AEC 1974

Final

environmental statement

related to the continued construction and proposed issuance of an operating license for the

BRUNSWICK STEAM ELECTRIC PLANT UNITS 1 AND 2

CAROLINA POWER AND LIGHT COMPANY

DOCKET NOS. 50-324 & 50-325

January 1974
1974

UNITED STATES ATOMIC ENERGY COMMISSION
DIRECTORATE OF LICENSING

SUMMARY AND CONCLUSIONS

This Final Detailed Environmental Statement was prepared by the U.S. Atomic Energy Commission, Directorate of Licensing (the staff).

1. This action is <u>administrative</u>.

2. The proposed actions are the continuation of construction permits CPPR-67 and CPPR-68, and the issuance of operating licenses to the Carolina Power and Light Company (the applicant) for the startup and operation of the Brunswick Steam Electric Plant Units 1 and 2 (the plant) located near the town of Southport, Brunswick County, North Carolina (Docket Nos. 50-324 and 50-325).

   Both units employ boiling water reactors of similar size to produce initially 4872 megawatts thermal (MWt) total. Two similar steam turbine-generators initially will convert thermal energy to 1694 MW of electrical power (1642 MWe net). Ultimately these power levels will be 5100, 1760, and 1710 respectively. During initial operation the exhaust steam will be condensed by once-through flow of brackish water drawn through a 3-mile long unlined canal from the Cape Fear Estuary and discharged through a 6-mile long unlined canal and outfall structure to the Atlantic Ocean.

3. Summary of principal environmental impacts and resulting beneficial and adverse effects.

   a. The generation of 11.5 x 10^9 kW-hr of electricity annually, worth $148 million dollars, that is forecast to be required by present and projected population increases and industrial development in the region.

   b. A positive short-term economic impact on the local economy due to construction activities.

   c. A long-term economic impact on Brunswick County by doubling the value of taxable real property within the county and increasing personal income by about $2 million a year.

   d. The loss of about 117 acres of marshland due to canal construction. This leads to an estimated reduction in landed fisheries of about 31 tons/yr and a loss of habitat to biota including the American alligator.

2558 → 2923
= 365
= 14.27

e. The modification of an estimated 1000 or more additional acres of marshland and further loss of habitat due to changes in salinity, tidal patterns, sedimentation, and nutrient fluxes. This could lead to a further reduction of landed fisheries estimated at 300 tons/yr.

f. Significant losses of estuarine biota from entrainment and impingement in the cooling system. A loss of several hundred thousand dollars per year of commercial and sport fishery and shellfishery is likely. Sufficient data about the estuary do not exist to quantify this loss adequately; however, fishery losses of the predicted magnitude are not believed compatible with the long-term well being of the Cape Fear Estuary ecosystem.

g. An estimated loss of between 3.7 and 4.6 cfs of the region's freshwater supply (Castle Hayne aquifer) through upwelling into the unlined canal system. In addition, shallow wells adjacent to the canal are lost. Approximately 1.0 cfs of downwelling brackish water from the discharge canal may enter the Yorktown - Castle Hayne aquifer system in the Dutchman Creek vicinity north of the Intracoastal Waterway. A travel time of approximately 700-900 years was calculated for water to move from the discharge canal to the Southport municipal wells under present groundwater development.

h. Modification of the saltwater wedge beneath the upper layer drift in the estuary. This could cause modification in the distribution of some organisms but the effect on the entire ecosystem will not be significant.

i. Reassignment of about 3000 acres of agricultural land for the plant facilities, and commitment of land associated with 358 miles of transmission lines.

j. Creation of spoil ponds totaling over 700 acres. The filled ponds will, for several years, support little or no vegetation without either soil treatment or seeding. This alteration represents a net loss of habitat to wildlife and of productivity since the soil in the spoils areas will remain, at best, a very simple grass-dominated system.

k. Discharge of small quantities of radioactive gases and liquids to the environment from which the estimated radiation dose to the population from operation of the plant is 1.4 man-rem/yr. The radiation dose to marine animals is estimated to be 10 mrad/yr and for algae 50 mrad/yr. No significant environmental impacts are anticipated from these doses.

l. Release of radioiodine in the plant's gaseous effluents in quantities sufficient to create the possibility for an infant to receive a thyroid dose of about 40 mrem/yr from the consumption of milk from dairy animals grazing on farms near the site.

m. Creation of a very low risk of accidental radiation exposure to nearby residents.

4. Principal alternatives considered included:

- Abandonment of the facility, including consideration of use of an alternative fuel as a power source rather than nuclear fuel,
- Modifications to present once-through cooling system, and
- Alternate cooling methods and alternate sites.

5. The following Federal, State and local agencies were asked to comment on the Draft Detailed Environmental Statement:

Advisory Council on Historic Preservation
Department of Agriculture
Department of the Army, Corps of Engineers
Department of Commerce
Department of Health, Education and Welfare
Department of Housing and Urban Development
Department of the Interior
Department of Transportation
Environmental Protection Agency
Federal Power Commission
State of North Carolina
Brunswick County (North Carolina) Board of Supervisors

6. Comments on the draft environmental statement, issued in June 1973 were received from the following Federal and State agencies:

- Advisory Council on Historic Preservation
- Department of Agriculture
- Department of the Army, Corps of Engineers
- Department of Commerce
- Department of Health, Education and Welfare
- Department of the Interior
- Department of Transportation
- Environmental Protection Agency
- Federal Power Commission
- State of North Carolina Department of Administration
- State of North Carolina Department of Human Resources
- State of North Carolina Department of Art, Culture and History
- State of North Carolina Department of Natural and Economic Resources

Comments were also received from local citizens and the applicant.

The text of the agencies' comments and those of the applicant and local citizens are appended to this statement.

7. This statement was made available to the public, to the Council on Environmental Quality, and to the other specified agencies in January 1974.

8. The staff concludes that the plant, as presently designed, and because of the unique features of the site and cooling system, has the potential for causing serious and perhaps irreversible adverse effects on the environment of the Cape Fear Estuary, and cannot be operated for an extended period without incurring unacceptable environmental impact.

The staff also concludes, based on the data available at this time, that it is unlikely that irreversible damage will occur during the first 3 years of plant operation. Such damage that may occur is not sufficient to justify delaying plant operation and to incur concomitant costs of replacement power. Additional data on the impact of the plant on the environment will be necessary for quantification of these impacts.

9. On the basis of the analysis and evaluation set forth in this statement and after weighing the environmental, economic, technical and other benefits against environmental costs and considering available alternatives, it is concluded that the action called for under NEPA and Appendix D to 10 CFR Part 50, is the continuation of Construction Permits CPPR-67 and CPPR-68 and the issuance of operating licenses for Units 1 and 2 of the Brunswick Steam Electric Plant subject to the following conditions for the protection of the environment:

   a. Operation of the plant with the once-through cooling system will be permitted for 3 years following issuance of an operating license for the first unit; subsequently a closed-cycle cooling system shall be required.

      If during the period of initial plant operation the monitoring program indicates that a serious environmental impact is occurring, the applicant will 1) take steps to reduce the impact to an acceptable level (Sect. V.C.2.) and 2) seek ways of alleviating any impact which is unavoidable (Section XI.B.3).

   b. Evaluation of the economic and environmental impacts of alternative closed-cycle cooling systems shall be made by the applicant which will lead to selection of the most favorable system from an economic and environmental point-of-view. This evaluation, together with proposed plans for the continued use, abandonment and/or restoration of the present canal system shall be submitted to the staff for review prior to the issuance of an operating license (Sect. XI.A.3).

   c. The time period during construction in which the discharge canal water surface is allowed to remain at, or below, +2.5 ft MSL shall be minimized. (Sect. IV.C.1.c.(2)).

   d. Prior to pumped circulation in the canal, the applicant shall submit to the staff a detailed sequence of circulation system testing, together with detailed monitoring and sampling procedures for evaluating entrainment, impingement, and other environmental aspects to provide an early measure of the impact of once-through cooling during the interim operating period. (Sect. V.C.2)

e. Prior to the issuance of an operating license, to quantify the impact to the Cape Fear Estuary that will result from the initial 3 year operation of the once-through cooling system, the applicant shall perform circulating system testing and submit to the staff a comprehensive report which considers the following data (both that collected by the applicant and by others) regarding the environmental impact of plant operation on the ecosystem.

Data and analyses presented shall include the following:

1) Characterization of the Cape Fear Estuary ecosystem to the extent necessary to evaluate the significance of the impact of operation of the cooling canal, including that arising from dredging operations, freshwater depletion, and tidal influences. (Sect. V.C.).

2) The nature and extent of the entrainment mortality of aquatic organisms based on sampling procedures which will permit statistically valid estimates of that mortality. (Sect. V.C.2.b)

3) The nature and extent of the impingement mortality based on counting the number, types, and sizes of fish and other aquatic organisms collected on the screens and trash racks of the intake structure during prepower operation at intervals which will permit statistically valid estimates of that mortality on seasonal and annual bases. (Sect. V.C.2.a)

4) Mathematical hydraulic simulation modeling of the intake canal inflow area. Physical modeling and field data shall also be included to define silting and erosion problems in the Snow Marsh area and alterations in salinity patterns, and to provide a technical basis for modifying the intake canal if required for interim operation. (Sect. V.B.2.a)

5) Groundwater monitoring and analysis around the plant and along the canal system. (Sect. V.B.3).

6) Marsh biota monitoring and analysis of productivity within Snow Marsh (including Walden Creek), Dutchman Creek Marsh, and Oak Island Marsh and surrounding areas. The analyses should attempt to predict changes to be expected in the marshes due to the operation of the plant and the presence of intake and discharge canals. (Sect. V C.1.b.).

f. The applicant will conduct a radiological monitoring program at a level considered adequate by the staff with particular emphasis on potential thyroid doses; one purpose of the monitoring program shall be to demonstrate that actual thyroid doses do not exceed as low as practicable guidelines to any individual offsite. (Sect. V.D.6).

10. The applicant will carry out the environmental monitoring and study programs outlined in this Statement and in the Technical Specifications accompanying the operating license.

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I. INTRODUCTION

The Brunswick Steam Electric Plant of the Carolina Power and Light Company comprises two boiling water reactors which will generate 1,642 MW (net) of electric power.[a] The plant is located in Brunswick County, near Southport, North Carolina, near the mouth of the Cape Fear River (Figures I-1 and I-2). One reactor is scheduled for commercial operation in December 1974; the second, 1 year later. On October 1, 1973, Unit 1 was 50% completed; Unit 2 was 79% completed.

The applicant, by application dated July 26, 1968, and amendments thereto, applied to the U.S. Atomic Energy Commission for license to construct and operate two nuclear power plants in Brunswick County, North Carolina. The applicant submitted a Preliminary Safety Analysis Report (PSAR)[1] along with the application for license. The PSAR was reviewed by the staff and the Advisory Committee on Reactor Safeguards (ACRS). A staff safety evaluation, including the ACRS report and those of a number of other federal agencies attached as appendices, was issued on October 31, 1969. A public hearing before an Atomic Safety and Licensing Board was held in Southport on December 2 and 3, 1969. The Commission issued two provisional construction permits on February 7, 1970.[2] Site preparation for the plant commenced in late September, 1969. The applicant filed an environmental report for these units on November 4 1971,[3] and amendments on June 5, 1972,[4] August 14, 1972,[5] September 1, 1972,[6] September 25, 1972,[7] January 3, 1973,[18] January 29, 1973,[19] and July 9, 1973.[20] Other information has also been received.[21,22,23] On November 18, 1971, the AEC issued (a) Determination to Suspend Certain Construction Activities at the Brunswick Plant Pending Completion of NEPA Environmental Review;[8] (b) Order to Show Cause;[9] and (c) Discussion and Findings by the Division of Reactor Licensing.[10] On December 15, 1971, the applicant filed its answer to the AEC Order to Show Cause.[11] On February 10, 1972, the AEC issued an Order Designating Time and Place for Hearing on Its Determination to Suspend Certain Construction Activities at the Brunswick Plant.[12] The hearings were held on March 14, 17 and 24, 1972.[13] The Atomic Safety and Licensing Board's decision was published on April 24, 1972, ruling in favor of the applicant.[14] On May 30, 1972, the applicant submitted its Final Safety Analysis Report.[15] On Nov. 3, 1972, the AEC issued a Notice of Consideration of Hearing for operating licenses for the plant.[16]

This final detailed statement takes all of the foregoing writings into account and also uses information available in the applicant's PSAR[1] and amendments and FSAR.[15] The statement also takes into account discussions held with the applicant, the Federal Power Commission, The U.S. Geological Survey, the Corps of Engineers (North Carolina District Office at

(a) Initial operation.

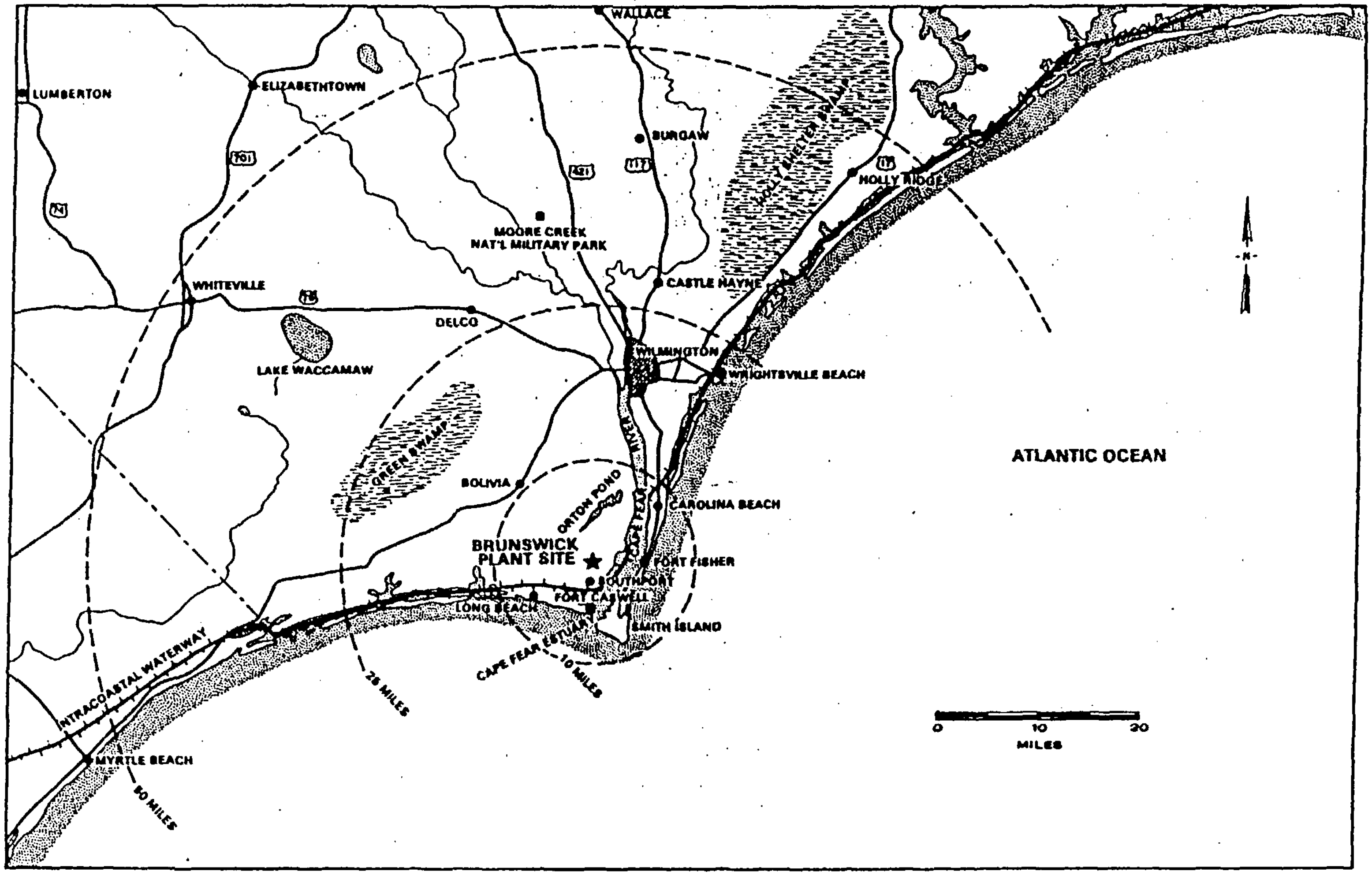


FIGURE I-1. BRUNSWICK PLANT, GENERAL SITE LOCATION

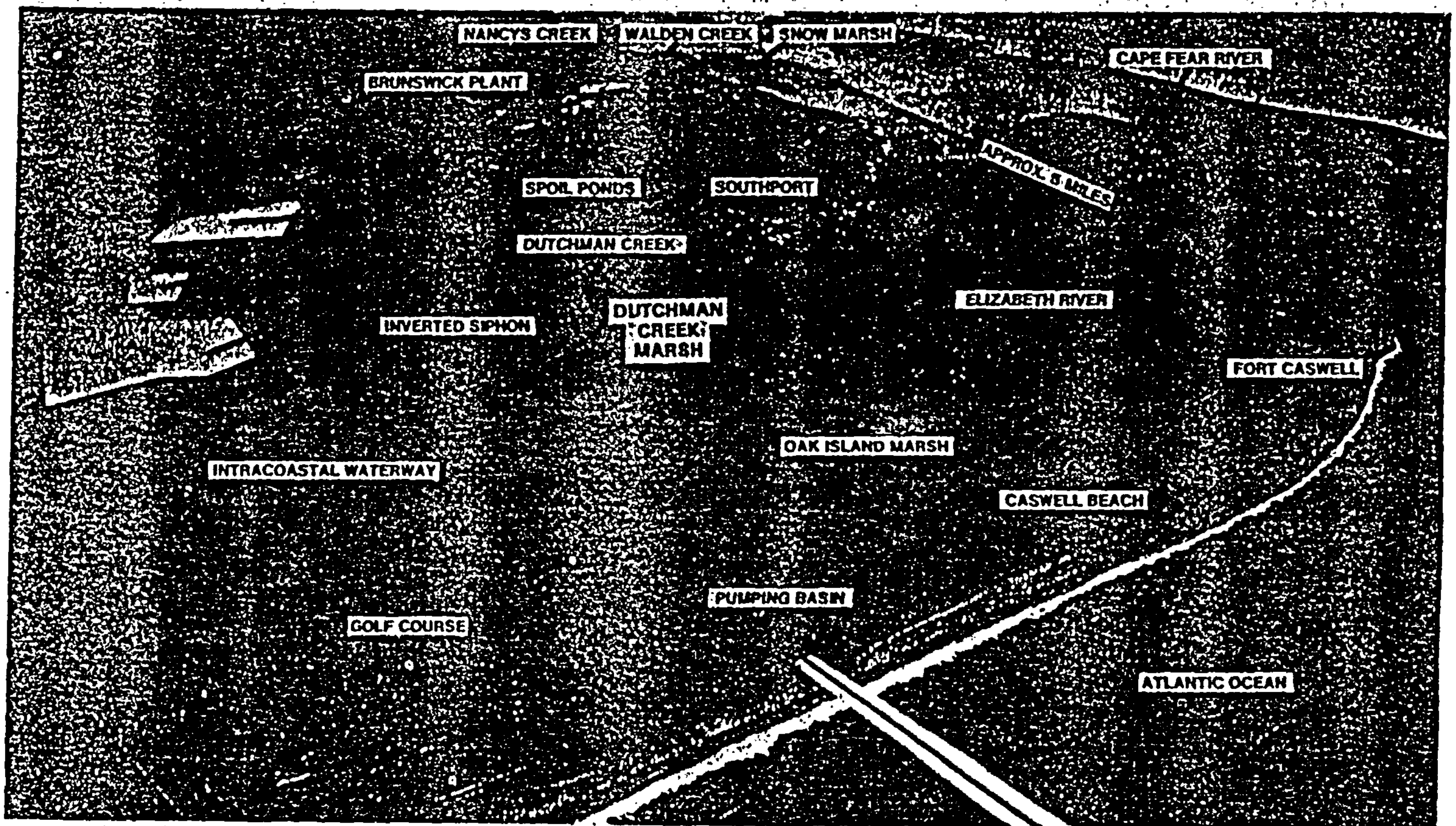


FIGURE I-2. BRUNSWICK PLANT, DETAILED SITE LOCATION

Wilmington, N.C.), the Department of Natural and Economic Resources of North Carolina, the North Carolina Utilities Commission, North Carolina State Planning Division, North Carolina State Board of Health, Conservation Council of North Carolina and the Resources Commission of Brunswick County and others. The foregoing material, together with information developed by the staff, serves as the information basis for the regulatory staff's calculations, appraisals and independent evaluations.

The Preliminary and Final Safety Analysis Reports with amendments, the report of the ACRS, the safety evaluation by the Commission's regulatory staff, the applicant's environmental report, supplements to the environmental report, the notice of consideration of hearing, and other pertinent documents are available for inspection by members of the public in the Commission's Public Document Room, 1717 H Street, N.W., Washington, D.C. 20545, and in the clearinghouse and Information Center, 116 West Jones Street, Raleigh, N.C. 27603.

As a part of its safety evaluation leading to the issuance of construction permits (and operating licenses) the Commission makes a detailed evaluation of the applicant's plans and facilities for minimizing and controlling the release of radioactive materials under both normal operating and potential accident conditions including the effects of natural phenomenon on the facility, of the adequacy of the applicant's effluent and environmental monitoring programs and of the potential radiation exposure that might be received by plant workers and members of the public. Inasmuch as these aspects are considered fully in other documents, only the salient features that bear directly on the anticipated dose to the public are repeated here. The comments that have been received from other federal and state agencies relative to radiological aspects are being taken into account by the staff in respect to overall safety evaluations and are not elaborated on here.

A. SITE SELECTION

Four sites were evaluated as possible locations for a major addition of nuclear units to the applicant's system.[3] The general location of the site to be selected was determined by considering load growth projections, locations of other plants, fuel costs and availability, and other factors.[17] The selection of nuclear fuel rather than fossil fuel was based on economic factors. Large hydroelectric sites or geothermed resources are not available in the applicant's service area. Two major factors influenced the final site selection: availability of sufficient water to permit once-through cooling for the plant (with adequate means of disposing of the heated water) and minimizing the number of people who would be disrupted by construction and operation of the plant. All four sites were sufficiently close to load centers and adequate transportation facilities.[3]

One site, an estuarine location on the lower Neuse River east of New Bern, North Carolina, was considered, but adequate means of disposing of the heated effluent posed problems (recirculation of condenser cooling water would result in excessive water temperatures in the estuary). A second site, a river location northwest of Wilmington, North Carolina, where two small fossil units are sited, did not have sufficient water during parts of the year for once-through cooling without exceeding temperature limits. A third site on a hydroelectric impoundment in central North Carolina, while apparently adequate from a cooling water availability standpoint, could have affected a considerably greater number of people who have summer cottages and permanent homes around the impoundment, than the Brunswick site. The applicant indicates that the third site may be used in future expansions of generating capacity. For reasons given in Section XI.A the staff did not pursue evaluation of this site.

The fourth site, the one selected for the plant is described in detail in Sections II and III-A; it is remote from population centers. Wilmington, North Carolina is the largest city within about 100 miles.

The Brunswick site was originally planned for once-through cooling by withdrawing from and discharging water to the Cape Fear Estuary. The intake and discharge canals were each to be of about 2 miles in length (Figure I-3). Further analysis of this plan (after construction of the plant had begun) showed that recirculation of cooling water could occur at certain times, resulting in discharge temperatures that would probably exceed future temperature limits for the estuary. Having committed to the site, the next best solution, by the applicant's analysis, was to extend the discharge canal an additional four or so miles to permit an ocean discharge. The site selected entails construction of about 358 miles of transmission lines.

B. APPLICATIONS AND APPROVALS

The Federal, State and local agencies from whom the applicant has secured, or must secure, licenses, permits and other approvals prior to facility operation include:

Federal

Atomic Energy Commission

1. Construction Permits (Issued February 7, 1970)
2. Operating Licenses

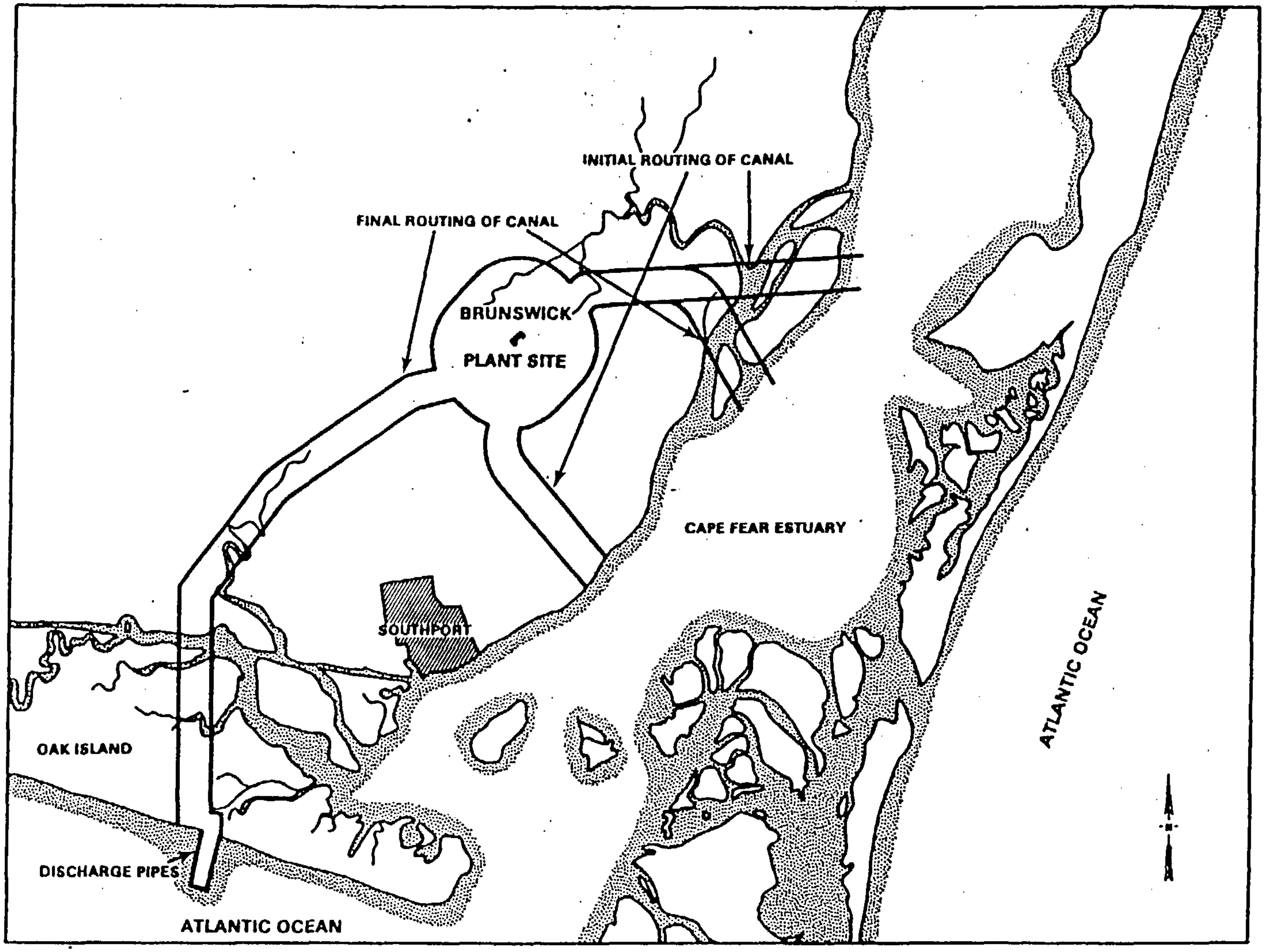


FIGURE I-3. BRUNSWICK PLANT, COOLING CANAL PLANS, INITIAL AND PRESENT

II. THE SITE

A. LOCATION OF THE PLANT

The plant is located approximately 135 miles SSE of Raleigh, North Carolina, 175 miles east of Columbia, South Carolina and 150 miles NE of Charleston, South Carolina. The plant is 16 miles south of the nearest boundary of Wilmington, North Carolina, in adjacent New Hanover County, and 2-1/2 miles north of Southport (Figure I-1). Approximate coordinates of the reactor buildings are latitude 32° 57.5' and longitude 78° 00.5'W. This places the reactor buildings about 6 miles from the Atlantic Ocean (both south and east of the plant) and about 2 miles west of the Cape Fear River.[1] (Figure I-2).

B. REGIONAL DEMOGRAPHY AND LAND USE

The plant is situated on the Atlantic Coastal Plain. It is in a region of low relief with elevations ranging from sea level to about 30 ft above mean sea level. Extensive areas of marshes and swamps occur in the region. The Green Swamp, an area of several hundred square miles, occupies a large part of Brunswick County.

A large estuary, the Cape Fear Estuary, is an important waterway in the region. The Atlantic Intracoastal Waterway ties into the estuary for a distance of several miles. Southport, the nearest town, is located 2-1/2 miles from the plant. The 1970 census count for Southport was 2220. Wilmington is the nearest city and has a population of about 50,000. Census data for the Wilmington Standard Metropolitan Statistical Area showed 107,219 in 1970, of which 24,223 were in Brunswick County and 82,996 in New Hanover County. There are no other large cities within 50 miles of the plant. However, Boiling Spring Lakes, a new development 7 miles NNW of the plant is anticipated to be a community of 18,000 by 1996. The 1970 census showed a population of 92.[1,2]

1. Recreational Land Use

The lower Cape Fear area in Brunswick and New Hanover counties is a popular recreational area. During the summer months the population of the beaches within 20 miles of the plant increases by about 10,000 people. Freshwater and ocean fishing are popular activities in the region. During the season, duck hunting takes place in the salt marshes. The waterways are used by fishing, motor and sailing boats.[2]

2. Agricultural Land Use

Land within a 50-mile radius of the plant is predominantly rural, except for the Southport and Wilmington areas. Less than half the land in this 50-mile radius is designated for farm use. The remainder is undeveloped.

Agricultural activity in Brunswick and surrounding counties is made up of corn, soybean, tobacco, poultry, truck and small dairy farms. In Brunswick County, where only 18% of the land area is under cultivation, most farming is in the southwestern section.[2]

3. Industrial Land Use

Industrial activity in the Cape Fear region is centered on the fertilizer, paper, chemical and synthetic fiber industries. Most of the industrial plants in the area are located north of Wilmington upstream on the Cape Fear River and the Northwest Cape Fear River. The Cape Fear has a 38-ft deep by 400-ft wide dredged ship channel that is used for ship traffic to the Port of Wilmington and these industrial plants. The Atlantic Intracoastal Waterway uses part of the Cape Fear River channel.

The closest major employer, Sunny Point Army Terminal which is located about 4 1/2 miles north of the plant, trans-ships munitions from trucks and railroad cars to ocean-going vessels. Approximately 290 employees are currently engaged full time at the terminal, augmented by up to several hundred longshoremen during loading operations depending on the number of ships being loaded.[2]

Major industrial activities in the Southport region may develop as a result of the availability of large amounts of electric power and other favorable industrial development aspects of the region. Some preliminary developments are underway. Pfizer Chemical Company has purchased 800 acres south of the plant on the Cape Fear River for a citric acid plant which will employ 300 initially.[3]

Industrial and commercial building in the plant vicinity will have an indeterminate, but probably negative, environmental impact on the surrounding area. These impacts would accrue from the reduction of biologically productive land, increased water use, and potential water pollution. The exact magnitude and type of effects would depend upon the size and type of new industry and is beyond the scope of this statement.

4. Committed Land Areas

The transmission lines for the plant interact with several committed land areas in the Cape Fear region and surrounding area. Included are:

1. Holly Shelter Wildlife Management Area - This 48,500-acre area in Pender County is mostly swampland with a small acreage which can be considered dry land throughout the year. The sand ridges rise a few feet above the level of the adjoining peat swamps, and provide good sites for pasture plantings, which are heavily used by deer. Still-hunting for deer has increased. The area is owned by the North Carolina Wildlife Resources Commission.

2. Orton Plantation Waterfowl Impoundment - This Waterfowl Impoundment is located about 10 miles north of the plant.

3. Brunswick Historic District - This area is located about 6 miles north of the plant. It is a rich archeological area dating from early colonial times.

The interaction of these three areas with the plant is described in Section IV.C.2.

C. HISTORICAL SIGNIFICANCE

The National Register of Historic Places[4] lists the following areas of historic significance in the vicinity of the plant (Figure II-1):

Bladen County

Carvors, Oakland Plantation, off State Route 1730
White Oak vicinity, Harmony Hall, west of White Oak on State Route 1351, near the Cape Fear River.

Brunswick County

Southport vicinity, Brunswick Historic District, bounded on the east by the Cape Fear River, on the South by County Road 1533, on the west by County Route 1529, and on the north by Orton Plantation; Orton vicinity, Orton Plantation, east of junction of State Routes 1529 and 1530, near the Cape Fear River.

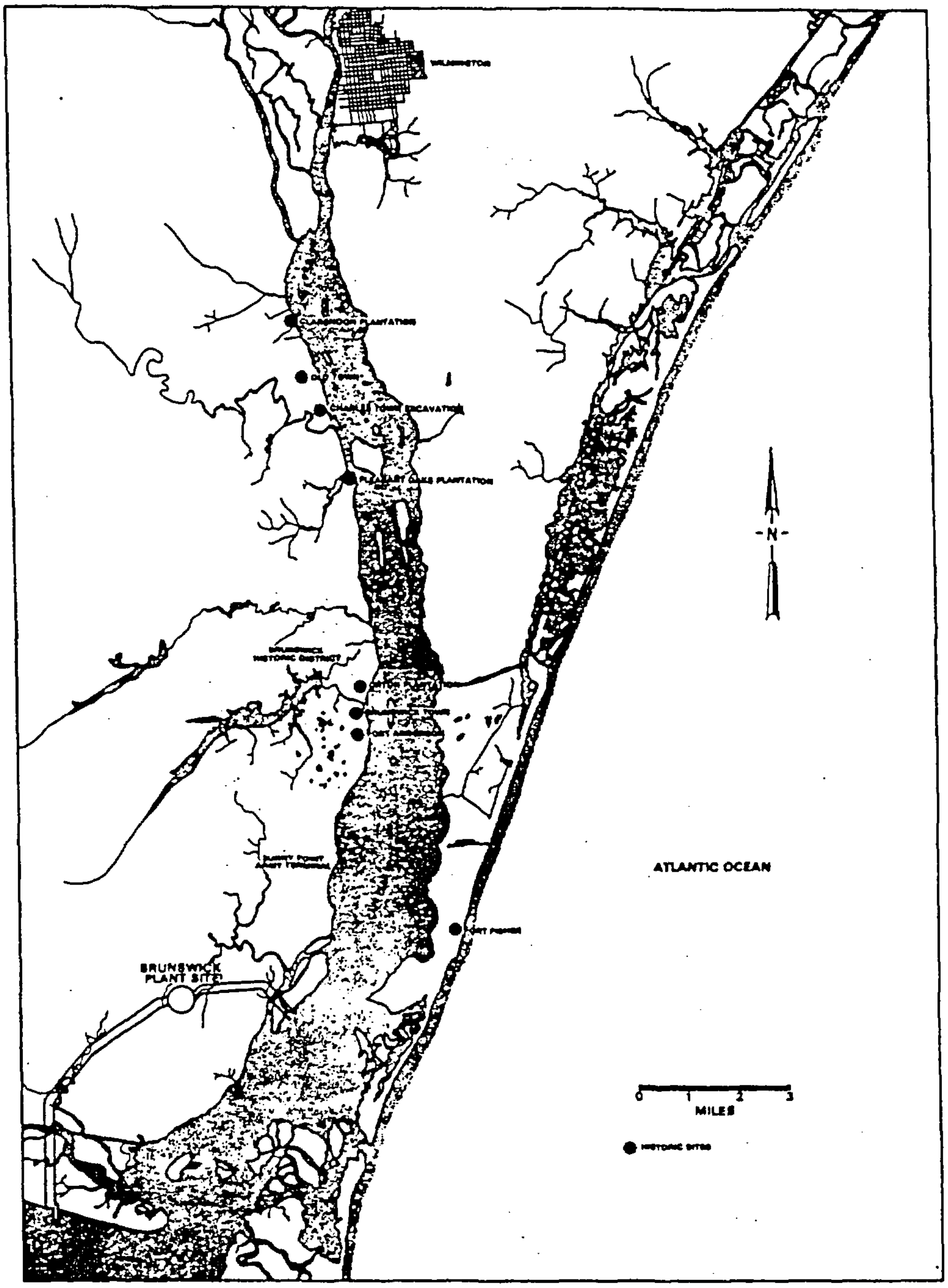


FIGURE II-1. AREAS OF HISTORIC SIGNFICANCE NEAR THE BRUNSWICK PLANT

New Hanover County

Wilmington, City Hall--Thalian Hall
Fort Fisher (18 miles south of Wilmington on U.S. 421)

Pender County

Moore's Creek National Military Park, 25 miles northwest of Wilmington on North Carolina 210.

There are no areas of historic significance listed for Columbus County.

The Brunswick Historic District is separated from the plant by the Sunny Point Army Terminal, a distance of about 6 miles. The District and surrounding environs extending northward to Clarendon Plantation is considered to be one especially rich in archeological materials. A number of potential sites, such as those located in the vicinity of Old Town Creek, have yet to be thoroughly investigated but may be among the earliest and richest sites, dating from the mid-1600's. Over 100,000 people per year visit the District and the number is increasing about 10% each year. Long-term plans are to develop additional sites along the west side of Cape Fear River. Activities are presently underway to plot ship wrecks (from the Civil War blockade era and earlier) in this area and the Fort Fisher area, adding further to the area's historic significance and value.

Fort Fisher is on the opposite side of the Cape Fear River from the Brunswick Plant (about 5 miles distance). During the period 1968-1970 about 300,000 people toured the visitors center. The interaction of the plant with these areas of historical significance is described later in Section IV.C.

D. ENVIRONMENTAL FEATURES

Potential major interactions between the plant and the environs occur at several points, primarily those related to: (a) impingement, entrainment and subsequent destruction of fin and shellfish fisheries in the plant cooling water system, (b) loss or modification of marshlands due to construction, lowering of perched water levels, changes in freshwater/saltwater regimens, and modification of erosion and siltation patterns, and (c) loss of fresh water from the Castle Hayne aquifer due to increased upwelling and/or to saltwater intrusion.

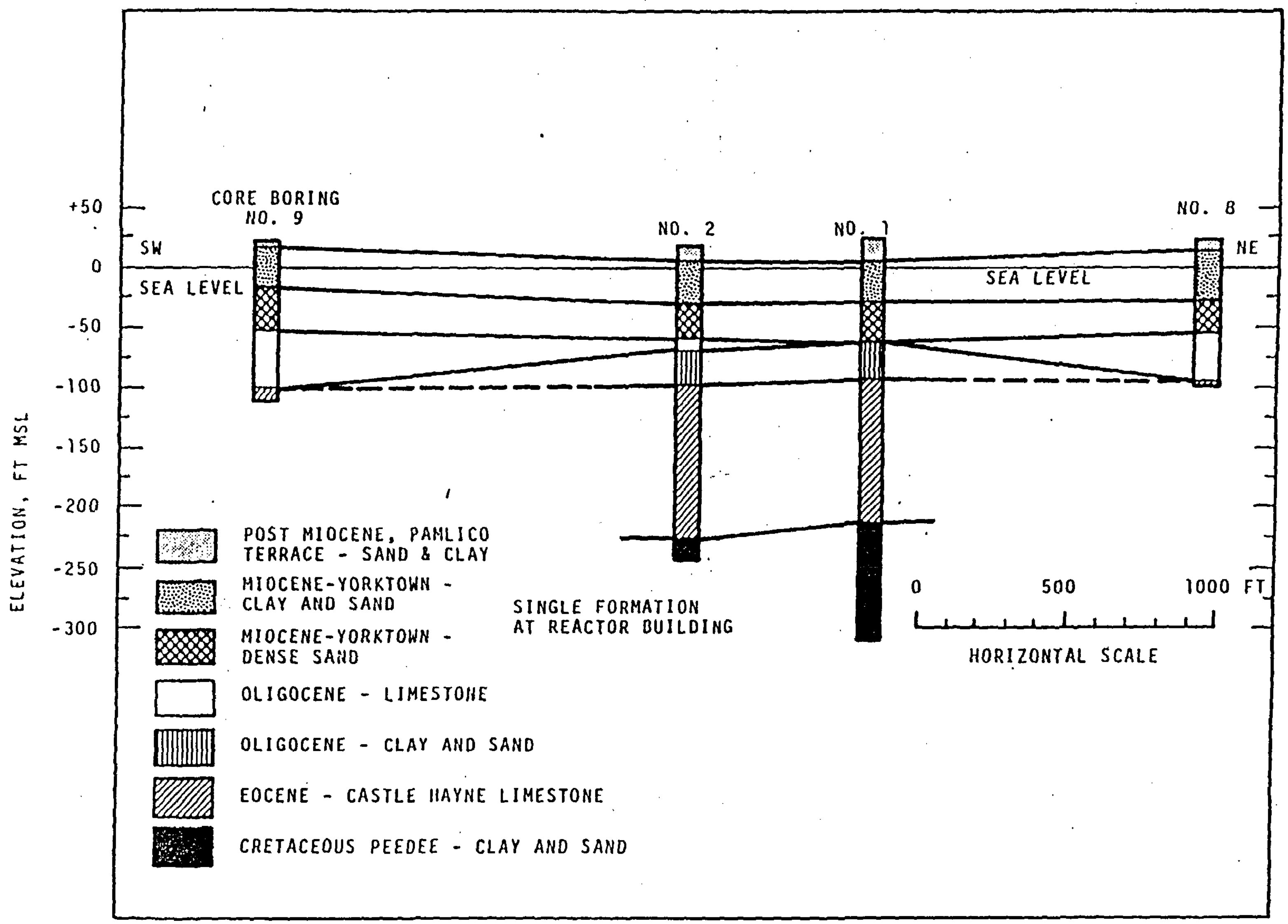


FIGURE II-2. GEOLOGIC CROSS SECTION AT BRUNSWICK SITE[2]

Cape Fear River is estimated by the Raleigh, North Carolina, District Office of the U.S. Geological Survey to range between 8100 and 10,000 cfs. The applicant used 30 years of Cape Fear River Stream-flow data from the Lock 3 gage, 17 years of stream-flow data from the gage on the Black River near Tomahawk, N.C., and the 3 years of Navassa tidal discharge data to estimate freshwater low-flow frequency curves for Navassa and freshwater, low-flow duration curves for Navassa and Southport. The latter curve indicates that the average daily freshwater discharge can be expected to exceed 1000 cfs at Southport more than 95% of the time.[1] Data on Cape Fear River temperatures are presented in Figure II-10.

Wells are used to obtain water for consumptive use throughout the Cape Fear region. A major exception is the City of Wilmington which obtains its water from the Cape Fear River. The water is withdrawn upstream from Lock and Dam No. 1, approximately 35 miles upstream from the plant and 23.5 miles north of the city. The Cape Fear River below the New Hanover County line is not potable because of tidal salinity influences.

Shallow wells in surficial deposits are used to obtain small potable water supplies, but for larger water yields the Castle Hayne limestone formation is the most important aquifer. Chemical analyses of Brunswick County groundwater indicate that the water is relatively hard and has a pH in range of 7.2 to 8.4.

The Castle Hayne aquifer provides the water supply to the Sunny Point Army Terminal and to the municipalities of Long Beach and Southport. Southport, which is the larger municipality, withdraws approximately 0.42 cfs (273,000 gal/day) from the Castle Hayne aquifer during the peak of the summer season and about 0.34 cfs (219,000 gal/day) on the average. In the Navassa area, industrial wells are in the surficial deposits. In New Hanover Country, wells for domestic use are in shallow sand, and wells for larger yields terminate in the Castle Hayne aquifer.

To determine the groundwater elevation and fluctuations at the plant, six temporary piezometers were installed. Results indicated that a perched water table (an isolated body of groundwater located above the normal water table) exists at the plant and that there are no appreciable changes in groundwater levels due to tidal fluctuations.[1]

As previously mentioned the recharge zone for the Castle Hayne aquifer is an outcrop area about 7 miles northwest of the plant. Since the dip of the aquifer is to the southeast toward the Cape Fear River and the Atlantic Ocean, the water infiltrating into the southern end of the outcrop area recharges the Castle Hayne aquifer in Brunswick County. The portion of the outcrop area that ultimately supplies water to Southport is approximately 5 by 15 miles in plan. A study by de Wiest, et al,[7] indicates that 15% of the precipitation percolates to the Castle Hayne aquifer. Therefore, the average annual groundwater recharge in Brunswick County is approximately 42 cfs. According to the applicant, the topography and local geology of the area suggest that, at present, about one third of the flow (14 cfs) remains in the Castle Hayne aquifer in the Southport region and is potentially available.[5] The rest of the groundwater recharge appears to upwell into the Cape Fear River, its tributaries and Long Bay (off Oak Island in the Atlantic Ocean). The staff estimates that in Brunswick County about 25 cfs of this resource is potentially available, but that at present, only about 15 cfs is practically available. These estimates are based upon limitations of present technology in determining the optimal locations of wells and upon the necessity of maintaining freshwater inflow by upwelling to the marsh areas of the local tidal creeks.

The applicant has presented piezometric data and a piezometric contour map (Figure II-3) for the Castle Hayne aquifer in the Southport-Brunswick vicinity. In general, the piezometric contours decrease in value towards the Cape Fear estuary and the Atlantic Ocean (Figure II-3). The Castle Hayne groundwater generally moves perpendicular to the piezometeic contours toward lower artesian pressure heads and converges on the two creek systems--Walden-Nancys Creek and Dutchman Creek.[5]

The rapid convergence of contours near the headwaters of Nancys Creek and the landward translation of piezometric contours in this vicinity suggest that significant upwelling is occurring. The applicant's subsurface investigations, including core borings, indicate that in this region the Oligocene clay layer does not exist and that the Castle Hayne water moves upward through the Yorktown formation and on through the Pamlico Terrace deposits that dissipate in the low-lying areas near Nancys Creek.[5]

The piezometric contours of Figure II-3 also suggest that upwelling is occurring from the Castle Hayne aquifer to Dutchman Creek. However, it appears to be less pronounced that in Nancys Creek. The applicant's subsurface investigations indicate that the Oligocene clay layer is missing over approximately 6000 ft of the discharge canal route north of the Intracoastal Waterway. Thus, the condition for upwelling exists.[5]

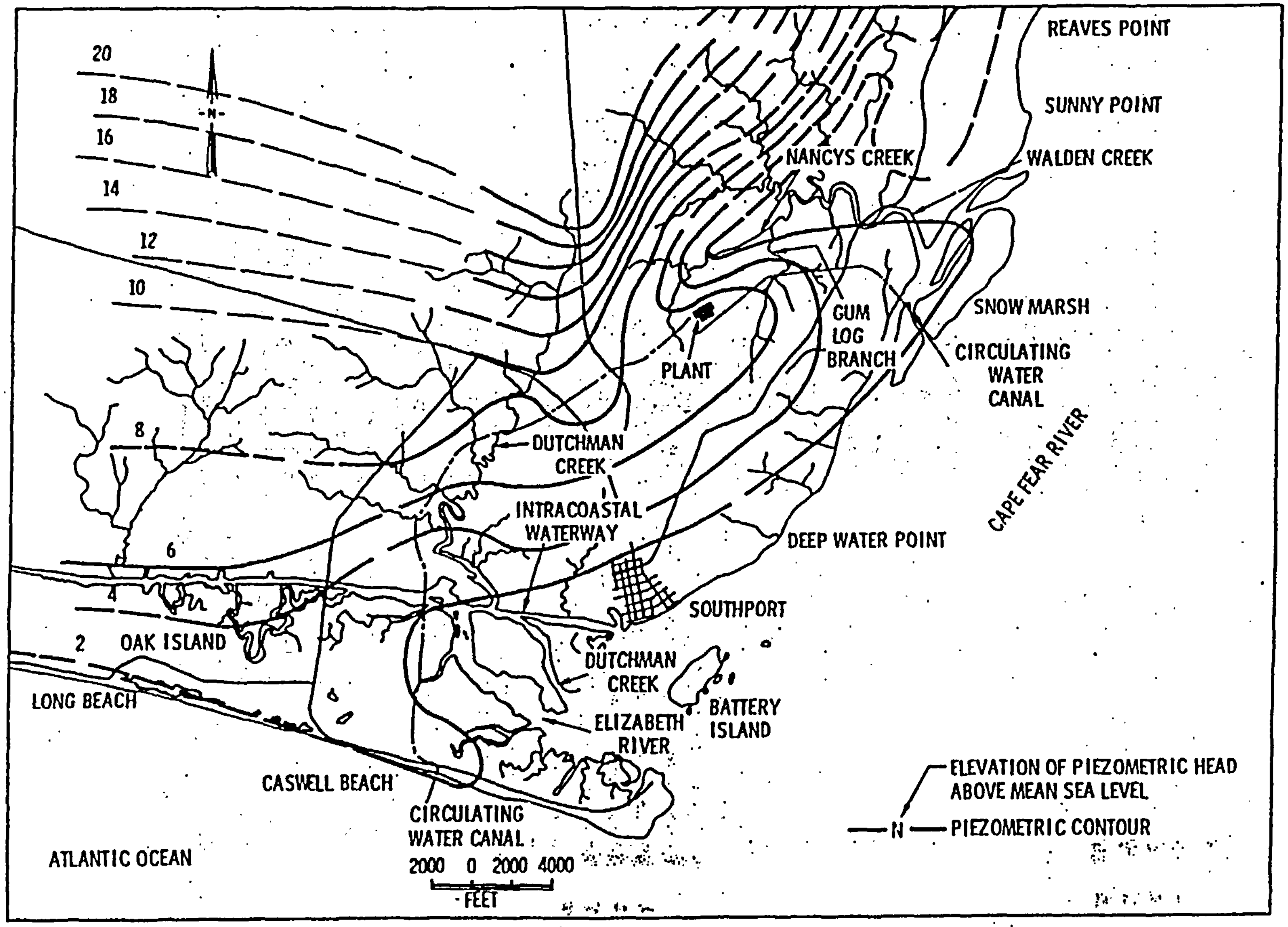


FIGURE II-3. EXISTING PIEZOMETRIC CONTOURS FOR THE CASTLE HAYNE AQUIFER[5]

Apparently, no upwelling occurs in the zone between the Walden-Nancys and Dutchman Creek systems. This is indicated by the shape of the piezometric contours in this region, and by the applicant's subsurface investigations which indicate that there is a thick, continuous silty clay layer of Miocene Age that overlays the Oligocene limestone. The applicant believes that the non-upwelling zone between the Walden-Nancys and Dutchman Creek systems is apparently the zone that transmits Castle Hayne groundwater to the town of Southport.[5] The staff believes that this may be true in part, but that Castle Hayne groundwater may also reach Southport from other directions.

The artesian pressure head found in the Castle Hayne and Yorktown formations were essentially the same, based on piezometric data at the plant and along the canal route. This fact indicates that a hydraulic link probably exists between the two formations throughout the area. Apparently, very little exchange of water occurs naturally between the overlying Pamlico Terrace formation and the Yorktown formation. In other words, the Pamlico Terrace formation serves to confine the Yorktown water to the extent that upwelling from the Castle Hayne occurs only through the Oligocene formation.[5] A series of in situ permeability tests were performed by the applicant in the sediments overlying the Peedee formation within the exclusion area near the reactor buildings during 1968 and 1969. Tests were performed with fresh water and salt water (37,000 ppm total dissolved solids) at ambient temperatures and with salt water heated to 102°F (39°C) (to simulate plant operating conditions). Only slight variations in permeability among the three fluid types resulted.[5]

The applicant has also initiated a water-quality investigation at the plant and along the canal routes to establish the quality of surficial waters and groundwater. Groundwater samples were obtained from piezometers and/or standpipes that terminate in the Yorktown and Castle Hayne formations and from the discharge pipes of the dewatering system for the reactor building excavation. For the 21 reported groundwater samples that were obtained from 13 piezometers located in the Castle Hayne aquifer, total dissolved solids ranged from 100-7365 ppm, and chloride content ranged from 25-4000 ppm. Chloride contents higher than the current federal standard for potable water, 250 ppm,[3] were reported in six of the groundwater samples extracted from four of the piezometers. These same six samples also contained the six highest values, ranging from 740-7365 ppm, reported for total dissolved solids.[5]

The highest chloride content, 4000 ppm, was obtained from a piezometer location in Snow Marsh; the second highest value, 1800 ppm, was obtained closeby from a piezometer location in the marsh at the mouth of Walden Creek. A chloride content of 1400 ppm was extracted from a piezometer location on Oak Island in the marsh east of the discharge canal and south of the Elizabeth River. Chloride content and total dissolved solids data obtained from these three piezometers locations also varied with tidal fluctuations. The other piezometer location that yielded a sample with high chloride content, 316 ppm, is located near the point where the intake canal crosses Gum Log Branch, a tributary to Nancys Creek.[5]

The remaining 15 groundwater samples, with the exception of two that were taken from a piezometer location on high ground near Caswell Beach on Oak Island, were all extracted from piezometers located on the mainland along the cooling canal from about 3/4 mile west of the mouth of Walden Creek to about 1 mile north of the Intracostal Waterway. All of these 15 samples were low in both chloride and total dissolved solids.[5] The results of this investigation indicate that the Castle Hayne aquifer has been intruded by salt water from the estuary and Atlantic Ocean in the vicinities of Snow Marsh and Oak Island east of the discharge canal.

b. Estuary Waters

Strong semidiurnal tides with a range of about 4 ft characterize the lower section of the Cape Fear River near the plant. Just upstream from the plant intake canal, measured annual salinity ranges were from 1,720 to 32,250 ppm.[2] Collected data (Figure II-4) indicate some evidence of stratification of salinity. Only infrequently does bottom salinity in the plant vicinity fall below half-strength seawater.

The data suggest that the seaward drift in the upper layers, which is maintained by a tidally driven upstream drift in the lower layers (salt-wedge movement) and vertical mixing, is much greater than the drift that would occur if only freshwater were moving seaward in the upper layer.

For the Cape Fear River near Southport, the salinity data obtained to date by the North Carolina Department of Air and Water Resources, the U.S. Geological Survey, and the applicant, indicate that the upper-layer flow is approximately 15 times the freshwater input during dry periods.[2] Thus, under a low-flow condition of 1000 cfs freshwater input which occurs 5% of the time, see section II.D.2.a., there would be an upper-layer flow of approximately 15,000 cfs. During such a low-flow condition and because of the shallow nature of the applicant's intake canal (18 ft deep), approximately 20% of the upper-layer, less saline (Figure II-4) estuarine flow could be diverted through the canal system.

The U.S. Army Corps of Engineers has estimated that the average total tidal flow rate at the mouth of the Cape Fear River is approximately 200,000 cfs during an ebb tide.[1] At the plant intake canal, it has been estimated that the entire flow in the estuary is not much greater than 60,000 cfs under minimum freshwater flow conditions.[5] The total prism area of the Cape Fear River, from Cape Fear to Wilmington, is about 25 miles long and has an average width of about 1.7 miles at mean tide. Under normal conditions, 3 hours is required for the crest to move from Cape Fear to Wilmington. Local winds and freshwater flow will affect these estimates.[1]

The Cape Fear River is characteristically a sediment-laden stream. This can be attributed to heavy rainfall in concert with erodible soils. This characteristic, combined with tidal currents in the estuary, requires the U.S. Corps of Engineers to dredge annually in the Cape Fear River ship channel to keep it open to navigation.

In a tidewater area, abnormal water levels can be produced by several factors during passage of a storm. These factors include hurricane winds, reduction in central pressure, accumulation of water at the coast from breaking waves, and storm rainfall. A negative surge can be encountered if storm winds blow offshore for a sufficient length of time.

The applicant postulates[1] and the staff concurs[9] that the probable maximum flood at the plant site would be caused by a hurricane having parameters that tend to maximize the storm tide in the plant area. If such a storm occurred on an exact path and with forward speed for maximum surge generation coincident with peak high astronomical tide at the plant site, the effect would be the probable maximum flood at the plant. Such a flood would include a stillwater flood (storm surge) level 2-1/2 ft above plant grade (20 ft MSL).[9]

Equally as important to the plant is a hurricane of equal magnitude and with a fetch oriented such that it produces a short-term, extremely low water level in the Cape Fear River. In this case, low astronomical tide is assumed in combination with other worst conditions. Based on staff calculation this combination of events would result in an extreme low tide elevation of -7.5 ft MSL.[9]

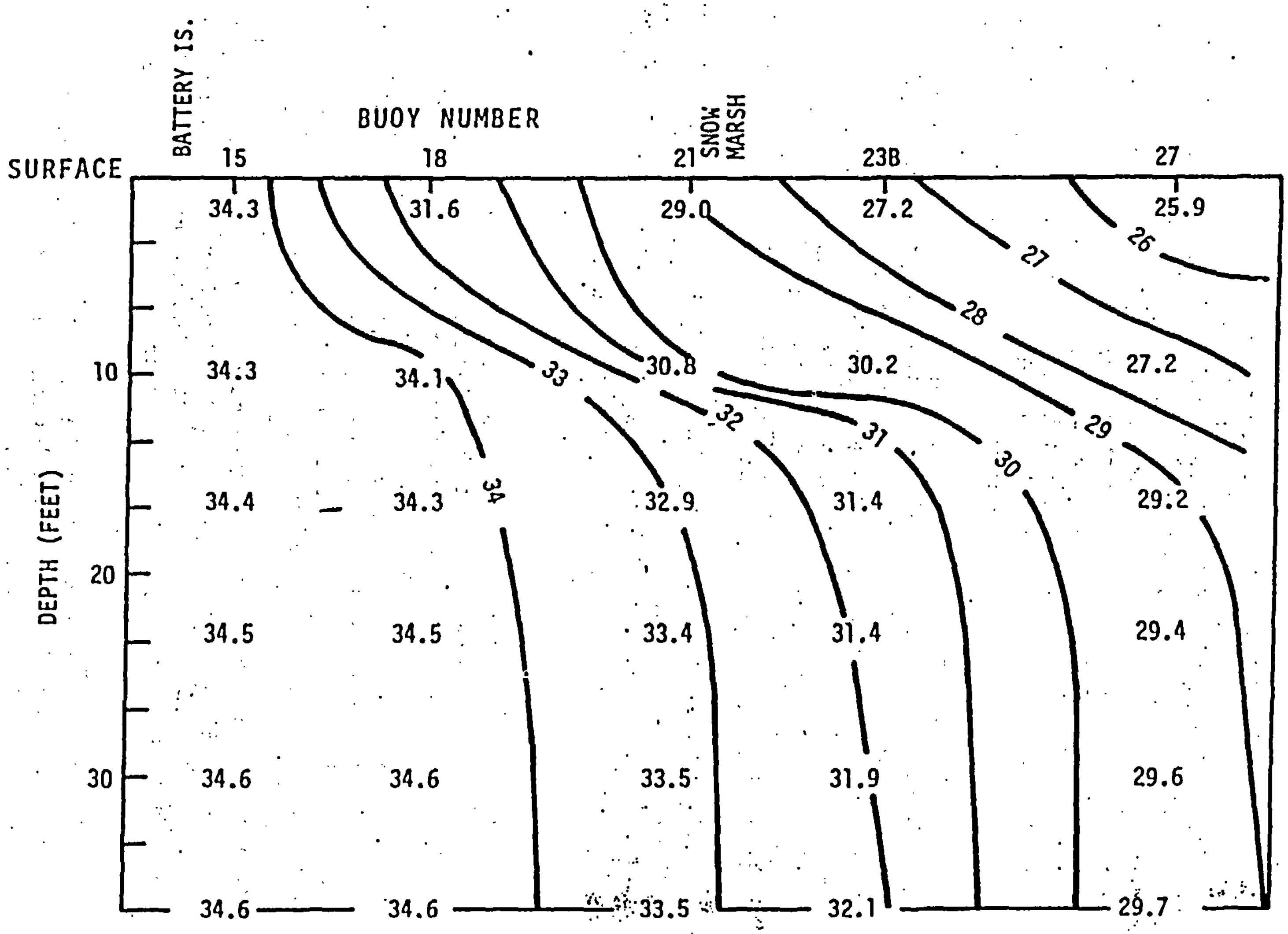


FIGURE II-4. OBSERVED SALINITY DISTRIBUTION (ppt), CAPE FEAR ESTUARY CHANNEL[8] (August 25, 1968, end of flood tide; See figure II-5 for approximate buoy locations)

c. Ocean Waters

During the spring of the year, ocean surface water temperatures at Cape Fear range from 64 to 80°F (17.8 to 26.7°C) with a mean temperature of 74°F (23.4°C). In the summer, the most commonly encountered surface water temperatures range from 75 to 85°F (23.9 to 29.5°C) with a mean of 81°F (27.3°C). Autumn water surface temperatures range from 64 to 79°F (17.8 to 26.2°C) with a mean of 70°F (21.2°C), and winter water surface temperatures range from 52 to 72°F (11.1 to 22.2°C) with a mean of 62°F (16.7°C). Mean salinity tends to vary in a seasonal manner. Concentrations are 34,000 ppm, 35,500 ppm, 35,500 ppm, and 34,500 ppm in the spring, summer, autumn and winter, respectively.[10]

The applicant conducted field studies in the outfall area of the ocean to obtain data that would enable evaluation of the effects of the plant's thermal release. One of the parameters studied was the natural drift of the ocean water. Free drifting drogues were used to measure the drift velocities which were 0.63 fps to the southwest (230 degrees true) during ebbtide and 0.73 fps to the west-northwest (305 degrees true) during flood tide. A moderate wind from the southwest of 4-6 knots was blowing at the time the measurements were taken.[8]

Large quantities of water are involved in the drift past the ocean-outfall discharge point. The mean depth in the first mile offshore is approximately 10 ft and the average drift speed is about 0.7 fps. Thus, the rate of flow through such a section would be 37,000 cfs.

3. Meteorology[(a)]

The climate of Brunswick County is strongly influenced by the adjoining Atlantic Ocean, which tends to moderate extremes of both high and low temperature. For example, Southport's average winter weather is warmer than that of most weather stations in South Carolina, and of about half of those in Georgia, Alabama and Mississippi. Yet midsummer temperatures at Southport average lower than at most places in the states bordering on the Gulf coast. The range of temperature from summer to winter and from day to night averages much smaller than that of interior points in the Carolinas and other eastern states. The temperature in summer reaches 90 degrees only one-third to one-fourth as often as at typical inland stations, while in winter the number of occurrences of freezing weather is less than half that of weather stations in interior North Carolina. In more than a century of weather observations, there is no record of

(a) Most of the information in this section has been taken directly from U.S. Weather Bureau Climatological Summaries and the applicant's analysis of the bureau data.

the temperature ever having dropped to zero °F at Southport. Table II-1 shows the monthly variation of the mean temperature, mean daily maximum and mean daily minimum temperatures. The highest and lowest temperatures recorded were 103 and 10°F.

Precipitation, on the average, is abundant in Brunswick County, and is very well distributed throughout the seasons of the year. Winter rains are usually associated with large moving low pressure systems which affect the interior and coast to about the same degree; these systems give a wide distribution of precipitation, often quite uniform from place to place over a large area. Hence, winter rains at Southport, as in most other parts of North Carolina, average a little over 3 in./month. Summer rainfall quite often results from afternoon and evening thundershowers. When heavy rain occurs in autumn it may be caused by offshore tropical storms or hurricanes. Such storms usually are accompanied by windy weather and rough seas.

Practically all the precipitation falls as rain. Although snow may be seen at some time during the winter in about half the years, measurable amounts occur in only about one winter out of five. Sleet is even less common and hail is very rare. Monthly mean and extreme precipitation amounts are shown in the preceeding tabulation. The mean number of days that thunderstorms have been reported at Wilmington, N.C. are also shown in Table II-1.

Prevailing winds at Southport blow from a northeasterly direction in the fall and from a southwesterly direction at other seasons of the year. Winds are from one of these opposing directions a majority of the time, but may blow from any direction at any season. Winds quite commonly shift directions several times during a day. In fair, quiet weather the direction of the wind may be influenced by land and sea breeze effects. The average speed of the wind is about 10 mph, with the highest speeds normally occurring around midday and early afternoon, and the lowest at night. Winds exceed 25 mph only about 1% of the time, and the highest wind recorded in an average year is between 40 and 50 mph. Gusts higher than this may occur, either in connection with an unusually severe thunderstorm or with a tropical disturbance. The highest wind for Southport reported by the weather bureau was 88 mph in 1958. Tornadoes are not common to the area, although a waterspout is occasionally seen from the shore. The mean recurrence interval for a tornado hitting the plant site is once every 2200 years. Historically, 1.1 tropical storms and hurricanes pass within 100 miles of the plant site each year.[2]

TABLE II-1

CLIMATOLOGICAL SUMMARY OF SOUTHPORT AND BRUNSWICK COUNTY(a)

	Mean Temperatures			Precipitation Totals (in.)					Thunderstorms(b)
	Daily		Monthly			Snow, Sleet			Mean No. of
	Max	Min		Mean	Greatest Daily	Mean	Max Monthly	Greatest Daily	Days
Jan.	56.1	39.3	47.7	3.31	2.50	0.2	5.4	5.4	-
Feb.	57.4	40.3	48.9	3.59	4.28	0.2	2.5	2.5	1
Mar.	63.0	45.9	54.5	3.97	4.00	0.1	2.0	2.0	2
Apr.	70.9	54.0	62.5	2.73	3.87				3
May	78.1	63.3	70.7	3.05	3.08				5
June	84.0	71.0	77.5	4.19	7.85				7
July	85.9	73.8	79.9	7.03	5.73				11
Aug.	86.0	73.1	79.6	5.75	4.20				9
Sep.	82.5	68.2	75.4	7.16	11.00				3
Oct.	74.5	57.7	66.1	3.49	5.70				1
Nov.	65.7	48.0	56.9	3.04	5.70	T	T	T	1
Dec.	56.8	40.3	48.6	3.54	3.40	0.2	4.0	4.0	-
Year	71.8	56.2	64.0	50.85	11.00	0.7	5.4	5.4	43

(a) From climatological summaries of U.S. Weather Bureau
(b) Wilmington, North Carolina

The inspection of the applicant's meteorological records show that one year of continuous data with 90% recovery (as suggested in Safety Guide 23[12]) are not available. Hence, a composite year of data was assembled for the 350-ft and 44-ft levels based on data taken for a period of 2 years and 4 months.[11] These data were used for the dose calculations reported in Section V. At the 350 foot level neutral conditions occurring 35% and stable conditions 50% of the time with average wind speeds of 14 and 12 mph, respectively.

Brunswick County is normally a sunny area. The sun shines more than half the daylight hours in winter, and nearly two-thirds in late spring and early summer. Even in cloudy weather, it is rare for a whole day to pass without some sunshine. At Wilmington the average annual number of clear, partly cloudy and cloudy days is 117, 113 and 135, respectively, and the number of days during which heavy fog occurs is 22. Relative humidities at Wilmington average about 73% with maximum humidities occurring at night and the minimums during the afternoons. The highest average 1 a.m. humidity was 90% during August and the lowest average 1 p.m. humidity was 49% observed in both April and November.

E. PHYSICAL AND BIOLOGICAL FEATURES

1. Aquatic

Unlike most North Carolina estuaries, which are the bar-built type, the Cape Fear Estuary opens directly into the ocean. For descriptive purposes, the Lower Cape Fear ecosystem can be divided into three subsystems: salt marshes, including tidal streams which intersect the marshes, the region of open water encompassing the Cape Fear River channel, and the oceanic waters off Oak Island.

a. Salt Marshes

There are three major marsh systems adjacent to the plant: Snow Marsh, Dutchman Creek Marsh and the Oak Island Marsh. Data on these marsh systems are given in Table II-2, including marsh areas, areas affected by plant construction and vegetation types in the marshes. This table is discussed in detail in Section IV.C.

TABLE II-2

SUMMARY OF LAND USE AND IMPACT AREAS FOR PLANT

APPROXIMATE LAND USE AREAS

EXCLUSION AREA	962 ACRES
COOLING CANAL RIGHT-OF-WAY[a]	1380 ACRES
SPOIL PONDS WITHIN RIGHT-OF-WAY OR EXCLUSION AREA	353 ACRES IF ALL SPOIL PONDS USED, 222 PRESENTLY USED
SPOIL PONDS NOT WITHIN CANAL RIGHT-OF-WAY OR EXCLUSION AREA	571 ACRES IF ALL SPOIL PONDS USED; 470 PRESENTLY USED
TRANSMISSION CORRIDORS	3500 ACRES

APPROXIMATE LAND IMPACT AREAS

	OAK ISLAND[b] MARSH	DUTCHMAN[c] CREEK MARSH	SNOW[d] MARSH
TOTAL AREA	2253	1119	1653
AREA DESTROYED IN CONSTRUCTION[e]	42	39	36
INFLUENCED BY WATER INTAKE[f]	----	----	1617
AREA INFLUENCED BY CHANGES IN HYDROLOGICAL FLOW PATTERNS[g]	541	526	----
AREA INFLUENCED BY LOWERED PIEZOMETERIC LEVELS[h]	238	220	----
AREA INFLUENCED BY CHANGE IN FRESHWATER AND NUTRIENT FLOW[i]	280	259	----
VEGETATION TYPES: SPARTINA	~80%		~99%
VEGETATION TYPES: JUNCUS	~12%	~99%	
VEGETATION TYPES: MIXED	~ 8%		

[a] OBTAINED BY MULTIPLYING RIGHT-OF-WAY BY THE LENGTH OF THE CANAL OUTSIDE OF THE EXCLUSION AREA.

[b] INCLUDES ALL AREA ON BOTH SIDES OF INTRACOASTAL WATERWAY INCLUDING THE MARSH AREA IN BEAVERDAM CREEK.

[c] INCLUDES ISLANDS ON BOTH SIDES OF DUTCHMAN CREEK ON SOUTH SIDE OF INTRACOASTAL WATERWAY.

[d] INCLUDES ALL MARSH AREA ON MAINLAND THAT IS TRIBUTARY TO WALDEN CREEK.

[e] ASSUMED TO BE 350 FT WIDE IN THE MARSH AREAS ON OAK ISLAND AND DUTCHMAN CREEK. ASSUMED TO BE THE CANAL WIDTH, 330 FT, AND LENGTH FROM HIGH GROUND ON MAINLAND TO OUTER EDGE OF SNOW MARSH.

[f] ASSUMED TO BE EQUAL TO THE TOTAL OF SNOW MARSH LESS THAT PART OF SNOW MARSH DESTROYED BY THE CANAL.

[g] ASSUMED TO BE MARSH AREA IN DUTCHMAN CREEK DRAINAGE ON THE MAINLAND AND THE MARSH AREA ON OAK ISLAND BETWEEN HIGHWAY 133 AND THE MOLASSES CREEK DRAINAGE, BOTH EXCLUSIVE OF AREA DESTROYED IN CANAL CONSTRUCTION. AREAS INFLUENCED BY LOWERED PIEZOMETRIC LEVELS AND BY CHANGE IN FRESHWATER AND NUTRIENT FLOW, LISTED IN THIS TABLE, ARE CONSIDERED PART OF THIS AREA.

[h] ASSUMED TO BE ADDITIONAL 1000 FT ON BOTH SIDES OF AREA DESTROYED BY CANAL AND DRAINAGE CHANNEL ISLAND AND DUTCHMAN CREEK BASED ON STAFF'S GROUNDWATER STUDY.

[i] ASSUMED TO BE EQUAL TO THE TOTAL OF (e) AND (f), i.e., AN ACRE AFFECTED DUE TO (e) AND (f) HAS AN EQUIVALENT INFLUENCE ON OTHER MARSHLAND DUE TO DEPRIVATION OF FRESH WATER AND NUTRIENT FLOWS.

Snow Marsh is bisected by the intake canal. Part of the marsh consists of cord grass (Spartina alterniflora) covered islands separated from the mainland by a channel which receives the discharge from Walden Creek, Figure I-2. Dutchman Creek Marsh is located north of the intercoastal waterway. The discharge canal crosses the western edge of the marsh including four tributaries to Dutchman Creek. The Oak Island Marsh is bordered by North Carolina Highway 133 on its western edge and the intracoastal waterway on its northern edge. The discharge canal crosses this marsh east of the Oak Island golf course.

The salt marshes, especially those consisting of Spartina alterniflora, are a dominating feature of Lower Cape Fear Estuary. To a large degree, the fertility of the Cape Fear Estuary is maintained by a net nutrient flow, primarily in the form of organic derivative from Spartina marshes. Nutrients produced by the bacterial decomposition of Spartina are released to the estuary by the flushing action of tidal waters which regularly flood the Spartina marshes.

In their role as sediment traps and reservoirs for nutrients, the marshes provide a productive and protective habitat for the developing larvae of many valuable fish and shellfish. Shrimp, blue crabs, spot and croaker are found in abundance within the marsh systems. Definitive descriptions of the marsh systems follow in Section II.F.1.

b. River Channel

The main body of water within the Cape Fear Estuary exhibits salinity stratification which indicates the estuary is of the partially mixed type. Phytoplankton and zooplankton are abundant and the annual cycle of abundance and species composition generally resembles that of other east coast estuaries. Commensurate with the concept of estuaries being nursery grounds, larval fish are found in the estuary during the entire year. Another feature common to Cape Fear and other east coast estuaries is the annual migration of clupeids through the estuary to their spawning grounds.

c. Offshore Region

A part of the offshore region adjacent to Caswell Beach comes under the influence of the discharge plume from the estuary. As described in more detail in Section II.F.1, this influence is reflected in the sediment types and the diversity of benthic organisms. Typically, the productivity of the offshore region is lower than that of the estuary.

Benthic communities in the vicinity of the discharge point have been investigated and these data are discussed in Section II.F.1. The offshore region supports extensive stocks of menhaden which are caught by purse seine and processed for fish meal. In addition, a beach seine fishery for spot is located on Caswell Beach in the vicinity of the discharge pipes. Larval spot, croaker and shrimp migrate through the offshore region in the vicinity of the discharge before entering their estuarine nursery grounds.

Species composition and abundance of plankton in the immediate offshore region generally parallels that of the estuary. Seasonal cycles of peak abundance, however, seem to occur earlier than similar peaks within the estuary.

2. Terrestrial

The terrestrial ecosystems in which the plant is located form a portion of the Atlantic Coastal Plain. The elevations range from sea level to about 20 ft at the reactor site. The landscape (Figure I-2) is undistinguished by notable topographic features. The topography consists of waterways, such as the Cape Fear River, Dutchman Creek, and Nancys Creek, saline and brackish marshes such as Snow Marsh, Dutchman Creek and Oak Island Marsh, coastal dunes, and uplands.

The favorable climatic conditions (described in Section II.D.3) result in a highly productive set of ecosystem types despite soil related limitations in some cases. Salt marshes, swamps, pocosins, ocean-dominated communities, and upland forests are scattered throughout the region. Salinity, sedimentation, degree of waterlogging, and topographic features are the major environmental features other than fire, which mold the vegetation.

a. Marshes

Saltwater marshes dominated by Spartina alterniflora occur in the lowest lands. These marshes, like others south of Cape Lookout, experience strong tidal influences. A detailed description of marsh vegetation follows in Section II.F.1.

b. Uplands

The regional vegetation is described by Odum[13] as a Pine "subclimax" maintained by virtue of poor, sandy soil and repeated disturbances by fire. In the absence of fires, a warm temperate deciduous forest will develop where drainage permits. These forests are characterized by various mixtures of deciduous oaks, maples, hickories, sweet gum, and similar species with both temperate and subtropical affinities. Kuchler[14] records the regional vegetation as "oak-pine."

F. ECOLOGY OF SITE AND ENVIRONS

1. Aquatic

The applicant's environmental studies provide the largest current source of published information on the biology of the Lower Cape Fear Estuary. These investigations conducted by Hobbie[15] and Copeland and Birkhead[16,30,42] provide the basis for a qualitative description of the Lower Cape Fear ecosystem. The research program now being conducted by the applicant has been expanded to include a larger area of the Cape Fear estuary and adjacent salt marshes and to provide a quantitative base of biological information. The State of North Carolina and the U.S. Corps of Engineers have initiated a biological survey of the Cape Fear Estuary but data are not yet available.

Hobbie[15] and Copeland and Birkhead[16,30,42] have monitored some physical characteristics of the Lower Cape Fear Estuary, including salinity, dissolved oxygen and temperature at various stations (Figure II-5). Salinity isohalines for Stations 23A; 19, 18, 15, O.I. (Oak Island) and Ocean are presented in Figures II-6 to II-9. Salinity data for Stations 1-14 are presented in Table II-3. The yearly temperature cycles for Station 23A and ocean are presented in Figure II-10. Percent saturation of dissolved oxygen for Stations 1-14 is presented in Table II-4.

The major emphasis in this section is directed toward species of commercial importance. The staff recognizes the presence of many noncommercial species and the importance of those organisms to the total economy of the ecosystem. By limiting the scope of this report to emphasize those organisms of commercial or recreational importance, the staff does not imply that a lesser value should be placed on noncommercial organisms. The staff believes that this point of view may be the only practical means of evaluating a complex ecosystem such as the Cape Fear estuary. In any event, in absence of data on noncommercial species, the staff believes that the impact on commercial species will serve as a useful index of impact on noncommercial species.

a. Salt Marshes

In terms of their monetary value, the most important inhabitants of the salt marshes are the three commercial shrimp species; brown shrimp, Penaeus aztecus, pink shrimp, Penaeus duorarum, and the white shrimp, Penaeus setiferus. The average annual landed value of the commercial shrimp catch in Brunswick County was about $300,000 during the period 1965-1970[17] (Appendix A).

TABLE II-3

SALINITY DATA FOR LOWER CAPE FEAR ESTUARY
(Salinity, ppt, for Stations 1-14 During 1971)[16]

Station	June 15	June 16	June 17	Aug 10	Aug 11	Aug 12	Oct 12	Oct 13	Oct 14
1 Surface	25.4		22.2	15.6	13.1			3.6	4.6
1 Bottom	25.4		23.1	15.6	13.1			3.7	4.7
2 Surface	25.4		22.2	16.4	13.1			4.2	6.2
2 Bottom	28.8		23.1	16.4	13.0			5.5	6.1
3 Surface	26.4		25.4	16.5			8.2		7.9
3 Bottom	26.4		25.4	17.2			10.4		7.9
4 Surface	25.4		23.1	19.4	13.4				
4 Bottom	27.7		24.3	19.7	13.5				
5 Surface	29.8		24.3	19.2	27.8		9.4		7.2
5 Bottom	30.9		25.4	29.3	28.0		13.7		11.7
6 Surface		18.8	24.3	18.4	30.7			4.9	8.9
6 Bottom		19.9	24.3	17.8	30.8			5.0	9.1
7 Surface			16.5	16.4	13.1		6.8		5.9
7 Bottom			16.5	16.9	16.4		13.6		6.5
8 Surface			12.1	15.9	16.1		6.4		2.6
8 Bottom			15.4	15.9	16.8		7.4		3.2
9 Surface		28.8	19.9	23.6	24.2		4.9		12.1
9 Bottom		29.8	20.9	23.7	24.2		15.4		13.1

TABLE II-3 (Continued)

Station	June 15	June 16	June 17	Aug 10	Aug 11	Aug 12	Oct 12	Oct 13	Oct 14
10 Surface			28.8	21.4	21.5		12.8		10.1
10 Bottom			29.8	21.4	21.7		12.9		10.6
11 Surface		34.4	28.8	21.6	23.6		16.1		11.7
11 Bottom		35.3	31.5	21.6	23.7		16.2		12.0
12 Surface		35.3				29.1		25.2	
12 Bottom		35.3				29.0		29.3	
13 Surface		35.3				31.6		23.8	
13 Bottom		36.3				34.5		29.4	
14 Surface		35.3				31.7		22.2	
14 Bottom		36.3				34.3		29.0	

TABLE II-4

PERCENT SATURATION OF DISSOLVED OXYGEN IN LOWER CAPE FEAR ESTUARY
(At Stations 1-14, During 1971)[29]

Station	June 15	June 16	June 17	Aug 10	Aug 11	Aug 12	Oct 12	Oct. 13	Oct. 14
1 Surface	106		88	86	76			64	60
1 Bottom	103		93	86	76			65	59
2 Surface	107		90	87				78	67
2 Bottom	99		102	87	79			77	60
3 Surface	114		94	92			79		66
3 Bottom	112		97	90			77		65
4 Surface	106		81	100	74				
4 Bottom	104		81	96	73				
5 Surface	113		88	100	104		78		65
5 Bottom	110		88	101	96		85		68
6 Surface		98	91	89	112			66	64
6 Bottom		96	94	94	110			65	64
7 Surface			49	84	70		73		58
7 Bottom			42	79	72		77		62
8 Surface			35	68	61		85		54
8 Bottom			43	66	64		73		53
9 Surface		68	66	91	101		62	74	
9 Bottom		62	54	86	99		71		67

TABLE II-4 (Continued)

Station	June 15	June 16	June 17	Aug 10	Aug 11	Aug 12	Oct 12	Oct. 13	Oct 14
10 Surface			86	80	102		78		71
10 Bottom			89	77	86		75		75
11 Surface		86	71	76	103		79		76
11 Bottom		82	77	76	98		71		69
12 Surface		109				103		87	
12 Bottom		104				81		79	
13 Surface		110				111		88	
13 Bottom		100				107		76	
14 Surface		122				112		68	
14 Bottom		101				115		72	

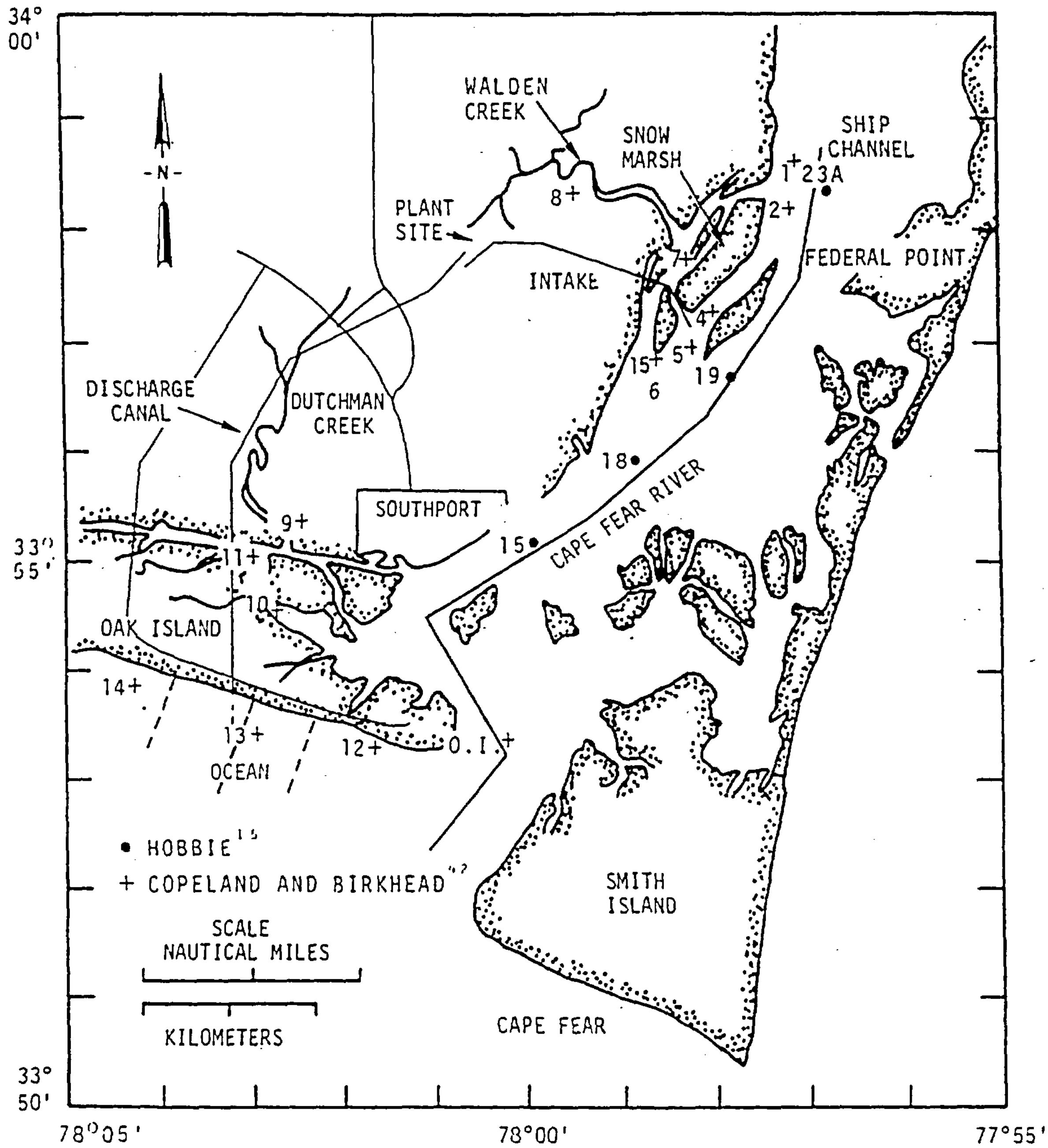
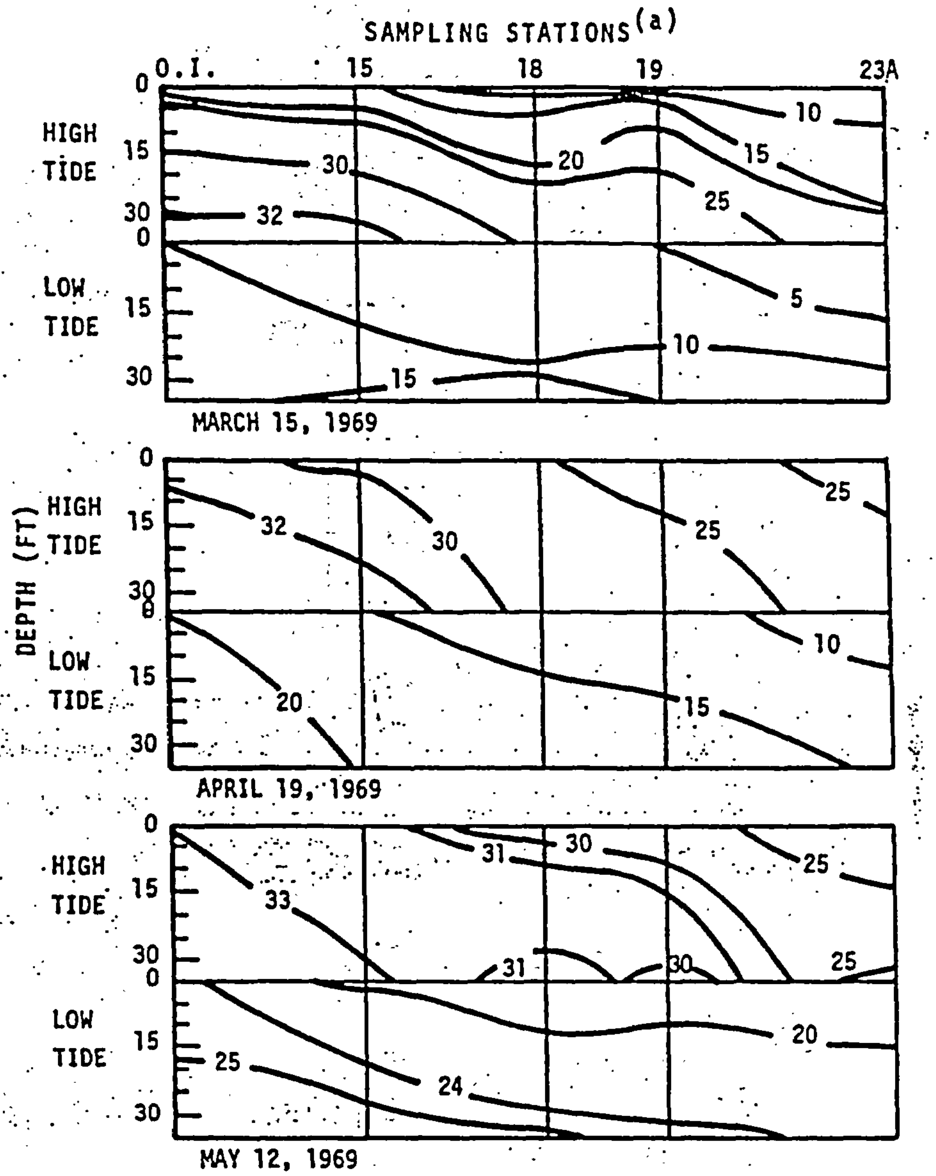
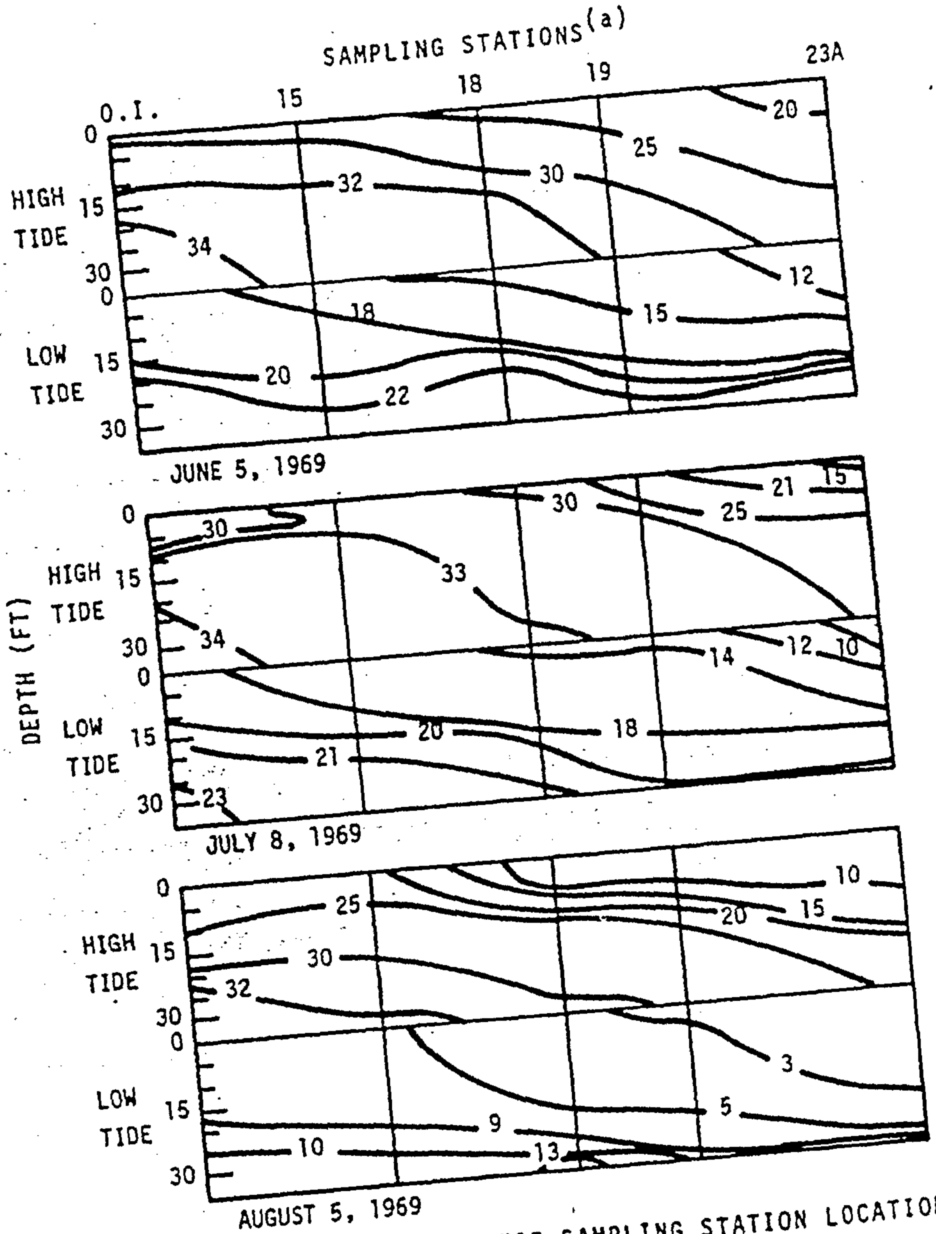


FIGURE II-5. DIAGRAM OF THE MOUTH AND LOWER END OF THE CAPE FEAR RIVER ESTUARY SHOWING SAMPLING STATIONS (Ocean Station transects from Hobbie[15,42])



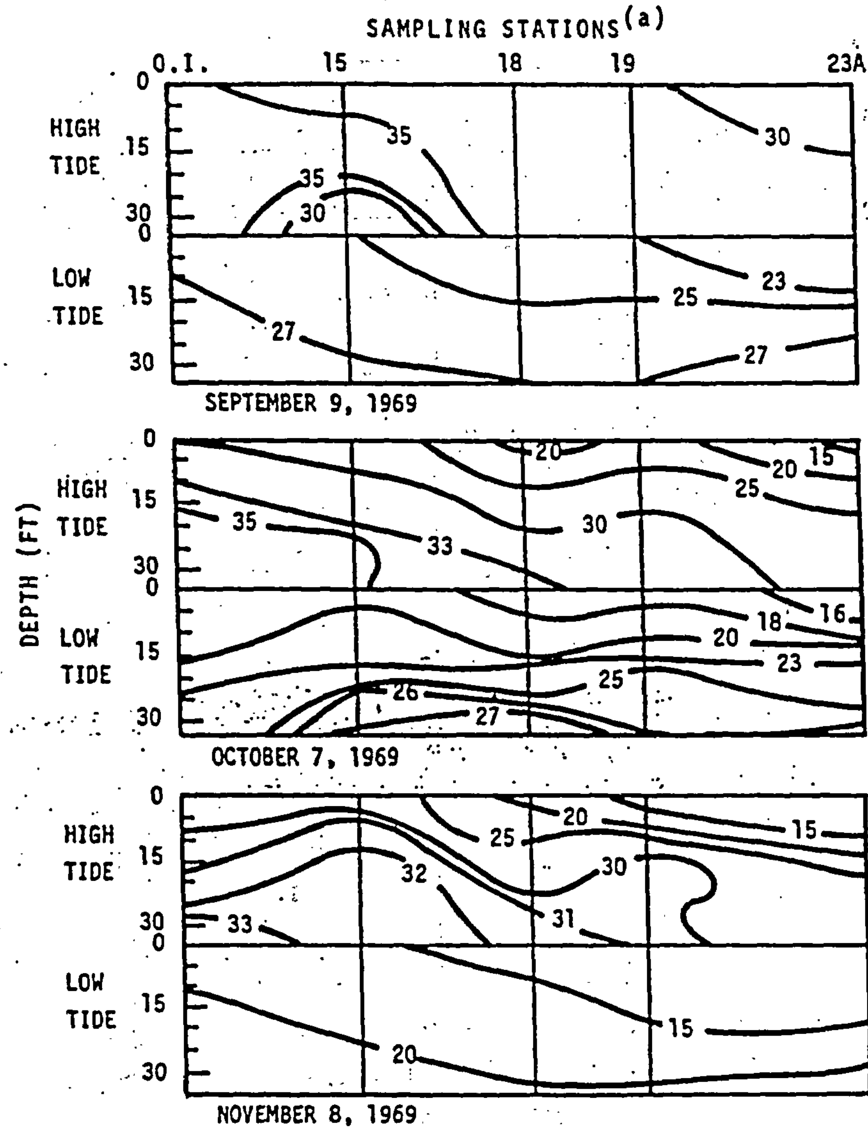
(a) SEE FIGURE II-5 FOR SAMPLING STATION LOCATION.

<u>FIGURE II-6.</u> ISOHALINES WITHIN LOWER CAPE FEAR ESTUARY, MARCH 15, APRIL 19 AND MAY 12, 1969. (Isohalines in ppt at high tide and low tide along a transect from Station 23A downstream to Oak Island during March through May 1969. Depth is indicated in feet on the vertical ordinate.)



(a) SEE FIGURE II-5 FOR SAMPLING STATION LOCATION.

FIGURE II-7. ISOHALINES WITHIN LOWER CAPE FEAR ESTUARY, JUNE 5, JULY 8, AND AUGUST 5, 1969. (Isohalines in ppt at high tide and low tide along a transect from Station 23A downstream to Oak Island during June through August 1969. Depth is indicated in feet on the vertical ordinate.)



(a) SEE FIGURE II-5 FOR SAMPLING STATION LOCATION.

FIGURE II-8. ISOHALINES WITHIN LOWER CAPE FEAR ESTUARY, SEPTEMBER 9, OCTOBER 7 AND NOVEMBER 8, 1969. (Isohalines in ppt at high tide and low tide along a transect from Station 23A downstream to Oak Island during September through November 1969. Depth is indicated in feet on the vertical ordinate).

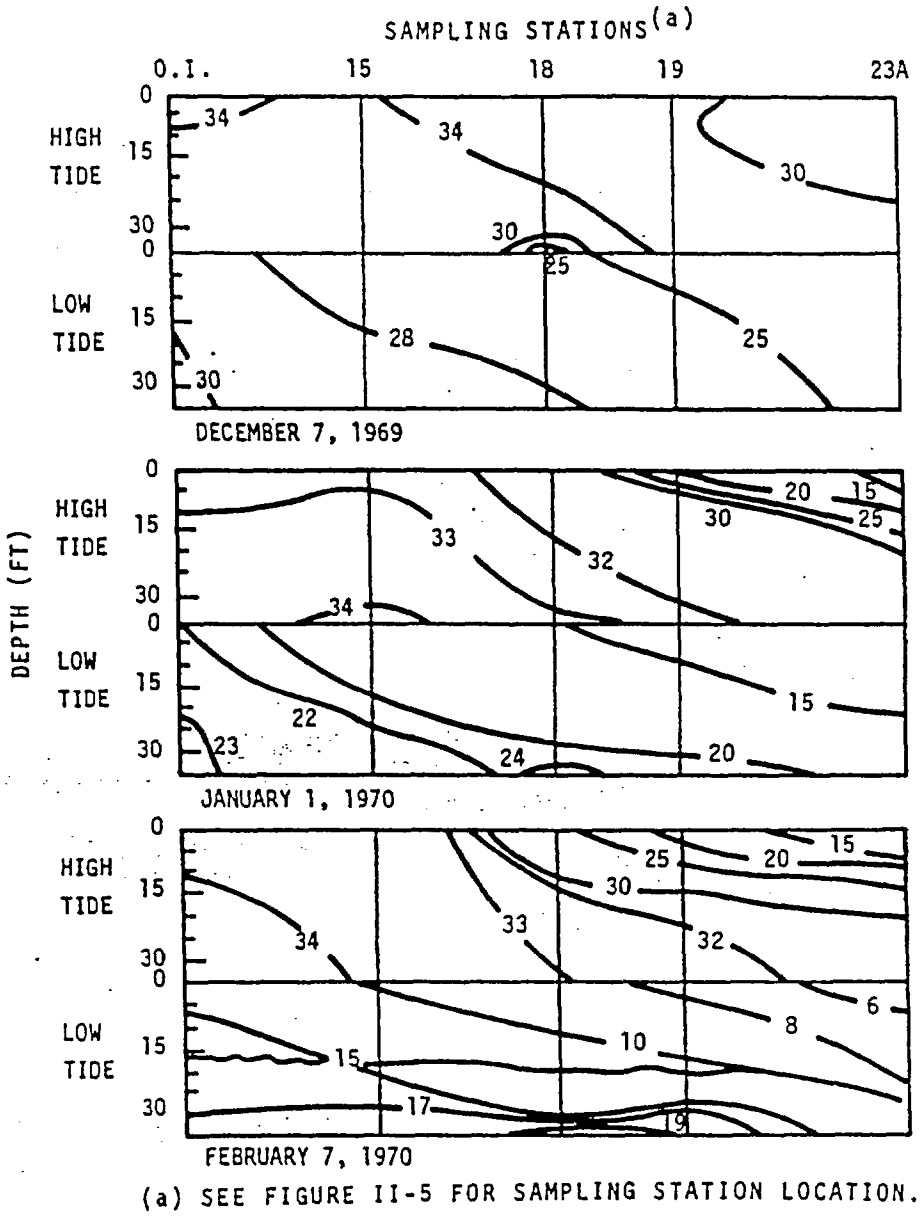


FIGURE II-9. ISOHALINES WITHIN LOWER CAPE FEAR ESTUARY, DECEMBER 7, 1969, JANUARY 1 and FEBRUARY 7, 1970. (Isohalines in ppt at high tide and low tide along a transect from Station 23A downstream to Oak Island during December 1969 through February 1970. Depth is indicated in feet on the vertical ordinate.)

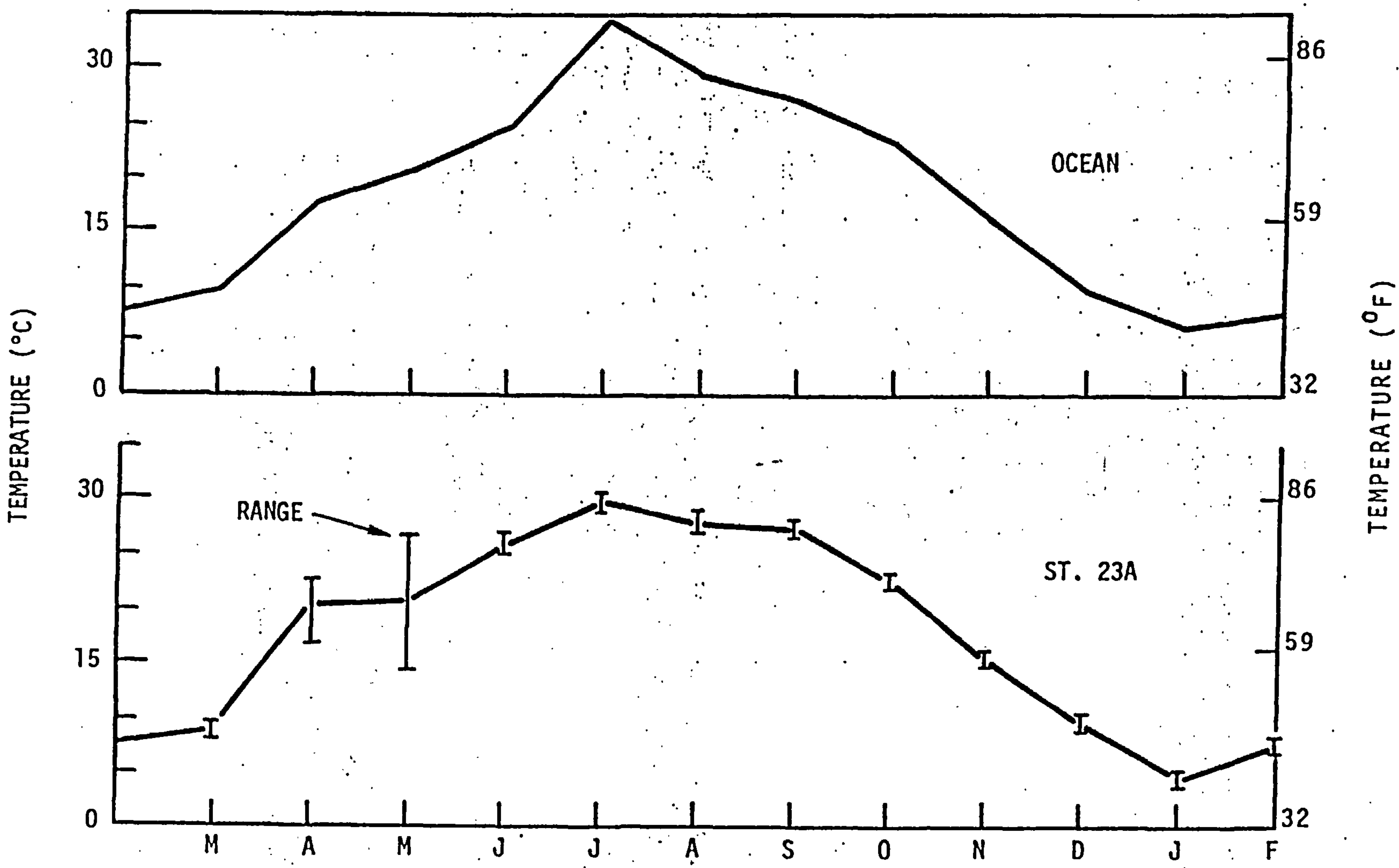


FIGURE II-10. SEASONAL CYCLE OF TEMPERATURE AT STATION 23A AND OCEAN STATIONS, CAPE FEAR RIVER AREA.[15] [The 23A curves are averages of all the data on that date (high and low tides). Data recorded during the period March 1969 through February 1970].

Shrimp spawn in the offshore waters and the post-larvae are recruited into the estuaries where they find food and protection. Maturing shrimp migrate to the deeper water where they are harvested by commercial fishermen.[13] White shrimp captured in the Cape Fear estuary and marked with biological stains demonstrated a distinct southward migration after leaving the estuary. Tagged shrimp were subsequently recovered as far south as St. Augustine, Florida. Since no major estuaries exist between the Cape Fear and Winyah Bay, South Carolina, one can assume that the migrating Cape Fear white shrimp are making a significant contribution to the white shrimp catch in northern South Carolina. The white shrimp catch in northern South Carolina amounted to $262,000 in 1970. In addition, white shrimp from the Cape Fear constitute an undetermined fraction of the shrimp catch as far south as Florida. Pink and brown shrimp are most endemic to North Carolina. The commercial catch of the pink and brown shrimp might be increased if suitable offshore trawling areas are located or new methods for harvesting are developed.[18]

Initial data from a continuing study by Copeland and Birkhead[16,42] demonstrated the presence of significant numbers of pink, brown and white shrimp in Snow, Dutchman Creek and Oak Island marshes during June, August and October 1971.

Shrimp census data were obtained from the State of North Carolina, Department of Marine Resources.[29] Combined data for all stations sampled within the Cape Fear Estuary during 1972, indicate that the white shrimp is the most abundant shrimp species with peak population density occurring July through October. The size distribution of white shrimp is presented in Figure II-11 and indicates the migratory patterns of this species. Juveniles apparently enter the estuary in late June or July where they develop and grow throughout the summer months. The major portion of the population present in the estuary from late fall through the following spring appear to be the larger sub adults.

White shrimp population densities are greater in the near shore marsh areas of Cape Fear Estuary.[29] This is illustrated in Table II-5 which lists the catch per hour for a station located near the river channel (T-6 Figure II-12) with catch per hour for a station located near an inshore marsh area (T-4 Figure II-12).

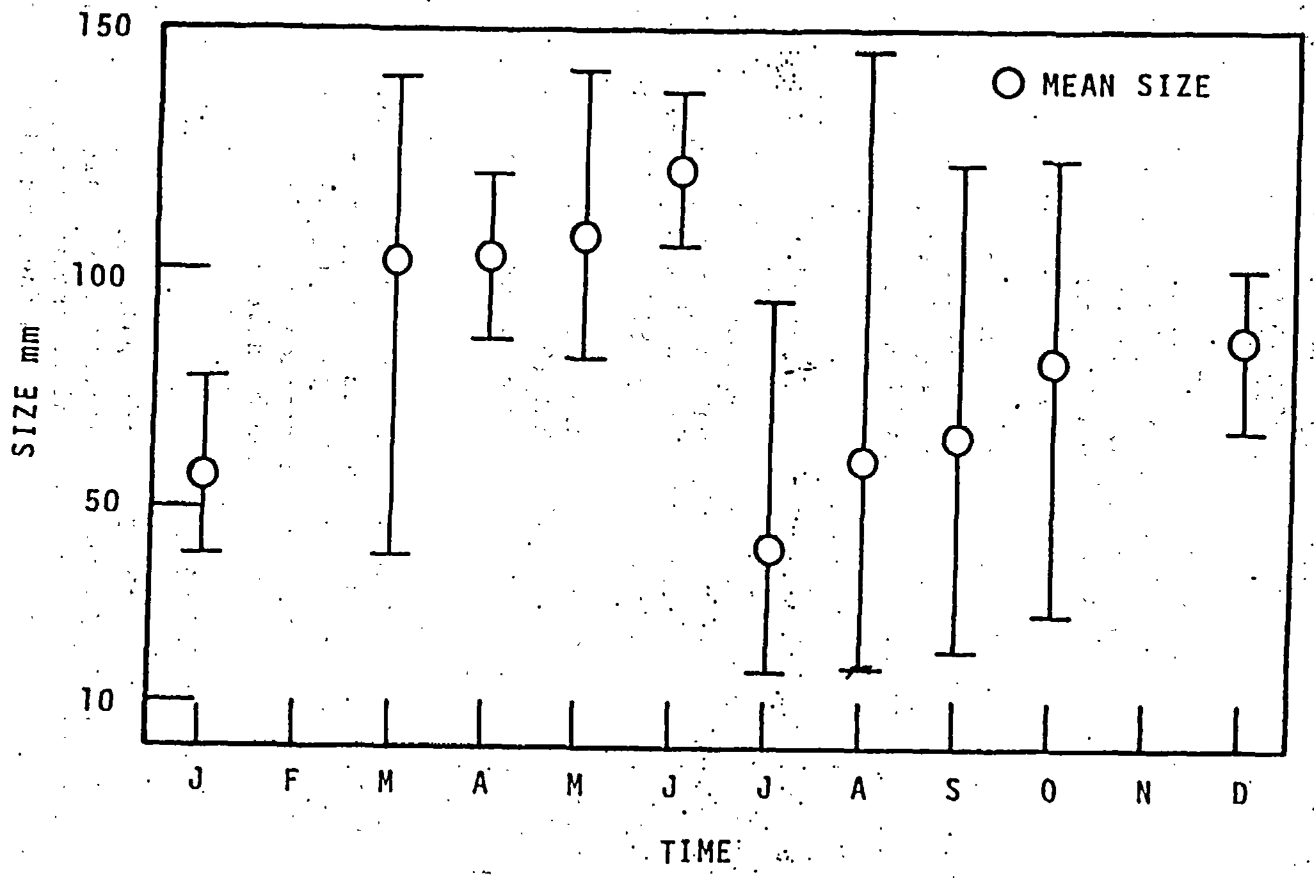


FIGURE II-11. SIZE DISTRIBUTION OF WHITE SHRIMP IN THE CAPE FEAR ESTUARY THROUGHOUT 1972. SIZE RANGES ARE PRESENTED WITH (O) INDICATING MEAN SIZE. DATA COLLECTED BY NORTH CAROLINA STATE DEPARTMENT OF COMMERCIAL FISHERIES AND REPRESENT COMBINED DATA FOR ALL SAMPLING STATIONS IN THE ESTUARY.

Copeland and Birkhead[42] collected significant numbers of spot in Walden Creek and Dutchman Creek in 1971 and 1972.

Croaker, Micropogon undulatus, one of the principal food fishes of North Carolina[19] is another inhabitant of the Cape Fear Estuary salt marshes. It is becoming increasingly important as a sport fish.[19] The Brunswick County commercial catch is small amounting to less than $700 each year for the period 1965-1970.[17]

Croaker spawn in the fall and winter in the ocean. The young move into the bays and estuaries where they spend their first year of life in shallow waters of low salinity. During their second year, there is a northward migration in spring to the middle Atlantic bight followed by a counter migration in fall.

Croaker were collected in Snow Marsh during the summer 1971. The other marsh areas, Dutchman Creek and Oak Island, produced significantly fewer. Other organisms collected in the marsh areas, which are of little immediate commercial value or exhibited lower densities, are presented in Table II-6.

The sampling technique used by Copeland and Birkhead[30,42] to survey the marsh inhabitants consisted of a 10-minute tow of an 11-ft trawl; the trawl wings were 5/8 in. mesh with a 1/4 in. cod end. The sampling technique was selective in that no organisms under 14 mm in length or over 200 mm in length were captured. New sampling techniques and programs were initiated in early 1973 but no results have been reported.

Figure II-13 presents the biomass of organisms caught in the sampling trawl. The data indicates that the marsh subsystems are the more productive areas sampled, however later collections[42] indicate that the region adjacent to the intake canal can be just as productive as the marshes.

The intake canal bisecting this area with a unidirectional current of 0.41 to 0.95 fps is likely to entrain or attract most of the migrating organisms. Quantitative estimates for the plant cannot be made at this time but experience at other steam electric stations indicate that the problem can be severe.

b. River Channel

Estuaries such as the Cape Fear, which open directly into the ocean, are hydraulically more dynamic than those which empty into sounds.[15] The Cape Fear is a partially mixed estuary which exhibits a defined salt wedge that can be discerned in the isohalines presented in Figures II-6 to II-9.

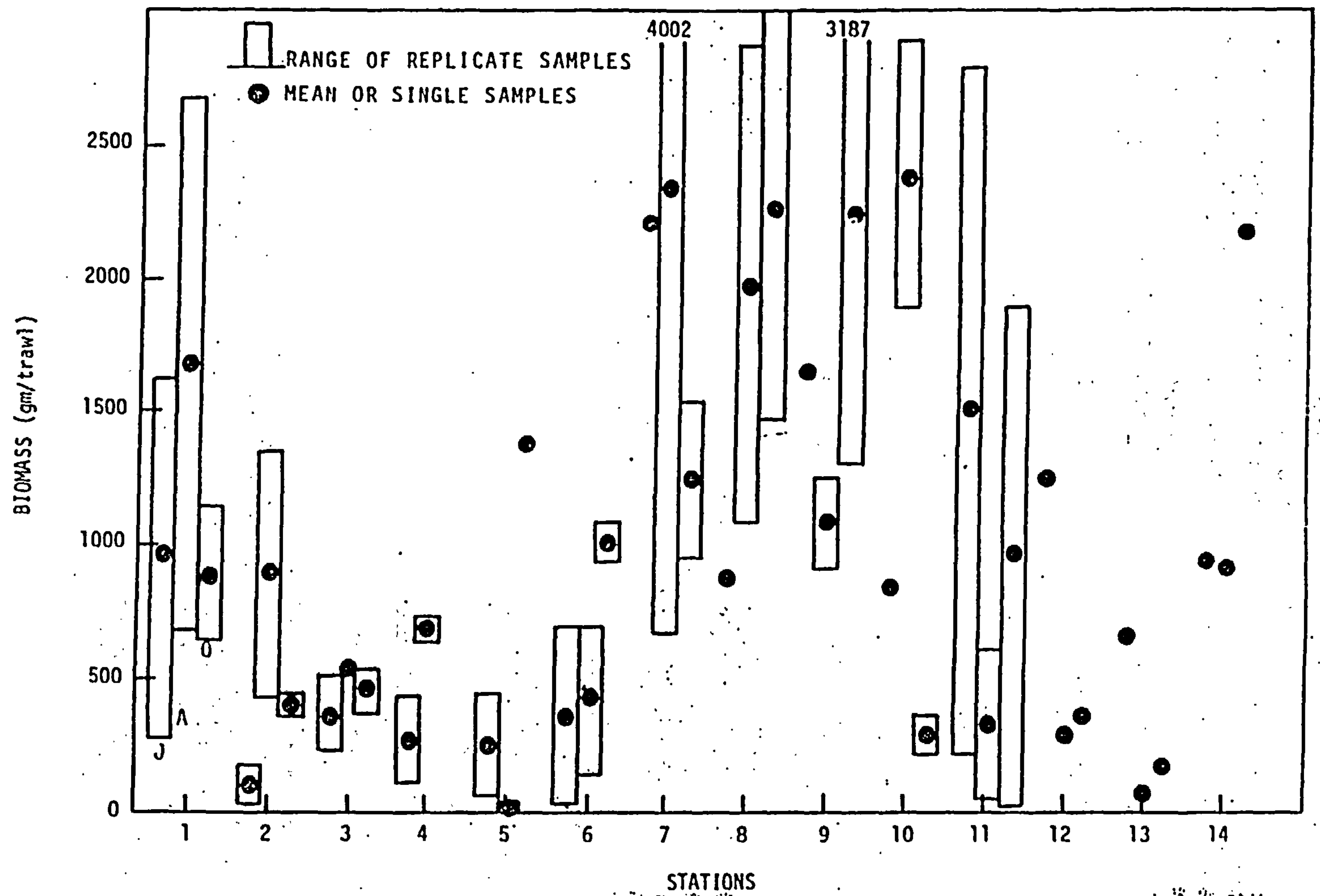


FIGURE II-13. BIOMASS OF ORGANISMS COLLECTED AT STATIONS 1 THROUGH 14 IN THE CAPE FEAR ESTUARY (Samples Taken in June, August and October 1971)[30]

TABLE II-6

OCCURRENCE OF AQUATIC ORGANISMS IN THE SNOW MARSH, OAK ISLAND MARSH AND DUTCHMAN MARSH[30]

Species	Location: Snow Marsh Station 7, 8	Oak Island Marsh Station 10	Dutchman Creek Marsh Station 9
Squilla empusa (mantis shrimp)	X		
Traclypenaeus constrictus		X	X
Anchoa hepsetus (striped anchovy)		X	X
Bairdiella chrysura (silver perch)	X		
Brevoortia tyrannus (Atlantic menhaden)		X	
Capanx bartholomoei		X	
Caranx hippos (crevalle jack)		X	
Calinectes similis		X	
Palaemonetes pugio	X	X	
Palaemonetes uvlgaris	X		
Panopeus herbstii		X	X
Chaetodipterus faber (spadefish)			X
Cithariehthys macrops (spotted wiff)	X	X	X
Cynoscion regalis (gray seatrout)	X	X	X

TABLE II-6 (Continued)

Species	Location: Snow Marsh Station 7, 8	Oak Island Marsh Station 10	Dutchman Creek Marsh Station 9
Etropus crossotus (fringed flounder)			
Logodon rhomboides (pin fish)			
Litianus griseus	X		X
Menticirrhus americanus (southern kingfish)	X		X
Monacanthus hispidus (planehead filefish)			X
Mycteropercia microlepis (gag)		X	
Opsanus tau (oyster toadfish)	X	X	X
Orthopristis chrysopteras (pigfish)	X	X	X
Paralichthys dentatus (summer flounder)	X		
Selene vomer (lookdown)	X		X
Symphurus plagiusa (blackcheek tonguefish)	X	X	X
Synodus foetens (inshore lizardfish)	X		
Trinectes maculatus (hogchoker)	X		

Movement of the salt wedge within a stratified or partially mixed estuary has biological significance since plankton distribution may be oriented to the salinity gradients within an estuary. Many planktonic organisms have been reported to aggregate at salinity and density interfaces.[20]

The studies conducted by Hobbie,[15] and Carpenter[21] were primarily concerned with the main channel of the Cape Fear Estuary. Both studies used the same sampling stations (Figure II-5).

Carpenter described the annual phytoplankton cycle in the Cape Fear Estuary as being similar to that of other east coast estuaries[21] The dominate phytoplankter is the diatom Skeletonema costatum; other dominating species are the diatoms Asterionella japonica and Thalassionsira nana, the dinoflagellate Katodinium rotundatum and the Loricate Flagellate Calycomonas ovalis. Carpenter identified 203 species with diversity being greatest at the estuary mouth; lesser diversities were found both up river and at the ocean station.

Hobbie surveyed the zooplankton of the Cape Fear Estuary.[15] Most of the animals identified were crustaceans and most of these were copepods. There were some molluscan and annelid larvae present during the spring and fall spawning periods. Figure II-14 graphically presents the seasonal distribution and abundance of the total number of zooplankters captured in plankton tows within the estuary and at the ocean stations. The estuarine stations as well as the ocean stations each exhibit two peaks in abundance: spring and fall. Peak abundance at the ocean station occurred a month earlier than similar peaks within the estuary.

The dominant copepod within the estuary was Acartia tonsa which is also abundant in other North Carolina estuaries. The spring peak of zooplankton abundance within the estuary primarily consisted of dense population of Acartia, Paracalanus and Balanus.

There was a shift in species composition for the fall peak which consisted of Acartia, Balanus and Oithona.

Developing larvae of commercial species were collected during limited periods of the year. Juvenile shrimp (pink, brown, and white) were collected at all stations in June 1969.[15] Blue crab larvae were collected sporatically at the estuarine stations from April 1969 through July 1969.[15]

While the commercial species (shrimp and blue crab) comprised a relatively small fraction of the total zooplankton collected, the sampling technique does not allow for quantitative estimates of

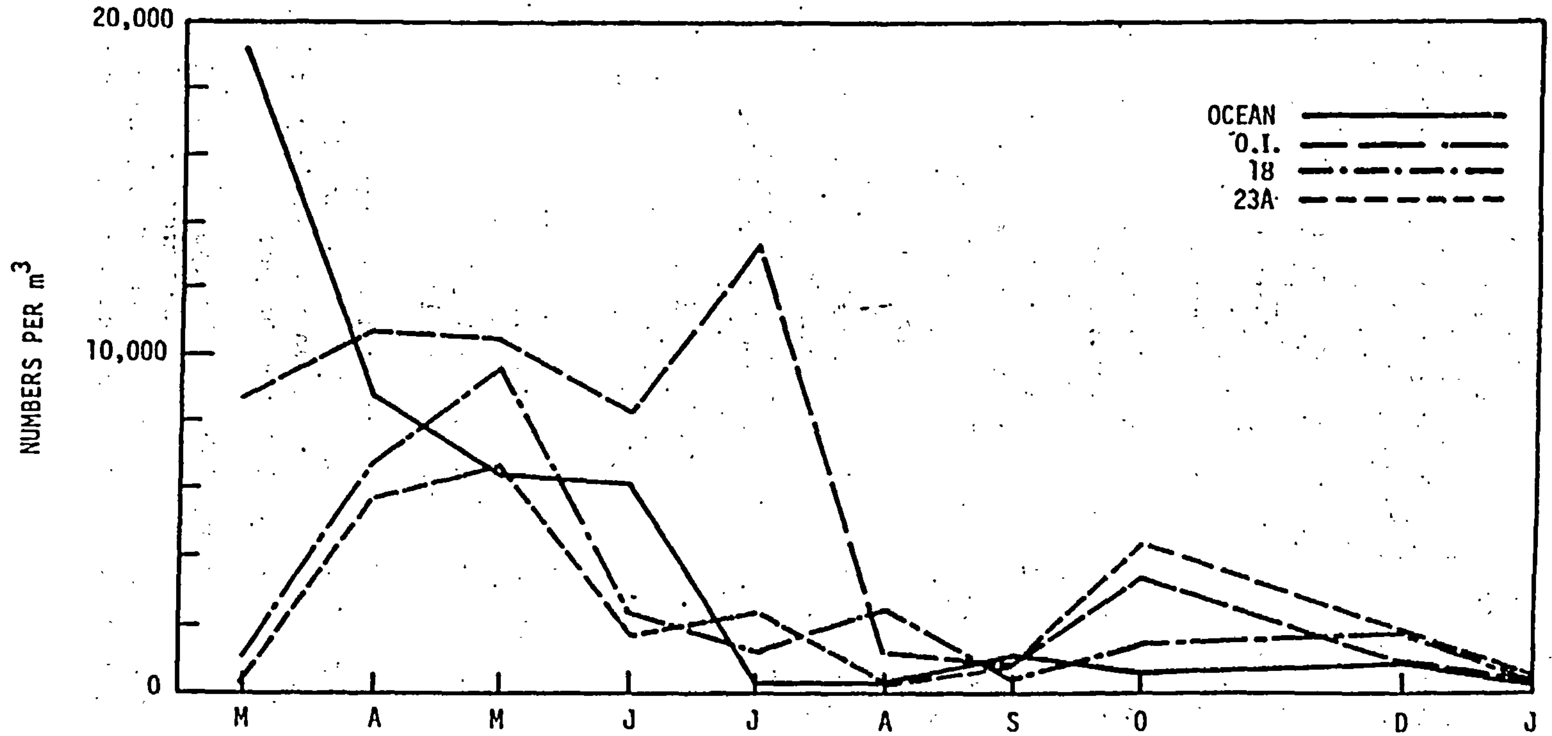


FIGURE II-14. SEASONAL CYCLE OF ZOOPLANKTON SAMPLES[12] (Numbers of zooplankton per m^3 in the Cape Fear and nearby ocean. At Oak Island Stations 18, and 23A, the high and low tide data have been averaged.)

abundance. The surface plankton tows which were employed in the above study do not provide sufficient information as to the vertical distribution of zooplankters within the water column. Zooplankters may aggregate at different depths within the water column in response to food, salinity, temperature and light gradients. Because of the above considerations, the data generated thus far are insufficient to describe, with a degree of confidence, the distribution and abundance of the zooplankton, especially the juvenile shrimp and blue crabs in order to adequately assess the impact of plant operation, it is essential to determine the depth distribution of the zooplankton, particularly to the depth of the intake canal.

Fish larvae were collected monthly at high and low tides over a 9-month period at three stations within the estuary[15] using a Gulf high-speed plankton sampler towed at 7 knots for 3 minutes. The estuary supports larval fishes throughout the entire year. Lowest abundance occurs in September and October. Anchovy, Anchoa sp, larvae appear in the estuary in June, July and August. Anchovies are found in greatest abundance at the estuary mouth; relatively few were found at Station 23a, the farther station from the ocean. Croaker, ranked second in total abundance: Station 23a exhibited the highest density followed by successively lower densities toward the estuary mouth. Larval croaker were collected from November 1969, through February 1970. Gobies, the third most abundant larvae, were evenly distributed throughout the estuary. Spot was another species present in significant quantities, and its total numbers decreased with increasing distance from the mouth of the estuary. Spot larvae were found in January and February 1970. Sixteen other taxa were collected and their distribution and abundance are presented in Table II-7.

Adult fish were collected with a 10-minute tow using a 6-ft ottertrawl with a mesh size of 5/8 in. and 1/8 in. cod end.[15] Tows were made north of Horseshoe Shoal, immediately south of Horseshoe Shoal and near Oak Island north of Fort Caswell. All samples were taken along the western side of the channel in water 3 to 10 ft deep.

The most abundant fish species was the gray sea trout which was present from July through December. There is a small commercial fishery for the gray sea trout which ranged in value (based on Brunswick County landings) from $16 to $919/yr over the 6-year period, 1965-1970.[17]

The next most abundant fish was the spot which was present in all months except January and February. Croaker were present throughout most of the year with their peak abundance in January. The Bay Anchovy was most abundant in June, September and October. No commercial value has been

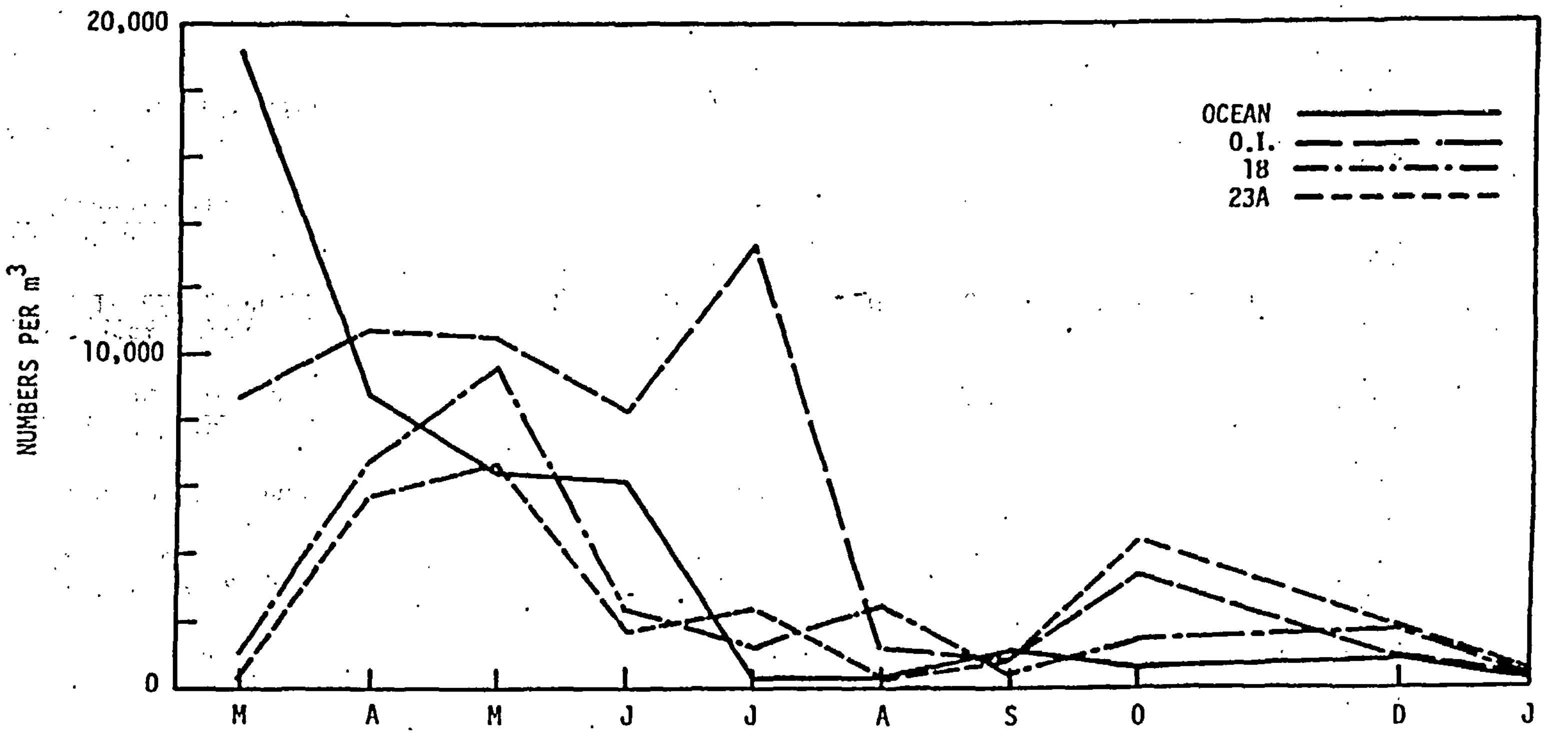


FIGURE II-14. SEASONAL CYCLE OF ZOOPLANKTON SAMPLES[12] (Numbers of zooplankton per m^3 in the Cape Fear and nearby ocean. At Oak Island Stations 18, and 23A, the high and low tide data have been averaged.)

TABLE II-7 (Continued)

Taxon	Oak Island Hi	Oak Island Low	Station 18 Hi	Station 18 Low	Station 23A Hi	Station 23A Low	Totals Hi	Totals Low	Totals Total	Ocean
Paralichthys dentatus (Summer flounder)	0	7	0	0	1	1	1	8	9	0
Paralichthys sp. (Flat fishes)	0	2	0	3	1	1	1	6	7	0
Symphurus plagiusa (Black cheek tongue fish)	0	0	1	1	1	0	2	1	3	0
Gobiesoma strumosus	1	0	0	0	0	0	1	0	1	0
Mugil cephalus (Stripped mullet)	1	1	0	1	0	1	1	3	4	0
Brevoortia tyrannus (Atlantic menhaden)	2	0	0	0	0	0	2	0	2	1
Clupeidae (Herrings)	1	0	0	0	0	0	1	0	1	0
Syngnathus fuscus (Northern pipefish)	1	0	1	0	0	0	2	0	2	0
Anchoa sp. (unidentified anchovies)	280	3	112	21	25	11	417	35	452	180
Anguilla rostrata (American eels)	1	0	0	0	0	0	1	0	1	0
Gobiidae (Gobies)	53	4	33	21	21	23	107	48	155	49
Total	418	141	185	197	98	201	701	539	1240	238
Taxons	16		11		12		19	12	20	8

abundant in June, September and October. No commercial value has been reported for this species. Other important fish in the estuary are the summer flounder and the windowpane; both are flatfish. The summer flounder was present from August through November while the windowpane was found from March through June.

Three anadromus clupeids migrate through the Cape Fear Estuary; American Shad, Alosa sapidissima, alewife, A. pseudoharengus, and blue backed herring, A. aestivalis.[22] An estimated 259,000 shad entered the Cape Fear River in 1971. Commercial fishermen caught about 69,250 or 27%.[15]

c. Offshore Region

Heated effluent from the plant will be discharged into the ocean 2,000 ft off Caswell Beach, Oak Island. Both Hobbie and Copeland have conducted a biological survey of the discharge area, and the sampling stations for both studies are shown in Figure II-5.

Peak abundance of zooplankton occurred in March 1970, a copepod Centropages sp, was the dominate organism collected. Acartia tonsa, the dominant estuarine copepod, ranked second in abundance at the ocean station. Larval blue crabs were not collected at the ocean station, however, shrimp larvae were found in June in about the same abundance as the estuarine stations. The seasonal cycle of zooplankton abundance at all zooplankton stations is presented in Figure II-14.

Ocean zooplankton samples were collected using a No. 25, 1/2 m metered plankton net towed at 1 knot along the surface. Limitations of this sampling technique were discussed in the previous section (b).

The ocean station yielded more individuals and fewer taxa than any other station except for Oak Island at high tide (Table II-7). Anchovies were most abundant followed by the gobies. During the 9-month sampling period (June through February) six other larval fish species were collected in relatively insignificant quantities including: spot, croaker, gray seatrout, pinfish and menhaden. Bivalve larvae were found only in the January samples.

Hobbie presents no data on the fish collected at his ocean stations.[15] He does mention that commercial shrimp were captured in May and June and that species diversity was higher at the ocean station than within the estuary proper. Copeland calculated species diversity for his three ocean stations, and found greatest diversity at Station 14, the furthest station from the estuary mouth.

The dominant fish species collected by Copeland at Stations 12, 13, and 14 was the anchovy.[30] Organisms of commercial value but less abundant were: blue crab, brown, pink and white shrimp, spot, king fish, Mentaicirrhus americanus, croaker, thread herring, Opisthonema oglinum, bluefish, Pomatomus saltaria, drum, Stellifer lanceolatus, and sole, Symphurus plagiusa.

Hobbie sampled the benthos in the vicinity of the proposed discharge site.[15] The sediments were characterized and described as mud in the area west of the discharge site and sand in the area south and east of the discharge site. Fifty-six different species were collected but the snail, Retusa canaliculata and the brittle star, Ophiophragmus dominated. Other species became abundant at different times of the year such as the polychaetes Clymenella torquatam, Glyceria americanus, and Meliina cristata in the fall. Diversity of benthic organisms was lowest at those stations nearest the estuary mouth.

In summary, there are insufficient quantitative, data available on the marsh and estuarine biota, especially those organisms small enough to pass through the plant's condensers. Also lacking are data on migration patterns for commercial fish and shell fish, specifically those which occur in the vicinity of the intake canal and the offshore discharge area. In addition, the distribution and abundance of important fish and shellfish stocks are not known for the area adjacent to the intake canal and the ocean discharge point. The requirements relating to the above deficiencies are presented in more definitive terms in Section V.C.2. The applicant's programs are summarized in Section V.C.2.e.

2. Terrestrial

The only readily available study of energy flow in a Spartina salt marsh is the work of Teal[24] for a marsh in the Savannah River of Georgia. This study details the pathways of energy incorporated by Spartina and algae in the marsh. Primary producers (Spartina and various algae) trap 36,380 kcal/m^2/yr or 6.1% of the available energy (Figure II-13). Of this 77% is respired by the primary producers resulting in a total of 8205 kcal/m^2/yr available to other components. Note that of this amount, Spartina accounts for 81%, or an average of 6855 kcal/m^2/yr. Of the total, 3,671 kcal/m^2/yr is available for export. This amounts to an "export efficiency" of 0.6%, a figure that is crucial to determining the amount of energy available to estuarian species. This energy is made available by the continual action of inundating tides.

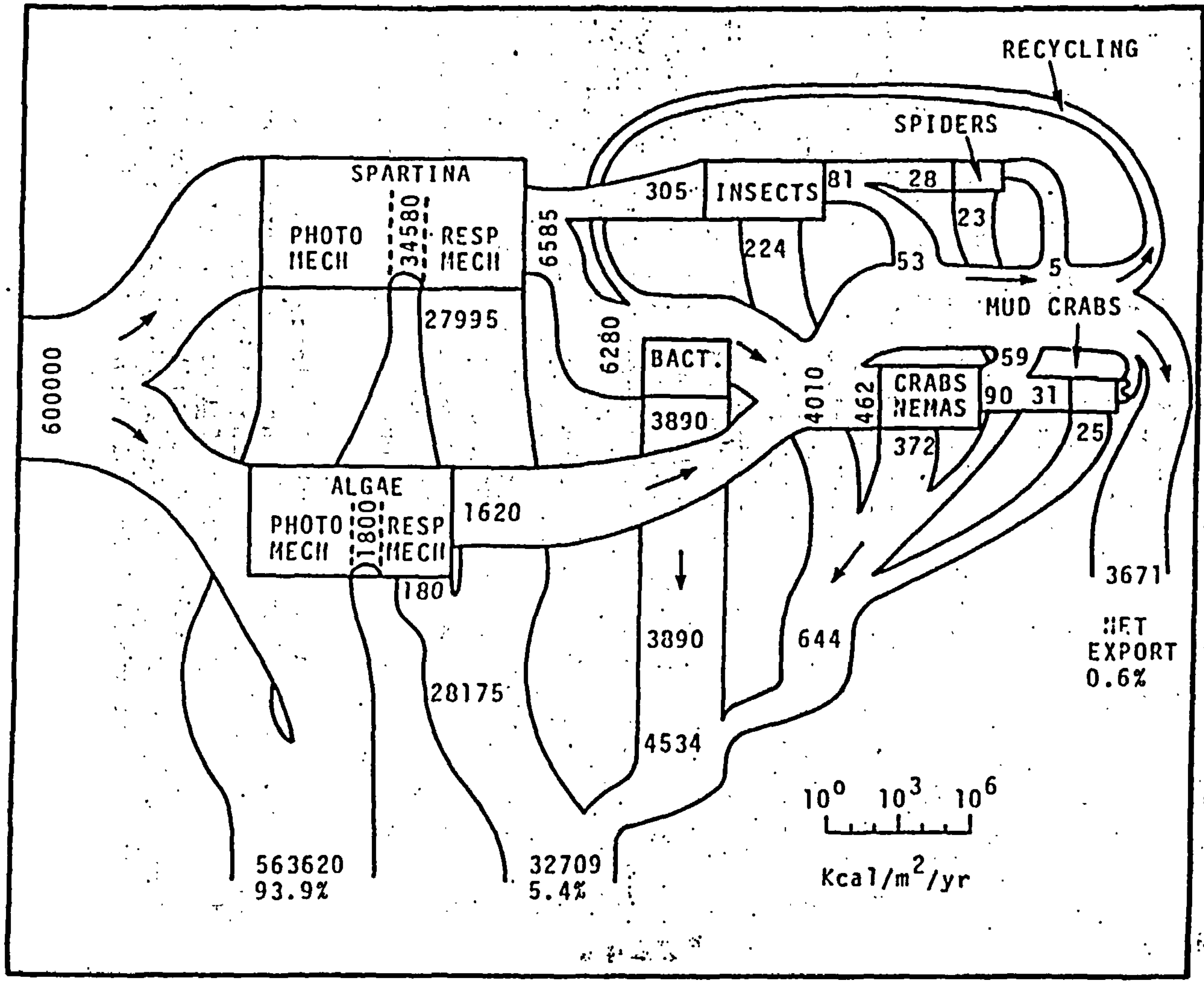


FIGURE II-15. ENERGY FLOW IN A *SPARTINA* MARSH IN THE SAVANNAH RIVER

North Carolina Spartina marshes are undoubtedly less productive than that studied by Teal owing to lower temperatures, shorter growing season, lower efficiency, and perhaps a different mix of tall, medium, and short Spartina acreage. Average marsh productivity for Spartina in North Carolina may vary from 1300 kcal/m^2/yr for short Spartina to 6471 kcal/m^2/yr predicted for tall Spartina in the Cape Fear region.[32] In the Teal study, 19% of the available energy was provided by algae. No estimates of this parameter have been made available by the applicant, nor have any been uncovered by the staff, for marshes in the vicinity of the plant. There are also no estimates of export efficiency for those marshes.

To estimate the net export production of Spartina marshes in the plant vicinity, the following assumptions and calculations were made. Stroud and Cooper[32] estimate Spartina production in Brunswick County average 2590 kcal/m^2/yr. To this value must be added an unknown quantity due to algae production. The staff assumes this value to be 20%, based on Teal's study. This value may be too low since the North Carolina marshes appear to have a greater marine influence than the Savannah River marsh.[40] This results in a total estimated net production of 3110 kcal/m^2/yr. To these values must be added, in the undisturbed state, any organic input from the higher and infrequently flooded Juncus romerianus marshes found surrounding Spartina marshes in this area. Stroud and Cooper[32] estimate that Juncus productivity is 5346 kcal/m^2/yr. However, since this figure is subject to considerable variation[40,41] and since an unknown quantity is exported, it will be assumed to be negligible. The amount available to estuaries is therefore some fraction of the approximately 3200 kcal/m^2/yr. Teal found this fraction to be 45%, and the staff assumes that 50%, or about 1600 kcal/m^2/yr is the amount of energy exported to the estuary. This number will be higher to the extent that algal production may have been underestimated and lower to the extent that Spartina production may have been overestimated.

In addition to the low, regularly flooded marsh less productive upper marshland abounds in the area. Immediately west of the discharge canal, near its crossing of the Intracoastal Waterway, is a Juncus romerianus marsh. Salicornia and Limonium are common in this marsh. Bordering these marshes are rarely flooded areas dominated by woody species such as Iva, Baccharis, Ilex, or Myrica. These areas provide considerable cover for the wildlife of the marsh.

Salt marshes have been studied in many parts of the world so that certain general features relating to their dynamic behavior have been described.[33,34,35]

The most important features controlling the marsh biota relate to surface elevation and topography and to tidal patterns. Very small (ca. 2-3cm) elevational changes may mark dramatic vegetational differences in the marsh.[34] Salt marsh communities are delicately balanced between land and sea and may be easily disrupted. The physical factors which interact to control the salt marsh may be summarized as follows: the degree of tidal inundation depends upon (a) the magnitude of the tides, (b) wind, (c) proximity to water, (d) slope of the land, and (e) elevation above mean sea level. Items (c) and (e) are subject to modification by engineering activities. The soil water salinity, which is a major determinant of species composition, is determined by (a) tidal inundation, (b) soil type, (c) evaporation, and (d) rainfall. Tidal inundation patterns are easily modified by engineering activities.[36] Drainage and aeration patterns of the marsh depend upon (a) the slope of the land and (b) upon topography. These patterns in turn determine the height of the water table, a major determinant of vegetation. By alteration in (b), i.e., by constructing berms or walls, drainage patterns are altered. Other factors, such as interactions among organisms and soil type, play lesser roles in determining the nature and extent of marsh communities. The speed with which marshes are transformed by natural[37] or artificial changes[38,39] should leave no doubt that such marshes are delicately balanced, unstable systems.

Dune-strand habitats occur at the interface between the sea and land. It is an intrinsicly unstable habitat subject to seasonal and long term changes due to the action of wind, waves, and tide. Uniola paniculata is the major dune species and acts to stabilize the sand against wind erosion. There is sparse cover for wildlife and species found in the dunes area are either those more typical of surrounding vegetation types, or a variety of shore birds.

seaoats

Fore-dune complexes in North Carolina protect over 3 million acres of low-lying agricultural and forest land and estuaries[40] The fore-dune absorbs much of the energy associated with storm tides and wave action and therefore protects associated community types. Over geological time, the sea appears to be rising, suggesting the gradual inland migration of the dunes. However, over the short term, maintenance of the fore-dune, including planting of sea oats if necessary, is the best way to insure that adjacent highly productive communities will not be destroyed by violent storms.

On Oak Island in the slack areas behind the dunes and generally to the west of the discharge canal is a maritime shrub thicket dominated by live oak (Quercus virginiana) and sabal palm (Sabal palmetto). This type is now rare in North Carolina, though the stand on Bald Head is a prime example. This vegetation helps to stabilize the island and acts to cut down wind. Salt spray (see Appendix D), wind, and nutrient poor, dry soil leads to a forest of low aspect consisting of a dense thicket of small trees and shrubs. Animal life is quite abundant and many microhabitats occur. Species of hawks, flickers, woodpeckers, jays, warblers and the cardinal are a few of the characteristic birds. Squirrels, mice, and several snake species may be found (Appendix B).

A variety of forests dominated by either pines or hardwoods occur in the vicinity of the site. The most important community in this region is dominated by Pinus palustris (longleaf pine), Quercus laevis (turkey oak) and Aristida stricta (wire grass). Fire maintains the shade intolerant pine as the dominant in this vegetation. The soils are medium to loamy sands which are well drained and thus this vegetation is not found where flooding is common. Old terraces, ancient dunes (those formerly barrier islands), and more recent, protected dunes can be expected to support this vegetation.

On soils of considerably more clay and where disturbance has been more pronounced, a forest of Pinus taeda (loblolly pine) with a variety of southern hard woods, such as Liquidambar styraciflua (sweet gum) and Nyssa sylvatica (black gum), xerophytic northern species of deciduous oaks and hickories occurs. In this type, loblolly pine is definitely seral, but is maintained by clearcut logging and periodic fires. The climax vegetation (without disturbance) would be an upland hardwood forest dominated by a variety of oaks, beech, and gum. Birds, mammals, amphibian, and reptile composition is rich.

The following three forest types occur on poorly drained, frequently flooded soils, but are not common in the immediate vicinity of the site.

The pine savanna occurs where the forest is often flooded. It is thought to be successional, developing on the remains of pocosin forests. Composition is highly variable, with pond pine (Pinus serotina) or longleaf pine (P. palustris) dominating. Several unique species occur in this type: Habenaria, Pogonia, Calopogon, and Spiranthes (all orchids); sundews (Drosera), pitcher plants (Sarracenia) and Venus flytrap (Dionaea muscipula). The animals are similar to those of pocosins and are not listed separately.

Pocosins, in contrast to the savanna described above, have well-developed layers of evergreen shrubs and small trees. Long hydroperiods and frequent fire characterize this type, which is found along the margins of ponds and streams and over "Carolina Bays." Carolina Bays are elliptical basins scattered over the Coastal Plain oriented to southeast to northwest. These forests are clearly successional, intermediate between open water swamp-lands or ponds, and upland forests. Soil is highly organic and very acid, but a sandy bottom is usually found. These bays are very important in retarding water movement in the area by acting as sponges which slowly release water following rains. A large number of small trees are common, including Magnolia virginiana and Persea borbonia. Where fire has been recent, Pinus palustris on sandier soils and P. serotina on the wetter sites will form important portions of the community. Owing to the density of vegetation, variety of resident animals is low, but refuge value is great.

A considerable portion of the Coastal Plain in this region is covered by swamp forests and bottomland hardwood vegetation. Such vegetation develops along water courses of the margins of open ponds or lakes. Where permanent fresh standing water occurs, soils are underlain with mulch and clay. Bald cypress (Taxodium distichum), pond cypress (T. asendens), swamp gum (Nyssa sylvatica var. biflora, and tupelo (N. aquatica) are the most abundant trees of the swamp forest. If the subsoil is more sandy, pond cypress will predominate. In slightly drier sites, where water may not be on the surface for a portion of the year, red maple (Acer rubrum), water hickory (Carya aquatica) and water oak (Quercus nigra) dominate. Disturbance or lowering of water table leads to the presence of several seral pine species. These forests are subject to destruction by drainage, but fires are not common. Animal life is extremely rich.

From aerial photographs it is clear that some of the terrain surrounding the plant is disturbed. The plant species of disturbed areas are highly varied. Many are native seral species such as the pines, but many others are introduced. The types of disturbance common in this area are canals, ditches, dredge spoils sites, and old fields. Old fields are abandoned agricultural plots that are going through natural succession. In most cases this leads to upland hardwood forest. These disturbance communities are quite diverse and provide abundant forage and cover for wildlife.

In Table II-8 are listed the rare or endangered species listed by the U.S. Fish and Wildlife Service[23] and thought to occur in the

TABLE II-8

RARE AND ENDANGERED SPECIES FOUND IN SOUTHEASTERN NORTH CAROLINA[23]

(Sunny Point Environmental Report, quoted from Committee on Rare and Endangered Wildlife Species, 1968)

A. Birds

Brown Pelican (Pelicanus occidentalis) -- Endangered

Southern Bald Eagle (Haliaeetes l. leucocephalus) -- Endangered

American Peregrine Falcon (Falco peregrinus anatum) -- Endangered

Red-Cockaded Woodpecker (Dendrocopos borealis) -- Endangered

Ipswich Sparrow (Passerculus princeps) -- Rare

American Osprey (Pandion haliaetus cardinensis) -- status undetermined

B. Reptiles

American alligator (Alligator mississipiensis) -- Endangered

Green turtle (Chelonia mydas mydas) -- Rare in U.S.

C. Fish

Atlantic Sturgeon (Acipenser oxyrhynchus) -- Rare

D. Plants

Dionaea muscipula (Venus fly trap) -- Unique

Drosera spp. (Sundew) -- Unique

vicinity of the plant. The southern bald eagle is rare and is not known to nest at present in Brunswick County. The peregrine falcon is sighted occasionally and nested in Brunswick County in the past; but none is known to nest there at present. The American osprey occurs and is nesting in the Orton ponds. The red cockaded woodpecker is not known at present, though records indicate that it has nested in Brunswick County. The Ipswich sparrow is very similar to the savanna sparrow and is a migrant not known to nest in Brunswick County. The brown pelican has nested in the vicinity but is decreasing.[31] It is a fishing bird and is endangered by the accumulation of pesticides which interfere with reproduction.[27]

The American alligator is a native reptile species that is endangered. It has been seen frequently in the marshes and swamps surrounding the plant. The green turtle is rare in the United States, but it is not clear whether it nests on the mainland.

Two species of plants are found in very specialized habitats in the vicinity. Boggy, acid soils will often have Venus flytraps or sundews. These species are "unique", but in a precarious position by virtue of their specialized habitat requirements.

G. Natural Radiation Background

The Environmental Protection Agency (EPA) has made an extensive radiological survey of the U.S. Its data indicate an average gamma background dose rate in North Carolina of 145 mrem/yr.[28]

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III. THE PLANT

A. EXTERNAL APPEARANCE

The plant contains two boiling water reactor installations housed in dual reactor buildings (Figure III-1). The flat terrain and low vegetation make it difficult to blend the buildings with the environs. Each reactor building is about 170 ft above grade. The turbine building measures about 328 by 190 ft, and is about 140 ft above grade. The usual appurtenances--a 100-meter stack, a transmission line corridor, switchgear yard, tanks for condensate and demineralized water, etc.--are part of the plant.

The once-through cooling system draws water in an open unlined canal from the Cape Fear River about 3 miles from reactor site and discharges the heated water into the Atlantic Ocean about 6 miles from the reactor site. There is one pump station at the reactor site and another on Caswell Beach adjacent to the ocean. The intake canal is about 310 ft wide at the water surface, about 18 ft deep and 168 ft wide at the bottom. The canal commences in the Cape Fear River ship channel, passes through 8500 ft of tidal marsh in the vicinity of Snow Marsh and 8500 ft of high ground to reach the plant.

The discharge canal passes through high ground from the plant to a marsh area at the headwaters of Dutchman Creek and then re-enters and remains in high ground to the Intracoastal Waterway, a total distance of 20,000 ft. The discharge canal is about 170 ft wide at the water surface, about 15 ft deep, and 20 ft wide at the bottom. The excavated material from the canal is used for embankments along the canal, and the dredged material is pumped into spoil ponds. The embankments vary in width up to the width of the right-of-way, which is 1500 ft over most of the length of the canal. The spoil ponds, which will ultimately comprise up to about 1000 acres (some of which are within the right-of-way and exclusion area), will be planted with Bermuda grass when they can sustain vegetation. Two ponds will be retained for operational dredging.

Prior to being pumped into the ocean, the effluent is retained in stilling basins on Oak Island. The effluent is then discharged through two 13-ft diameter, 2000-ft long pipes into the Atlantic Ocean.

A drainage canal parallels the west side of the discharge canal for about half its length on both sides of the Intracoastal Waterway. The drainage canal is about 75 ft wide at the bottom on the reactor side of the Intracoastal Waterway, and 50 ft wide at the bottom on the ocean side. The canal is described in greater detail in Section D.

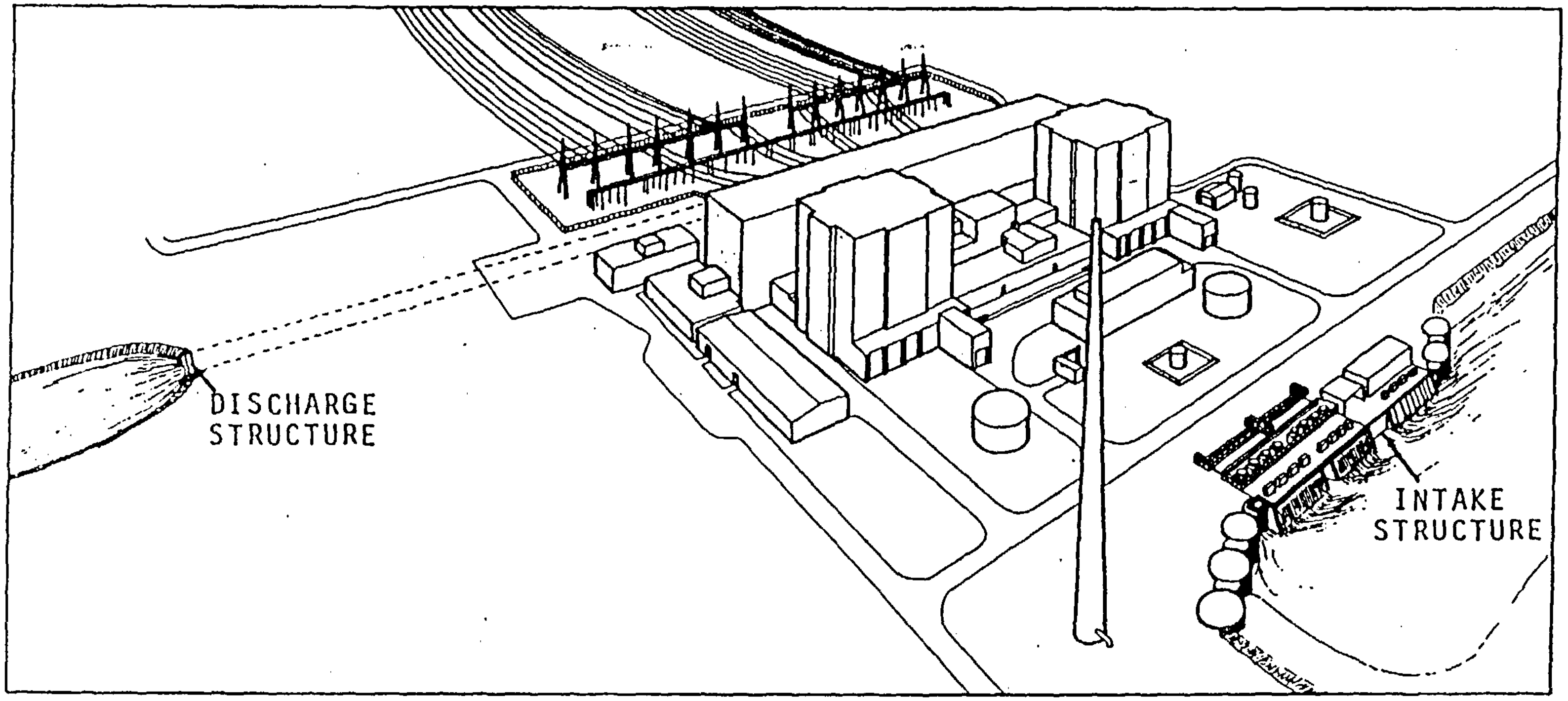

FIGURE III-1. ARTISTS" CONCEPTION OF THE BRUNSWICK STEAM ELECTRIC PLANT

B. TRANSMISSION LINES

1. Physical Features of System

The relative isolation of the plant from the major load centers in the applicant's service area, and the magnitude of the electrical energy being generated by the plant (1642 MW) combine to require about 358 miles of new transmission lines in 205 miles of new (or enlarged) transmission corridors. About 3500 acres of new land is required. The applicant plans to transmit the power via eight 230 kW lines as shown in Figure III-2. These eight lines occupy corridors of varying widths and lengths as shown in Figure III-3.

Each of the transmission lines will be supported by H-frame wooden structures extending about 65 ft above ground level. Approximately nine structures are required per mile per line. Two self-supporting steel towers 335 ft high are to be used in crossing Cape Fear River at Barnard Creek, south of Wilmington. Two other guyed steel towers will be used on each bank of the river at this location--one for each circuit (two circuits cross at Barnard Creek).

The discharge pumps on Oak Island will receive power over two 24 kV lines from the Caswell Beach 230/24 kV transformers in the plant switchyard to the pumping station. Each circuit will be buried in a 36-in. deep trench dug on top of the western dike of the discharge canal. The routing is entirely underground, including the crossing of the Intracoastal Waterway.

2. Basis for Transmission System Design

The criteria stated for transmission line location include:

- Provides adequate line reliability
- Minimum possible view by the general public
- Minimum crossing of lands where a line would interfere with normal land use development
- Avoids scenic or recreation areas
- Avoids unnecessary clearing of timber
- Avoids historical sites
- Prevents visibility down long corridors at road crossings

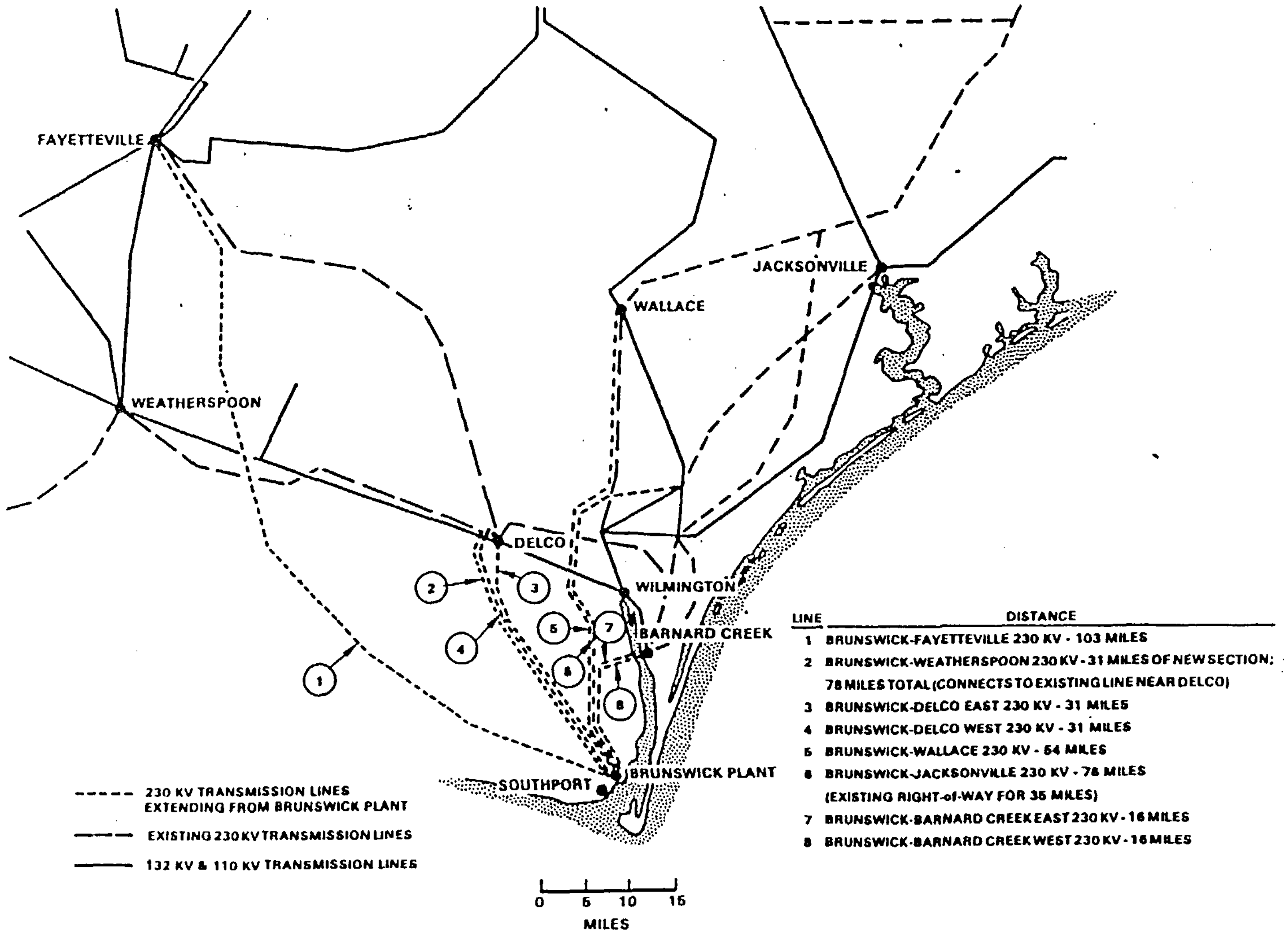

FIGURE III-2. TRANSMISSION SYSTEM FOR BRUNSWICK PLANT SHOWING MAJOR INTERCONNECTIONS (1975)

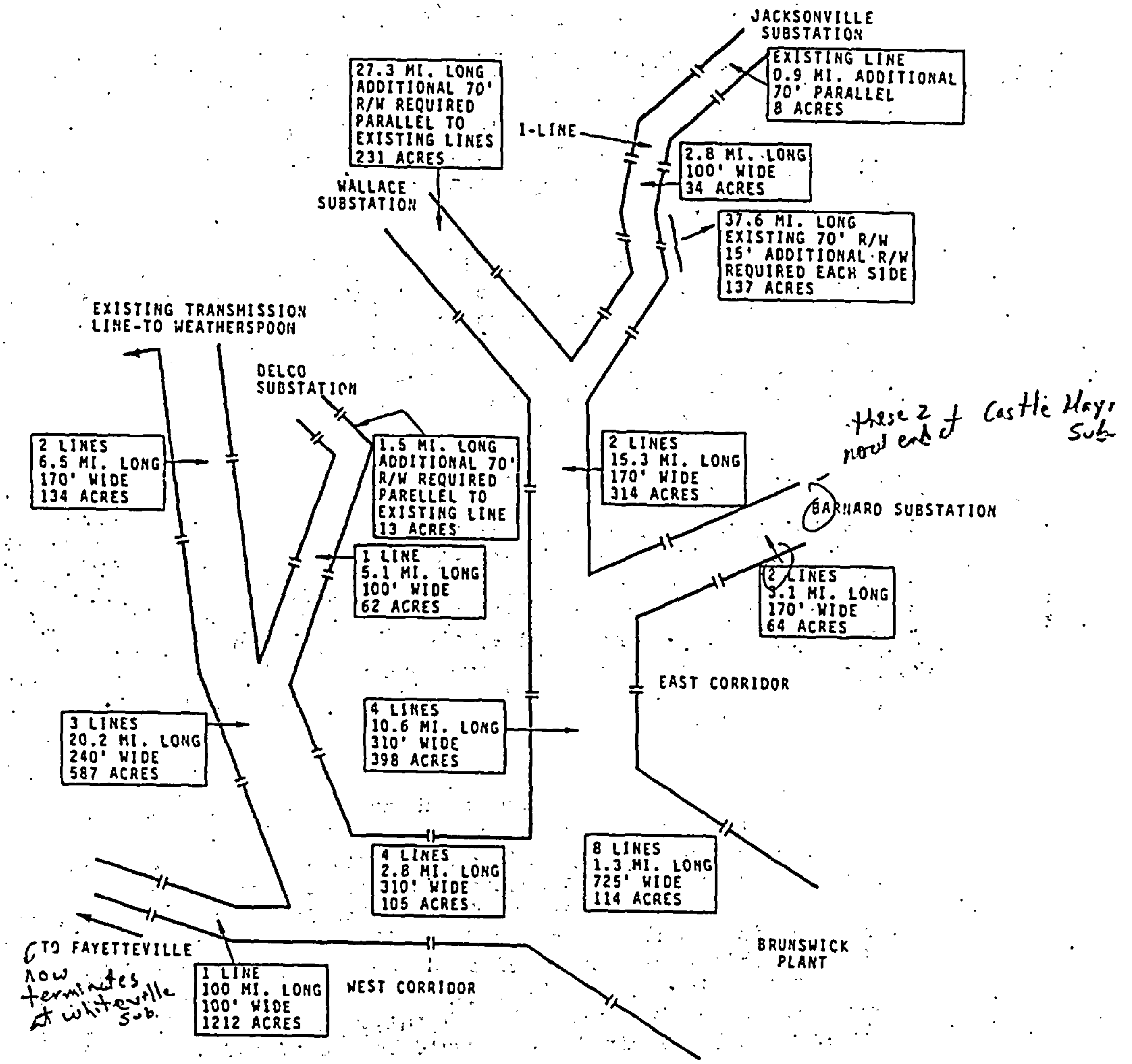

FIGURE III-3 TRANSMISSION LINE CORRIDORS - AREA REQUIRED

- Uses or parallels existing utility or railroad corridors
- Minimum line cost.[1]

All of these criteria can seldom be satisfied in any new transmission system especially one of the size and complexity needed for the plant. These criteria, and the applicant's adherence to them, are discussed in Section IV.C.2.

The applicant states that "reliability of service was considered by Carolina Power and Light to be of paramount importance in the design of the transmission system. The design criteria adopted were for a system which would assure that the plant generators would remain electrically stable under the severe condition of a three-phase electrical fault on one transmission line at the plant, simultaneous with a breaker failure."[1]

The applicant further states that:

"Various plant transmission designs were studied. An all 500 kV transmission scheme was considered, which included three 500 kV lines from the plant to the system grid. In addition, schemes for various combinations of 500 kV and 230 kV transmission were considered. These schemes included: four 230 kV lines and two 500 kV lines; five 230 kV lines and one 500 kV line; and three 230 kV lines and two 500 kV lines. An all 230 kV transmission scheme was also considered which involved seven 230 kV lines between the plant and the system grid.

"Load flow studies of the above schemes were made. These studies indicated that each of the above schemes had adequate transmission capacity to move the power into the system; however, when stability studies were run, it was determined that none of these schemes would meet the electrical stability criteria and that more transmission lines would be required by all of the plans. An analysis of the stability studies indicated that at least six 500 kV or eight 230 kV lines would be required to meet the stability criteria. For combination 500 kV and 230 kV the studies indicated that eight lines would be required. Six would be 230 kV and two would be 500 kV.

"The right-of-way requirements were less for eight 230 kV lines than any other acceptable plan by approximately 18%."[1]

The terminal points for the eight lines were selected from further load-flow studies. Having selected the number of lines and knowing the origin and terminal points, the actual corridors selected would be a matter of judgment guided by the preceding criteria.

3. Biological Environment

The applicant states that the 205 miles of right-of-way consists of 98 miles of loblolly pine or old fields and 92 miles of bottomland hardwoods and swamplands (see Section II.F.2). The remaining 15 miles is through agricultural land. This does not include the short crossings of the Orton Plantation or Holly Shelter Wildlife refuge (discussed in Section IV.C.2).

C. REACTOR AND STEAM-ELECTRIC SYSTEM

The reactor units in the Brunswick Plant are General Electric Company single cycle, forced circulation, boiling water reactors.[2] Each of the twin units has a design rating of 2436 MWt. Each electrical generator is rated at 847 MWe, with a net output to the grid of 821 MWe. Ultimately these power ratings are expected to be 2550, 880, and 855 respectively. The reactors are similar to Tennessee Valley Authority's Brown's Ferry Nuclear Power Station, Units 1 and 2; the Vermont Yankee Nuclear Power Station, Unit 1; and the Nebraska Public Power District's Cooper Nuclear Station.

United Engineers and Constructors, Inc., is the architect-engineer. Brown and Root, Inc. is the constructor.

D. EFFLUENT SYSTEMS

1. Thermal Waste Systems

Based upon evaluation of Cape Fear River data obtained from the U.S. Corps of Engineers, the North Carolina Department of Water and Air Resources, and others, the applicant initially selected a circulating water system consisting of a river intake and a river discharge (Figure I-3).

During the summer of 1968, the applicant conducted an investigation in the Cape Fear River that included temperature and salinity measurements and dye tracer studies to predict possible temperature distributions in the discharge vicinity. Results of this investigation indicated that 1) the maximum river water temperature would be 87°F (30.6°C) instead of 82°F (27.7°C) as preliminary data suggested, and 2) thermal recirculation of warm water discharged into the Cape

Fear River near Price's Creek would result in an increase in circulating water inlet temperature near Walden Creek of approximately 1.3°F(0.7°C)/821-MWe reactor unit.[1]

The applicant thought that the existing state water quality standards could have been met with the proposed design, but it was less certain that evolving Federal water quality standards could be satisfied. The possibility of utilizing an ocean discharge was then considered. Other options were also considered, including a cooling lake and dilution of the effluent with cooler water.

The applicant considered a high-level aqueduct to convey the effluent to the ocean. This design specified that the water level across Oak Island should be maintained at about 10 ft above the surrounding terrain to avoid the need for ocean discharge pumps. This design was considered infeasible because of the amount of marshland usage, the potential effect of downwelling on groundwater quality, the inability of the marsh to support the canal, and the additional head was still insufficient to move the discharge through 2000 ft of ocean discharge pipes with adequate terminal velocity to assure rapid mixing.[1]

In all the designs considered, there appeared to be two major areas of concern; the possibility of saltwater intrusion from the canals into the groundwater aquifers and the utilization of marshland by the canals or lakes.

In the present design, the intake canal is routed to take advantage of an existing cut running through Snow Marsh. To preserve productive marsh areas, the discharge canal is routed across the headwaters of Dutchman Creek and to the west of the creek. Stilling basins on both sides of the Intracoastal Waterway, an inverted siphon under the Intracoastal Waterway, an open canal across Oak Island, a pumping station on Caswell Beach, and high-velocity, horizontal, momentum-jet mixing discharge pipes in the ocean (Figures I-1 and I-3) are part of the present design. The plan also provides secondary drainage canals north and south of the Intracoastal Waterway to reroute creeks that are separated from normal flow patterns by the main canal. Drainage and tidal influences are, therefore, maintained in the upstream areas.[1]

A typical cross-section of the intake canal is in the form of an inverted trapezoid with a bottom width of 168 ft, a depth of 18 ft, and sides that slope to a width of approximately 400 ft at the top.

Cooling water is transported by gravity flow in a southwesterly direction to the plant about 3 miles from the start of the intake canal at the Cape Fear River ship channel.[1]

The applicant had planned to modify, subject to regulatory approval, the intake canal by installing sheet piling on both sides of the canal from the ship channel to high ground on the mainland. The applicant hoped that flow from Walden Creek and other shallow zones in the Snow Marsh area will thus be blocked from entering the intake canal. All cooling water will be drawn from the area of the ship channel.[3] Problems related to the siltation of Snow Marsh have suspended considerations of this plan.[7]

The intake and discharge structures at the reactor site and the circulating water tunnels between the intake structure, condenser, and discharge structure are being constructed of reinforced concrete. Coarse bar racks and traveling 3/8-in. mesh, vertical traveling screens are being provided to restrict some debris and marine life from entering the condensers.[1]

The design circulating water flow for the two units is approximately 1,300,000 gpm (2900 cfs). The increase in temperature of water passing through the condensers will normally range from 12 to 18°F (6.7 to 10°C), depending upon the output of electrical power. The estimated seasonal variation of the natural water temperature of the Cape Fear Estuary in the vicinity of the plant is shown in Figure II-10.[1]

The applicant estimates that temperatures in the discharge canal will drop up to 1 1/2°F (83°C) during the 5-hr travel time to the Caswell Beach pumping station. The remaining heat will be dissipated by mixing in the ocean.

Velocities in the plant intake canal will generally be in the range of 0.5-1.0 fps (velocities will vary with tide and number of pumps in operation). Velocities may approach 1.4 fps under very low water conditions.

Vertical traveling screens provided at the intake pumping bays are intended to prevent fish and shellfish of larger sizes from entering the condensers. A screen-wash system and sluice will also be provided; the sluice will consist of a series of small holding ponds at successively lower elevations between the plant and the river. Fish will be returned to the Cape Fear River downstream of the intake canal.[1]

Velocities in the plant discharge canal will be less than 2 fps to reduce erosion of canal banks and subsequent buildup of solid materials at the discharge to minimize the need for periodic dredging.[1] The cooling water will be discharged through the pumping station in a horizontal direction at a velocity of 10 fps through the two 13-ft diameter concrete pipes that terminate 2000 ft offshore from Oak Island.[4]

2. Radioactive Waste Systems

During the operation of the plant, radioactive materials will be produced by fission and by neutron activation reactions in metals and other material in the reactor coolant system. Small amounts of gaseous and liquid radioactive wastes enter the waste streams, which will be processed and monitored within the plant to minimize the radioactive nuclides that will ultimately be released to the atmosphere and into the Atlantic Ocean. The radioactivity that may be released during normal operation of the plant will be required to be in accordance with the Commission's Regulations, as set forth in 10 CFR Part 20 and 10 CFR Part 50.

a. Liquid Waste

The liquid radwaste treatment system will collect, process, store, monitor, and prepare for reuse or disposal all normally and potentially radioactive aqueous liquid wastes from both Units 1 and 2. The system is being designed to collect various types of liquid wastes separately so that each type of waste can be processed by those methods most appropriate to that type. Liquid wastes will be processed on a batch basis, and each batch sampled and analyzed to determine that the discharge requirements are met prior to release. Processed aqueous liquid wastes will be either returned to the condensate storage tank for reuse in the plant or released to the discharge canal after sampling and analysis and dilution with condenser circulating water. The sources of liquid waste and the system for processing these wastes are shown schematically in Figure III-4.

Radioactive and potentially radioactive liquid wastes will be collected and processed in four basic treatment subsystems comprising the liquid radwaste treatment system. These wastes will be collected and treated in (1) the equipment drain subsystem for low conductivity (high purity) wastes, (2) the floor drain subsystem for higher conductivity (low purity) wastes, (3) the chemical drain subsystem for solution wastes, or (4) the detergent drain subsystem for treating detergent wastes.

Tanks, equipment and piping which may contain liquid radioactive wastes will be enclosed within radwaste areas in buildings or tunnels. These areas will be drained to sumps which will return the liquid to the radwaste treatment system. The main components of the liquid radwaste system will be located in the radwaste building. Table III-1 lists the principal parameters used in evaluating the waste treatment systems.

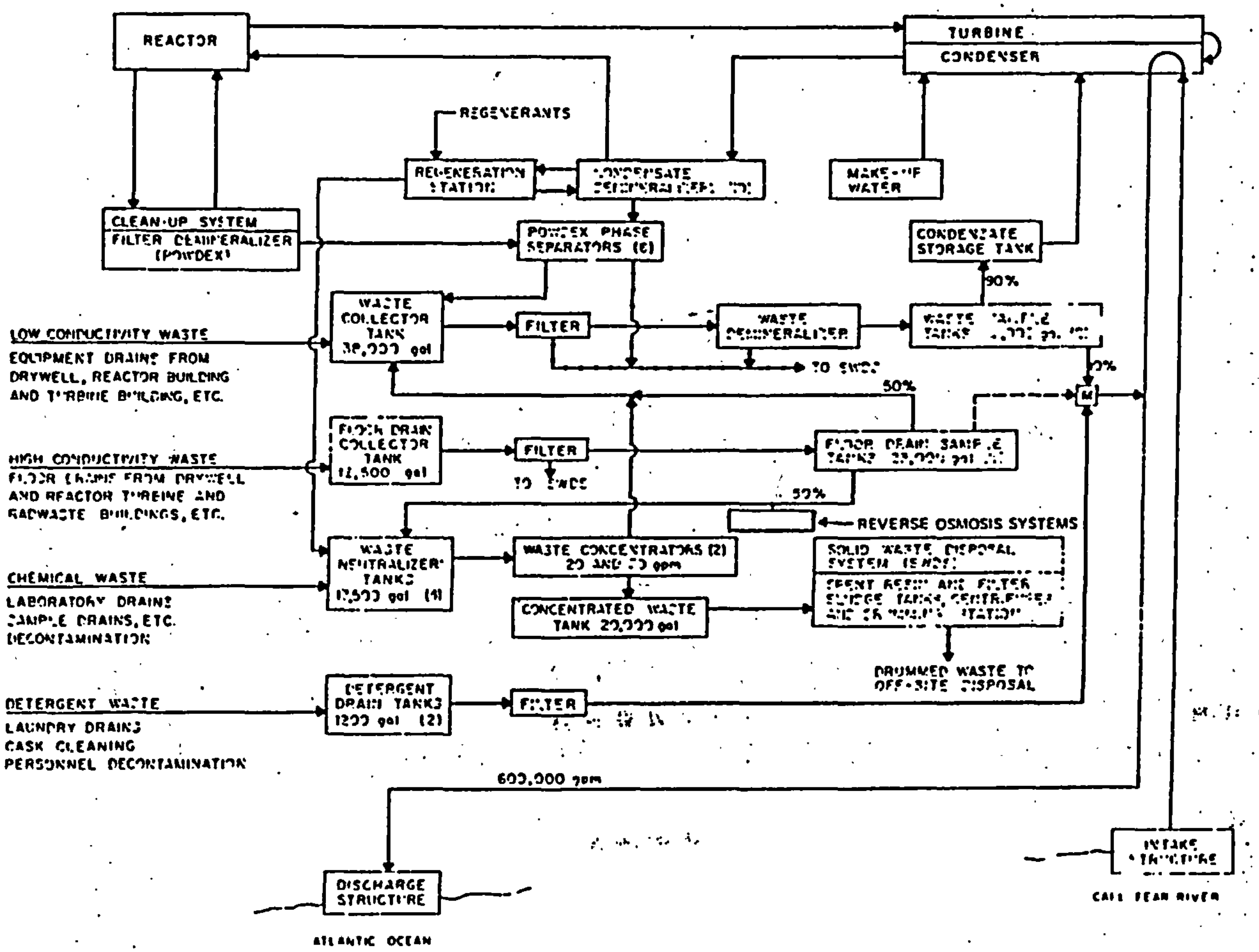

FIGURE III-4. LIQUID RADWASTE, BRUNSWICK PLANT, UNITS 1 and 2

TABLE III-1

ASSUMPTIONS USED IN CALCULATING RELEASES OF RADIOACTIVITY IN EFFLUENTS FROM BRUNSWICK STEAM ELECTRIC PLANT, UNITS 1 AND 2

Thermal Power	2,550 MW
Total Steam Flow	10,950,000 lb/hr
Plant Factor	0.8
Weight of Liquid in the System	409,000
Weight of Steam in the System	16,200
Cleanup Demineralizer Flow	100,000 lb/hr
Failed Fuel	Equivalent to 100,000 μCi/sec with 30 min hold for a 3,400 MWt Reactor
Leaks	
Reactor Bldg. Liquid	500 lb/hr
Turbine Bldg. Steam	1,700 lb/hr
Condenser Air Inleakage	20 cfm
Gland Seal Flow	10,950 lb/hr
Iodine Partition Coefficients	
Steam/Liquid in Reactor	0.010
Reactor Bldg. Liquid Leak	0.001
Turbine Bldg. Steam Leak	1
Gland Seal	1
Air Ejector	0.005
Fraction of Iodine Getting Through the	
Condensate Demineralizer	0.001
Cleanup Demineralizer	0.1
Gland Seal Condenser	0.01
Air Ejector Recombiner System	0.01
Holdup Times	
Gland Seal Gas	0.03 hr
Air Ejector Gas	0.5 hr
Cryogenic Holdup Time for	
Kryptons	90 days
Xenons	90 days
Cryogenic Effectiveness	
Kryptons	10^4
Xenons	4×10^3
Iodine	10^4
Holdup Times, Liquid Systems	
Clean Wastes	0.6 Days Filling 0.7 Days Processing
Floor Drains	0.7 Days Filling, 3 Days Processing
Chemical Wastes	4 Days Filling, 4 Days Processing

TABLE III-1 (Continued)

Decontamination Factors, Liquids System	
Clean Waste,	10^2
Except Cs and Rb	10
Floor Drains; 1/2 to Clean Waste and 1/2 to Chemical Wastes	
Chemical Wastes (Followed by Clean Waste),	10^6
Except I, Cs, Rb	10^5
Removal Factors to Account for Plateout for all Liquid Systems;	
Mo and Tc	100
Y	10

Low conductivity aqueous liquid wastes (high purity water) from piping and equipment drains will be collected in sumps. These wastes will be pumped to a waste collector tank (38,000 gal) and processed on a batch basis through a waste precoat filter and a mixed bed demineralizer (210 gpm) and then collected in the waste sample tanks (two at 23,000 gal each). Radioactive materials will be removed from the waste stream by the combination of filtration for removal of insoluble matter and ion-exchange for removal of soluble matter. Normally the wastes will be returned from the sample tanks to the condensate storage tank for reuse in the plant; however, a portion of this waste may be discharged to the environment.

The staff's evaluation considered a daily input into this system from the equipment drains of both units of 28,000 gal at about 42% of primary coolant activity. The staff further considered that 90% of this water would be recycled and that 10% would be discharged to the circulating water system. The annual release of radioactivity from this source was calculated to be approximately 0.5 Ci from each unit.

Aqueous wastes of moderate to high conductivity (low purity water) mainly from floor drains, will be collected in sumps and will be pumped to the floor drain collector tank (12,500 gal). From the floor drain tank the wastes will be processed on a batch basis, through a precoat type filter (210 gpm) and collected in a sample tank. After these processed wastes are sampled and analyzed, they will be routed to the waste collector for demineralization or to the neutralizer tank for evaporation.

The analysis of the staff considered a daily input into this system of 18,000 gal at 33% of primary coolant activity; one half to be processed through the waste demineralizer, the other half to be processed through the evaporator. The annual release from this subsystem was based on releasing 10% of each stream through the waste sample tanks after processing. This method of operation yielded annual releases of less than 0.5 Ci/unit.

Radioactive high conductivity chemical wastes such as condensate demineralizer regenerants, laboratory drains and chemical decontamination solutions will be collected in the waste neutralizer tanks (four at 17,500 gal each). The inputs to the chemical wastes were based on the use of the deep bed condensate demineralizers. The use of the Powdex[a] system would result in a lower input to the liquid waste system. The wastes will be neutralized and evaporated in two waste concentrators of 20 and 50 gpm capacity. The condensate from both will be routed to the waste collector system for further purification for reuse in the plant.

(a) Registered trade name

The staff's analysis considered a daily input into this system of the regeneration solutions from the condensate demineralizers and 1000 gal of other chemical waste at 50% of the primary coolant activity with 10% of the evaporator condensate released after processing through the waste collector system. The annual release from this source was calculated to be a small fraction of the wastes from other systems.

Liquid waste containing detergents or similar cleaning agents from the laundry drains and the fuel cask and personnel decontamination station drains will be collected in a detergent drain tank. Processing will consist of passing the wastes through the detergent drain filter to remove solids. Each batch will be sampled and analyzed and then discharged to the environment. The staff considers the potential effluents from the detergent system to be a negligible fraction of the wastes from the other systems.

Analysis by the staff indicates that annual releases from the primary sources for normal operation will be less than 5 Ci/unit. The applicant performed similar analysis and also calculated an annual release of less than 5 Ci. The values in Table III-2 have been normalized to 5 Ci/unit to compensate for equipment downtime and anticipated operational occurrences. Based on operating experience at similar reactors, the staff has estimated the tritium in liquid effluents will be about 20 Ci/yr.

b. Gaseous Wastes

During power operation of the facilities, radioactive materials released to the atmosphere in gaseous effluents include low concentrations of fission-product noble gases (krypton and xenon), halogens (mostly iodines), tritium contained in water vapor, and particulate material including both fission products and activated corrosion products. A simplified schematic of the various treatment systems is shown in Figure III-5.

The primary source of gaseous radioactive waste will be the noncondensible gases removed from the main condenser by the air ejector. These gases will consist of air which has leaked into the condenser, hydrogen and oxygen produced by the radiolytic decomposition of water, and very small volumes of radioactive gases (primarily krypton and xenon). Other sources include the noncondensible radioactive gases removed from the turbine gland seal condenser and the reactor, turbine, and radwaste building ventilation systems. Potentially radioactive gases include the off-gas removed from the main condenser during startup by the mechanical vacuum pump, and the offgas from purging the drywell and suppression chamber during shutdowns.

TABLE III-2

CALCULATED ANNUAL RELEASE OF RADIONUCLIDES IN THE LIQUID EFFLUENT FROM ONE UNIT OF BRUNSWICK STEAM ELECTRIC PLANT, UNIT 1 OR 2

Nuclide	Ci/yr/unit	Nuclide	Ci/yr/unit
Rb-86	0.00039	Te-132	0.043
Sr-89	0.18	I-130	0.0029
Sr-90	0.011	I-131	0.26
Sr-91	0.15	I-132	0.047
Y-90	0.072	I-133	0.54
Y-91m	0.10	I-135	0.14
Y-91	0.58	Cs-134	0.19
Y-93	0.85	Cs-136	0.063
Zr-95	0.0020	Cs-137	0.15
Zr-97	0.0017	Ba-137m	0.13
Nb-95	0.0018	Ba-140	0.29
Nb-97m	0.0016	La-140	0.15
Nb-97	0.0017	Ce-141	0.0055
Mo-99	0.22	Ce-143	0.0052
Tc-99m	0.20	Ce-144	0.0012
Ru-103	0.0013	Pr-143	0.0021
Ru-106	0.00041	Pr-144	0.0012
Rh-103m	0.0013	Nd-147	0.00069
Rh-105	0.0015	Pm-147	0.00015
Rh-106	0.00041	Cr-51	0.032
Sn-125	0.000011	Mn-54	0.0025
Sb-125	0.000007	Fe-55	0.12
Sb-127	0.00010	Fe-59	0.0050
Te-125m	0.000055	Co-58	0.32
Te-127m	0.00035	Co-60	0.032
Te-127	0.0013	P-32	0.0012
Te-129m	0.0035	Zn-65	0.000062
Te-129	0.0022	W-187	0.062
Te-131m	0.0046	Np-239	0.029
Te-131	0.0085		

Total (per Unit) ~5 Ci
Tritium (per Unit) 20 Ci

In each unit the gases removed from the main condenser by the air ejectors will be processed in a gas delay system consisting of: a 30 min. holdup pipe; a catalytic H_2-O_2 recombiner to reduce the volume of gases to be treated; a condenser to remove the water vapor; a compressor and a 7.8-minute holdup pipe to permit the decay of short-lived radioactive gases; a high efficiency particulate air (HEPA) filter; a liquid N_2 cooled cryogenic distillation system wherein most of the xenons and kryptons will be collected in the liquid oxygen "bottoms;" a charcoal adsorber; and a second HEPA filter. The gases will be released to the environs through the 100-meter, main off-gas stack. The xenons and kryptons will accumulate and hold in the "bottoms" for approximately 90 days. Then most of the "bottoms" (mainly liquid oxygen) will be gradually bled off to another hydrogen-oxygen recombiner where the oxygen will be combined with added hydrogen to form water vapor. The water vapor will be condensed and transferred to the liquid radwaste treatment system. The remaining gases, principally xenons and kryptons, will be stored in pressurized cylinders for further decay. The contents of the cylinders will be released under controlled conditions to the environs as indicated in Figure III-5.

Primary system steam will be used in the turbine gland seal system; hence the gases released from the turbine gland seal condenser can be radioactive. These gases will be held up approximately 1.8 minutes before being exhausted into the off-gas stack without further treatment.

During unit startup, air and any radioactive gases present will be removed from the main condenser by a mechanical vacuum pump. These gases will be discharged through the same holdup pipe into which the turbine gland seal condenser exhausts. These gases will be released through the main vent stack without further treatment.

The ventilation air from the reactor building will be discharged through the reactor building vent without treatment. The flow will be monitored, and the building will be isolated if the activity exceeds a predetermined level. During building isolation, air flow will be reduced to 3000 cfm and directed through the standby gas treatment system (SGTS) before release through the main stack. The SGTS will consist of a prefilter, a HEPA filter, a charcoal adsorber, and another HEPA filter in series.

The drywell and suppression chambers will be isolated during normal reactor operation. However, during shutdowns and startups these areas will be purged, with the gases exhausting through the standby gas treatment system, or directly to the main stack if the activity is below a predetermined level.

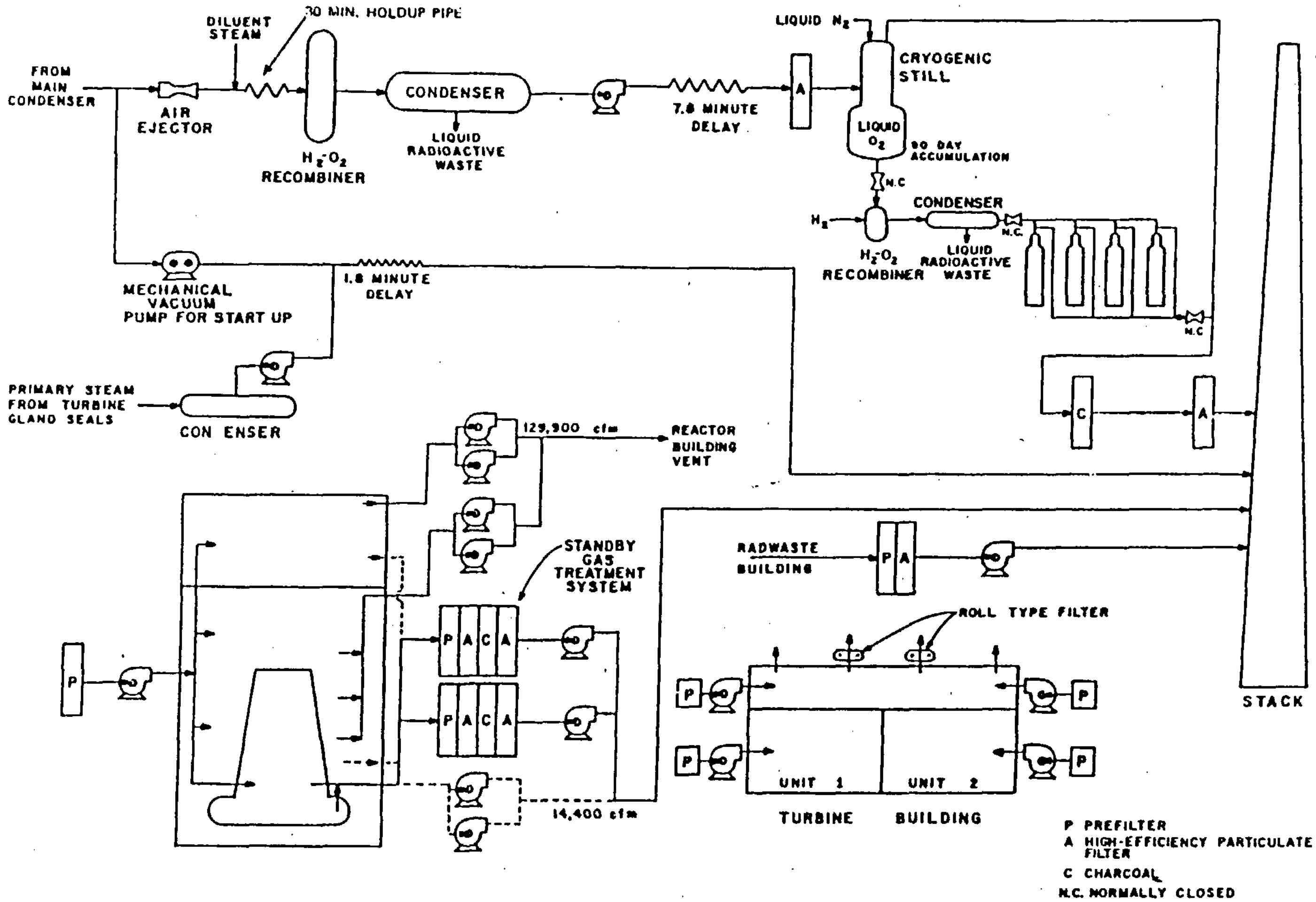

FIGURE III-5. GASEOUS WASTE AND VENTILATION SYSTEMS, BRUNSWICK PLANT, UNITS 1 and 2

The turbine building ventilation system will utilize area cooling coils to assist in cooling the turbine building thereby reducing the volume of air required for ventilation. The lower volume of exhaust air makes it practical for all of the turbine building exhaust air to be passed through HEPA filters and charcoal adsorbers before being continuously released through monitored vents. The charcoal adsorbers will be of sufficient depth to provide a residence time of 0.25 seconds and an iodine removal efficiency of 90%.

Units 1 and 2 have separate waste gas treatment and ventilation systems as shown in Figure III-5. However, the final HEPA filter in each of the waste gas treatment systems is connected to a common spare standby HEPA filter. The station has one off-gas stack.

Table III-3 lists the results of the staff's calculations of annual gaseous effluents based upon the assumptions listed in Table III-1. This table shows an annual per-unit release of noble gases of about 11,000 Ci/yr. The applicant has estimated annual releases based on use of the augmented off-gas system of about 8,000 Ci/yr/unit.[5] The difference between these estimates is not considered significant. The staff estimate is used in subsequent calculations. Table III-3 also shows a calculated I-131 release of 0.37 Ci/yr for each unit.

c. <u>Solid Radwaste</u>

The solid radwaste system is a contiguous part of the liquid radwaste system and is located in the radwaste building. The system will process wet and dry solid wastes.

Because of physical differences and differences in radioactivity or contamination levels, various methods will be employed for processing and packaging the solid radwastes. Wet wastes will be dewatered and packaged in 55-gal steel drums. Dry wastes will be compacted to reduce free volume and packaged in 55-gal steel drums, or other approved shipping containers, as applicable. Each type of waste will be kept segregated to reduce shielding requirements during storage and shipping.

Shielded areas will be provided for drum processing and temporary storage. Wet wastes will be drummed semi-remotely to reduce radiation exposure to personnel. It is expected that most of the dry wastes will be sufficiently low in radioactivity to allow manual handling. Wash-down facilities with floor drain return to the liquid radwaste system will be provided.

disposal. Certain solids will be decontaminated by cleaning methods which are required to reduce contamination and exposure levels prior to packaging. If cleaning is not practicable or feasible, high level wastes will be packaged and temporarily stored to permit decay.

Most wastes, however, will be of relative low radioactivity, handled manually and collected locally in fiber drums, cartons, or boxes. All containers are monitored as filled for control purposes. Compressible wastes will be compacted in 55-gal steel drums by a hydraulic press in the solid waste disposal area of the radwaste building. All solid wastes will be packaged and shipped to a licensed burial ground in accordance with AEC and Department of Transportation regulations.

The staff anticipates annual shipments from both units of about 600 drums of resins and filter material containing a total of about 500 Ci, and about 900 drums of solidified evaporator bottoms. The activity in any drum is not expected to exceed 80 Ci.

3. Chemical and Sanitary Waste Systems

The normal operation of the power plant requires the use of certain chemicals, some of which are discharged ultimately into the Atlantic Ocean via the circulating water discharge canal. These chemicals serve various functions, including (1) the production of high purity water, and (2) biological growth control in the cooling water circuits.

Table III-4 lists the nonradioactive chemical discharges from the station. A discussion of the significant chemical waste effluents is given below.

a. Water Treatment Wastes

Water is pumped from two wells drawing from the Castle Hayne aquifer at an average depth of about 150 feet. The raw well water is pumped through a series of ion exchange demineralizers and degasifiers to produce the plant's domestic and steam generator makeup needs. The ion exchange unit sorb the ionic impurities in the well water such as sodium, magnesium, chloride, and sulfate; and when the capacity of the ion exchange beds to remove those chemicals is exhausted, the beds are regenerated by treating them with sulfuric acid and sodium hydroxide solutions. The spent regenerant acid and caustic solutions, containing the desorbed ionic impurities, are routed to a holding tank along with water flushes where they are mixed, adjusted to about pH 7. These neutral salt wastes are then released to the discharge canal.

The neutralized waste has a composition approximately as shown in Table III-4. The demineralizer system discharges a total of about 100 tons of solids annually, mostly sodium sulfate, into the Atlantic Ocean.

b. Biocides

Circulating and service water systems are chlorinated periodically (1/2 hour for each condenser half each 8 hours) to control the growth of biological species which flourish in the intake structures, the circulating water tunnels, and on the warm heat exchanger surfaces, restricting the flow of cooling water through the equipment and reducing the effectiveness of the heat transfer function of the cooling systems. Chlorine gas is diffused into the seawater in the intake structures and circulated throughout the entire cooling water circuit. The frequency and amount of biocide used is dictated by the condition of the cooling circuits and by seasonal variations, with the warmer summertime water temperatures promoting the more rapid ingrowth of the fouling organisms. The chlorine addition rate is adjusted to match the existing chlorine demand of the seawater such that the chlorine residual, measured at the condenser outlet, is maintained at less than 0.5 mg/l.

Based on the mixing occurring during the 5-hour travel time from the condenser to the ocean outfall, and on the operating experience at other plants, the applicant estimates that the peak residual chlorine concentration of the cooling water discharged to the ocean will be less than 0.1 mg/l.

c. Laundry Wastes

Detergent wastes from the radioactive laundry operation are collected in the detergent drain tank. These wastes will be monitored for radioactivity and released to the discharge canal if less than applicable discharge limits.

d. Sanitary Wastes

The domestic wastewater treatment system will be designed to treat a minimum of 7500 gal/day of domestic sewage having a 5-day Biological Oxygen Demand (BOD) of 20 lb/day. The extended aeration process will be used to treat the sanitary sewage that is collected. The raw domestic sewage contains approximately 300 mg/l of 5-day BOD. It will enter an aeration tank where it will be mixed with activated sludge and continuously aerated by air supplied at a minimum rate of 2100 cu. ft of air per pound of 5-day BOD in the domestic sewage. The mixed liquor then passes to a sludge holding tank that collects

TABLE III-4

NONRADIOACTIVE CHEMICAL DISCHARGES[6]

Descriptions	Source	Discharge Point	Discharge
Treated Sanitary Waste-Liquid	Sewage Treatment Plant	Discharge Canal	2,000,000 gal/yr treated waste with 30 mg/1 5-day BOD, 1 ppm chlorine, 20 ppm suspended solids, 6.0 to 8.0 pH
Makeup Water Demineralizer Regeneration Waste-Liquid	Makeup Water Treatment Plant	Discharge Canal	4,750,000 gal/yr well water with 5,000 ppm total dissolved solids as Na_2SO_4 treated in normalizing tank to 7.0 pH
Service Water Chlorination for Algae and Slime Control	Chlorination System	Discharge Canal	600,000,000 gal/yr sea water with 0.5 ppm residual chlorine
Main Condenser Cooling Water Chlorination for Algae and Slime Control	Chlorination System	Discharge Canal	624,000 gpm sea water with 0.5 ppm residual chlorine 30 minutes, twice per day

the large particles of sludge and continues to aerate the liquor. The liquor enters the final settling tank where the settled activated sludge is continuously returned to the aeration tank by air lifts. The clarified liquid leaves the final settling tank and enters the chlorine contact tank where it is treated with chlorine solution. It is then discharged as treated effluent with a BOD less than 30 mg/l into the circulating water discharge canal. Descriptions, sources, and discharge points for all chemical releases from the plant are listed in Table III-4.

4. Other Waste Systems

a. Oil and Grease

Pipelines from floor drains where oil and grease can enter are equipped with traps. The turbine-lube oil tanks are placed in concrete moats that are equipped with sumps to permit collection. The collected oil and grease is periodically removed for disposal.

b. Storm Drainage

Roof drains from the turbine building, administration building, and radwaste building and some drains in the turbine building service areas will flow by gravity into the storm-drain system which will discharge eventually into the Cape Fear River. Noncontaminated equipment drains and floor drains located on the operating level of the turbine building will also discharge into the storm-drain system.[2]

c. Auxiliary Boiler Emissions

Combustion products will be released to the atmosphere during occasional use of two auxiliary oil-fired boilers. Both boilers will be fired with No. 2 fuel oil but will have the capability to use No. 6 fuel oil if No. 2 oil is not available. Estimated atmospheric emissions are given in Table III-5

TABLE III-5

ESTIMATED EMISSIONS FROM AUXILIARY BOILERS[1,2,3]

Emission Type	Average Emission[4] (tons/yr)	Maximum Emission[5] (lbs/hr)
Particulates	31	14
Sulfur Oxides	118	55
Carbon Monoxide	8	4
Hydrocarbons	6	3
Nitrogen Oxides	164	76

[1]U.S. Environmental Protection Agency, Office of Air and Water Programs, 1973. "Compilation of Air Emission Factors," Second Edition, AP-42, Research Triangle Park, North Carolina.

[2]Letter from J. A. Jones, CP&L, to J. F. O'Leary, USAEC. Response to EPA Comments, page 42.

[3]No. 2 fuel oil with 0.4 percent sulfur.

[4]Total annual fuel oil consumption: 4.102×10^6 gal/yr.

[5]Minimum rate of fuel oil consumption: 954 gal/hr.

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1. Carolina Power and Light Company, "Answer to Order to Show Cause and Supplemental Information in Support of Answer to Order to Show Cause," vol. I, II and III, December 15, 1971.

2. Carolina Power and Light Company, Brunswick Steam Electric Plant, Units 1 and 2, Preliminary Safety Analysis Report, vol. I, II and III with Amendments 1-10 last dated, August 18, 1969.

3. Carolina Power and Light Company, Brunswick Steam Electric Plant, Units 1 and 2, Environmental Report, Docket Nos. 50-324 and 50-325, Amendment No. 4, September 25, 1972.

4. Carolina Power and Light Company, Brunswick Steam Electric Plant, Units 1 and 2, Environmental Report, Docket Nos. 50-324 and 50-325, November 4, 1971.

5. Letter, Sherwood H. Smith, Jr., Carolina Power and Light, to E.J. Bloch, May 5, 1972.

6. Carolina Power and Light Company, Brunswick Steam Electric Plant, Units 1 and 2, Environmental Report, Docket Nos. 50-324 and 50-325, Amendment No. 2, August 14, 1972.

7. Letter J. A. Jones to J. F. O'Leary dated July 20, 1973.