CREEK SITE

Month	Hours of Persistence	Direction[a]	Distance (miles)	Near Ground Airborne Concentration ($\mu g/m^3$)
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

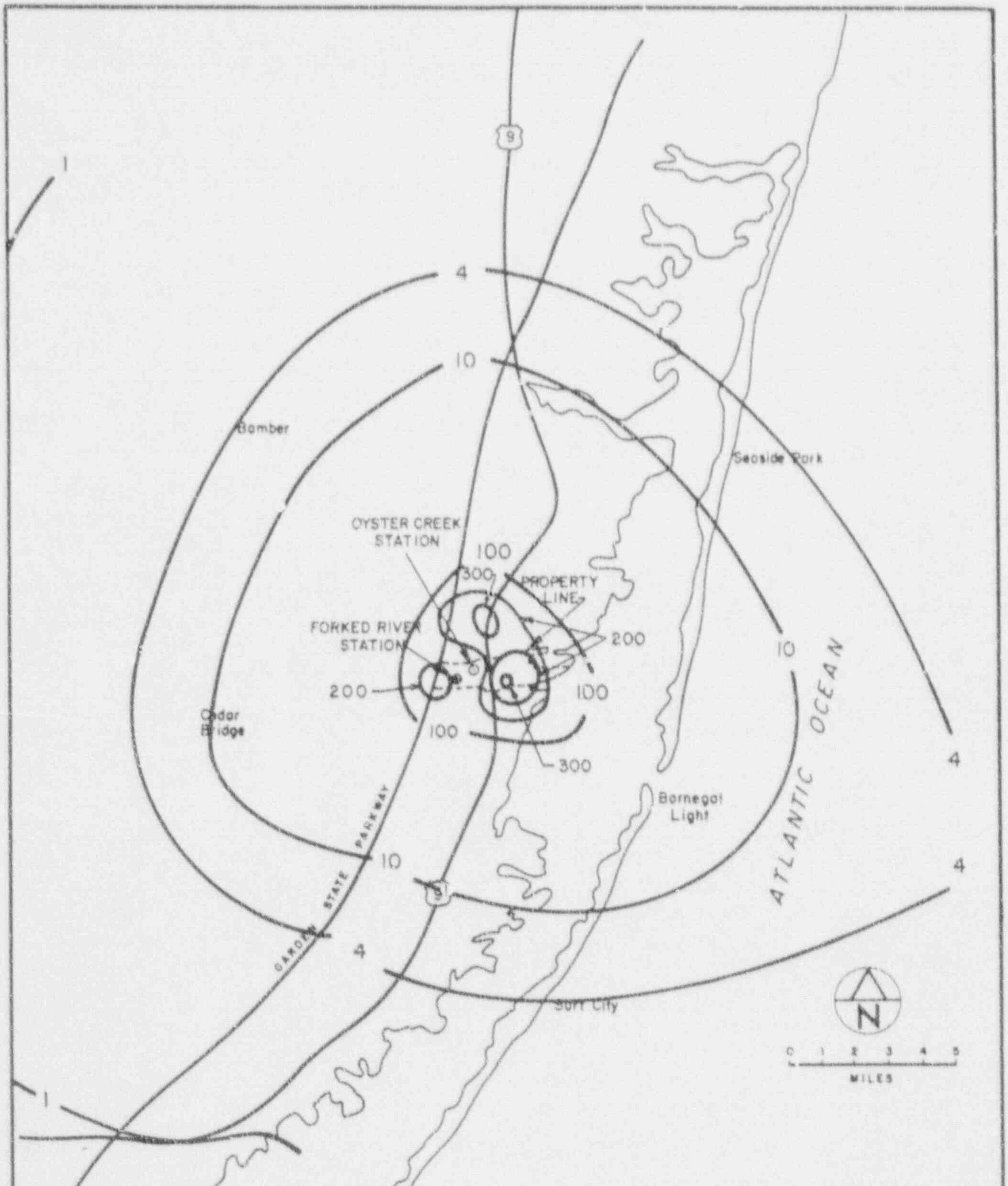
TABLE 3

PREDICTED MAXIMUM PEAK SHORT-TERM NEAR GROUND AIRBORNE CONCENTRATION (ug/m^3) 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

Month	Hours of Persistance	Direction[a]	Distance (miles)	Near Ground Airborne Concentration (ug/m^3)
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

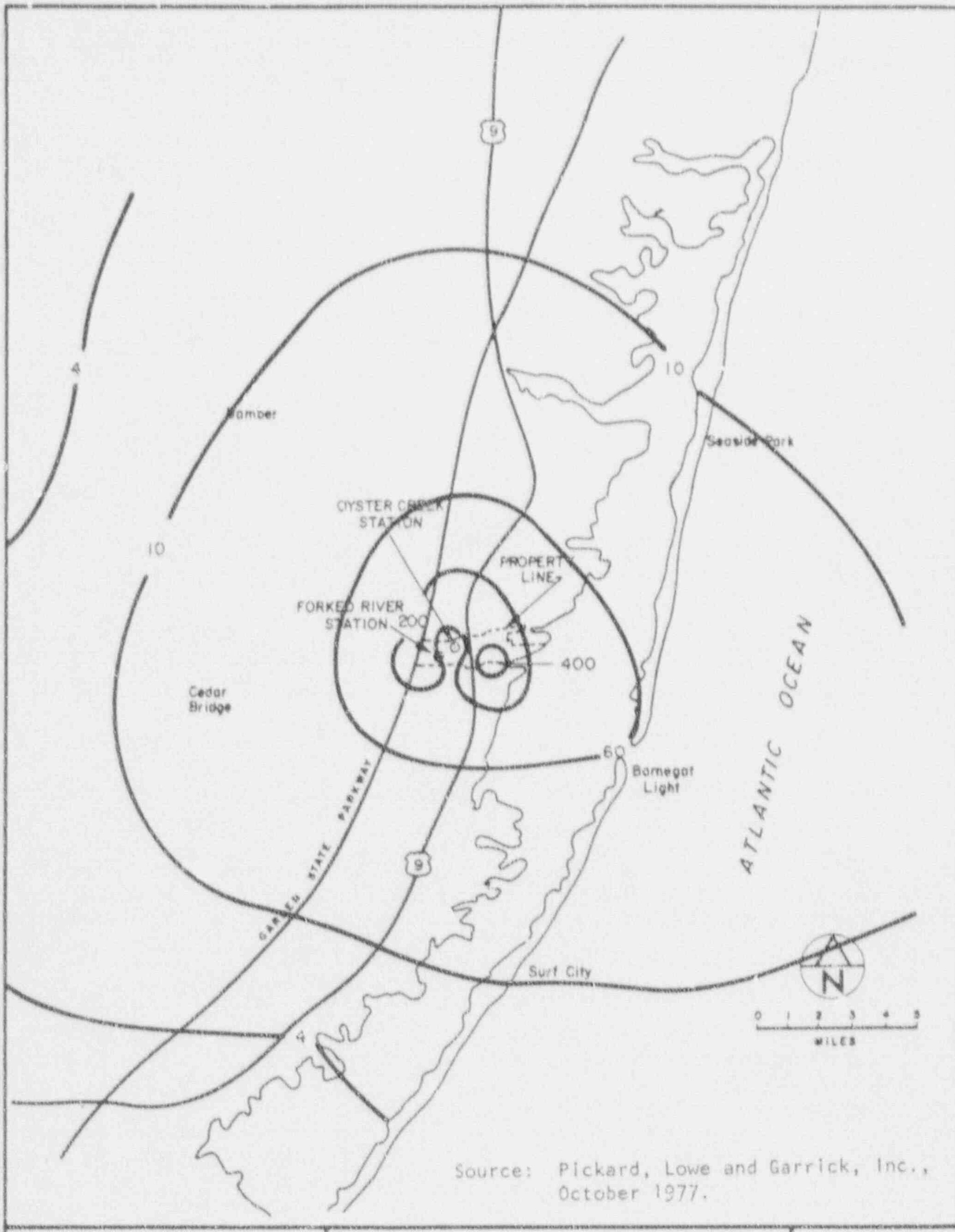
(a) Indicates direction where salt is deposited - winds come from opposite direction

Source: Pickard, Lowe and Garrick, Inc., October 1977.



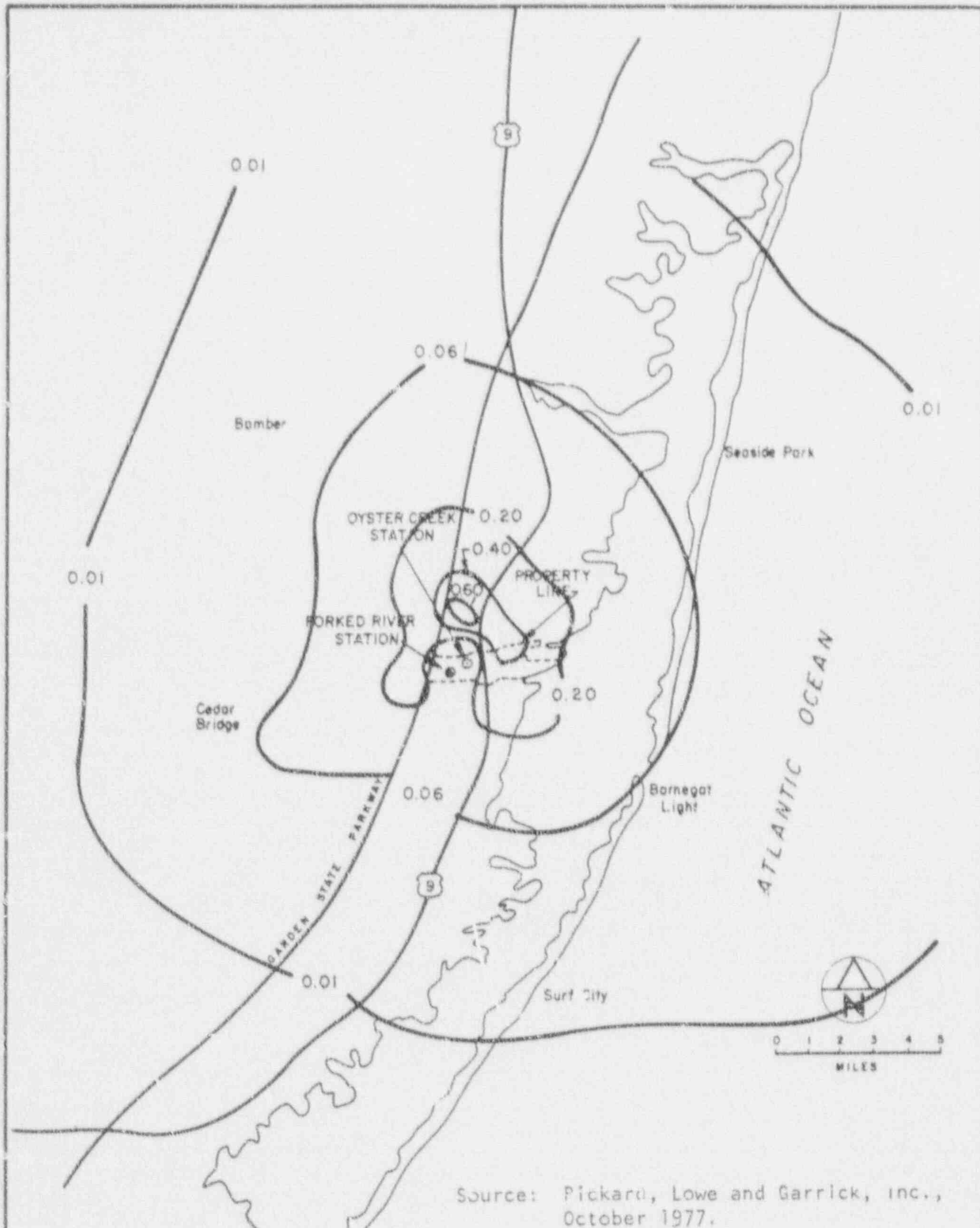
Source: Pickard, Lowe and Garrick, Inc., October 1977.

JERSEY CENTRAL POWER & LIGHT COMPANY EBASCO SERVICES INCORPORATED New York	ANNUAL AVERAGE SALT DEPOSITION RATE (kg/km^2-MONTH) FROM TWO ROUND TOWERS AT THE OYSTER CREEK SITE (0-15 MILES)	EXHIBIT 190



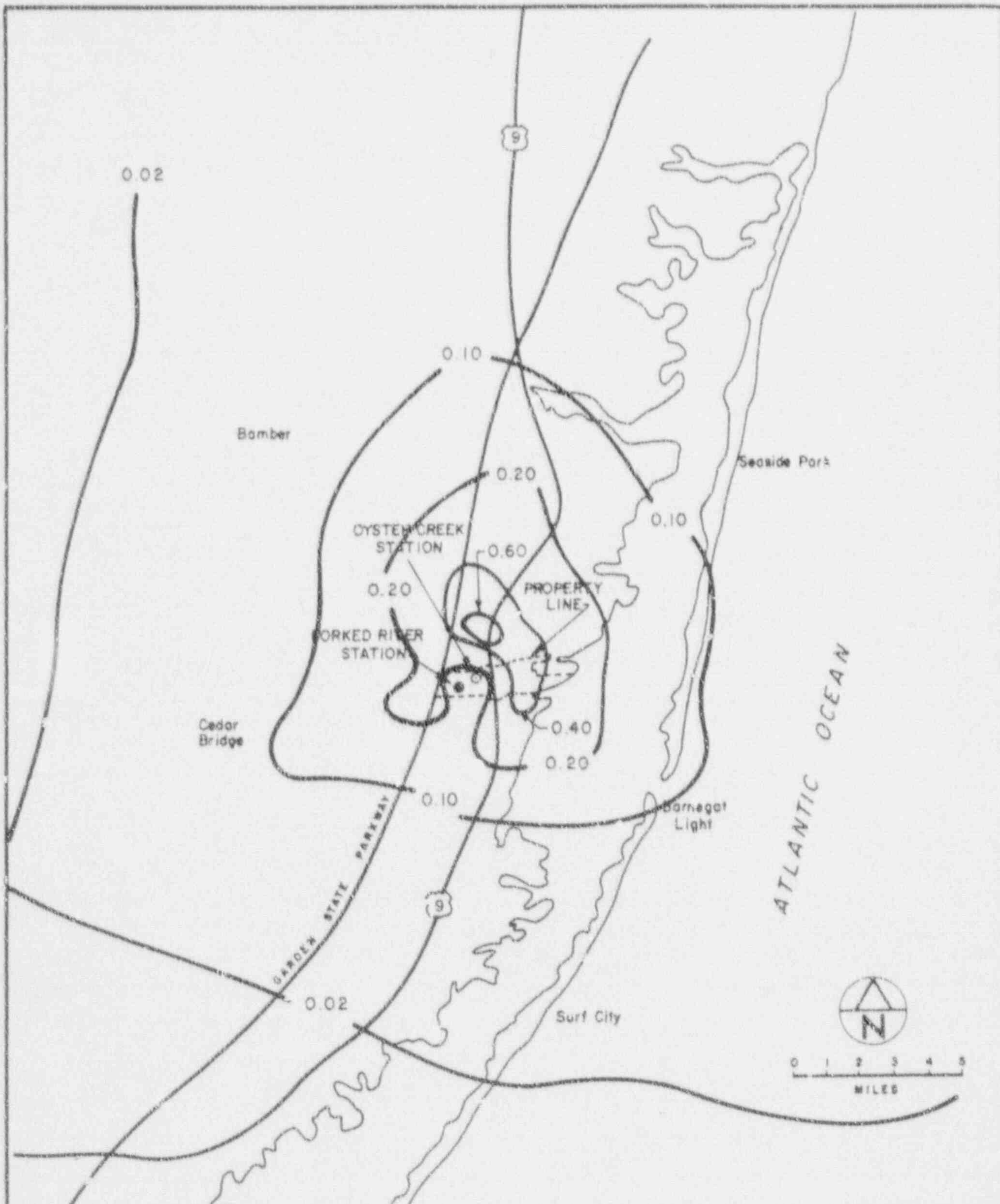
Source: Pickard, Lowe and Garrick, Inc., October 1977.

JERSEY CENTRAL POWER & LIGHT COMPANY EBASCO SERVICES INCORPORATED New York	ANNUAL AVERAGE SALT DEPOSITION RATE (kg/km^2-month) FROM TWO ROUND TOWERS AT OYSTER CREEK AND ONE NATURAL DRAFT TOWER AT FORKED RIVER (0-15 MILES)	EXHIBIT 191



Source: Pickard, Lowe and Garrick, Inc., October 1977.

JERSEY CENTRAL POWER & LIGHT COMPANY EBASCO SERVICES INCORPORATED New York	AVERAGE SUMMER AIRBORNE SALT CONCENTRATIONS (ug/m3) FROM TWO ROUND TOWERS AT THE OYSTER CREEK SITE (0-15 MILES)	EXHIBIT 192



Source: Pickard, Lowe and Garrick, Inc., October 1977.

JERSEY CENTRAL POWER & LIGHT COMPANY EBASCO SERVICES INCORPORATED New York	AVERAGE SUMMER AIRBORNE SALT CONCENTRATIONS (ug/m3) FROM TWO ROUND TOWERS AT THE OYSTER CREEK AND ONE NATURAL DRAFT TOWER AT FORKED RIVER (0-15 MILES)	EXHIBIT 193

Exhibit 193

AVERAGE CONDITIONS

ROUND MECHANICAL DRAFT TOWERS

Month	Oyster Creek NGS Discharge Flow GPM	Forked River NGS Discharge Flow GPM	Required* Dilution Flow GPM	Combined Flow to Oyster Creek GPM	Combined Temperature Rise in Oyster Creek Deg F
January	16,200	26,400	520,000	562,600	2.5
February	16,200	26,200	260,000	302,400	[illegible].9
March	16,000	25,600	260,000	301,600	3.1
April	15,400	25,000	260,000	300,400	[illegible].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

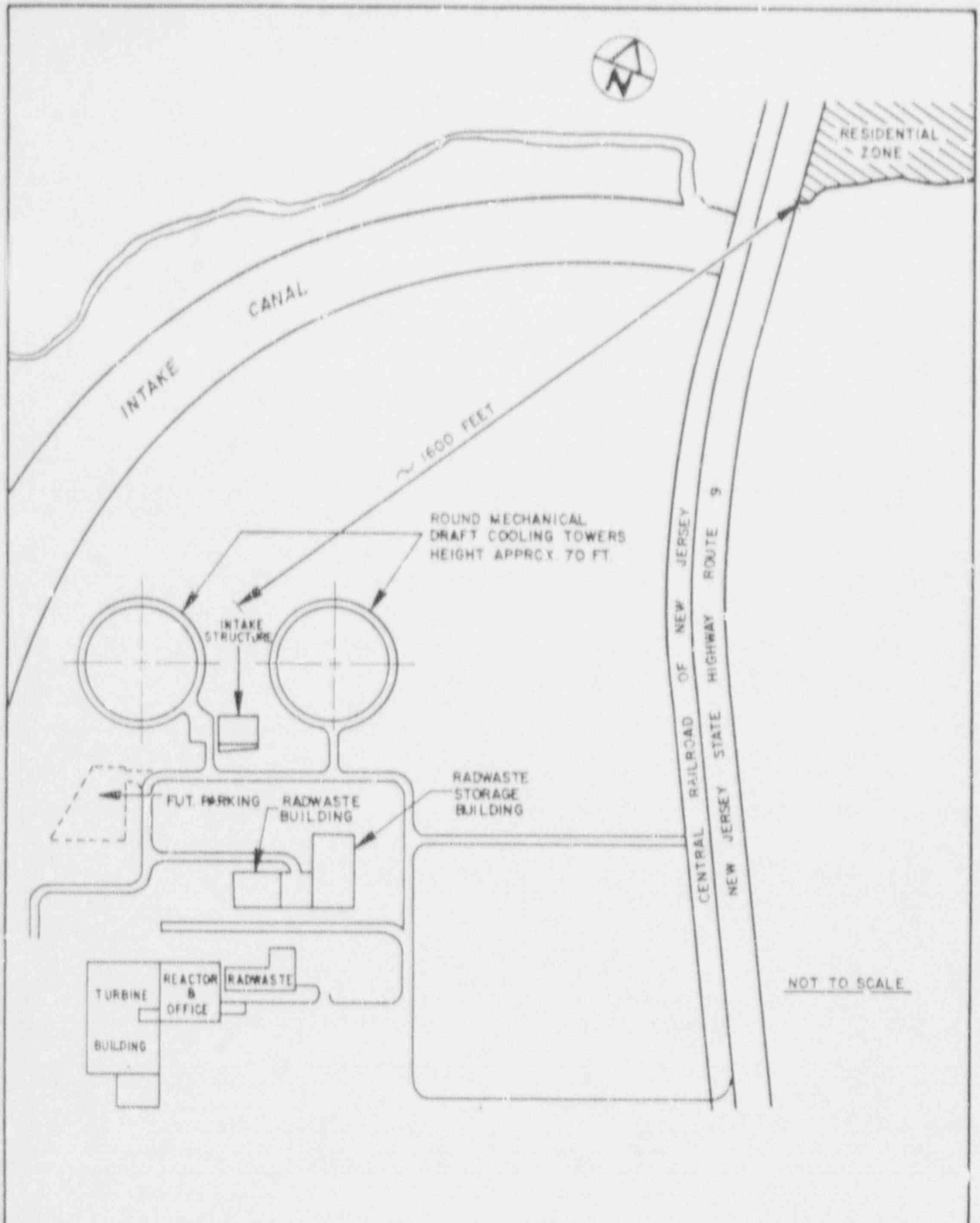
Exhibit 135

EXTREME CONDITIONS

ROUND MECHANICAL DRAFT TOWERS

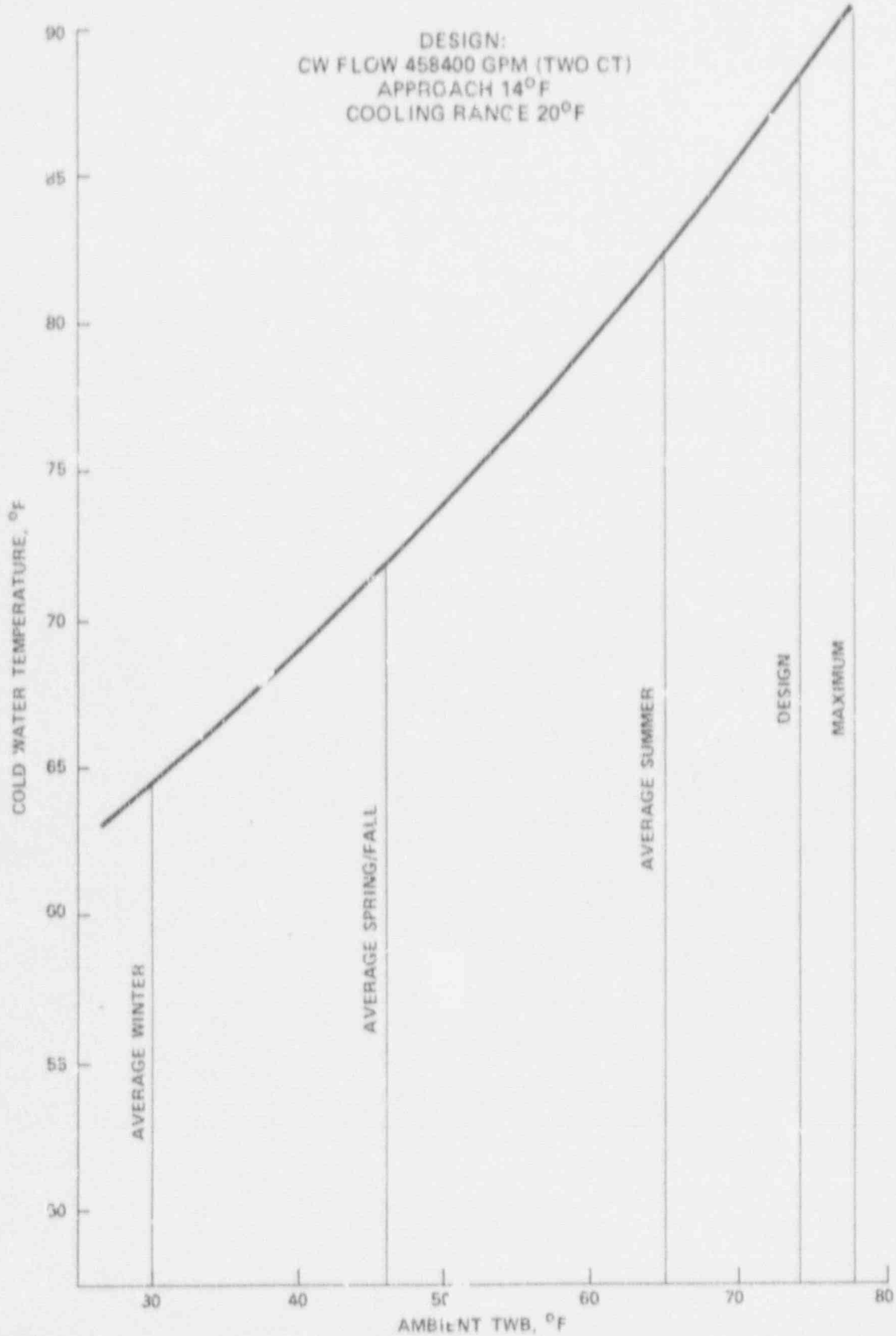
Month	Oyster Creek NGS Discharge Flow GPM	Forked River NGS Discharge Flow GPM	Required* Dilution Flow GPM	Combined Flow to Oyster Creek GPM	Combined Temperature Rise in Oyster Creek Deg F
January	14,700	24,400	520,000	559,100	3.4
February	14,600	24,300	520,000	558,900	3.2
March	14,500	24,200	520,000	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

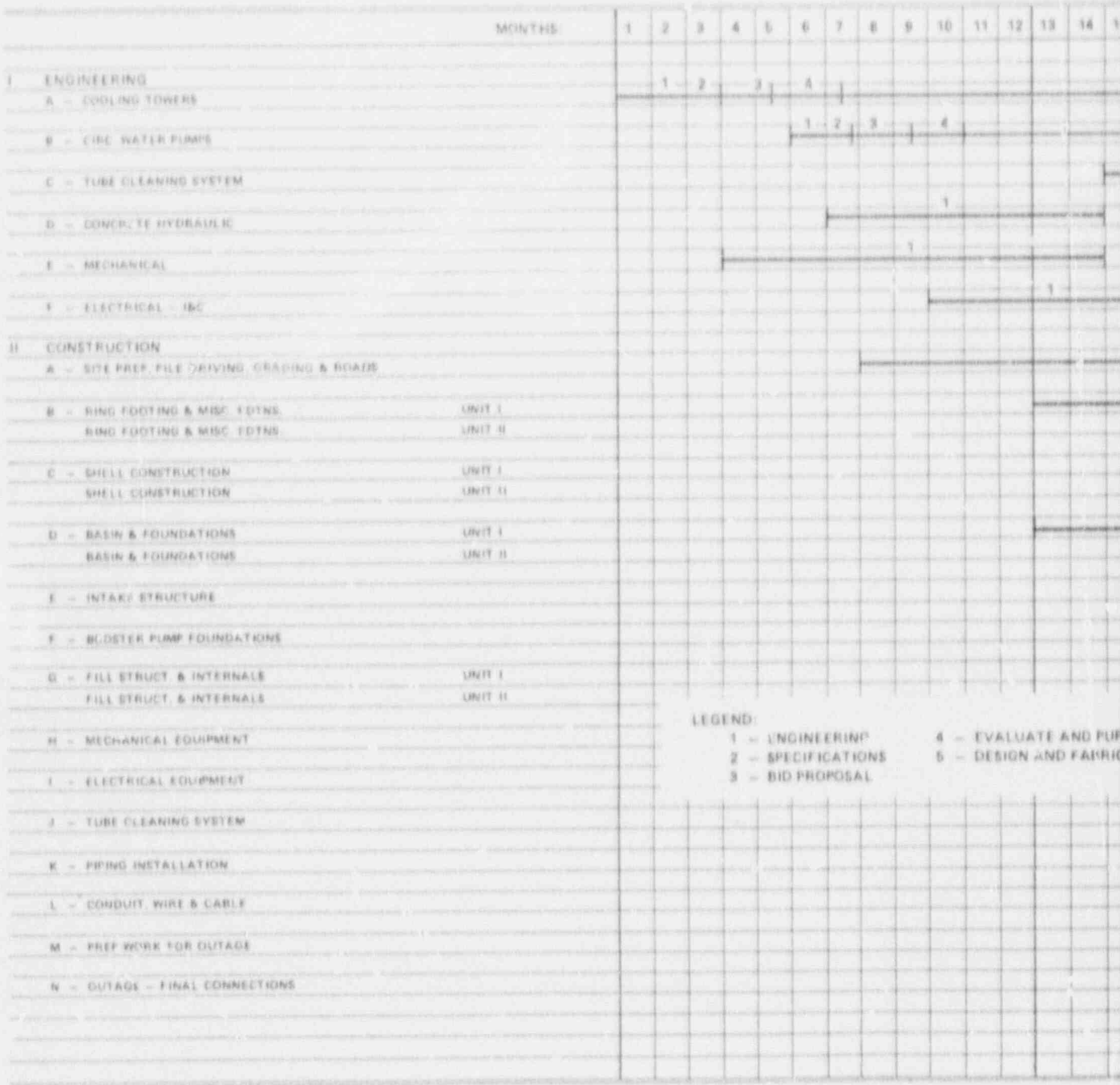


JERSEY CENTRAL POWER & LIGHT COMPANY EBASCO SERVICES INCORPORATED New York	LOCATION OF ROUND MECHANICAL DRAFT COOLING TOWERS WITH RESPECT TO NEAREST RESIDENTIAL ZONE	EXHIBIT 196

JCP&L OYSTER CREEK NGS FAN ASSISTED COOLING TOWER THERMAL PERFORMANCE AT FULL LOAD OPERATION AND 100% FAN POWER



JERSEY CENTRAL
OYSTER CREEK NU
TWO FAN ASSISTED NA
ENGINEERING &

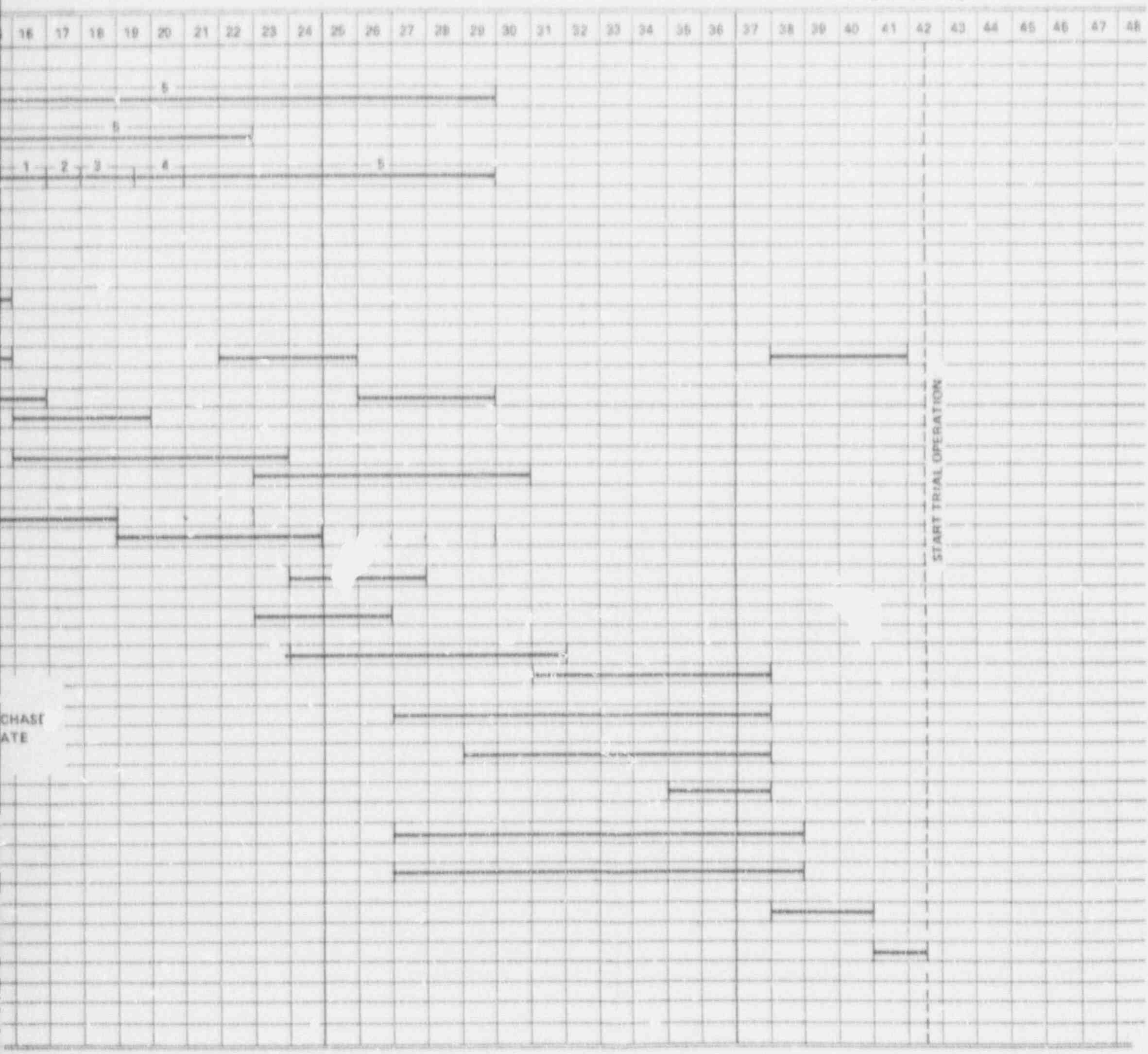


POWER & LIGHT COMPANY
LEAR GENERATING STATION
TURAL DRAFT COOLING TOWERS
CONSTRUCTION SCHEDULE

SI
APERTURE
CARD

Also Available On
Aperture Card

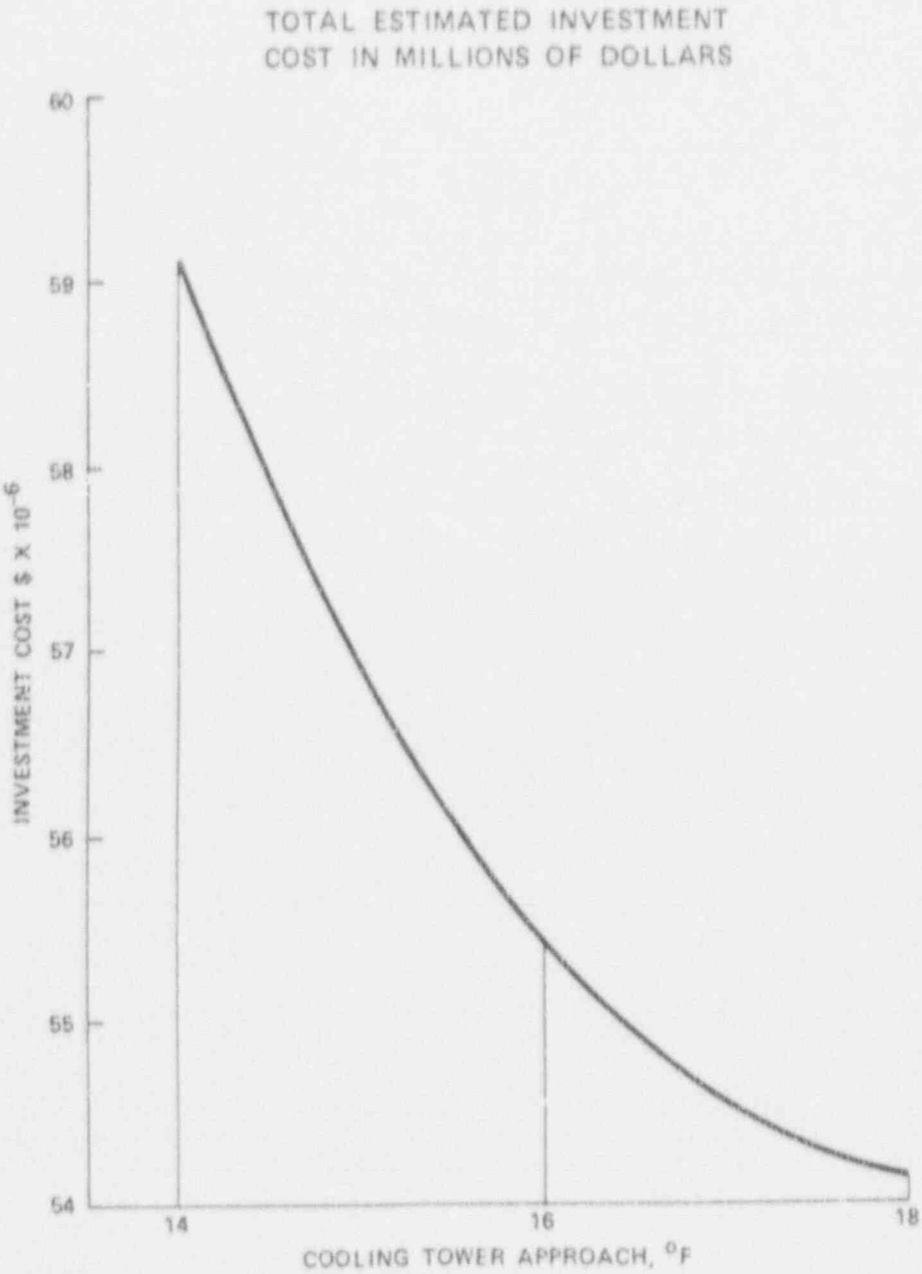
EXHIBIT 199



9111110048 -94

JCP&L OYSTER CREEK N
ALTERNATIVE COOLI

OPTIMUM FAN · ASSIST
EC



IUCLEAR GENERATING STATION
NG WATER SYSTEM STUDY

TED COOLING TOWER SYSTEM
ONOMICS

SI
APERTURE
CARD

Also Available On
Aperture Card

TOTAL COMPARABLE ANNUAL COST
IN MILLIONS OF DOLLARS PER YEAR

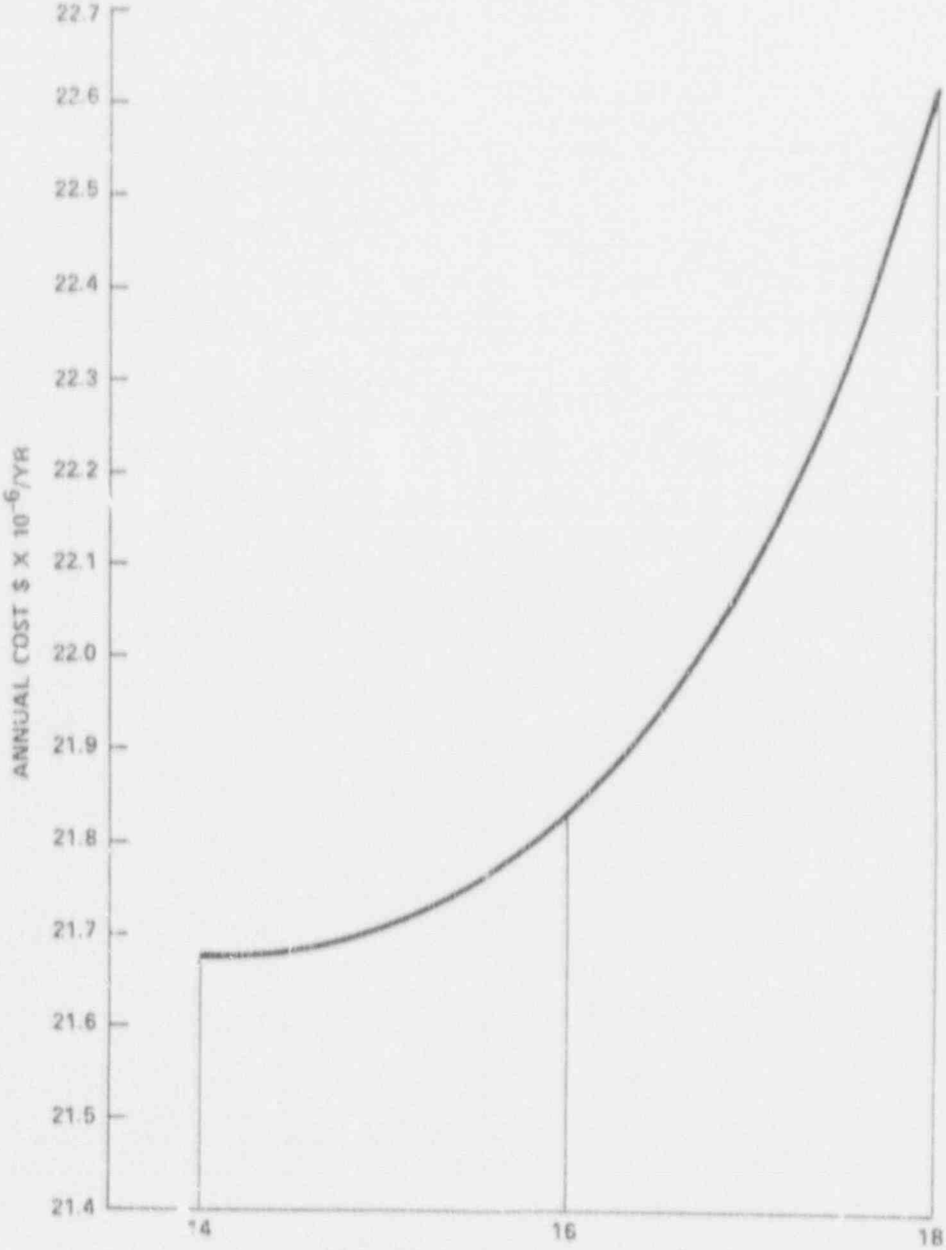


EXHIBIT 200

9111110048 - 95

E B A S C O S E R

THE FOLLOWING APPLIES TO ALL CONDENSING SYSTEM C

UNIT: BASED ON GE-TC6F-38"LSB RATED 640MW @ 1.0

CONDENSER:
 TUBE MATERIAL TITAN
 TUBE GAUGE 2
 TUBE CLEANLINESS FACTOR 0.90
 SINGLE OR MULTI BACK PRESSURE SINGL
 NO. OF CONDENSER SHELLS

 NO. OF PUMPS
 TYPE OF PUMPS VERT

ECONOMIC FACTORS
 RATE OF RETURN (%) 0.0
 FIXED CHARGE RATE (%) 22.2

TYPE OF COOLING SY
 DESIGN WET BULB T
 DESIGN DRY BULB T
 DESIGN APPROACH T

USER'S SELECTED SY
 MAX. CONDENSER BA
 MAX. TEMPERATURE

CASES NUMBERED 1 TO 100
PLUS OR MINUS 0.25 IN.H

THE OTHER CASES ARE WIT
OF THE FOLLOWING AVERAG

AVERAGE DESIGN BACK PRESSURE
2.50
3.00
3.50
4.00
4.50

CASES NUMBERED 6001 TO
AND TUBE VELOCITY FOR T
COST INCLUDING CAPABILI

*** FOR ZERO RATE OF RETURN IF MORE THAN
ANNUAL FUEL COST IS THE AVERAGE OF ALL TH

ASES:

"HGA

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

2
0
E
3
4
.
0
5

STEM: FAN ASSISTED ND COOLING TOWER SYSTEM

EMP. (F)	74.00
EMP. (F)	88.90
EMP. (F)	14.00

STEM LIMITATIONS

CK PRESS. (IN.HGA)	5.00
RISE (F)	25.0

SI
APERTURE
CARD

Also Available On
Aperture Card

O SHOW CONDENSING SYSTEMS WITHIN A RANGE OF
GA OF AN AVERAGE BACK PRESSURE OF 2.00 IN.HGA

HIN A RANGE OF PLUS OR MINUS 0.25 IN.HGA
E DESIGN BACK PRESSURES:

CASES

1001 TO 2000
2001 TO 3000
3001 TO 4000
4001 TO 5000
5001 TO 6000

6075 SHOW SMALLER VARIATIONS OF SURFACE AREA
HE PREVIOUS THREE BEST CASES BASED ON ANNUAL
TY AND GENERATION ADJUSTMENTS

ONE LINE IS FILLED IN UNDER LOADING PERIOD DATA THEN
E YEARS' FUEL COSTS

9111110048-96

SORT IN ASCENDING ORDER OF ANNUAL

CASE NO	ANNUAL SYSTEM COSTS WITHOUT ADJUSTMNTS	ANNUAL SYSTEM COSTS INCLUDES ADJUSTMNTS	INVESTMENT COSTS INITIAL + ESCAL	INVESTMENT COSTS TOTAL	PERFO[RMANCE] D[...] CON[...] TG CAPAB (MW)
1	13939	21305	37168	57632	616.[illegible]

COST INCLUDING CAPABILITY & GENERATION ADJUSTMENTS

A&C DEPT A J MUSTO 11/10/77

PERFORMANCE AT DESIGN CONDITIONS		SURFACE CONDENSER AND CONDENSER TUBES						PERFORMANCE AT PEAK LOAD CONDITION WATER TEMP	
IL.	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
46	3.47	423000	20.0	448.4	6.25	43	0.875	574.23	4.09

SI APERTURE CARD

Also Available On Aperture Card

9111110048 - 97

SPECIFICATIONS FOR CASE NO. 1 FAN ASSISTED ND
CW INLET DESIGN TEMPERATURE (F) 86.60 PERFORMA
CONDENSER TEMPERATURE RISE (F) 19.96 TG CAP
TUBE DIAMETER (INCHES)/GAUGE 0.875/22 AVG CO
TOTAL TUBE LENGTH (FT/SHELL) 42.50
NO. OF: TUBES PER SHELL/SHELLS 14562/3
NO. OF: TUBE PASSES/PRESS ZONES 1/1 PERFORMA
TOTAL SURFACE AREA (SQ FT) 423000 TG CAP
CIRCULATING WATER FLOW (GPM) 448400 AVG CO
TUBE VEL. AT ABOVE CW FLOW (FPS) 6.25

AVG SEAS

E S T I M A T E D I

SI APERTURE CARD

Also Available On Aperture Card

ACCOUNT CODE	INITIAL INVESTMENT COST ITEMS
	MAJOR SITE DEVELOPMENT
1.11	LOCAL IMPROVEMENT TO SITE-CLEARING
2.1	LOCAL GRADING
2.5	PILING
3.02	INTAKE STRUCTURE
3.2	CIRCULATING WATER CONDUIT: MAIN
3.2	BRANCHES
3.32	DISCHARGE STRUCTURE
3.41	COOLING TOWER BASIN
3.44	COOLING TOWER SUPERSTRUCTURE
5.1	TG BUILDING (DIFFERENTIAL)
4.18	TG PEDESTAL (DIFFERENTIAL)
7.1	TG & ACCESSORIES (DIFFERENTIAL)
10.211	CONDENSER SHELL
10.213	CONDENSER TUBE (TITAN)
10.221	CIRCULATING WATER PUMP
15.3	CIRCULATING WATER PUMP MOTOR
14.1	INSTRUMENTATION & CONTROL
1-.11	START-UP & STANDBY TRANSFORMER (DIFFERENTI
15.12	UNIT AUXILIARY TRANSFORMER (DIFFERENTIAL)
15.21	CIRCULATING WATER SWITCHGEAR
15.6	WIRING FOR CIRCULATING WATER SYSTEM
15.1	UNIT MAIN POWER TRANSFORMER (DIFFERENTIAL)
15.23	FAN MOTOR POWER CENTER + REQ'D SWGR & FEED
	TOTAL

TOTAL DIRECT ESCALATED COST: MATERIAL
INDIRECT CONSTRUCTION COST INCLUDING
CONTINGENCY (10.00% OF DIRECT PLUS IN
UTILITY'S EXPENSES. INTEREST DURING C

TOTAL ESTIMATED IN

E S T I M A T E D C O M P A R A B L

UNIT NET CAPABILITY W/SF/S/P (MW) 621.3 614.7 596
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$)

COOLING TOWER SYSTEM
ARC DEPT A J MUSTO 11/10/77 PAGE 7

NCE AT DESIGN CONDITIONS:
ABILITY (MW) 616.46
NDENSER PRESSURE (IN.HGA) 3.47

NCE AT MAX SUMMER TEMPERATURE
ABILITY (MW) 604.14
NDENSER PRESSURE (IN.HGA) 4.09

ONAL COND PRESS (IN.HGA) 1.81 2.22 3.00

NO. OF COOLING TOWERS-CT	2
NO. OF CELLS PER CT	24
CT DESIGN APPROACH TEMP (F)	14.00
TOTAL CT FAN MOTOR INPUT KW	2789
TOTAL CW PUMP MOTOR INPUT KW	8622
CW PUMP MOTOR RATING (HP)	3000
CW SYSTEM TDH (FT)	79.00
CW MAIN CONDUIT DIAM (FT)	10.50
NO. OF CW PUMPS	4
TOTAL DILUTION PUMP INPUT KW	1000

N I T I A L   I N V E S T M E N T   C O S T

	TODAY'S MATERIAL COST UNIT	TOTAL 1000$	TODAY'S INSTALLATION COST UNIT	TOTAL 1000$	ESCALATION 1000$ MATERIAL	INSTALLATION
	----- --------	4080	---------------	1600	1380	751
	--------------		0$/ACRE	0		0
	--------------		2.50$/CU YD	26		9
	1.45$/SQ FT	121	1.00$/SQ FT	83	32	30
	4.10$/CU FT	498	10.75$/CU FT	1306	168	766
	365$/LIN FT	584	244.00$/LIN FT	390	198	229
	71.67$/LIN FT	172	67.60$/LIN FT	162	58	95
	0.00$/CU FT	0	0.00$/CU FT	0	0	0
	0.80$/SQ FT	67	8.20$/SQ FT	684	23	321
	2699949$/EACH	5400	2209049$/EACH	4418	2260	2593
	0.00$/CU FT	0	0.00$/CU FT	0	0	0
	0$/FT HT	0	0$/FT HT	0	0	0
	0.00$/KVA	0	0.00$/KVA	0	0	0
	0$/EACH	0	0$/EACH	0	0	0
	0.0000$/FT	0	0.0000$/FT	0	0	0
	292320$/EACH	1169	29232$/EACH	117	395	69
	206375$/EACH	826	8255$/EACH	33	279	19
	1484.62$/EACH	77	1015.38$/EACH	53	26	31
AL)	0$/MVA	0	0$/MVA	0	0	0
	6700$/MVA	65	1200$/MVA	12	22	7
	43000$/PUMP	172	18000$/PUMP	72	58	42
	48445$/MVA	614	143727$/MVA	1822	208	1069
	0$/MVA	0	0$/MVA	0	0	0
ER	166000$/CENTER	830	37000$/CENTER	185	281	109
		14675		10964	5388	6141

PLUS 0.00% SALES/USE TAX PLUS INSTALLATION	37168
PROFESSIONAL SERVICES	5598
DIRECT COST)	5987
ONSTRUCTION, & LAND	8879

VESTMENT COST 1000$	57632

9111110048-98

E I N V E S T M E N T & A N N U A L C O S T S

		1000$/YR	MILLS/KWH
.1 574.2	CW SYSTEM FUEL COST (BASE VALUE)	163	
45.77	ANNUAL FIXED CHARGES (AT RATE 0.2225)	12823	
	WATER COST (AT 0.00$/MILLION GALLONS + CHEMICALS)	156	
3423209	MAINTENANCE (1.20% OF TOTAL INV + 2000$/FAN)	788	
116520	SUBTOTAL ANNUAL COST	13930	
	NET PRODUCTION COST		4.069
1242			
	ADJUSTMENT FOR DIFFERENTIAL CAPABILITY	1111	
	ADJUSTMENT FOR DIFFERENTIAL NET ANNUAL GENERATION	6265	
23981	TOTAL COMPARABLE ANNUAL COST INCLUDING ADJUSTMENTS FOR EQUALIZED CAPABILITY & NET ANNUAL GENERATION	21305	
62624	COMPARABLE NET PRODUCTION COST INCL. ADJUSTMENTS		6.019

Exhibit 202

OYSTER CREEK FAN ASSISTED

NATURAL DRAFT TOWER IMPACTS

TABLE 1

ANNUAL FREQUENCY OF ELEVATED PLUMES FROM FAN-ASSISTED NATURAL DRAFT TOWER
OYSTER CREEK STATION

Plume Lengths (ft)	Hours per Year for Given Direction from Towers															
	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
0 - 500	0	0	0	0	4	11	0	1	0	0	0	0	0	0	0	0
500 - 1,000	101	23	19	74	90	89	37	23	4	4	7	28	20	34	25	50
1,000 - 1,500	166	54	73	113	121	136	56	56	58	25	37	64	53	49	63	112
1,500 - 2,000	131	68	56	116	171	191	84	87	67	33	27	41	37	33	27	70
2,000 - 2,500	145	66	48	67	137	135	105	91	53	46	32	48	38	36	23	63
2,500 - 3,000	112	54	67	66	108	130	95	56	49	38	38	37	38	29	11	53
3,000 - 3,500	77	62	45	71	78	73	53	45	44	37	43	28	34	35	15	36
3,500 - 4,000	67	54	47	38	74	60	36	38	61	45	21	35	40	23	18	30
4,000 - 4,500	41	29	26	35	46	57	25	42	42	26	15	17	30	34	10	29
4,500 - 5,000	35	25	22	21	42	27	19	20	35	22	22	19	14	28	11	20
5,000 - 5,500	23	28	16	31	29	27	9	15	16	16	14	18	8	14	7	15
5,500 - 6,000	21	23	16	22	21	16	19	21	7	18	12	12	15	6	7	9
6,000 - 6,500	16	9	21	7	20	11	4	9	9	10	7	8	6	12	9	10
6,500 - 7,000	1	3	8	11	19	6	4	6	2	5	6	3	5	5	5	7
7,000 - 7,500	10	5	4	9	11	3	3	6	5	5	9	5	3	2	4	4
7,500 - 8,000	5	3	4	5	7	5	4	1	3	2	5	3	0	2	0	9
8,000 - 8,500	2	3	3	1	2	4	0	3	2	1	1	2	0	1	0	0
8,500 - 9,000	6	0	3	2	2	3	1	3	2	0	1	2	0	0	0	3
9,000 - 9,500	1	0	0	0	1	1	2	1	0	0	1	1	0	0	0	0
9,500 - 10,000	0	1	0	0	1	0	0	0	0	1	0	0	1	0	0	1
10,000 - 10,500	0	0	2	1	1	0	0	2	2	0	1	1	0	1	0	0
10,500 - 11,000	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0
11,000 - 11,500	0	0	0	1	1	0	0	0	0	0	2	2	1	0	0	0
11,500 - 12,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12,000 - 12,500	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
12,500 - 13,000	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0

Exhibit 202

OYSTER CREEK FAN ASSISTED

NATURAL DRAFT TOWER IMPACTS

TABLE 2

PREDICTED MAXIMUM PEAK SHORT-TERM NEAR GROUND AIRBORNE CONCENTRATION (UG/M^3) OF SALT RESULTING FROM OPERATION OF TWO FAN ASSISTED NATURAL DRAFT COOLING TOWERS AT THE OYSTER CREEK SITE

Month	Hours of Persistance	Direction[a]	Distance (miles)	Near Ground Airborne Concentration (ug/m^3)
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

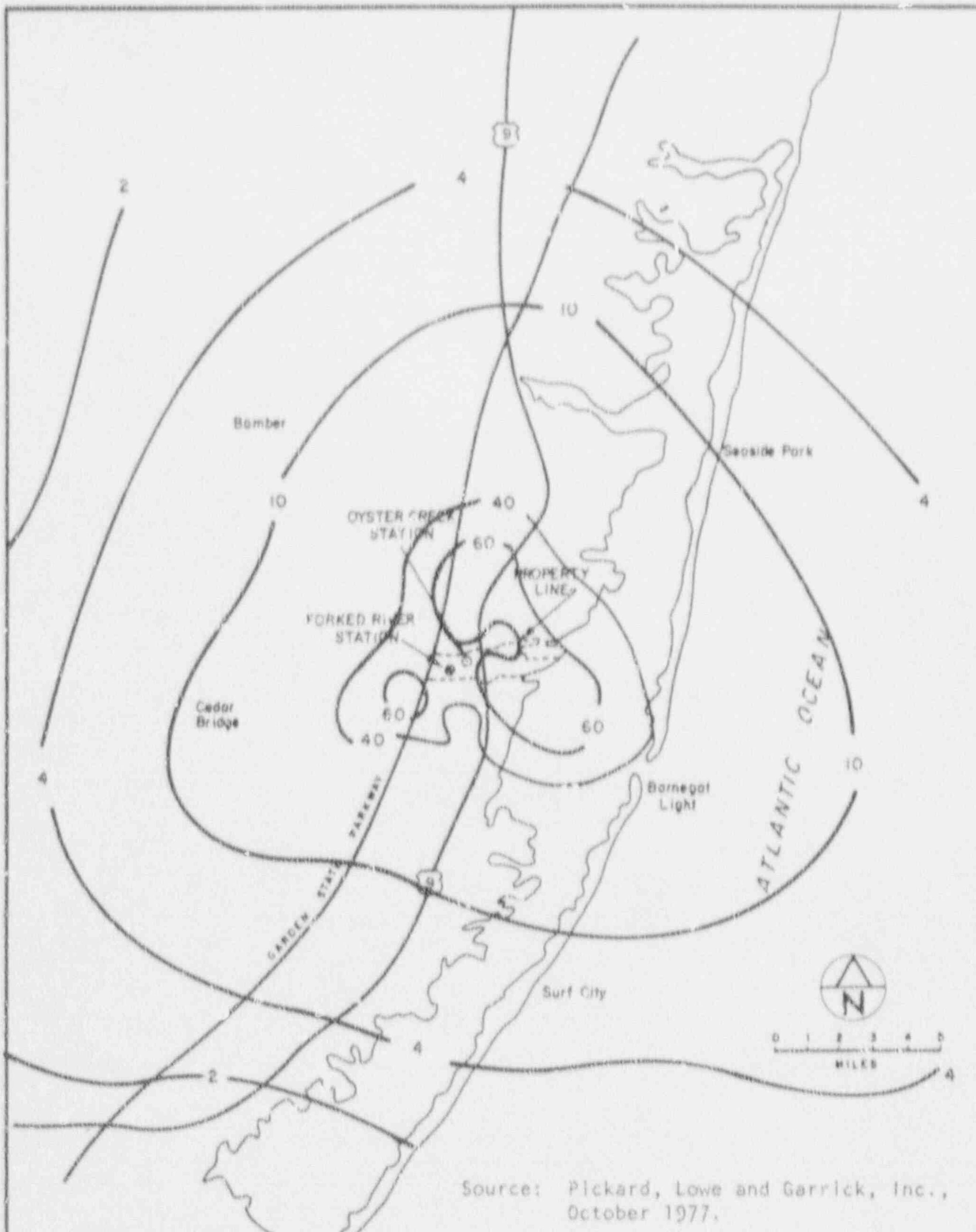
TABLE 3

PREDICTED MAXIMUM PEAK SHORT-TERM NEAR GROUND AIRBORNE CONCENTRATION (ug/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

Month	Hours of Persistence	Direction[a]	Distance (miles)	Near Ground Airborne Concentration (ug/m^3)
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

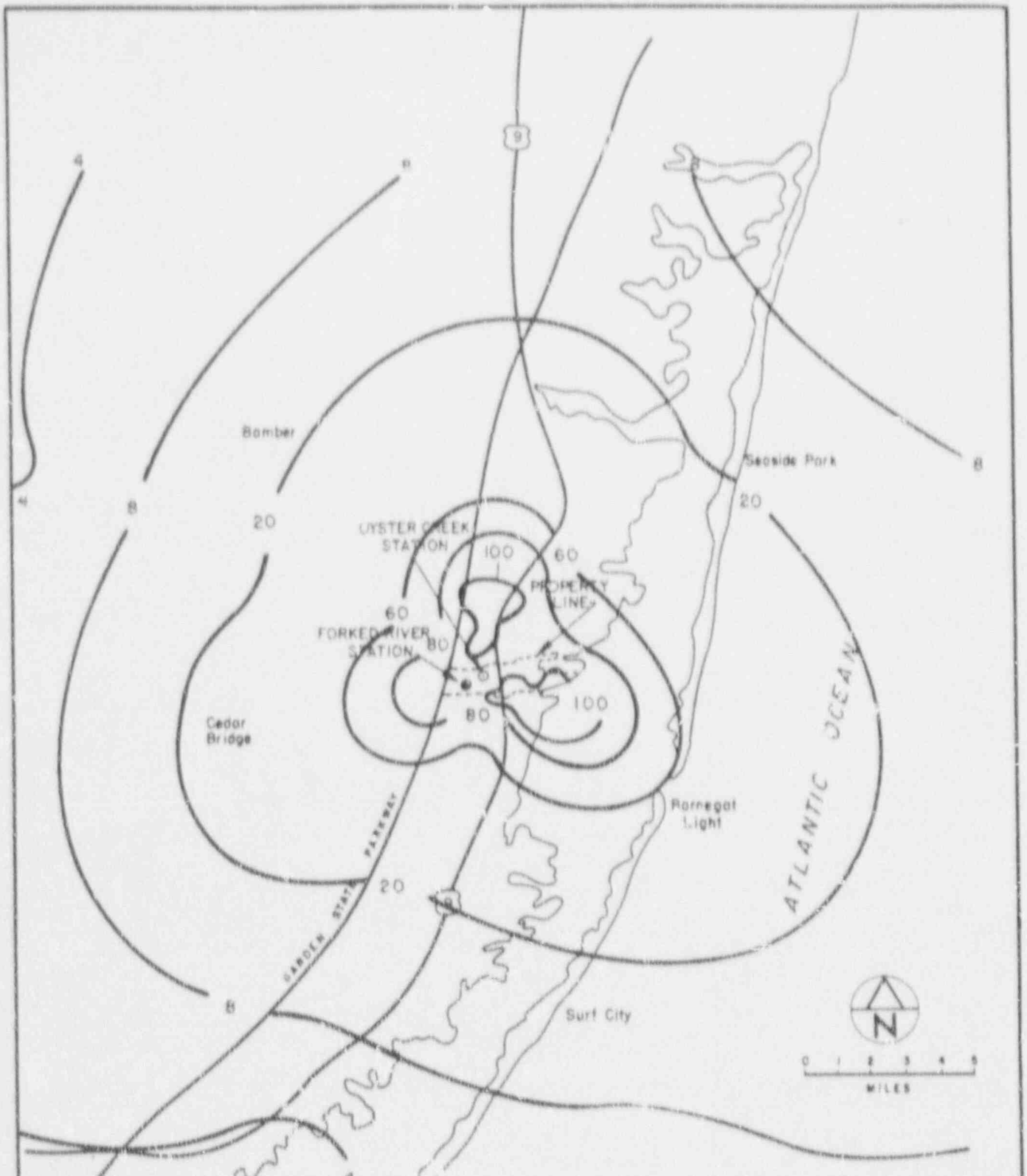
(a) Indicates direction where salt is deposited - winds come from opposite direction

Source: Pickard, Lowe and Garrick, Inc., October 1977.



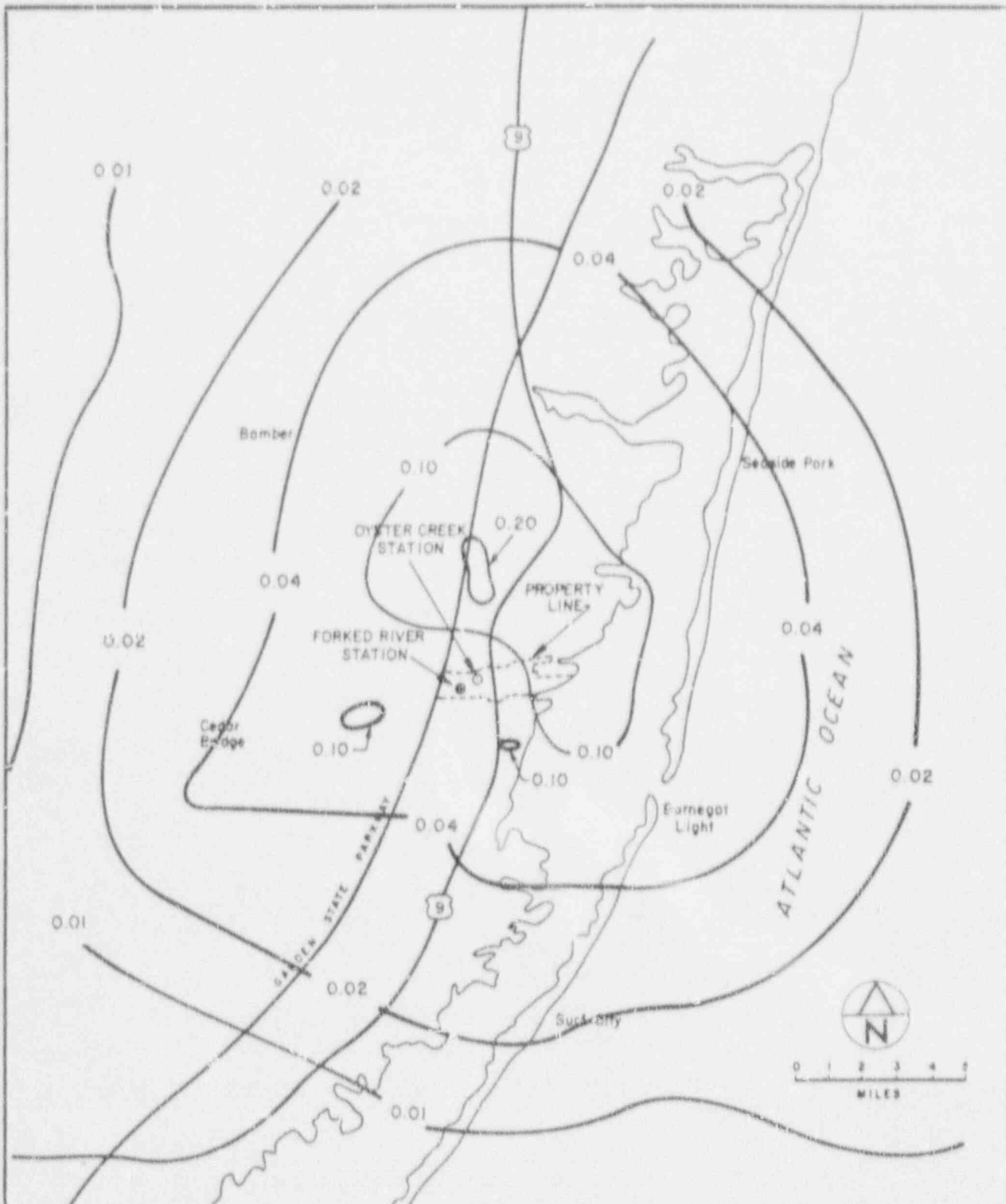
Source: Pickard, Lowe and Garrick, Inc., October 1977.

JERSEY CENTRAL POWER & LIGHT COMPANY EBASCO SERVICES INCORPORATED New York	ANNUAL AVERAGE SALT DEPOSITION RATE (Kg/Km2 - Month) FROM TWO FAN ASSISTED TOWERS AT THE OYSTER CREEK SITE (0 - 15 MILES)	EXHIBIT 203



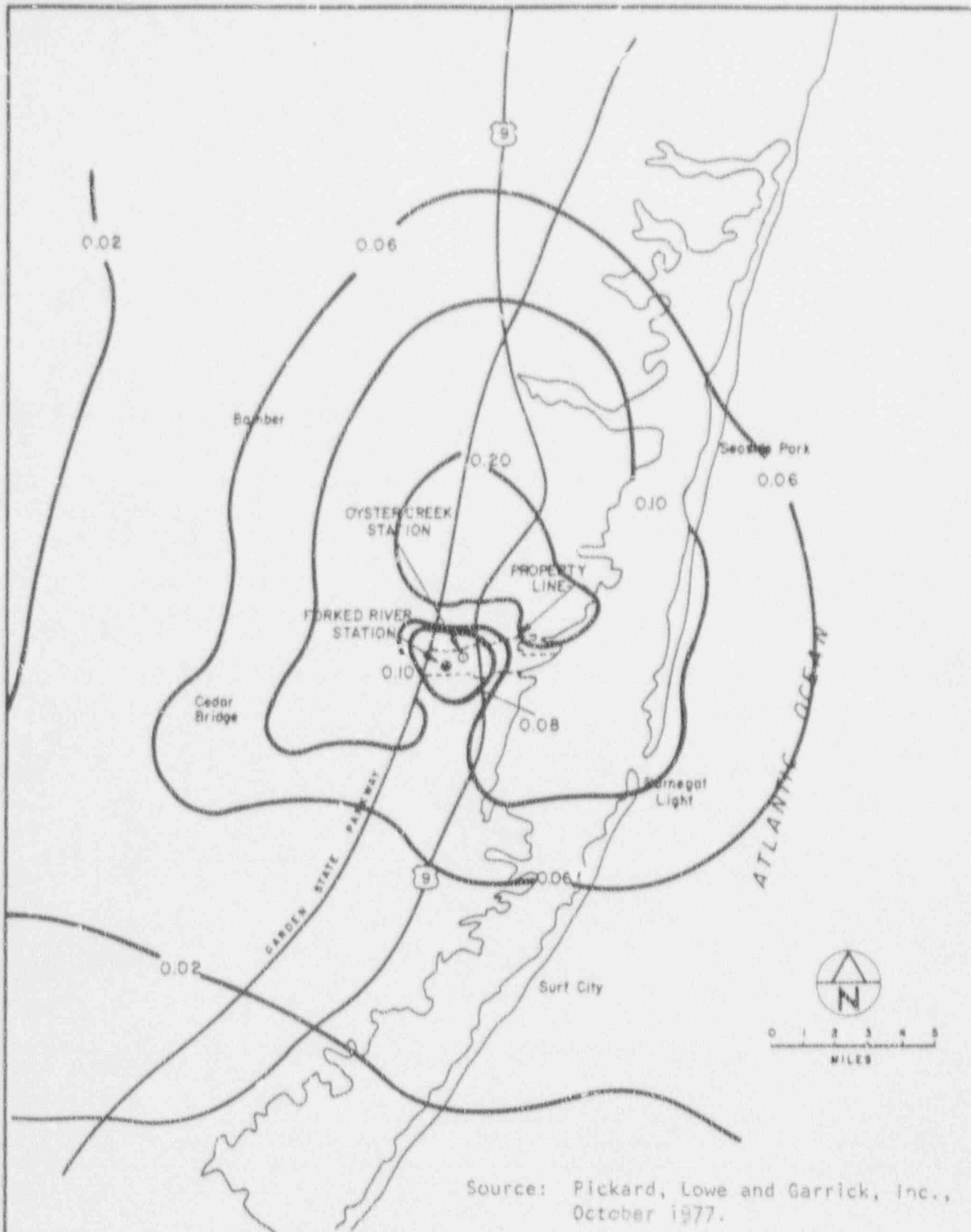
Source: Pickard, Lowe and Garrick, Inc., October 1977.

JERSEY CENTRAL POWER & LIGHT COMPANY	ANNUAL AVERAGE SALT DEPOSITION RATE (kg/km² - month) FROM TWO FAN ASSISTED TOWERS AT OYSTER CREEK AND ONE NATURAL DRAFT TOWER AT FORKED RIVER (0-15 MILES)	EXHIBIT 204
EBASCO SERVICES INCORPORATED New York		



Source: Pickard, Lowe and Garrick, Inc., October 1977.

JERSEY CENTRAL POWER & LIGHT COMPANY EBASCO SERVICES INCORPORATED New York	AVERAGE SUMMER AIRBORNE SALT CONCENTRATIONS (μg/m3) FROM TWO FAN ASSISTED TOWERS AT THE OYSTER CREEK SITE (0 - 15 MILES)	EXHIBIT 205



Source: Pickard, Lowe and Garrick, Inc., October 1977.

JERSEY CENTRAL POWER & LIGHT COMPANY EBASCO SERVICES INCORPORATED New York	AVERAGE SUMMER AIRBORNE SALT CONCENTRATIONS (ug/m3) FROM TWO FAN ASSISTED TOWERS AT OYSTER CREEK AND ONE NATURAL DRAFT TOWER AT FORKED RIVER (0-15 MILES)	EXHIBIT 206

Exhibit 207

DISCHARGE PARAMETERS UNDER AVERAGE CONDITIONS

FAN-ASSISTED TOWERS

Month	Oyster Creek NGS Discharge Flow GPM	Forked River NGS Discharge Flow GPM	Required* Dilution Flow GPM	Combined Flow to Oyster Creek GPM	Combined Temperature Rise in Oyster Creek Deg F
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,[illegible]	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

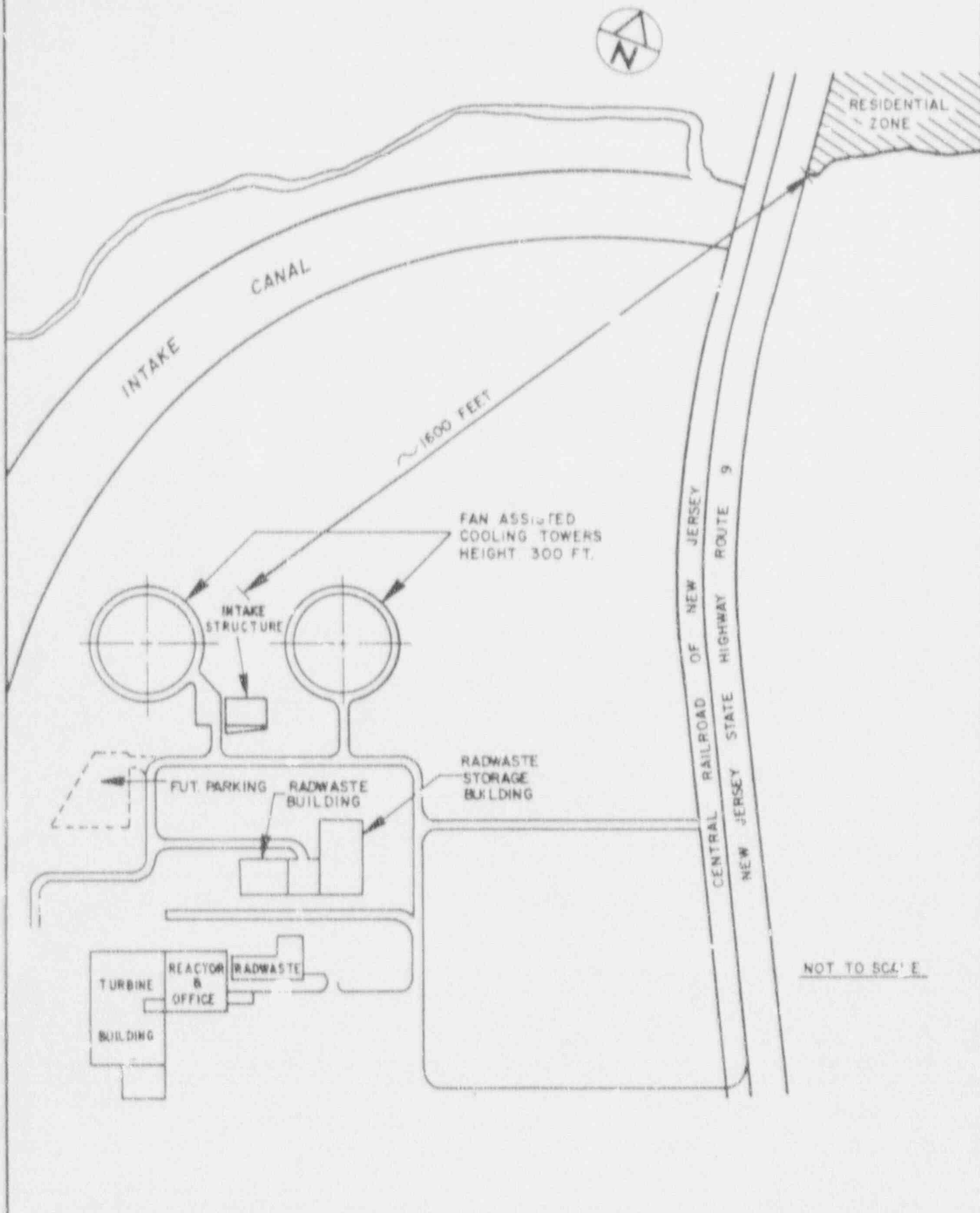
Exhibit 208

DISCHARGE PARAMETERS UNDER EXTEME CONDITIONS

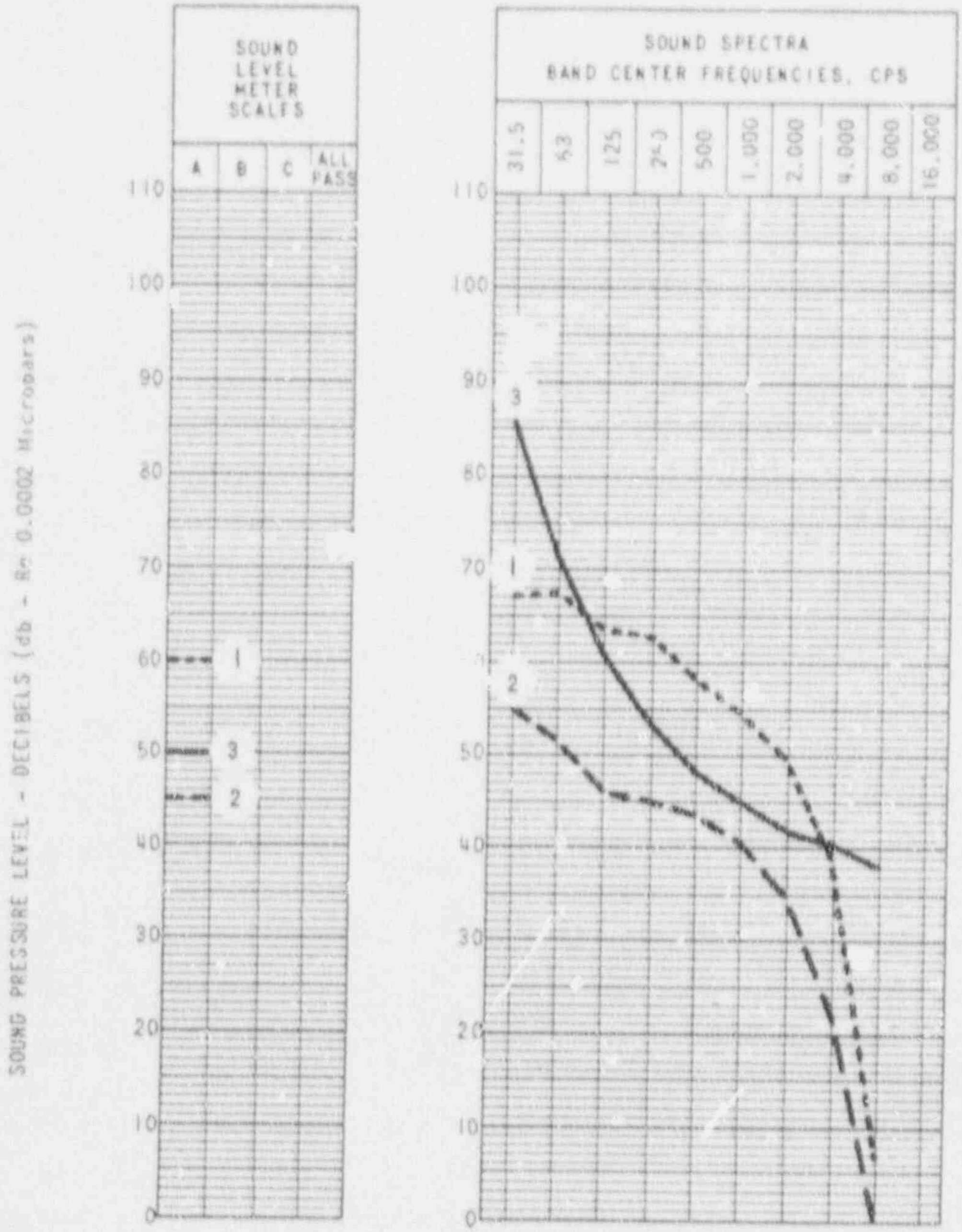
FAN-ASSISTED TOWERS

Month	Oyster Creek NGS Discharge Flow GPM	Forked River NGS Discharge Flow GPM	Required* Dilution Flow GPM	Combined Flow to Oyster Creek GPM	Combined Temperature Rise in Oyster Creek Deg F
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	2 ,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

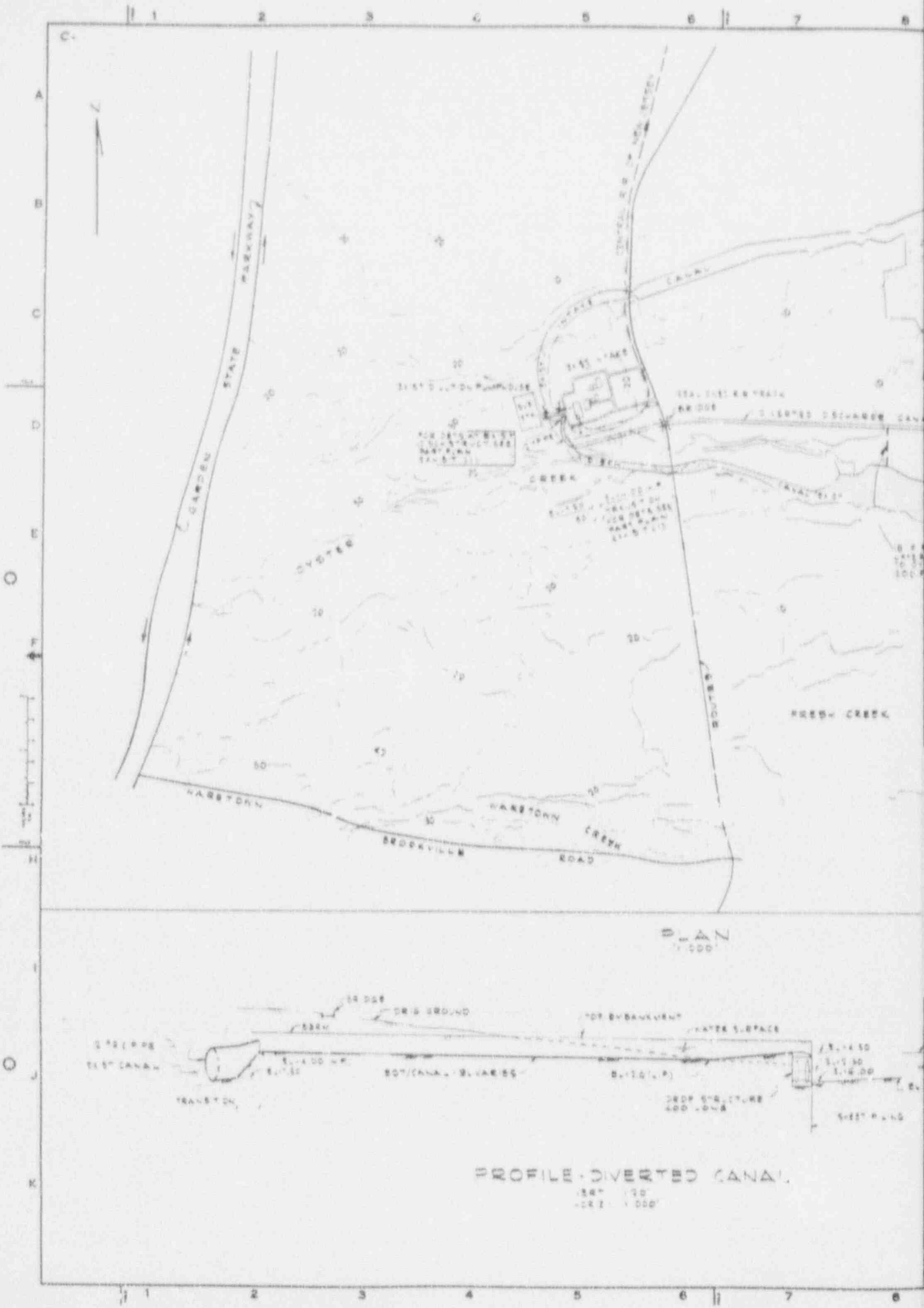


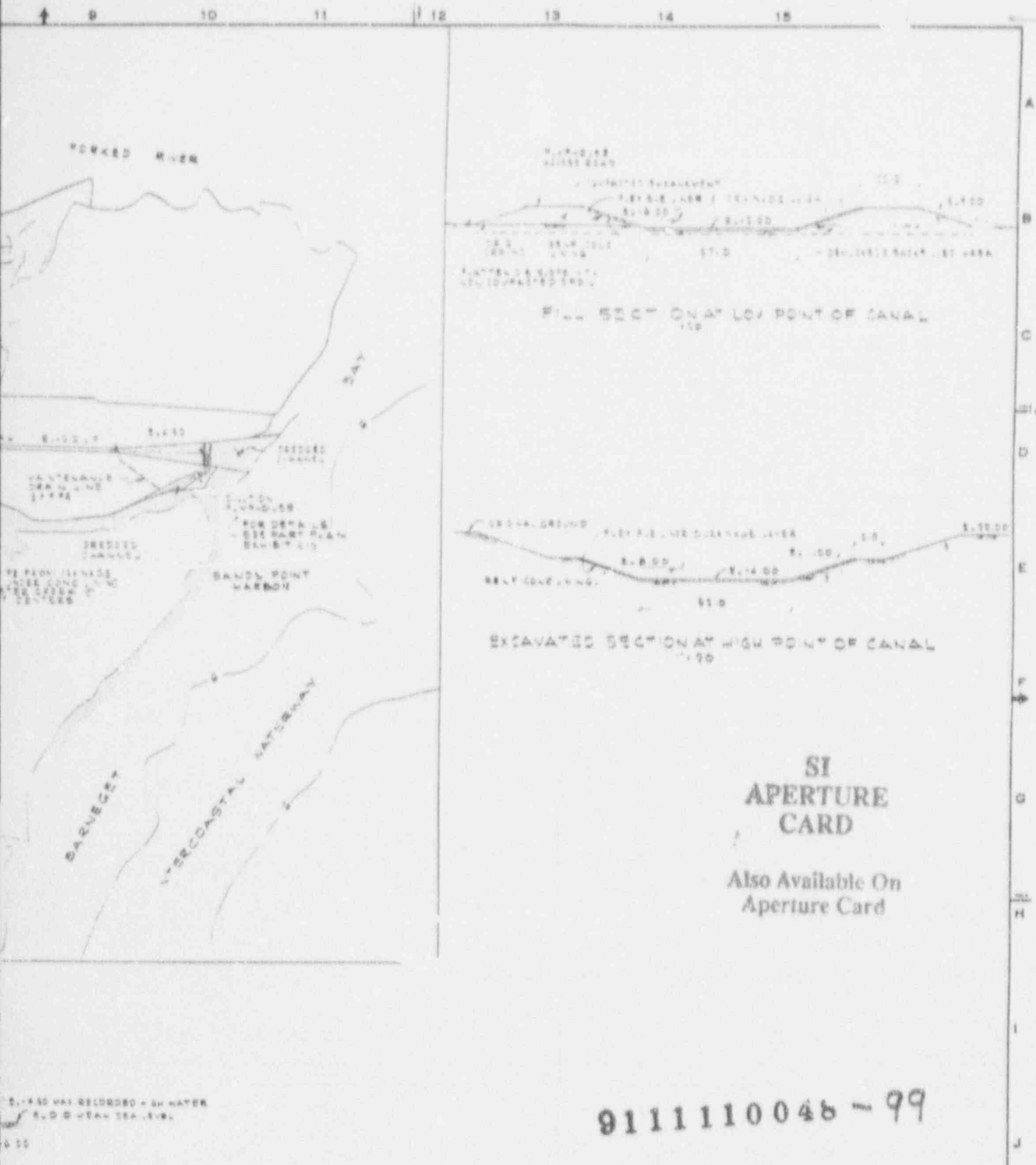
JERSEY CENTRAL POWER & LIGHT COMPANY	LOCATION OF FAN ASSISTED COOLING TOWERS WITH RESPECT TO NEAREST RESIDENTIAL ZONE	EXHIBIT 209
EBASCO SERVICES INCORPORATED New York		



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


GARDEN STATE PARKWAY
OYSTER CREEK
WARETOWN
WARETOWN CREEK
BROOKVILLE ROAD
FRESH CREEK
CANAL
BRIDGE
PLAN
PROFILE - DIVERTED CANAL
TRANSITION
DROP STRUCTURE



SI APERTURE CARD

Also Available On Aperture Card

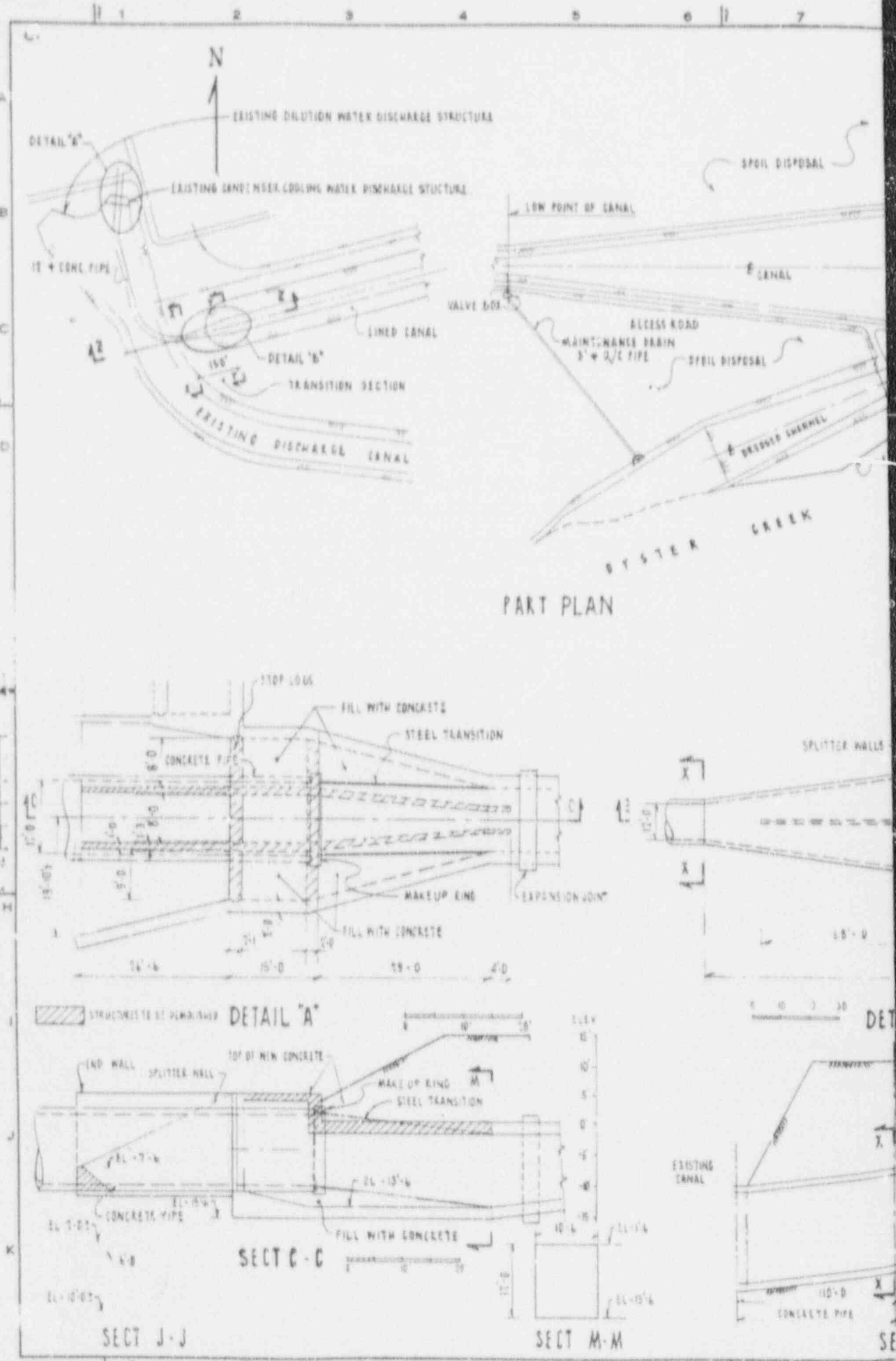
9111110048 - 99

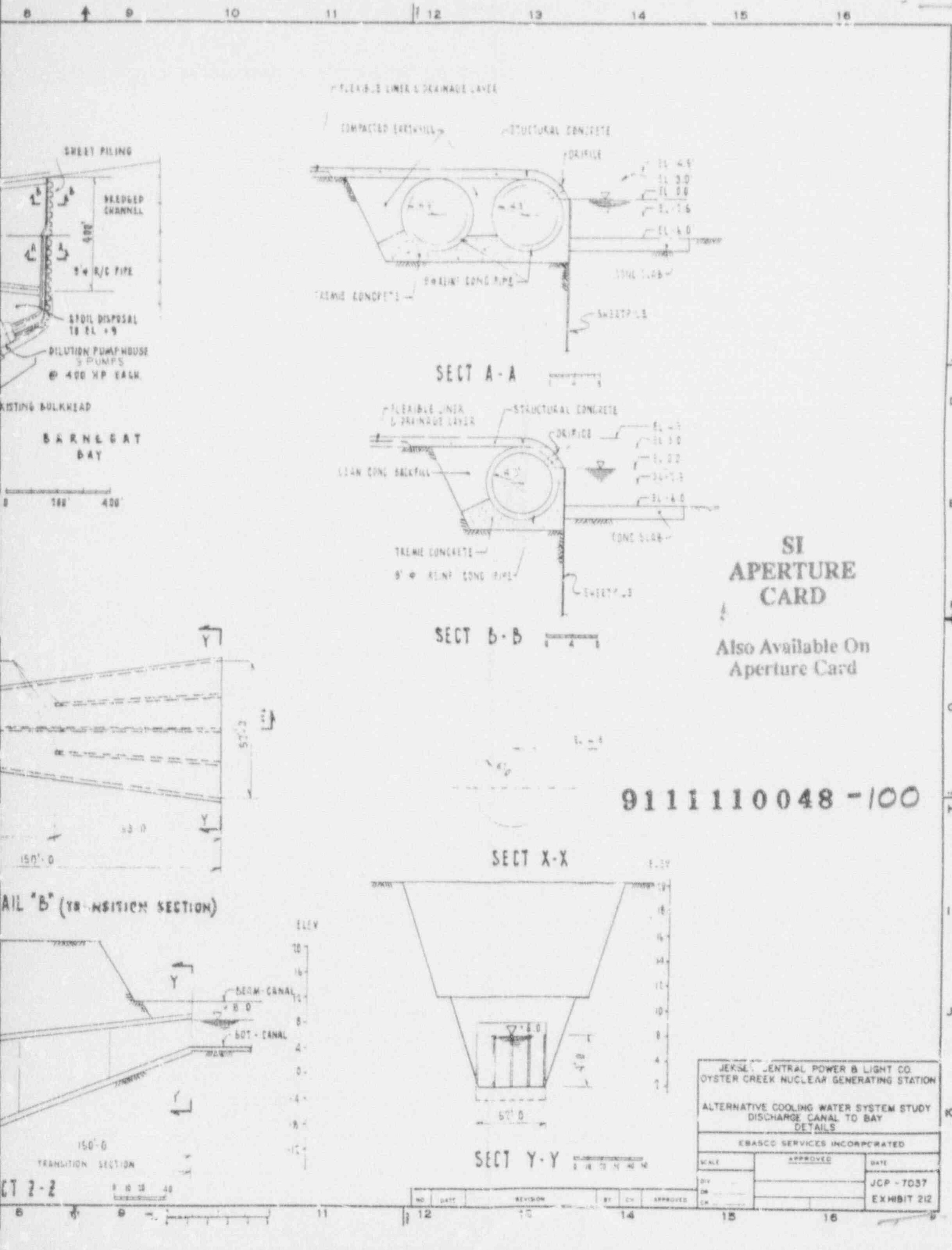
JERSEY CENTRAL POWER & LIGHT CO.
OYSTER CREEK NUCLEAR GENERATING STATION

ALTERNATIVE COOLING WATER SYSTEM STUDY
DISCHARGE CANAL TO BAY
LAYOUT AND SECTIONS

EBASCO SERVICES INCORPORATED

JCP-7037
EXHIBIT 211


N
EXISTING DILUTION WATER DISCHARGE STRUCTURE
DETAIL "A"
EXISTING CONDENSER COOLING WATER DISCHARGE STUCTURE
LOW POINT OF CANAL
SPOIL DISPOSAL
CANAL
VALVE BOX
ACCESS ROAD
MAINTENANCE DRAIN
LINED CANAL
DETAIL "B"
TRANSITION SECTION
EXISTING DISCHARGE CANAL
DREDGED CHANNEL
OYSTER CREEK
PART PLAN
STOP LOGS
FILL WITH CONCRETE
STEEL TRANSITION
CONCRETE PIPE
MAKEUP RING
EXPANSION JOINT
SPLITTER WALLS
DETAIL "A"
END WALL
SPLITTER WALL
TOP OF NEW CONCRETE
MAKE UP RING
STEEL TRANSITION
CONCRETE PIPE
FILL WITH CONCRETE
SECT C-C
EXISTING CANAL
SECT J-J
SECT M-M



SI APERTURE CARD

Also Available On Aperture Card

9111110048 -100

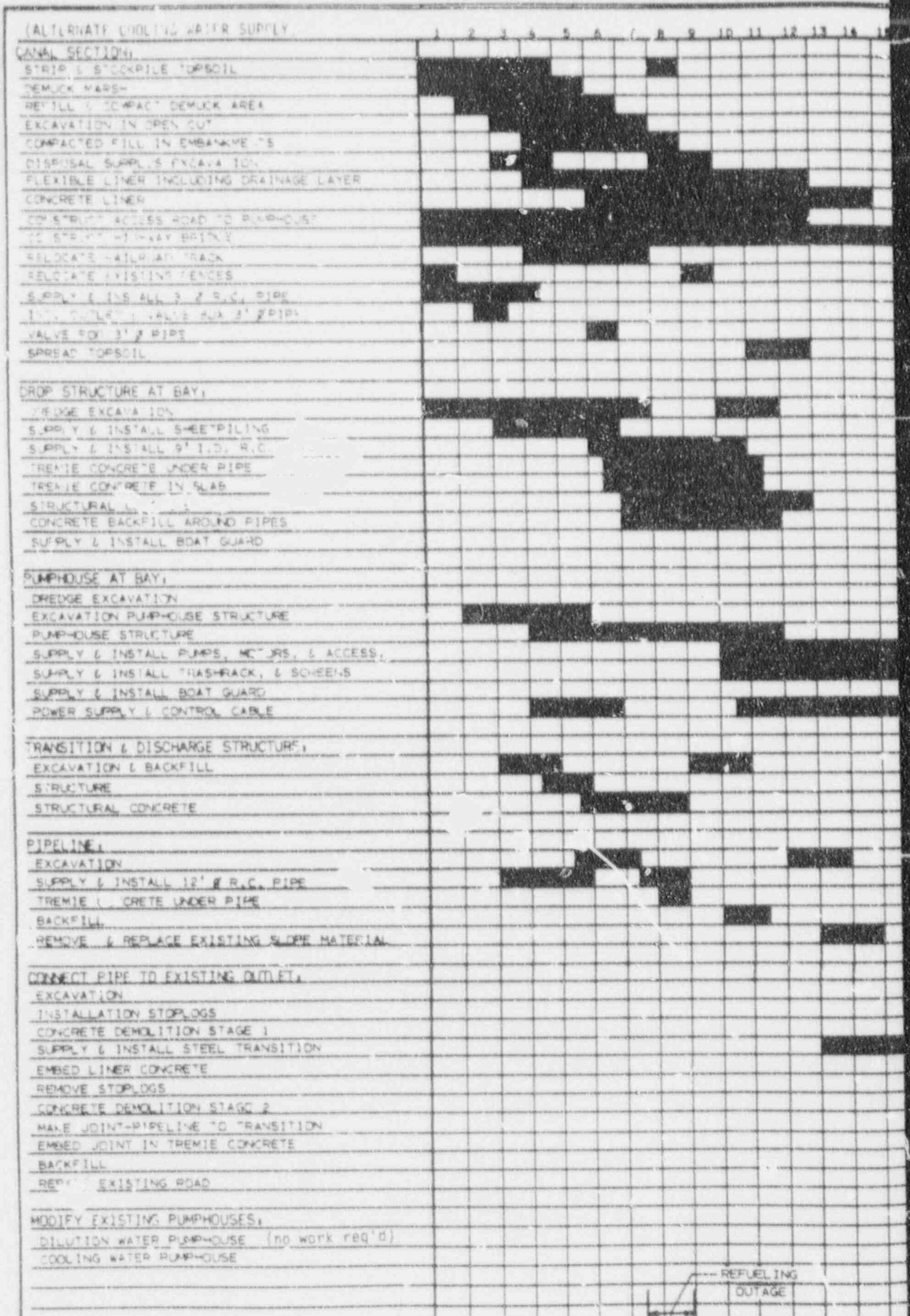
JERSEY CENTRAL POWER & LIGHT CO.
OYSTER CREEK NUCLEAR GENERATING STATION

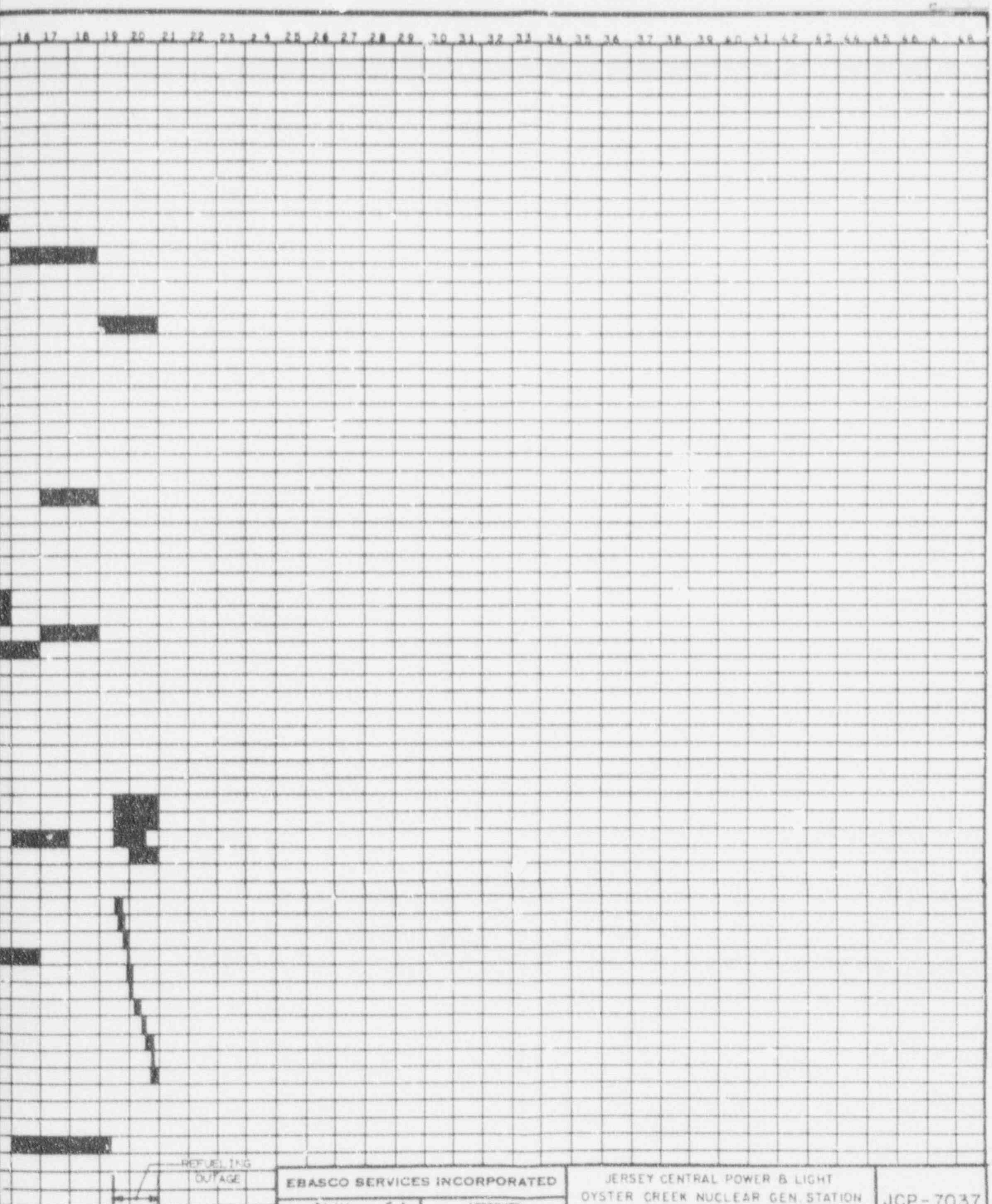
ALTERNATIVE COOLING WATER SYSTEM STUDY
DISCHARGE CANAL TO BAY
DETAILS

EBASCO SERVICES INCORPORATED

JCP - 7037

EXHIBIT 212


(ALTERNATE COOLING WATER SUPPLY
1 2 3 4 5 6 7 8 9 10 11 12 13 14
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 HIGHWAY BRIDGE
RELOCATE RAILROAD TRACK
RELOCATE EXISTING FENCES
SUPPLY & INSTALL 3' Ø R.C. PIPE
VALVE FOR 3' Ø PIPE
SPREAD TOPSOIL
DROP STRUCTURE AT BAY;
DREDGE EXCAVATION
SUPPLY & INSTALL SHEETPILING
SUPPLY & INSTALL 9' I.D. R.C.
TREMIE CONCRETE UNDER PIPE
TREMIE CONCRETE IN SLAB
STRUCTURAL
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 CRETE 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
EXISTING ROAD
MODIFY EXISTING PUMPHOUSES;
DILUTION WATER PUMPHOUSE (no work req'd)
COOLING WATER PUMPHOUSE
REFUELING OUTAGE



EBASCO SERVICES INCORPORATED DIV CIVIL DR G A SCALE NTS CH DATE APPROVED	JERSEY CENTRAL POWER & LIGHT OYSTER CREEK NUCLEAR GEN. STATION ALTERNATIVE COOLING WATER SYS. STUDY DISCHARGE CANAL TO BAY CONSTRUCTION SCHEDULE	JCP-7037 EXHIBIT 213

9111110048-101

EXHIBIT 214

DISCHARGE PARAMETERS UNDER AVERAGE CONDITIONS

CANAL-TO-BAY SYSTEM

Month	Oyster Creek NGS Discharge Flow Into Canal GPM	Forked River NGS Discharge Flow Into Oyster Creek GPM	Required* Dilution Flow into Oyster Creek GPM	Combined Flow To Barnegat Bay From Canal & Oyster Creek GPM	Combined Initial Temperature Rise To Barnegat Bay From Canal Deg F
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 [illegible] Times

EXHIBIT 215

DISCHARGE PARAMETERS UNDER EXTREME CONDITIONS

CANAL-TO-BAY SYSTEM

Month	Oyster Creek NGS Discharge Flow Into Canal GPM	Forked River NGS Discharge Flow Into Oyster Creek GPM	Required* Dilution Flow Into Oyster Creek GPM	Combined Flow To Barnegat Bay From Canal & Oyster Creek GPM	Combined Initial Temperature Rise To Barnegat Bay From Canal Deg F
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

Month	Extreme Conditions	Average Conditions
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

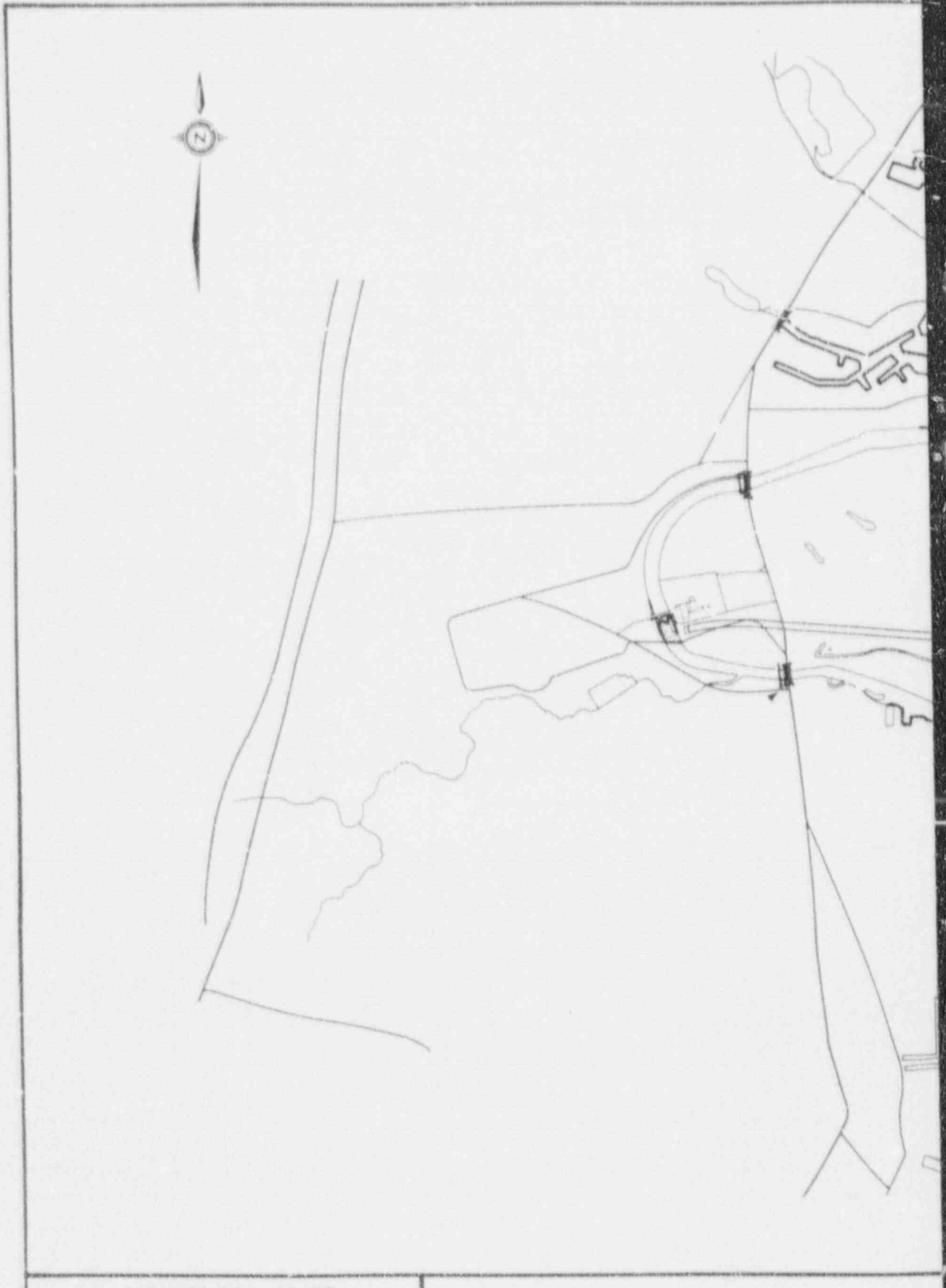
EXHIBIT 21

SUMMARY OF THERMAL MEASUREMENTS FOR EXISTING STATION

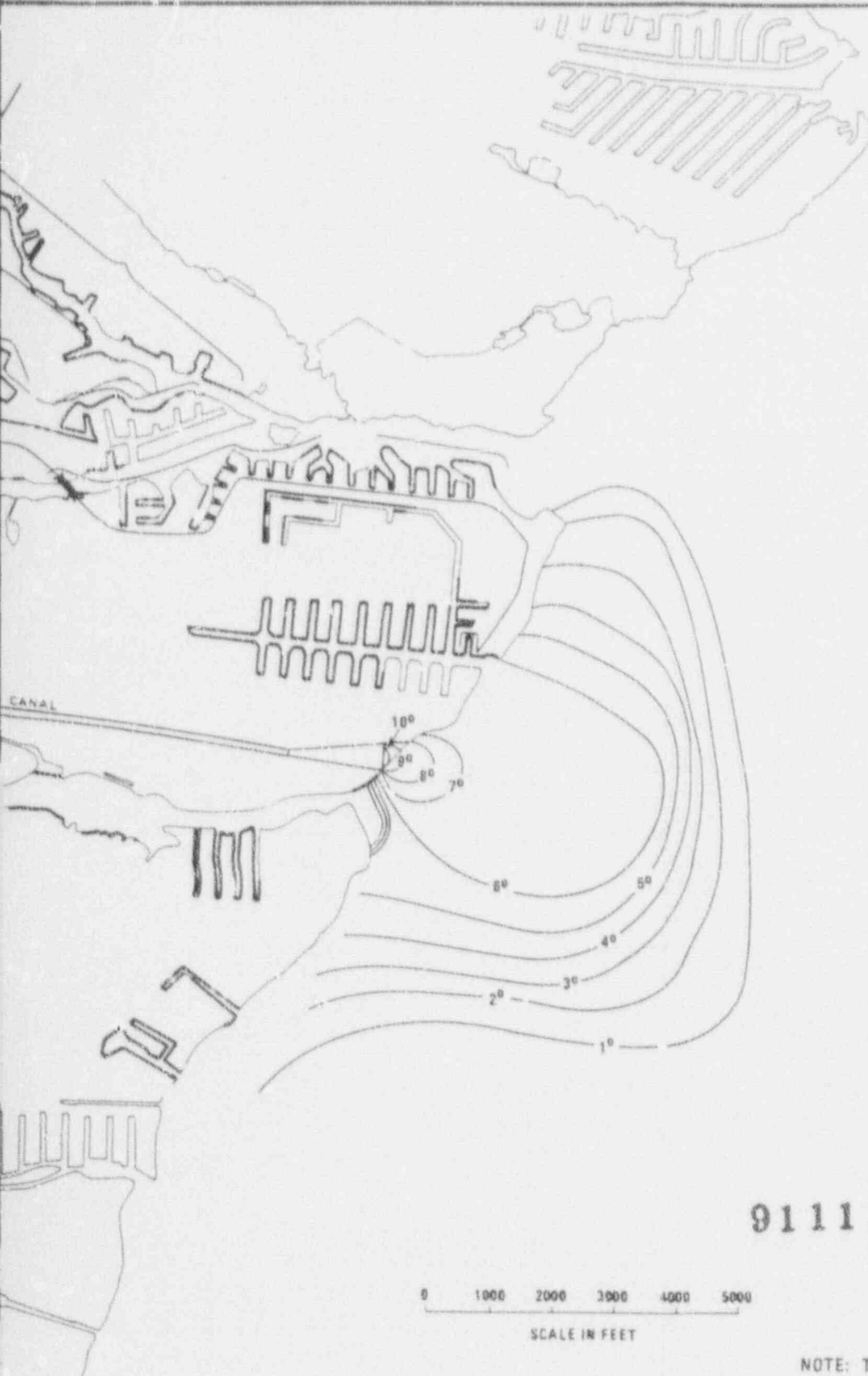
DURING SUMMER CONDITIONS

Survey Date	Wind Condition	Tidal Current*	Percent Surface Within 1.5 Deg F	Percent Cross-Section Within 1.5 Deg F
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



JERSEY CENTRAL POWER AND LIGHT COMPANY	PREDICTED CANAL TO BAY SYSTEM TEMPERATURE D TEM TWO DILUT
EBASCO SERVICES INCORPORATED New York	



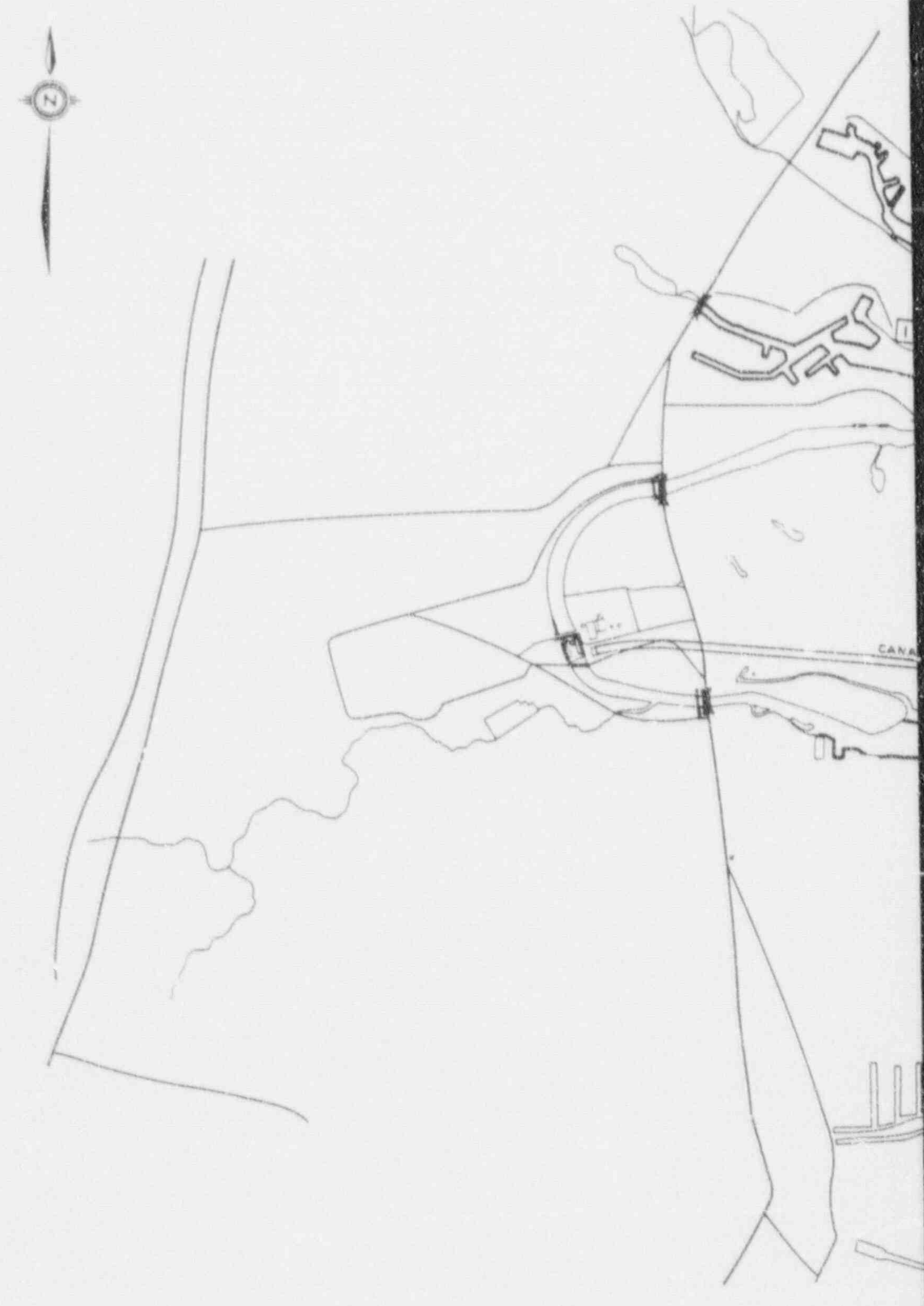
SI APERTURE CARD

Also Available On Aperture Card

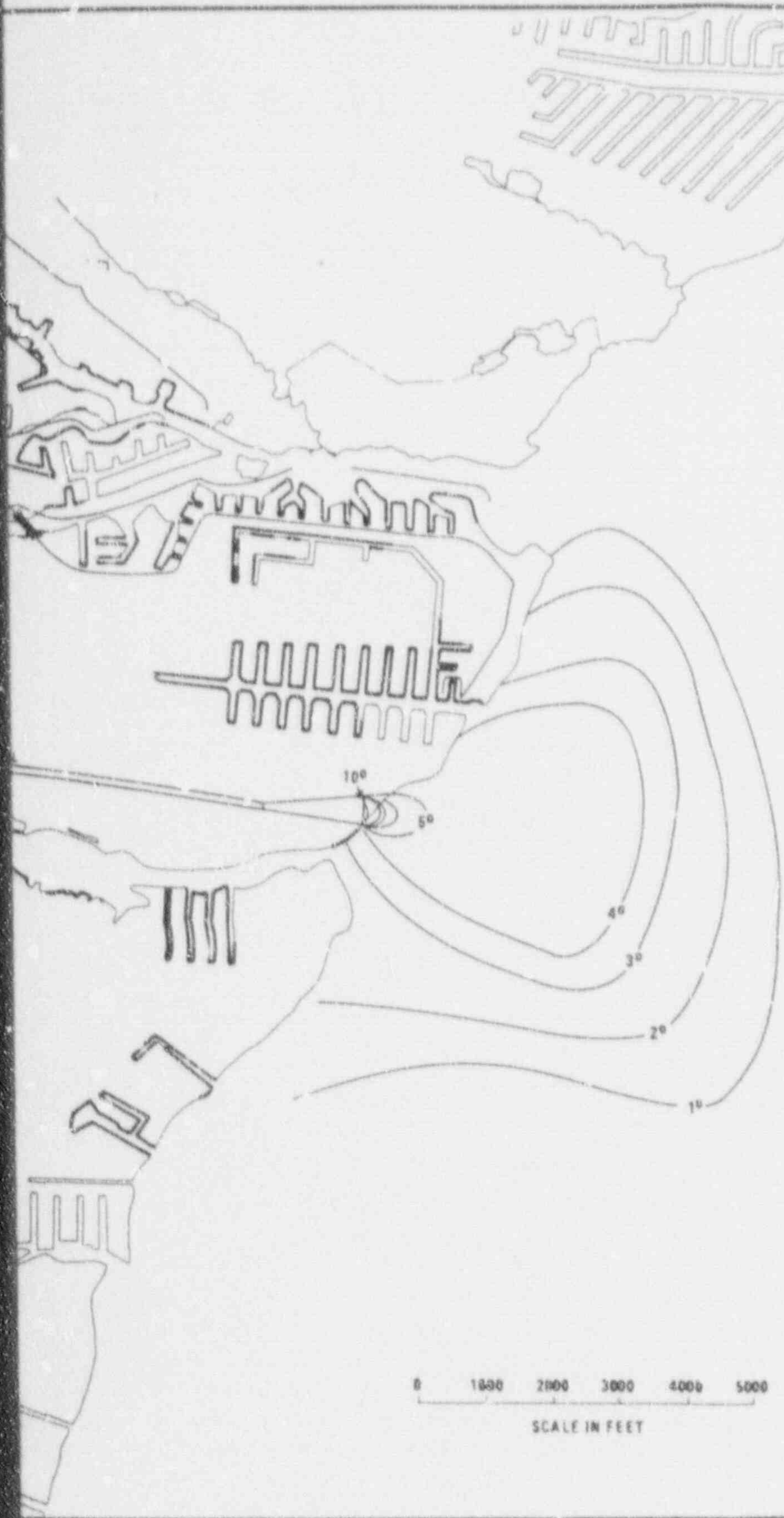
9111110048 -102

NOTE: TEMPERATURE RISE IN DEGREES F
AMBIENT WATER TEMPERATURE OF 40 F

ISTRIBUTION FC·! THE COMBINED FORKED RIVER AND OYSTER CREEK STATIONS' DISCHARGES PERATURES AT SURFACE AND 2.5 FOOT DEPTH ON PUMP OPERATION UNDER JANUARY CONDITIONS	EXHIBIT 218



JERSEY CENTRAL POWER AND LIGHT COMPANY	PREDICTED CANAL TO BAY SYSTEM TEMPERATURE DISTR
EBASCO SERVICES INCORPORATED New York	TWO DILUTION



SI
APERTURE
CARD

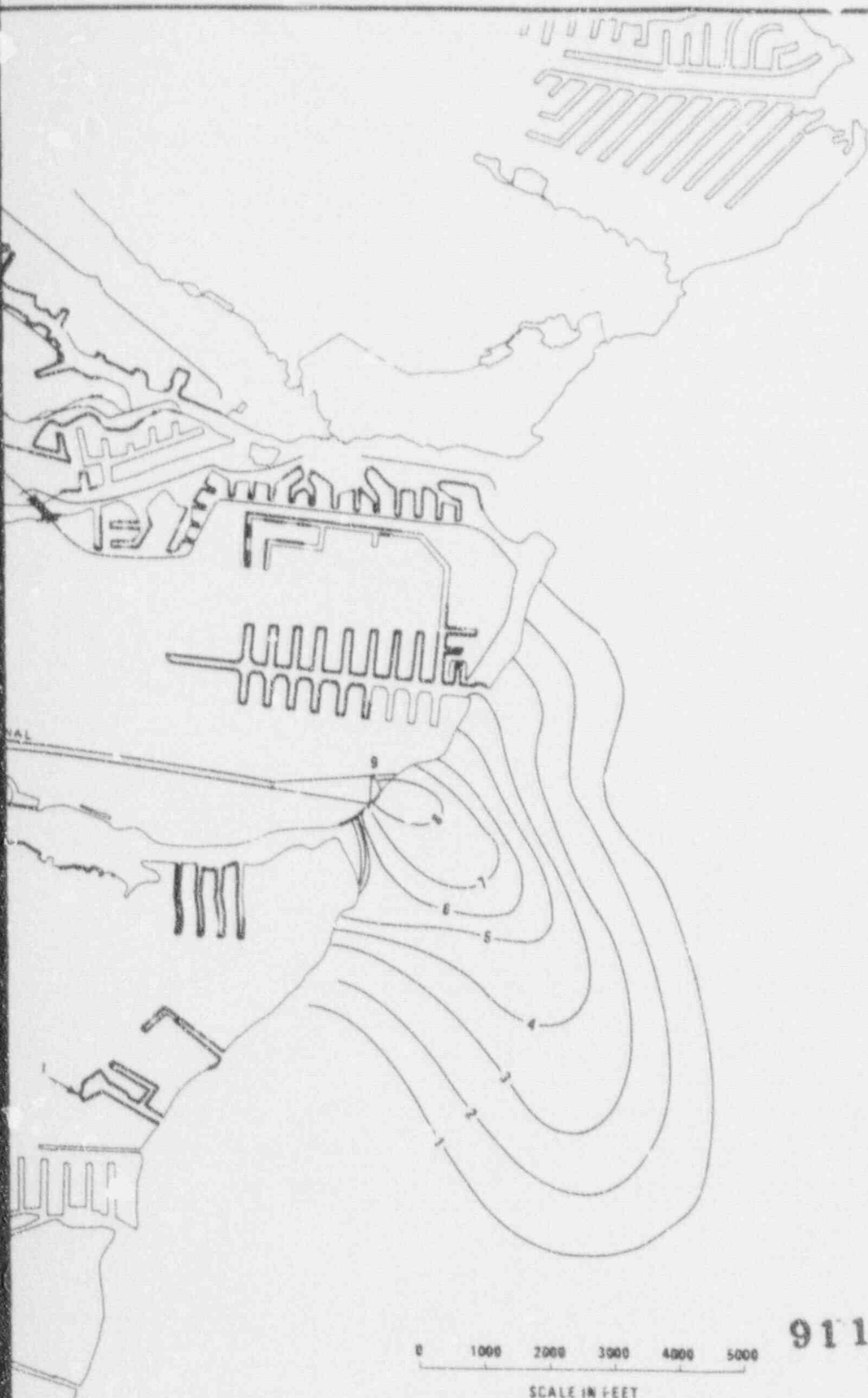
Also Available On
Aperture Card

9111110048 - 103

NOTE: TEMPERATURE RISE IN DEGREES F
AMBIENT WATER TEMPERATURE OF 40.0 F

IBUTION FOR THE COMBINED FORKED RIVER AND OYSTER CREEK STATIONS' DISCHARGES TEMPERATURES AT 5.0 FT DEPTH PUMP OPERATION UNDER JANUARY CONDITIONS	EXHIBIT 219

JERSEY CENTRAL POWER AND LIGHT COMPANY	PREDICTED CANAL TO BAY SYSTEM TEMPERATURES DIS TEMPER TWO DILUTI
EBASCO SERVICES INCORPORATED New York	

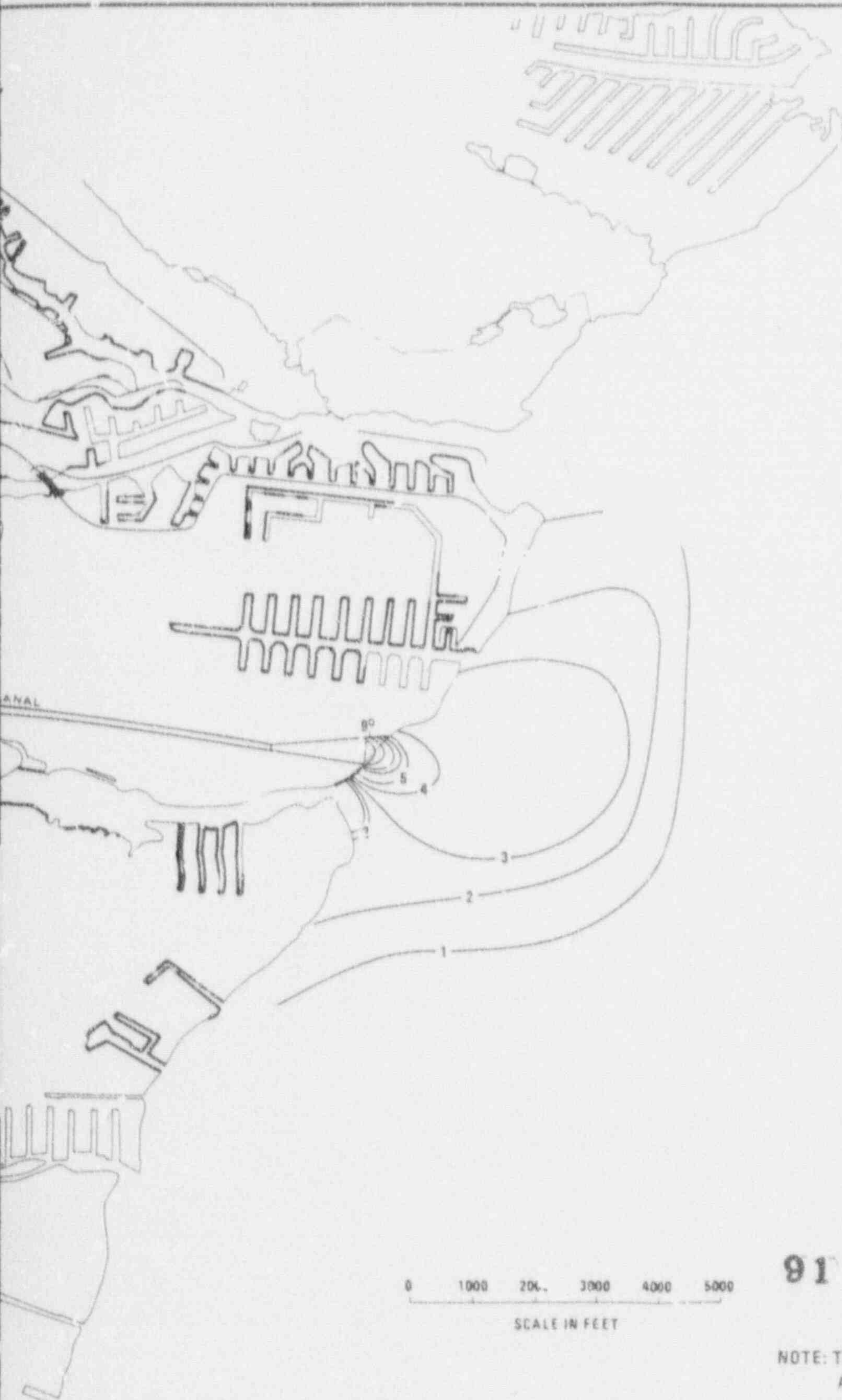


NOTE: TEMPERATURE RISE IN DEGREES F
AMBIENT WATER TEMPERATURE OF 54.0 F

TRIBUTION FOR THE COMBINED FORKED RIVER AND OYSTER CREEK STATIONS' DISCHARGES
RATURES AT SURFACE, 2.5 AND 5.0 FT DEPTH
ON PUMP OPERATION UNDER APRIL CONDITIONS

EXHIBIT
220

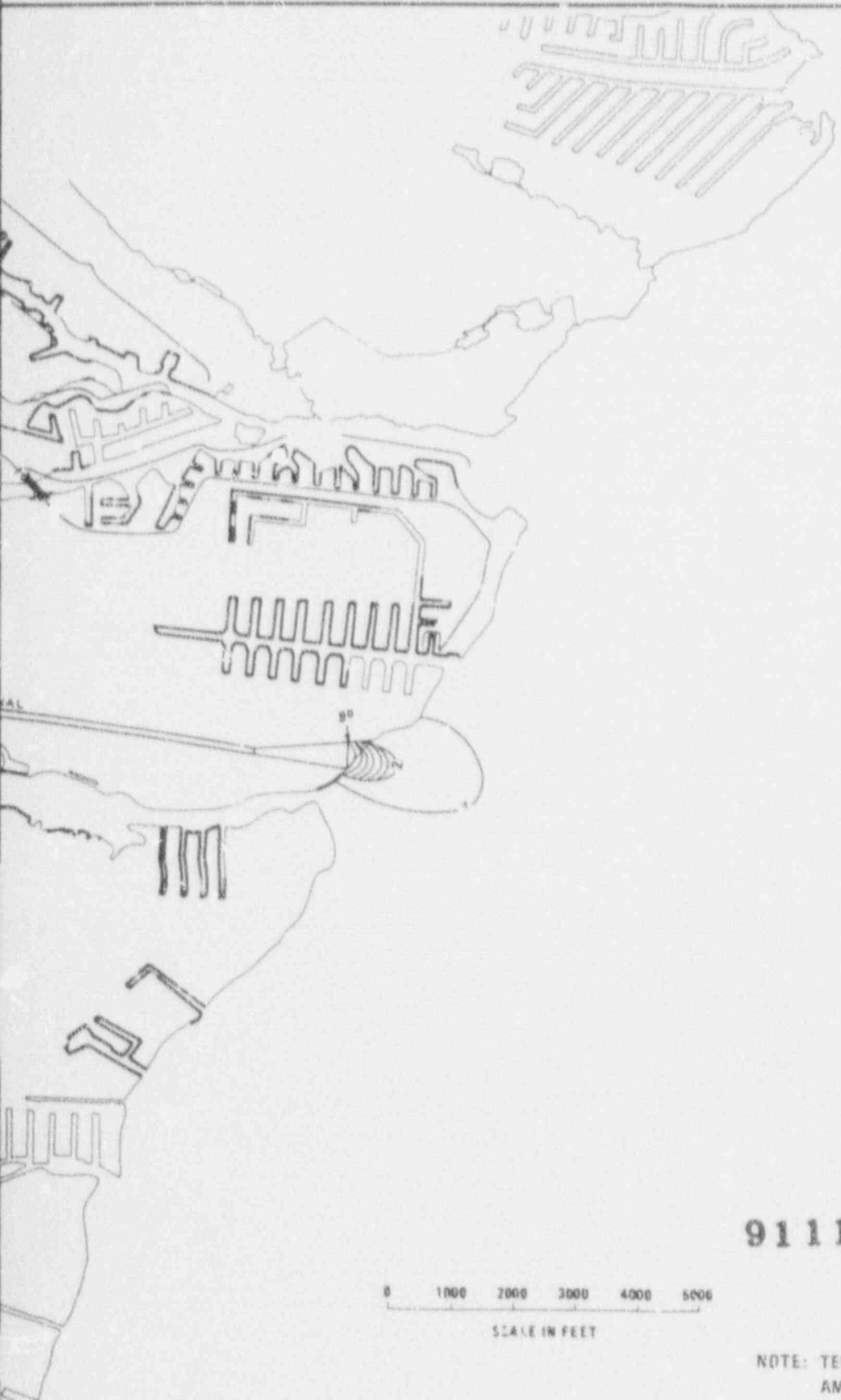
JERSEY CENTRAL POWER AND LIGHT COMPANY	PREDICTED CANAL TO B/Y SYSTEM TEMPERATURE D
EBASCO SERVICES INCORPORATED New York	TWO DILU



NOTE: TEMPERATURE RISE IN DEGREES F
AMBIENT WATER TEMPERATURE OF 78.0 F

STRIBUTION FOR THE COMBINED FORKED RIVER AND OYSTER CREEK STATIONS' DISCHARGES TEMPERATURES AT THE SURFACE TION PUMP OPERATION UNDER JULY CONDITIONS	EXHIBIT 221

JERSEY CENTRAL POWER AND LIGHT COMPANY	PREDICTED CANAL TO BAY SYSTEM TEMPERATURE DIST
EBASCO SERVICES INCORPORATED New York	TWO DILUTION



SI APERTURE CARD

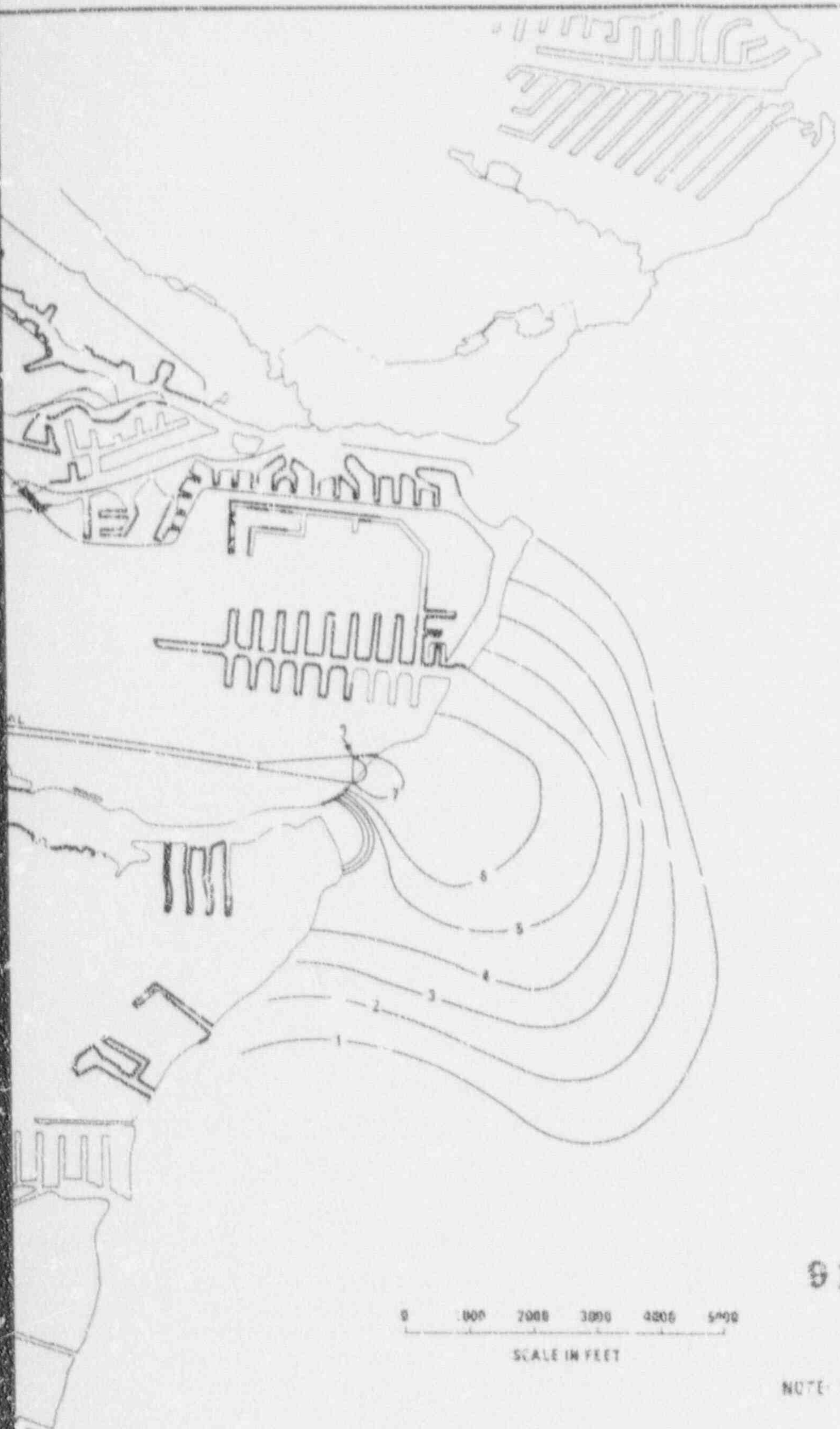
Also Available On Aperture Card

9111110048 -106

NOTE: TEMPERATURE RISE IN DEGREES F
AMBIENT WATER TEMPERATURE OF 78.0 F

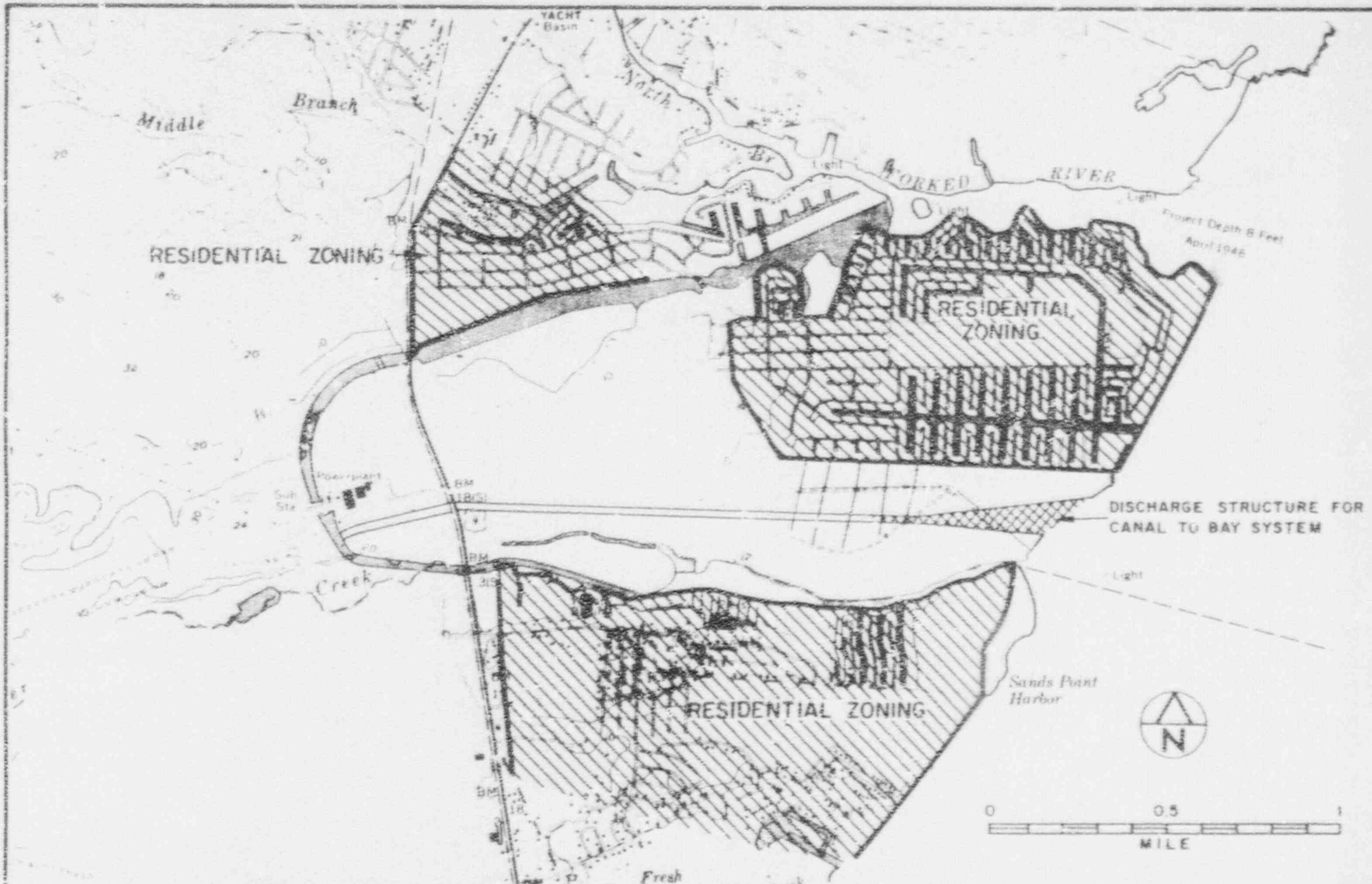
RIBUTION FOR THE COMBINED FORKED RIVER AND OYSTER CREEK STATIONS' DISCHARGES TEMPERATURES AT 5.0 FT DEPTH PUMP OPERATION UNDER JULY CONDITIONS	EXHIBIT 222

JERSEY CENTRAL POWER AND LIGHT COMPANY	PREDICTED CANAL TO BAY SYSTEM TEMPERATURE DIST
EBASCO SERVICES INCOR JRATED New York	TEMPER TWO DILUTION

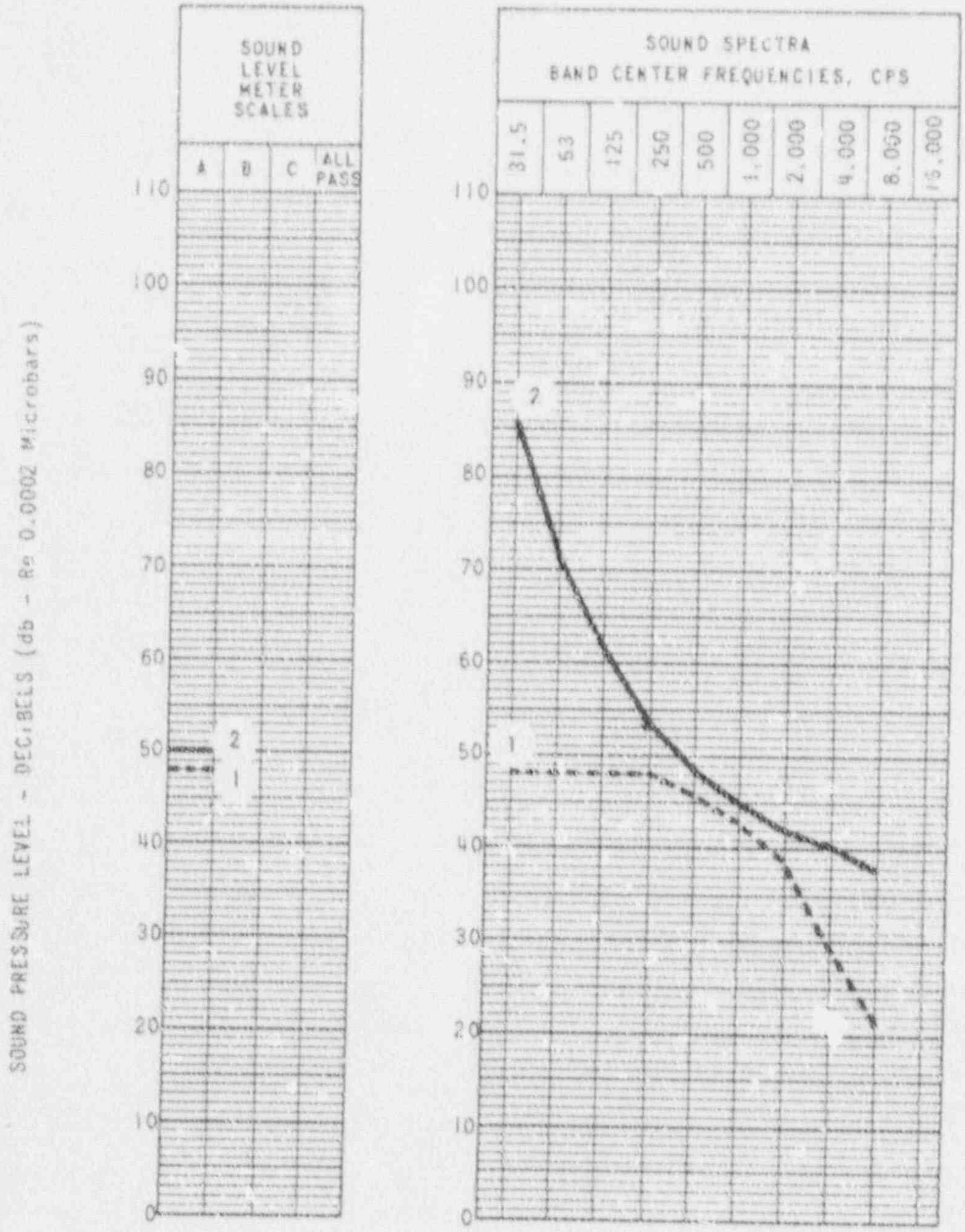


NOTE: TEMPERATURE RISE IN DEGREES F
AMBIENT WATER TEMPERATURE OF 60.0 F

RIBUTION FOR THE COMBINED FORKED RIVER AND OYSTER CREEK STATIONS' DISCHARGES ATURES AT SURFACE, 2.5 AND 5.0 FT DEPTH PUMP OPERATION UNDER OCTOBER CONDITIONS	EXHIBIT 223

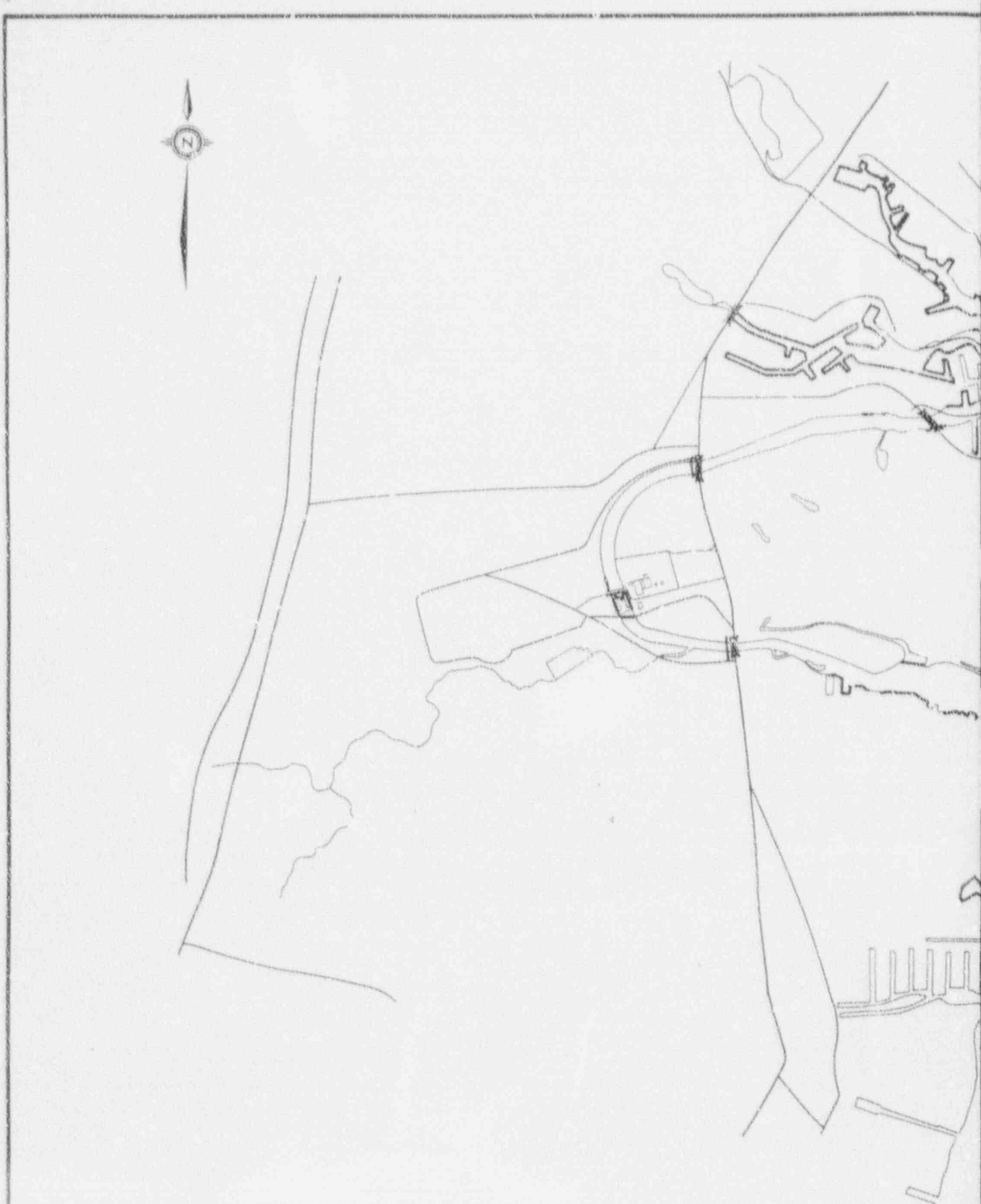


JERSEY CENTRAL POWER AND LIGHT COMPANY EBASCO SERVICES INCORPORATED New York	LOCATION OF CANAL-TO-BAY ALTERNATIVE WITH RESPECT TO NEAREST RESIDENTIAL AREAS	EXHIBIT 224



1. SPL AT A DISTANCE OF ABOUT 600 FT FROM THE DROP STRUCTURE
2. NEW JERSEY NIGHTTIME CRITERION

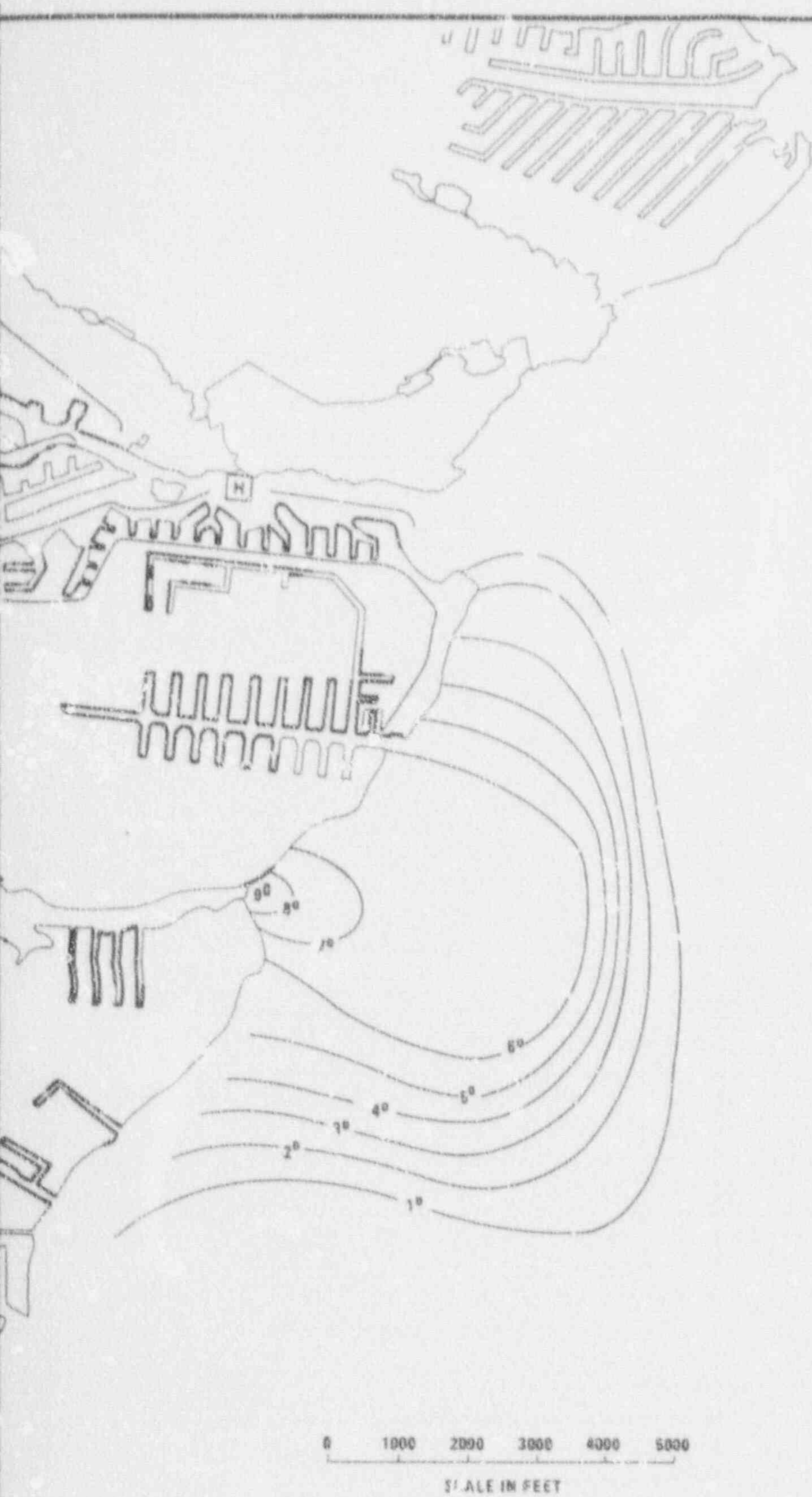
JERSEY CENTRAL POWER & LIGHT COMPANY	ROUND DROP STRUCTURE	EXHIBIT
EBASCO SERVICES INCORPORATED New York	NOISE DATA	225



JERSEY CENTRAL POWER
AND LIGHT COMPANY

EBASCO SERVICES INCORPORATED
New York

EXISTING OYSTE
THERMA
TEMPERATURES



SI APERTURE CARD

Also Available On Aperture Card

NOTE: TEMPERATURE RISE IN DEGREES F
AMBIENT WATER TEMPERATURE OF 40.0 F

R CREEK NCS COOLING SYSTEM L SURVEY DATA OF 1/8/75 AT SURFACE AND 2.5 FT DEPTH	EXHIBIT 226

9111110048 -108

Exhibit 227

PLANT NET CAPABILITY, ANNUAL HEAT RATE AND ANNUAL GENERATION FOR THE PREFERRED COOLING WATER SYSTEMS

Type of Cooling Water System	Plant Net Capability at Average Summer Conditions		Plant Net Annual Average Heat Rate			Net Annual Generation	
	MW	Differential MW	Btu/kWh	Differential Btu/kWh	Differential %	MWh/yr	Differential 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	94,394
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

[1] Includes additional dilution pumps at mouth of Oyster Creek

CHEMICAL EFFLUENT LIMIT

BPCTA - TO BE MET

Effluent Source[3]	pH	TSS (mg/1)		Oi Gre (mg
Once-Through Cooling Water	-	-	-	-
Cooling System Blowdown	6.0-9.0	-	-	-

BATEA - TO BE MET

Effluent Source[3]	pH	TSS (mg/1)		Oi Gre (mg
Once-Through Cooling Water		-	-	-
Cooling System Blowdown	6.0-9.0	-	-	-

[1] The (daily) quantity of pollutants discharged shall times the concentration listed in this table.

[2] Neither free available chlorine nor total residual day and not more than one unit in any plant may disc utility can demonstrate to the regional administrat in a particular location cannot operate at or below

[3] Low volume wastes, ash transport water, metal cleani

EXHIBIT B-1

ATIONS[1] FOR STEAM ELECTRIC GENERATING SOURCES

BY ALL EXISTING UNITS BY JULY 1, 1977

l & ase (/1)	Total Copper (mg/l)		Total Iron (mg/l)		Free Available Chlorine[2] (mg/l)		Zinc (mg/l)		Chromium (mg/l)		Phosphorus (mg/l)		Other Corrosion Inhibiting Materials (mg/l)	
-	-	-	-	-	0.2	0.5	-	-	-	-	-	-	-	-
-	-	-	-	-	0.2	0.5	-	-	-	-	-	-	-	-
BY ALL EXISTING UNITS BY JULY 1, 1983														
-	-	-	-	-	0.2	0.5	-	-	-	-	-	-	-	-
-	-	-	-	-	0.2	0.5	1.0	1.0	0.2	0.2	5.0	5.0	Limit to be established on a case by case basis	

not exceed the qu. ntity determined by multiplying the (daily average) flow

hlorine may be discharged from any unit for more than two hours in any one harge free available or total residual chlorine at any one time unless the r or state, if the state has NPDES permit issuing authority, that the units this level of chlorination.

ng and boiler blowdown are not included here.

SI APERTURE CARD

Also Available On Aperture Card

9111110048-109

1. Class FW-3 Definition:

   Fresh surface water suitable for the maintenance, migration and p
   al and agricultural water supply and any other reasonable uses.

2. Class FW-3 Criteria:

   i. Floating, Suspended, Colloidal and Settleable Solids; Oil, G

      (1) None noticeable in the water or deposited along the sho
      would render the waters unsuitable for the designated u

      (2) Maximum 30-day average of 20 Jackson Turbidity Units (J

   ii. Toxic or Deleterious Substances, Including but not Limited t
   Compounds, Chlorine, Phenols, Pesticides, etc.

   None, either alone or in combination with other substances,
   produce undesirable aquatic life, or which would render the

   iii. Taste and Odor Producing Substances

   None offensive to humans or which would produce offensive ta
   unsuitable for the designated uses.

   iv. pH

   Between 6.5 and 8.5. Natural conditions outside this range

   v. Dissolved Oxygen

      (1) Nontrout Waters - 24-hour average not less than 5.0 mg/

   vi. Temperature

      (1) Nontrout Waters -

         (a) General - No thermal alterations which would cause
         temperatures. No heat may be added which would ca
         waters or 86 degrees F (30 degrees C) for other no

         Temperatures shall be measured outside of designat

         (b) Heat Dissipation Areas - The limitations specified
         by-case- basis.

         (c) Heat Dissipation Area Determinations - The determin
         receiving waters so as to meet the intent and purpo
         drifting organisms so that negligible or no effects
         to no more than 1/4 of the cross-sectional area and
         of 1/3 surface measured from shore to shore at any

         (d) Adjacent Heat Dissipation Areas - Where waste disch
         impair protected uses, additional limitations may b

         (e) Rate of Temperature Change - The rate of temperatur

   vii. Radioactivity

   Current U S Public Health Service Drinking Water Standard

   viii. Bacterial Quality

   Fecal coliform levels shall not exceed a geometric avera

   ix. Total Dissolved Solids

   Not to exceed 133 percent of background. Notwithstanding
   increases exceeding this limit provided the discharger r
   such increases will not significantly affect the g

   Any authorization by the Department of such increases sh

SEY SURFACE WATER QUALITY CRITERIA CLASS FW-3 WATERS

opagation of the natural and established biota; and for primary contact recreation; industri-

ease, Color and Turbidity

e or on the aquatic substrata in quantities detrimental to the natural biota. None which
es.

TU), a maximum of 110 JTU at any time, unless exceeded due to natural conditions.

Mineral Acids, Caustic Alkali, Cyanides, Heavy Metals, Carbon Dioxide, Ammonia or Ammonium

in such concentrations as to affect humans or be detrimental to the natural aquatic biota,
water unsuitable for designated uses.

stes and/or odors in biota used for human consumption. None which would render the waters

shall prevail.

SI APERTURE CARD

Also Available On Aperture Card

l. Not less than 4.0 mg/l at any time.

temperatures to deviate more than 5 degrees F (2.8 degrees C) any time from ambient stream
use temperatures to exceed 82 degrees F (27.8 degrees C) for small mouth bass or yellow perch
ntrout waters.

ed heat dissipation areas.

above may be exceeded in designated heat dissipation areas by special permission on a case-

ation of heat dissipation areas shall take into consideration the extent and nature of the
se of the criteria and standards including provision for the passage of free-swimming and
are produced on their populations. As a guideline, heat dissipation areas shall be limited
/or volume of flow of the stream, leaving 3/4 free as a zone of passage including a minimum
flow.

arges would result in heat dissipation areas in such close proximity to e . other as to
e prescribed to avoid such impairment.

change in designated heat dissipation areas shall not cause mortality of fish.

s shall apply.

ge of 200/100 ml.

this criterion, the Department, after notice and opportunity for hearing, may authorize
esponsible for such increases can demonstrate to the satisfaction of the Department that
and propagation of indigenous aquatic biota or other designated uses.

ll be conditioned upon utilization of the maximum practicable control technology.

EXCERPTS FROM STATE OF NEW JER

1. Class TW-1 Definition:

   i. Tidal waters approved as sources of public water supply. The required by law or regulation.

   ii. These waters shall be suitable for shellfish harvesting wh

   iii. These waters shall also be suitable for the maintenance, mig tion; industrial and agricultural water supply and any other

2. Class TW-1 Criteria:

   i. Floating, Suspended, Colloidal and Settleable Solids; Oil, Gr

      (1) Same as Class FW-3 Waters.

      (2) Maximum 30-day average of 25 Jackson Turbidity Units (JT

   ii. Toxic or Deleterious Substances, Including but not Limited to Compounds, rine, Phenols, Pesticides, etc.

      Same as Class FW-3 Waters.

      In addition, where tidal waters are approved as sources of pu 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 (0.8 degrees C) during June through August; nor sha degrees C) in other nontrout waters.

            Temperatures shall be measured outside of designate

         (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 Program as set forth in its current manual of operations

      (2) All Other Waters - Fecal coliform levels shall not excee

   ix. Same as Class FW-3 Waters.

SEY SURFACE WATER QUALITY CRITERIA CLASS TE-1 WATERS

e waters shall be suitable for public potable water supply after such treatment as shall be

permitted.

ation and propagation of the natural and established biota; and for primary contact recrea-
reasonable uses.

ease, Color and Turbidity.

U), a maximum of 130 JTU at any time, unless exceeded due to natural conditions.
Mineral Acids, Caustic Alkali, Cyanides, Heavy Metals, Carbon Dioxide, Ammonia or Ammonium

blic water supply, none which would cause standards for drinking water to be exceeded after

SI
APERTURE
CARD

Also Available On
Aperture Card

than 4 degrees F (2.2 degrees C) during September through May, nor more than 1.5 degrees F
ll temperatures exceed 82 degrees F (27.8 degrees C) in yellow perch or 85 degrees F (29.4

d heat dissipation areas.

of shellfish is permitted, requirements established by the National Shellfish Sanitation
shall apply.

d a geometric average of 200/100 ml.

9111110048 - 111

1. Class CW-1 Definition:

   i. The waters of the Atlantic Ocean within 1,500 feet from mean low ever is more distant from the mean low tide shoreline.

   ii. These waters shall be suitable for shellfish harvesting where per

   iii. These waters shall be suitable for primary contact recreation; th other reasonable uses.

2. Class CW-1 Criteria:

   i. Floating, Suspended, Colloidal and Settleable Solids; Oil, Grease

      (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 Mi 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 t ing September through May, nor more than 1.5 degrees F (0.8 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

   ix. Total Dissolved Solids

      Same as Class FW-3 Waters. In addition, total dissolved solids

URFACE WATER QUALITY CRITERIA CLASS CW-1 WATERS

tide shoreline or to a bottom depth of 15 feet below the mean low tide elevation, which-

mitted.

e maintenance, migration and propagation of the natural and established biota and any

, Color and Turbidity.

eral Acids, Caustic Alkali, Cyanides, Heavy Metals, Carbon Dioxide, Ammonia or Ammonium

mperature shall not be raised above ambient by more than 4 degrees F (2.2 degrees C) dur-
degrees C) during June through August, nor shall temperatures exceed 80 degrees F (26.7

geometric average of 50/100 ml.

are not to exceed 500 mg/1 for waters approved as sources of public water supply.

1. Class CW-2 Definition:

   i. Atlantic Ocean waters beyond those established under CW-1 to t

   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 tempe through May, nor more than 1.5 degrees F (0.8 degrees Temperatures shall be measured outside of designated h

      (2) Heat Dissipation Areas - Same as Class TW-1 waters.

      (3) Heat Dissipation Area Determinations - The determinati nature of such waters so as to meet the intent and pur drifting organisms so that negligible or no effects ar

      (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 wa

      (2) All Other Waters - Same as TW-1 waters.

Y SURFACE WATER QUALITY CRITERIA CLASS CW-2 WATERS

he three mile limit.

ratures to be raised above ambient by more than 4 degrees F (2.2 degrees C) during September
C) during June through August, nor shall temperatures exceed 80 degrees F (26.7 degrees C).
eat dissipation areas.

on of designated heat dissipation areas shall take into special consideration the extent and
pose of the criteria and standards including provision for the passage of free-swimming and
e produced on their populations.

ters.

Exhibit B-3

NEW JERSEY REGULATIONS ON AIR POLLUTION FROM MANUFACTURING PROCESSES

Maximum Allowable Emission Rate for Particles

1	2	3	4
Potential Emission Rate From Source Operation (lbs/hr)	Allowable Emission Rate (based on 99% Collection Efficiency) (lbs/hr)	Source Gas Emitted from Source (SCFM)	Allowable Emission Rate (based on 0.02 gr/SCF) (lbs/hr)
50 or less	0.5	3,000 or 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 greater	30.0	140,000	24.0
		175,000 or greater	30.0