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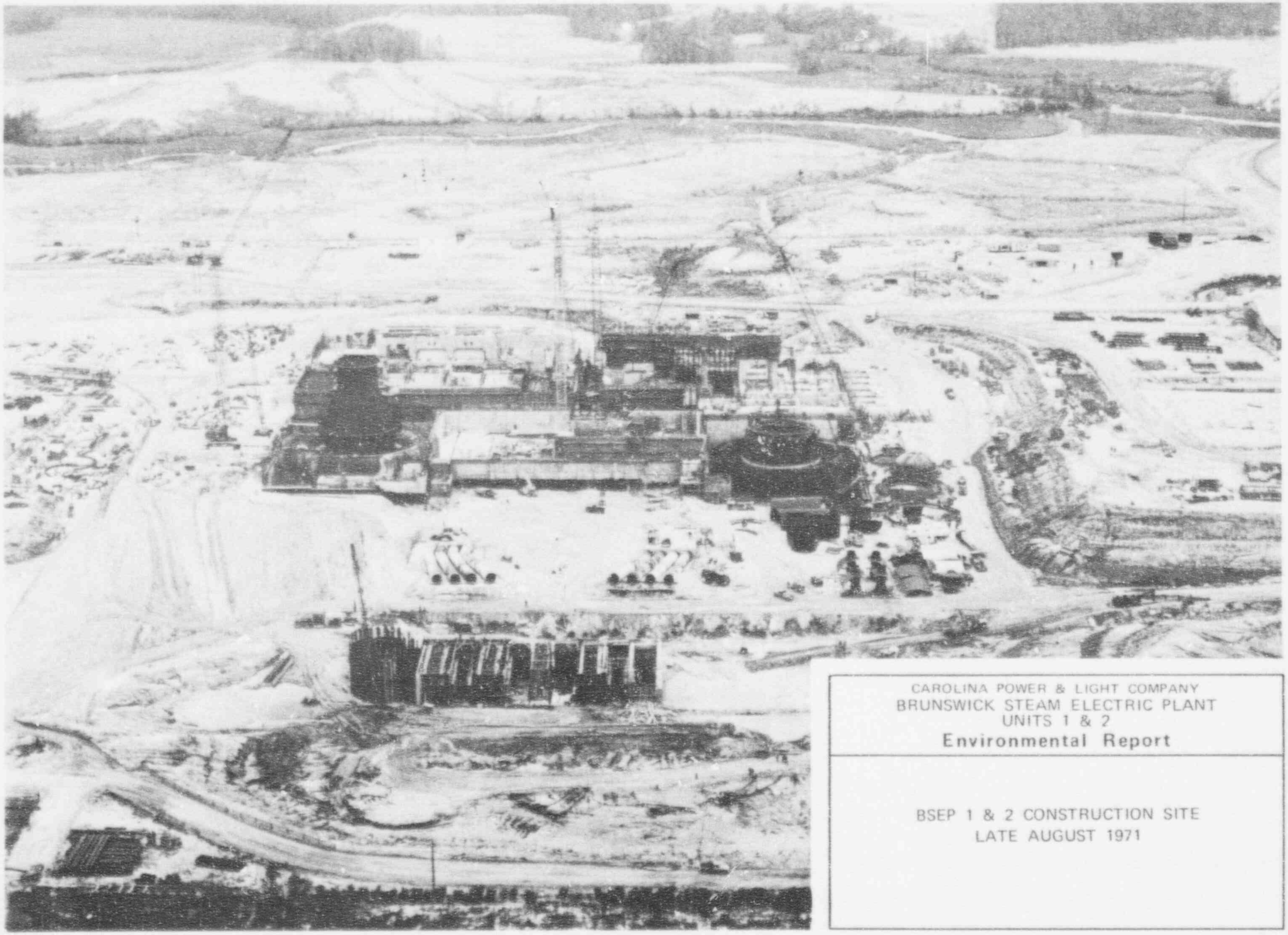
ENVIRONMENTAL REPORT

Carolina Power & Light Company

BRUNSWICK STEAM ELECTRIC PLANT

UNITS 1 & 2



CAROLINA POWER & LIGHT COMPANY
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UNITS 1 & 2
Environmental Report

BSEP 1 & 2 CONSTRUCTION SITE
LATE AUGUST 1971

FOREWORD

The Carolina Power & Light Company (CP&L) has a mandate, in common with all public utilities, to make every reasonable effort to satisfy the electric power needs of its service area.

The demands for electric energy within the CP&L service area are growing at a rate matching the expansion of the area's economy. CP&L is constructing the present project, the Brunswick Steam Electric Plant - Units 1 and 2 which comprises two boiling water nuclear reactor steam generators, to add generating capacity to help meet the needs for electric energy required in 1974 and beyond.

This report has been prepared to define and illustrate the compatibility of the Brunswick Steam Electric Plant with its environs. In the preparation of this report, CP&L has followed the "Draft -- Guide to the Preparation of Environmental Reports for Nuclear Power Plants," issued in February 1971 by the U.S. Atomic Energy Commission for comments and interim use, as supplemented by the "Scope of Applicant's Environmental Reports with Respect to Transportation, Transmission Lines, and Accidents", issued September 1, 1971 by the USAEC.

Carolina Power & Light illustrates in this report that its Brunswick Steam Electric Plant is in full compliance with the letter and the spirit of the National Environmental Policy Act of 1969 (PL 91-190) as implemented by U.S. Atomic Energy Commission's regulations set forth in Appendix D to Part 50 of Title 10 of the Code of Federal Regulations, published in the Federal Register on September 9, 1971.

BRUNSWICK STEAM ELECTRIC PLANT
UNITS 1 & 2
ENVIRONMENTAL REPORT
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1. Introduction

1.1 Objectives and Implementation

Carolina Power & Light Company (CP&L) is undertaking a program of expanding its generating capacity in order to meet the increasing electric power demands in its service area. The Brunswick Steam Electric Plant Units 1 and 2 (also referred to as BSEP, BSEP 1 & 2, or Brunswick Plant) are an integral part of CP&L's current expansion program. When completed, the two units of the plant will generate 1,642 megawatts of electric power.

Carolina Power & Light Company has an extensive background in the design and operation of nuclear power plants. The Company's first nuclear venture, the Carolinas-Virginia Nuclear Power Plant, at Parr, South Carolina, achieved sustained commercial operation in 1964, and was based on design work dating back to the early beginnings of the nuclear power industry in 1956. CP&L has demonstrated its management, technical, and operational skills both in the Parr Nuclear Plant, which was entered into in conjunction with neighboring utilities, and in the H. B. Robinson Unit No. 2, a 700 MWe nuclear unit which became operational in 1971. The design of the Brunswick Plant has been thoroughly reviewed by the USAEC, under the guidance of the Division of Reactor Licensing, as a part of their determination whether or not the plant should be permitted to be constructed. A number of federal and private organizations were asked to contribute their findings to this determination. In addition, the State of North Carolina and local agencies also conducted inquiries, and made determinations, regarding design and operating features of the Brunswick Plant.

The nuclear steam supply systems used in the BSEP are provided by the General Electric Company and are similar to those used in BWR nuclear power plants both in the United States and overseas.

United Engineers & Constructors Inc. is the architect-engineer for the Brunswick Plant. United Engineers & Constructors Inc. has been an active participant in the engineering and/or construction of a number of power plants over the last 44 years, representing an aggregate generating capacity in excess of 10,000 megawatts.

Brown & Root, Inc., one of the world's largest constructors, is the constructor of the Brunswick Plant.

In order to provide sufficient data for a knowledgeable evaluation of the impact of the site environs on the plant and of the plant on the environs, Carolina Power & Light Company has conducted extensive studies of the site environs in such fields as geology, seismology, meteorology, hydrology, zoology and demography. A number of nationally recognized consultants from pertinent disciplines have been retained by CP&L to perform numerous studies to investigate the compatibility of the Brunswick Plant with the local environs. They are identified in Table 1.1-1.

In the U.S. Atomic Energy Commission's evaluation of the Brunswick Steam Electric Plant Units 1 and 2, they have utilized both their staff and outside consultants in specific disciplines. Other federal agencies provided consultation and review for a wide spectrum of environmental subjects.

1.2 Summary Description of Site and Plant

The Brunswick Steam Electric Plant is located in Brunswick County, North Carolina, approximately 2½ miles north of Southport, and approximately 9,000 feet west of the Cape Fear River, as identified in Figures 1.2-1 and 1.2-2. This county is predominately rural, with some 18 percent of the land under cultivation. The terrain is generally flat, and a significant part of the county is covered by swamps and marshes.

Figure 1.2-3, an aerial photograph of the site, shows that there are no dense population areas within a distance of 2 miles from the plant. The nearest metropolitan area, Wilmington, North Carolina, whose outskirts begin 16 miles northeast of the plant, is also the nearest industrial center. According to the 1970 census, the population of Wilmington is 46,169 and of Southport 2,220.

Geologically, the plant is founded on a very dense sand which rests on a deep limestone formation, the Castle Hayne. Historical records indicate that the area is not seismically active. The most severe local seismic event on record was the effect of the Charleston, South Carolina quake of 1886, and had a local intensity of VI on the Modified Mercalli Scale.

Generally, the Cape Fear climate is mild all year, being moderated by the nearby Gulf Stream.

The most severe storm on record as measured by the Central Pressure Index was Hurricane Helene which occurred in 1958 and passed off-shore of the site at a distance of 80 miles. Although tornadoes have been known to occur in the area, they do not frequently pass through the coastal area of North Carolina.

The Brunswick Steam Electric Plant Units 1 and 2 utilize direct-cycle, forced circulation, boiling water reactors to produce steam for direct use in steam turbines.

As in a conventional steam power plant, the turbines drive electric generators, and the spent steam leaving the turbines is condensed in the main condenser, which transfers the heat of the steam to cooling water taken from the Cape Fear River via the intake canal. After being used to condense steam in the main condenser, the cooling water is discharged into the Atlantic Ocean via the discharge canal.

Each electric generator is rated at 847 MWe, with a net output to the system of 821 MWe.

The plant equipment is housed in a compact cluster of structures which provide an aesthetically pleasing appearance. An artists sketch of the plant is shown in Figure 1.2-4. Each reactor is housed in its own Reactor Building. The two turbine generators and associated main condensers are installed in a single Turbine Building structure, immediately adjacent to both Reactor Buildings. The Control Building contains the control room for both units and communicates directly with the Turbine Building and the common Radwaste Building.

The Diesel Generator Building, which is situated nearby, houses the diesel generators that supply emergency power in the event of failure of on-site and off-site power sources. Two intake pump structures, several small auxiliary structures and a 100-meter plant stack complete the plant grouping.

1.3 Project Schedule

Carolina Power & Light's Brunswick Plant construction schedule requires that one unit be completed and begin inservice (commercial) operation in March, 1974, while the other unit is still under construction. The other unit is scheduled to begin inservice (commercial) operation one year later, in March, 1975. At the present time (Autumn, 1971) the project is on schedule. The following schedule includes significant project schedule dates for the units.

Significant Project Schedule Dates

	Unit No. 2	Unit No. 1
1) Submittal of Final Safety Analysis Report (FSAR)	Jan. 72	Jan. 72
2) Receipt of Facility Operating License	9-1-73	9-1-74
3) Initial Core Loading	9-1-73	9-1-74
4) Inservice (commercial) operation	3-1-74	3-1-75

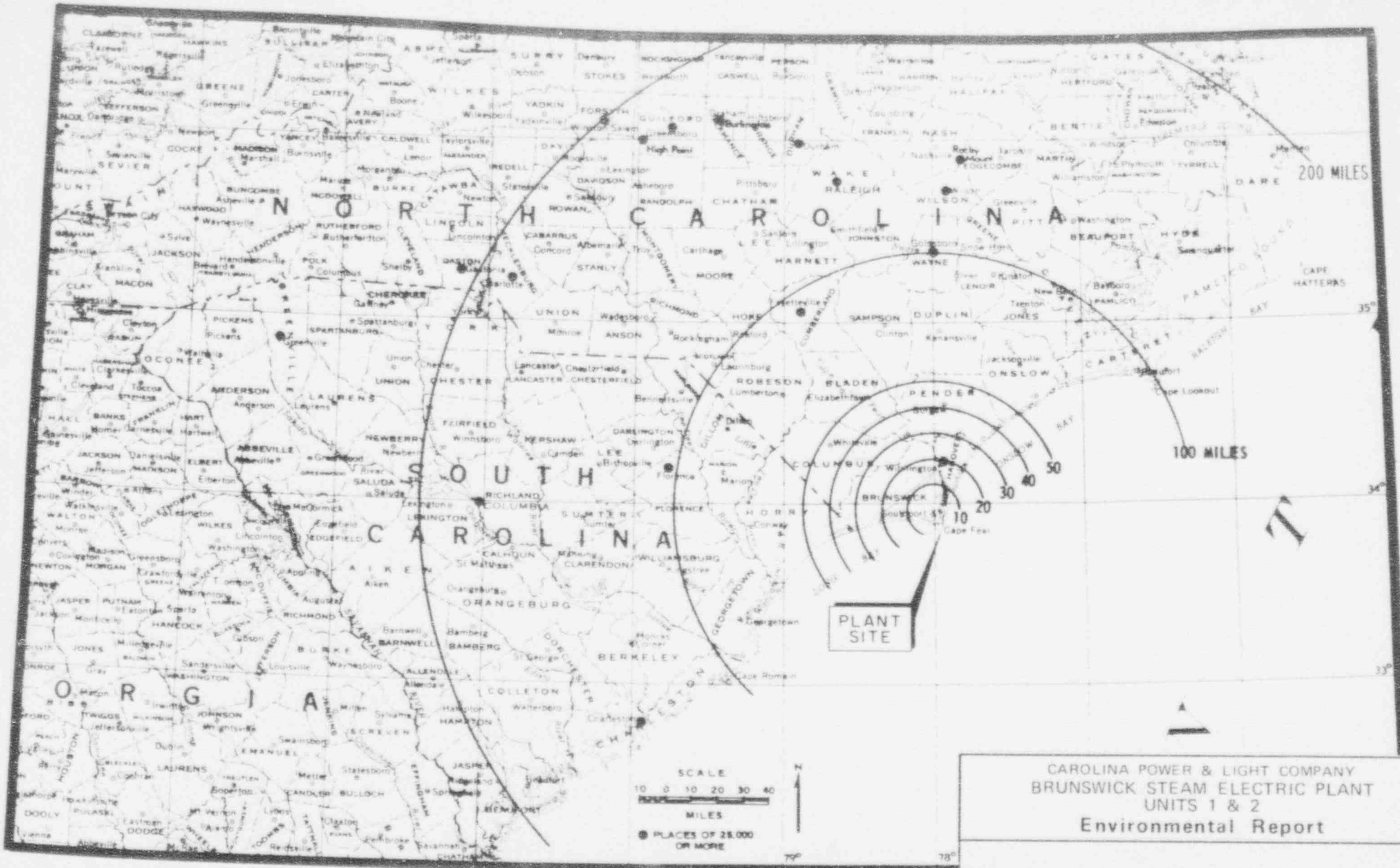
Carolina Power & Light estimates that the Brunswick Plant, including fuel, will cost approximately $425,729,000.

A recent (late August 1971) photograph of the site, shown on the frontispiece, indicates the current status of construction of the project.

TABLE 1.1-1

CONSULTANTS

	Discipline	Consultant
a)	Seismic Design	Hansen, Holley & Biggs (Massachusetts Institute of Technology)
b)	Soils Mechanics and Foundation Engineering	E. D'Appolonia Consulting Engineers, Inc.
c)	Geology	Dr. J. L. Stuckey (NC State Geologist, ret.)
d)	Hydrometeorology	R. O. Eaton T. E. Hauessner
e)	Marine Biology	Dr. B. J. Copeland Dr. J. E. Hobbie (NC State University)
f)	Meteorology	NUS Corporation
g)	Oceanography	Dr. J. H. Carpenter (Johns Hopkins University)
h)	Seismic Response Spectra	Dr. C. Allin Cornell Prof. R. V. Whitman (Massachusetts Institute of Technology)
i)	Seismology	Weston Geophysical Research, Inc.
j)	Site & Demography	NUS Corporation
k)	Radioecology	Dr. D. S. Grosch (NC State University)



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UNITS 1 & 2
Environmental Report

GENERAL SITE LOCATION

FIG. NO. 1.2-1

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PLANT AND SURROUNDING AREA

FIG. NO.	1.2-3

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2. Site and Plant Description

2.1 Site Description

2.1.1 Location

The Brunswick site is located in the southeastern portion of North Carolina in Brunswick County, approximately 135 miles SSE of Raleigh, North Carolina, 175 miles due east of Columbia, South Carolina and 150 miles NE of Charleston, South Carolina, as shown in Figure 1.2-1. The site is 16 miles south of the nearest boundary of Wilmington, North Carolina, in adjacent New Hanover county, and 2½ miles north of Southport. Approximate coordinates of the reactor buildings are latitude 32° 57.5' N and longitude 78° 00.5' W.

The site region is influenced by the Atlantic Ocean, which bounds the southern edge of Brunswick County, and the Cape Fear River, along the eastern border. The site is approximately 5 miles west and north of the Atlantic Ocean.

Topography in the site region is typical of the Atlantic Coastal Plain with low relief, as shown in Figure 1.2-3. Elevations range from sea level to about +30 feet mean sea level (MSL).

2.1.2 Land Use

2.1.2.1 Agricultural Land Use

Land within a 50 mile radius of the site 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 percent of the land area is under cultivation, most farming is in the southwestern section. The nearest dairy farm is approximately 11 miles NNE from the site.

2.1.2.2 Industrial Land Use

Industrial activity in the Cape Fear region is centered on the fertilizer, paper, chemical and synthetic fiber industries. Fertilizer companies are located in the vicinity of Navassa, 20 miles north of the site near Wilmington; representative companies are Armour, Mobil, Royster, Borden and W. R. Grace. Most of the industrial plants in the area are located north of Wilmington upstream on the Cape Fear River and the Northeast Cape Fear River.

Sunny Point Army Terminal, which is located some 4½ miles north of the site, 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 300 longshoremen during loading operations depending on the number of ships being loaded.

Ships are loaded at three separate piers located approximately 3400 feet apart such that explosion at one pier would not lead to explosion at an adjacent pier.

Exclusion boundaries have been established for this operation. The furthest exclusion distance in the direction of the Brunswick Plant is the K-70 line. The K-70 boundary is based upon damage estimates of less than 0.1% of the replacement cost of frame dwellings, and upon the effects of an explosion of the largest concentration of explosives allowed at this site (7 million pounds High Explosives). It extends approximately 13,390 feet from the pier. The Brunswick Plant structures are located at least an additional 5,300 feet from the edge of the Sunny Point K-70 line.

The interaction between BSEP and Sunny Point Terminal has been thoroughly investigated by Carolina Power & Light, the USAEC, and their consultants and was found to be inconsequential.

2.1.2.3 Recreational Land Use

The lower Cape Fear area in Brunswick and New Hanover counties is a popular recreational area. The ocean beaches are well developed and camping facilities and several modern hotels provide good accommodations. During the summer months the population of the beaches within 20 miles of the site increases by about 10,000 people.

Both fresh water and ocean fishing are popular; however, sewage pollution in the Cape Fear River from upstream municipalities prevents the harvesting of oysters and clams. During the season, duck hunting takes place in the salt marshes. The waterways are used by fishing, motor, and sailing boats.

2.1.3 Water Use

2.1.3.1 Surface Waters

Major use of the Cape Fear River is for ship traffic via the approximately 40 feet deep by 400 feet wide dredged ship channel to the Port of Wilmington and the industrial plants to the north of the city. The Intracoastal Waterway passes the site via a portion of the Cape Fear River Channel.

2.1.3.2 Potable Water

Water for consumptive use in the lower Cape Fear region is obtained from wells, with the exception of the city of Wilmington, which obtains its water from the Cape Fear River. This water is withdrawn upstream of Lock and Dam No. 1, approximately 23.5 miles north of the city of Wilmington and upstream from the Brunswick site. Tidal salinity influences preclude potable use of the Cape Fear River below Lock and Dam No. 1.

Small potable water supplies in Brunswick County are obtained from surficial deposits with shallow wells. For larger water yields, the most important aquifer is the Castle Hayne limestone formation. The quality of the water obtained from the Castle Hayne is not uniform, but is acceptable for most domestic and industrial uses.

Results of chemical analyses of water from various wells throughout Brunswick County show that the water is relatively hard and has a pH of 7.2 to 8.4.

Municipal water supplies in Brunswick County are furnished to Long Beach and Southport, whose wells terminate in the Castle Hayne aquifer. Sunny Point Army Terminal also draws its water from this aquifer. Industrial wells in the Navassa area, 20 miles north, are in the surficial deposits. A partial listing of wells in Brunswick County within a 25 mile radius of the Brunswick site is given in Table 2.1-1.

Most wells in New Hanover County are in shallow sand (10-25 feet) for domestic use and in the Castle Hayne aquifer for larger yields. A partial listing of wells within a 10 mile radius of the site in Fort Fisher, Kure Beach and Carolina Beach is also given in Table 2.1-1.

2.1.3.3 Marine Biota

In common with other estuaries in the Carolinas, the lower Cape Fear River has commercial species that are semi-permanent or migratory. Shellfish exist in the lower river. Because of pollution resulting from the release of sanitary wastes downstream from Lock and Dam No. 1, the oysters have been transplanted by the Department of Fisheries to other areas. About 40,000 bushels per year have been taken for this purpose.

Shrimp utilize the shallow, marshy, tidal creeks in the lower Cape Fear area, as "nursery" grounds.

In 1970 a total of 38.6 million pounds of fish, valued at just over $686,000 were landed in Brunswick County.* These fish were taken from offshore and from deep waters in the ocean. Of this amount more than 87 percent were menhaden which are used for fertilizer and livestock feed; the remainder consisting of herring, sea bass, kingfish, flounder and spot. Shellfish landings, mostly shrimp, amounted to 0.7 million pounds in 1970 and were valued at approximately $332,000 during the year. The shrimp also are taken from offshore waters.

Carolina Power & Light Company has undertaken an extensive study of the marine biota in the Cape Fear River and in nearby offshore waters to ascertain the marine ecology before operation of the plant. Continuation of this program will determine if any unanticipated effects arise from plant operations. Should any such effects be found, then appropriate countermeasures will be determined and initiated.

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* H. S. Davis, Fishing Reporting Specialist, U. S. Department of Commerce, National Oceanographic and Atmospheric Administration, letter to CP&L dated August 30, 1971

2.1.4 Population

Population centers of 25,000 or more within a 200 mile radius of the site are indicated in Figure 1.2-1. The only population center of 25,000 or more within 50 miles is Wilmington, with a population of 44,013 in 1960 and 46,169 according to the 1970 census. Wilmington became a Standard Metropolitan Statistical Area (SMSA) in 1965 encompassing Brunswick and New Hanover counties with populations of 20,278 and 71,742, respectively, in 1960. Estimates in 1965 for the Wilmington SMSA totaled 95,000. The 1970 census data for the Wilmington SMSA showed 107,219, of which 24,223 are in Brunswick and 82,996 in New Hanover Counties.

Population within a five mile radius of the site is primarily in the south southwest and south sectors (Southport 1960 population 2034) as shown in the population wheel in Figure 2.1-1 with data for 1966 and projections for 1996. The 1970 census figure of 2,220 tends to verify this projection.

Population within a 50 mile radius of the site is centered in Wilmington, with distributions for 1966 and a projection for 1996 shown in Figure 2.1-2.

The source of information for population in the range of 0-5 miles was 1966 U.S.D.A. aerial photographs from which houses were counted and converted to population by multiplying by four, the average number of occupants per household in Brunswick county in the 1960 census. These data were extrapolated to 1996 based on population projections made by Southern Bell Telephone and Telegraph Company which serves the site area including Southport.*

Seasonal population increases occur in the site region along the seashore during the summer months. This increase amounts to about 10,000 people within 20 miles of the site as a result of seasonal attractions. Population densities in the most dense sectors, 0-5 miles south towards Southport and 5-50 miles NNE towards Wilmington, are shown in Figure 2.1-3.

Boiling Spring Lakes, a new development 7 miles NNW of the site with a population of 40 in 1960, is anticipated to reach its capacity of 18,000 by 1996. The 1970 census shows a population of 92.

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* H. P. Woodard, Jr., District Forecast Supervisor, Southern Bell Telephone and Telegraph Company, Wilmington, North Carolina, March 8, 1968; personal communication to E. M. Stanfield, NUS, Inc.

2.1.5 Geology

2.1.5.1 Physiography and Structure

From the standpoint of relief or physiography and structural geology, there are good bases for the relative infrequency of earthquakes in the South Atlantic states. Earthquakes are most common in those areas characterized by narrow coastal plains, with recent mountains rising abruptly from near the coast and having narrow continental shelves extending seaward from the shore. Such conditions prevail along the mountain-rimmed Pacific where coastal plains are lacking or at most very narrow and where a shelf generally extends only 10 or 20 miles before plunging downward into the deep ocean. In such areas, the rocks are usually closely folded and intensely broken and faulted, which conditions favor earthquakes. In addition, the valleys between mountain ridges often contain thick accumulations of water-soaked alluvium which makes the earthquakes more destructive.

On the other hand, North Carolina and adjoining states along the Atlantic Seaboard have a coastal plain 100 or more miles wide while mountains of ancient geologic origin occur another 100 miles inland. The continental shelf slopes gradually beneath the sea for another 50 to 100 miles before dropping off more rapidly. This combination of physiographic conditions is indicative the world over of relative seismic stability.

2.1.5.2 Regional Geology

The Castle Hayne limestone of middle and upper Eocene age is the most important rock unit in the area under consideration. It crops out in a belt up to 20 miles wide that extends from the center of Brunswick County to the southern part of Beaufort County. To the east, it dips beneath Oligocene and younger sediments and in the site area overlies the Peedee formation. In the upper part, it consists of well consolidated light gray fossiliferous limestone. The lower part contains considerable sand and clay with some phosphatic nodules and is less well consolidated.

The Oligocene is present only in the subsurface and is restricted to the southeastern part of the Coastal Plain in North Carolina. It consists of a light gray, well consolidated limestone member and a dark gray compacted, sandy clay member.

The Yorktown formation of Miocene age is well developed in outcrop areas in the northern half of the Coastal Plain of North Carolina, but in the site area is present only in the subsurface. It consists essentially of sand and dark gray, sandy clay.

Post-Miocene sediments, probably belonging to the Pamlico terrace formation of Pleistocene age, cover the surface in the site area.

Detailed information on the geology of the plant site was obtained from cores and cuttings recovered from numerous holes drilled on the site to depths ranging from 82 to 325 feet.

The diagrams presented in Figures 2.1-4 and 2.1-5, which are based on these drillings, illustrate the salient subsurface geological features of the site.

2.1.5.3 Faulting

Faulting took place at various times and places throughout the Piedmont and Mountain regions of North Carolina during the Paleozoic Era and the Triassic period of the Mesozoic Era. Faulting also probably took place at the same time in the crystalline floor beneath present Coastal Plain sediments. Established proof for post-Triassic faulting in the Coastal Plain of North Carolina is lacking.

2.1.6 Seismology

North Carolina is not a seismically active state. Between 1774 (the date of the first recorded shock) and October 1959, only three earthquakes occurred in this region that are listed by the United States Coast and Geodetic Survey as "important," and all three occurred west of the Blue Ridge Mountains in the region southwest of Asheville.

The only earthquake shocks of any importance in the South Atlantic Coastal Plain during the 360 years between the first permanent English settlement in America at Jamestown, Virginia in 1607 and the end of 1967 were a part of the Charleston, South Carolina earthquake of August 31, 1886. These shocks caused no damage in North Carolina.

Although MacCarthy* reported that on the order of 100 earthquakes were recorded within the borders of North Carolina, only approximately one-half of these earthquakes had their epicenters in the state, and only eight of these epicenters were recorded in the Coastal Plain. Six of these eight were reported as occurring in the Cape Lookout-Wilmington-Southport area, of which five were near Wilmington and Southport. Only one had an estimated or established intensity as great as V (on the Modified Mercalli Scale).

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* MacCarthy, Gerald R., "An Annotated List of North Carolina Earthquakes," Elisha Mitchell Scientific Society, Journal, Vol. 73, No. 1, 1957.

2.1.7 Hydrology

Two aspects of the surface water hydrology in the area, the normal hydrology of the Cape Fear River and estuary tides and the hydrology associated with severe weather conditions, in the area, have been studied and are discussed below. Ground water hydrology is discussed in Section 3.1.1.

2.1.7.1 Normal Hydrology

The lower section of the Cape Fear River near the site is characterized by strong semidiurnal tides with a range of about four feet. Salinity data available from the North Carolina Department of Water and Air Resources and the United States Geological Survey were supplemented by salinity data collected at monthly intervals over a period of one year from March of 1969 through February of 1970.

The annual salinity range at buoy No. 23A, just upstream of the plant intake canal, was from 1.72 to 32.25 parts per thousand (ppt). The minimum salinity for the year was measured at the surface during low slack tide on August 5, 1969 during a period of unusually high fresh water input to the estuary. Salinity at the bottom was 9.1 ppt during the same low slack tide. During periods of high fresh water inflow, salinity of the surface waters varied little over the tidal cycle and a salinity of only 2.12 ppt was recorded during high tide on the same day. Stratification of salinity was pronounced and bottom salinities were 9.1 ppt on slack tide and 24.1 ppt on high tide. Only on infrequent occasions does the salinity at the bottom in the vicinity of the plant intake canal fall below about half-strength seawater. The data suggests that there is a tidally driven salt wedge which moves up the river along the bottom, while the fresh water from the Cape Fear River moves downriver in the surface layers. The rapid tidal movement of water in the estuary causes mixing between the layers which weakens the stratification. Therefore, the net flow of water past the plant intake toward the ocean, which is maintained by fresh water input and vertical mixing of the ocean water, is considerably greater than the flow that would exist if only fresh water were moving toward the ocean in the upper layer. Net flow toward the ocean in the upper layer is approximately 15 times the fresh water input during dry periods. Under a low flow condition of 1,400 cubic feet per second (cfs) fresh water input, there would be a net flow toward the ocean in the upper layer of approximately 21,000 cfs.

2.1.7.2 Storm Tide Flooding

A detailed evaluation of storm tide flood conditions was performed because it is necessary to assure that critical plant elements, such as the service water intake structure, are not disabled during the most severe flooding conditions which might possibly occur. For the Brunswick site, the most severe flood that can reasonably be postulated is presumed to be caused by a hurricane more severe than any on record, having a recurrence interval of once in about 2000 years, and possessing all the qualities in coincidence which would contribute to the severity of the flood. The AEC requires, in order to achieve uniform conservatism, that the hurricane be characterized using parameters from a standard hurricane model,* which is based on extensive observations of severe storms and hurricanes.

Water levels in a tidewater area can be affected during passage of a storm by the hurricane winds, by the reduction in central pressure, by the accumulation of water at and along the coast from breaking waves, by the Coriolis force which causes a "piling up" of water along the coast to the right of the current, by storm rainfall, and by the positive or negative contribution of the astronomical tide. Similarly, if storm winds blow offshore for a sufficient length of time a negative surge could be experienced.

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* "Meteorological Characteristics of the Probable Maximum Hurricane, Atlantic and Gulf Coasts of the United States," Interim Report No. HUR 7-97, U. S. Department of Commerce, Environmental Science Services Administration, Weather Bureau, Silver Spring, Md. 20910; May 7, 1968.

Allowing for the requirement that the storm occur on an exact path and forward speed for maximum surge generation coincident with peak high astronomical tide at the plant site, the return fraquency of a hypothetical Maximum Probable Hurricane in the site area would be approximately once in 10,000 years. This hurricane has a Central Pressure Index of 26.8 inches mercury, even though the lowest known pressure in the region, 27.52 inches, was recorded in hurricane Helene, September 1958, some 80 miles offshore.

The effect of this once-in-10,000 years event would be a very severe flood of the site environs to a level of about 2½ feet above the plant grade of 20 ft MSL. Wave effects would raise the maximum intermittent water height to approximately 26 feet above mean sea level in the general plant area. The flooding would last about one hour. The Brunswick Plant is designed to withstand such a storm safely. The plant service water system is designed to function in the event of an equally intense hurricane whose fetch is so oriented that it produces a short term extremely low water level in the Cape Fear River.

Various factors affect, and, to a large extent control, the value of extreme low tide elevation to be expected at the Brunswick Plant site. They are essentially as follows:

(A) Hurricane wind direction, duration, and intensity in storms passing offshore in the area with winds to the left of center of the storm directed offshore.

(B) The location of the plant site with respect to the length of the tidal estuary, i.e., whether it is close to the tidal entrance or far distant.

(C) Channel depth of the tidal estuary and available fetch length for wind tide generation.

(D) The general orientation of the river with respect to anticipated wind direction.

(E) Normal astronomical tide condition.

The path of a storm was selected to give a minimum water depth in the river near the site. Low astronomical tide was assumed in combination with other worst conditions. Under these circumstances, an extreme low tide elevation of -4.5 feet mean low water (MLW) level (-6.5 feet MSL) was computed for the plant site area.

2.1.8 Meteorology

Carolina Power & Light Company conducted an analysis of weather data which had been collected by the U. S. Weather Bureau at nearby Wilmington during the period from 1871 through 1967. The meteorological norms and extremes are shown in Tables 2.1-2 and 2.1-3, respectively. It is not expected that Wilmington data should vary significantly from data for the site; nevertheless, a program has been initiated to monitor weather data at the site for a period of at least two years prior to plant operation. A 364 foot meteorological tower was erected at the site in 1970 and data are being collected. One year of meteorological data have been collected; however, the data have not yet been processed for inclusion in this report.

The Southport area lies in the path of a large number of hurricanes or tropical storms which follow the coastal storm track. From 1871 through 1966, 108 tropical storms or hurricanes passed within 100 miles of the area, an average of 1.1 per year. Similarly, the mean recurrence interval for a tornado hitting the plant site is once every 2300 years. The fastest mile of wind for Southport, North Carolina, reported by the Weather Bureau was 88 miles per hour in September 1958.

Wind persistence, averaged over the years from September 1959 through December 1963 for Wilmington, North Carolina, was obtained; a persistence wind rose of the longest one-sector duration is shown in Figure 2.1-6, along with the Pasquill stability criteria for each occurrence.

Wind data for Wilmington from 1948 through 1965 were examined. They show winds well distributed on an annual basis; seasonally, they show in Figure 2.1-7 preponderant winds from the southwest and autumn winds from the north.

TABLE 2.1-1

MUNICIPAL AND INDUSTRIAL GROUND WATER USAGE
WITHIN 25 MILE RADIUS FROM BRUNSWICK SITE*

Location and Direction from Site	No. of Wells	Depth feet	Total Yield gpm
Brunswick County			
Fort Caswell, 4 mi S	2	800-1500	203
Fort Caswell, 5 mi S	4	125	N/A
Southport (municipal) 2 mi S	3	162-176	700
Southport, 2 mi S	2	100-104	40+
Long Beach (municipal), 10 mi WSW	2	100-145	60+
Long Beach, 10 mi WSW	1	74	N/A
Sunny Point Army Terminal, 3 -6 mi N	5	171-192	1288
Orton Plantation, 8 mi N and NNW	(2) Springs		N/A
Holden Beach, 15 mi W	2	70	N/A
Shallotte Point/Little Beach, 22 mi W	4	335-400	60+
Shallotte, 22 mi W	4	59-303	37½+
Supply, 15 mi WNW	2	16-109	N/A
Bolivia, 11 mi NW	3	30-156	N/A
Bell Swamp, 13 mi NNW	1	35	N/A
Lanvale, 17 mi N	1	75	N/A
Bellville, 20 mi N	1	75	N/A
Leland, 21 mi N	2	20-72	N/A
Navassa, 20 mi N	6	20-60	20-30
New Hanover County			
Fort Fisher, 6 mi ENE	4	135-207	1014
Kure Beach, 7 mi ENE	6	135-196	1090
Carolina Beach, 8 mi NE	7	142-201	817+

NOTES:

N/A: Not Available

* "North Carolina Department of Water Resources Reconnaissance of the Water Resources of the Southport - Elizabethtown Area, North Carolina," Ground Water Bulletin No. 6, 1965.

TABLE 2.1-2

METEOROLOGICAL NORMS*

	Temperature	Precipitation	Snow	Thunderstorms
	Degrees F	Inches	Inches	Number
January	47.9	2.85	0.3	0.5
February	48.7	3.42	0.3	1
March	54.2	4.03	0.5	2
April	62.5	2.86	0	3
May	70.5	3.52	0	6
June	77.7	4.26	0	8
July	80.0	7.68	0	11
August	79.4	6.86	0	9
September	75.2	6.29	0	3
October	65.4	3.01	0	1
November	55.4	3.09	Trace	1
December	48.2	3.42	0.3	0.5
Annual	63.8	51.29	1.4	46
	(average)	(total)	(total)	(total)

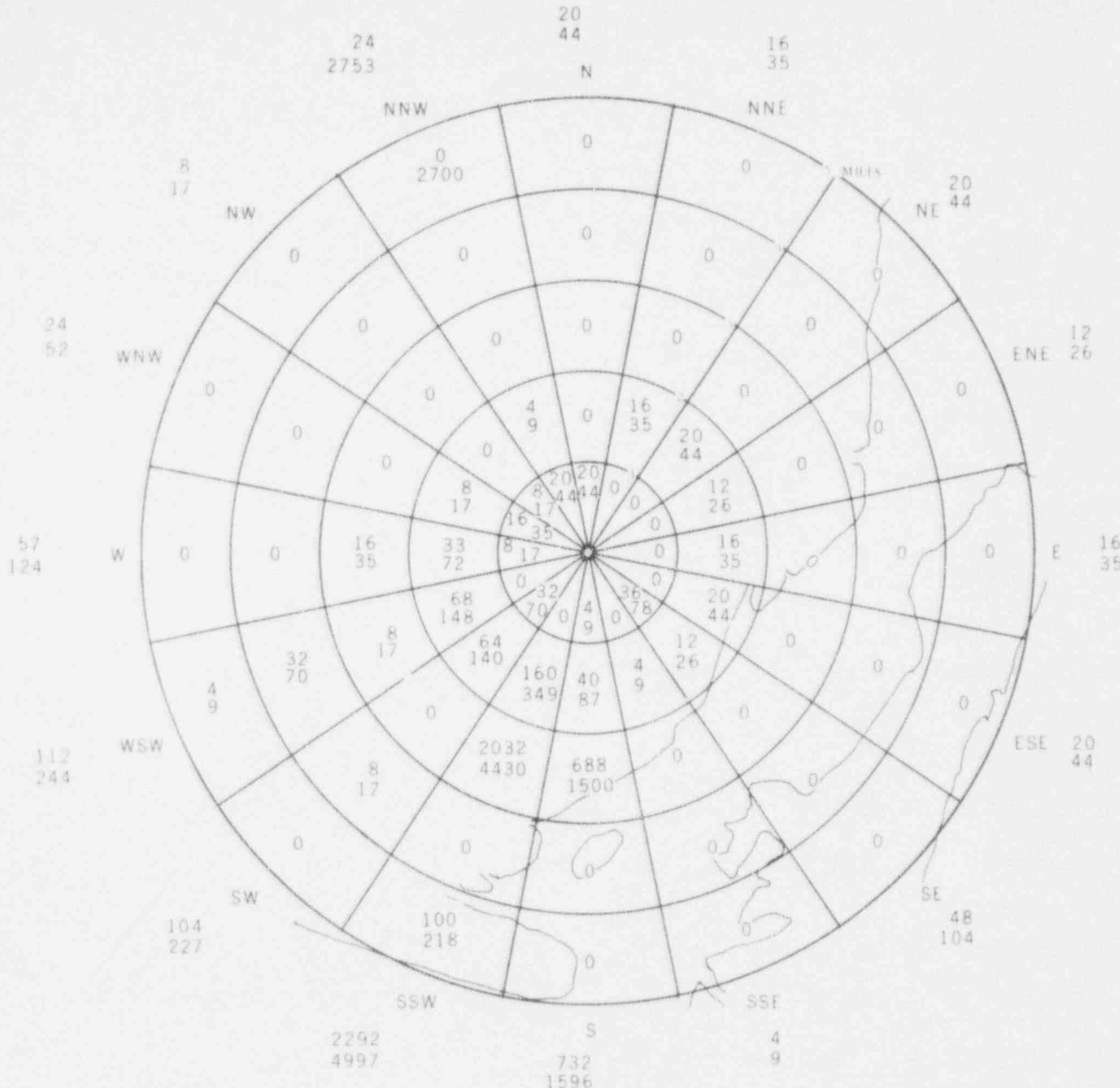
* Based on data from Wilmington, North Carolina - 1871-1967.

TABLE 2.1-3

METEOROLOGICAL EXTREMES*

	Wilmington		Cape Hatteras		Myrtle Beach South Carolina
Maximum Temperature (degrees F)	104	(6-52)	97	(6-52)	104
Minimum Temperature (degrees F)	5	(2-99)	8	(12-80)	11
Maximum Monthly Precipitation (Inches)	21.12	(7-86)	20.95	(6-49)	15.5
Maximum 24-Hour Precipitation (Inches)	9.52	(9-38)	14.73	(6-49)	8.2
Minimum Monthly Precipitation (Inches)	0.02	(10-43)	Trace	(11-90)	0.0
Maximum Monthly Snowfall (Inches)	12.1	(2-96)	12.0	(12-17)	-
Maximum 24-Hour Snowfall (Inches)	11.1	(2-96)	12.0	(12-17)	-
Fastest Mile Wind (mph)	N 88	(9-58)	W 110	(9-44)	-

*Where available, the observation date (month-year) is given in parentheses following the data value.



MILES	0-1	0-2	0-3	0-4	0-5
1966	144	621	3365	3405	3509
1996	314	1355	7337	7924	10,351

NOTES:
UPPER FIGURES REFER TO 1966 DATA.
LOWER FIGURES REFER TO 1996 DATA.

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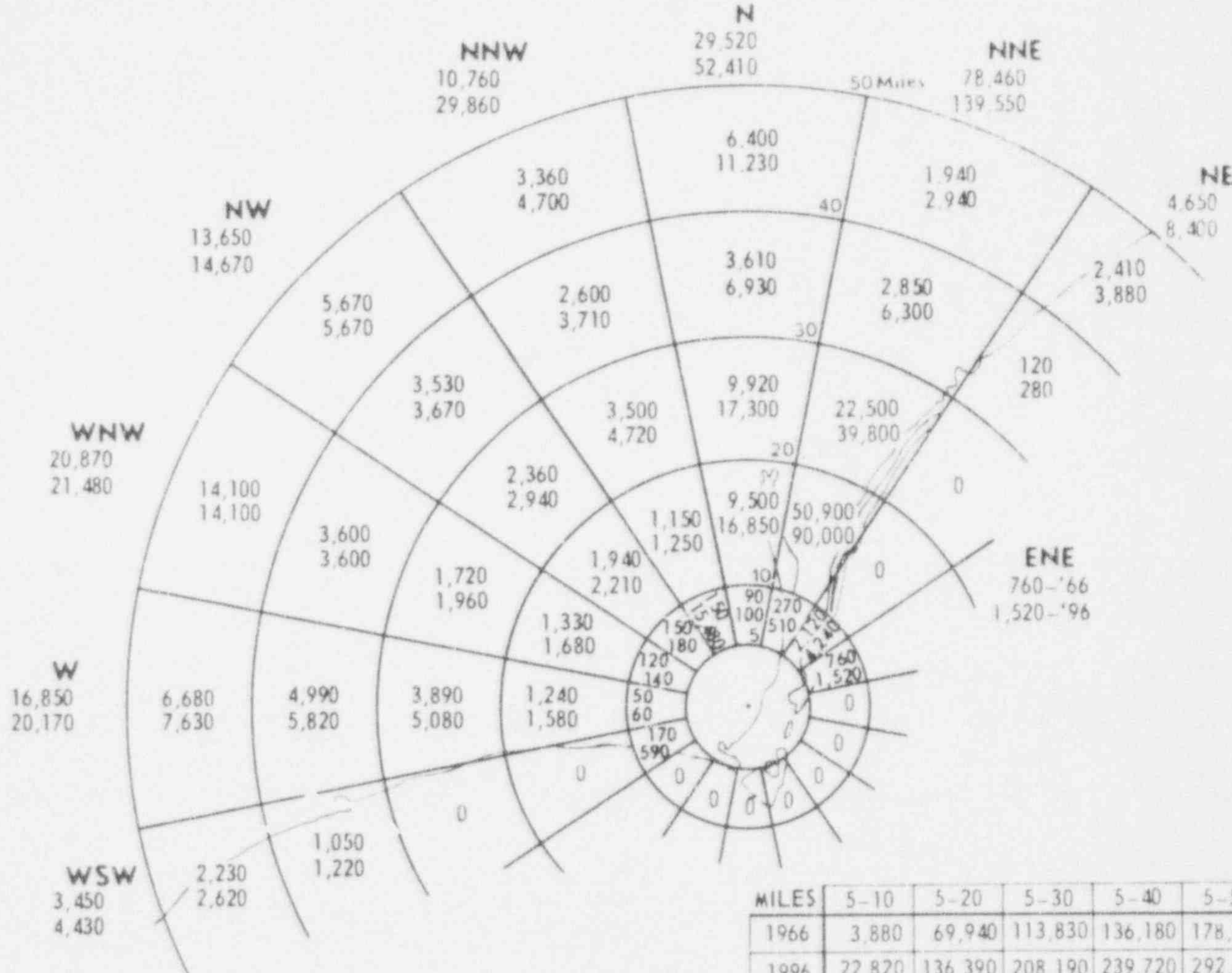
POPULATION DISTRIBUTION: 0–5 MILES

FIG. NO. 2.1–1



MILES	5-10	5-20	5-30	5-40	5-50
1966	3,880	69,940	113,830	136,180	178,970
1996	22,820	136,390	208,190	239,720	292,490

NOTES:
UPPER FIGURES REFER TO 1966 DATA.
LOWER FIGURES REFER TO 1996 DATA.

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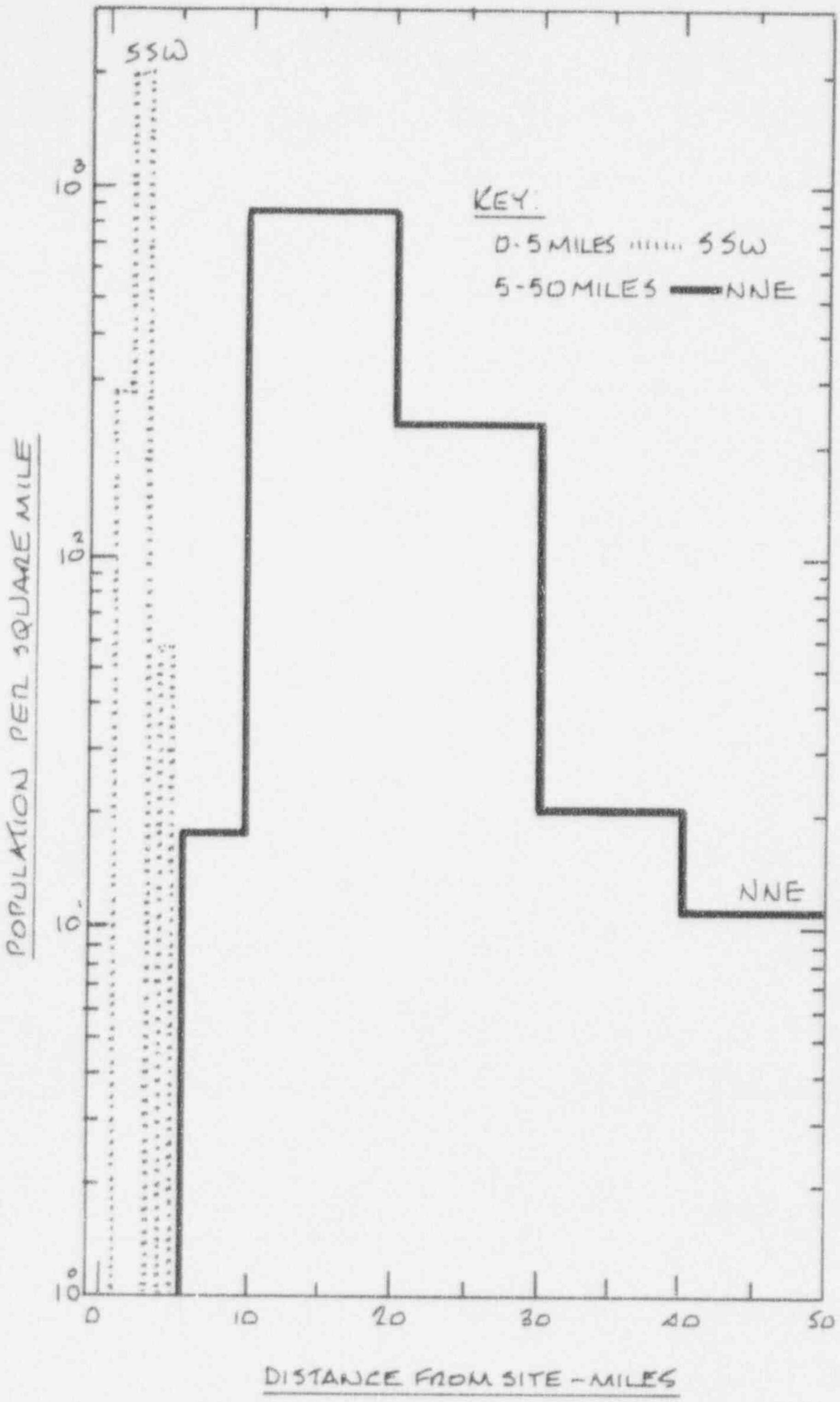
POPULATION DISTRIBUTION: 5-50 MILES

FIG. NO. 2.1-2



NOTE:

MOST POPULOUS SECTORS REPRESENTED, BASED ON 1966 DATA.

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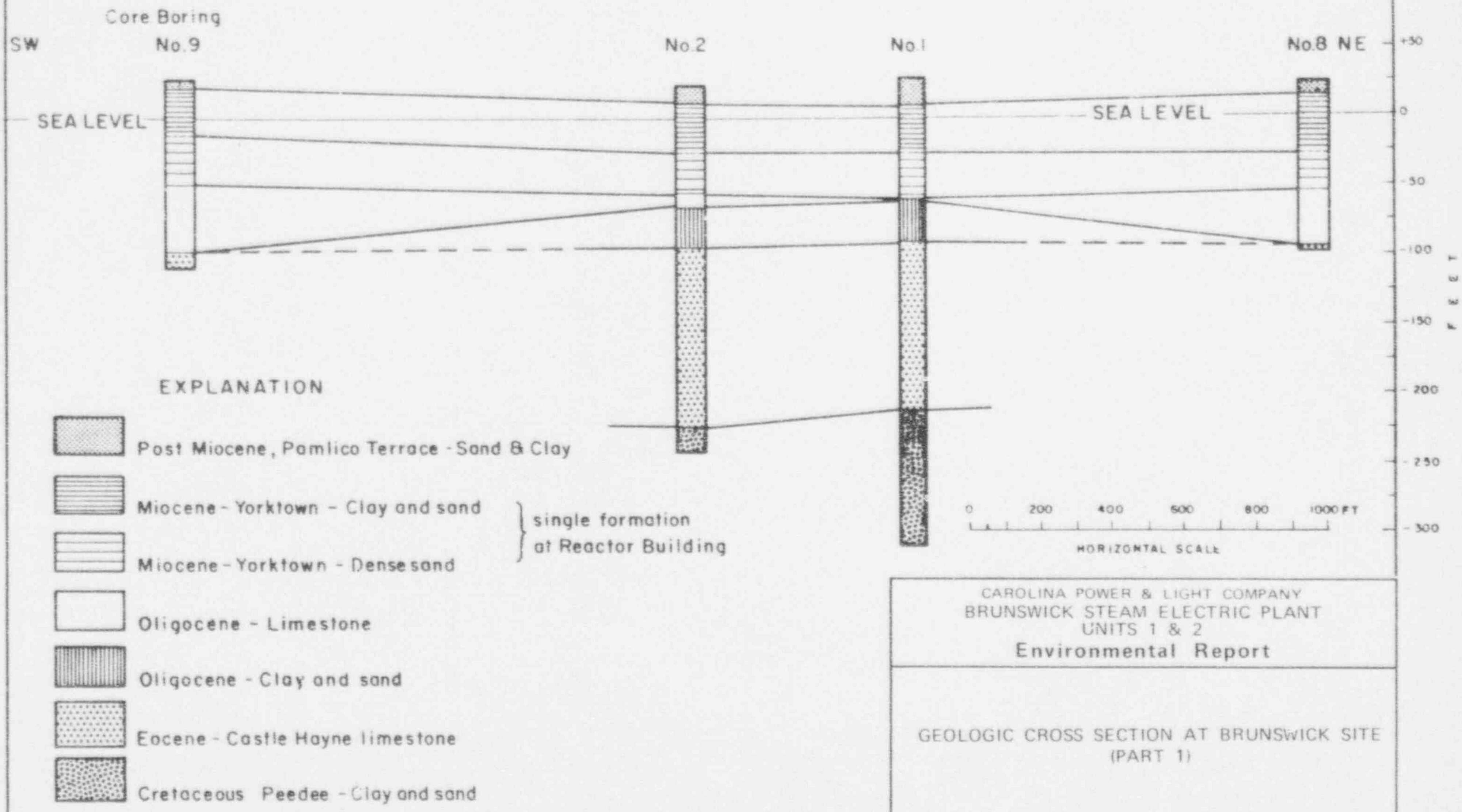
POPULATION DENSITY ABOUT BRUNSWICK SITE

FIG. NO. 2.1-3



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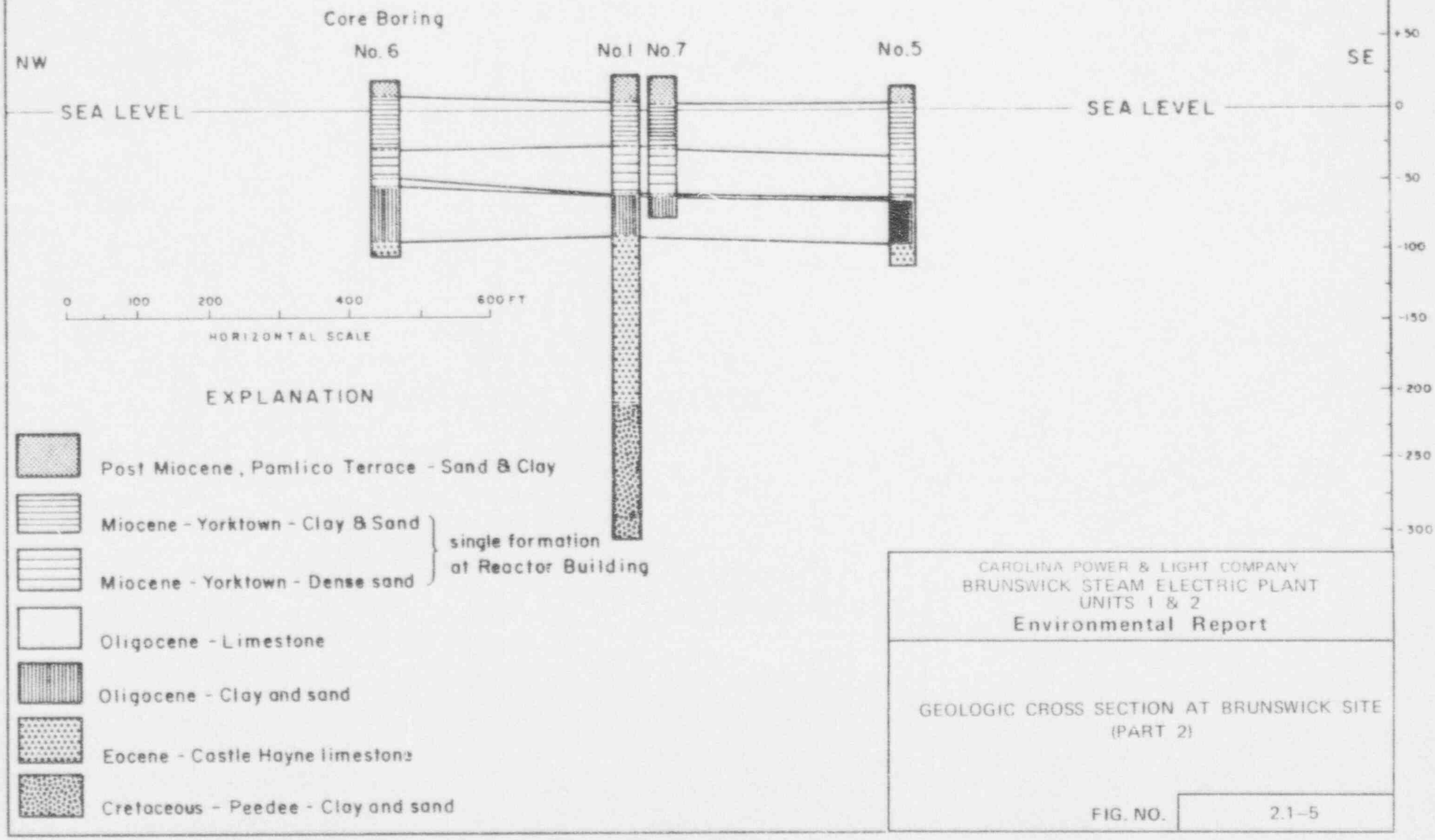
GEOLOGIC CROSS SECTION AT BRUNSWICK SITE (PART 1)

FIG. NO. 2.1-4



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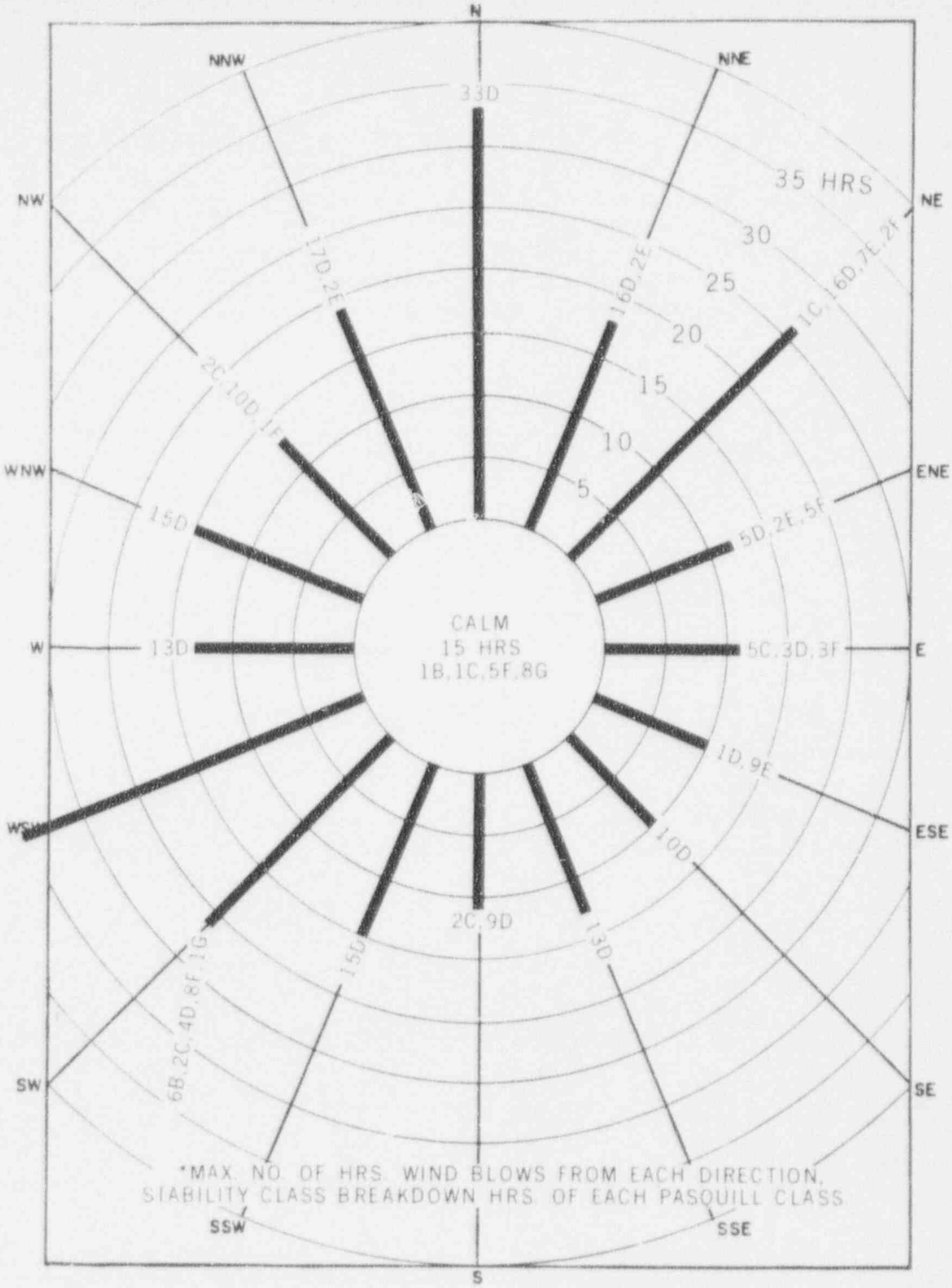
GEOLOGIC CROSS SECTION AT BRUNSWICK SITE
(PART 2)

FIG. NO. 2.1-5



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BRUNSWICK STEAM ELECTRIC PLANT
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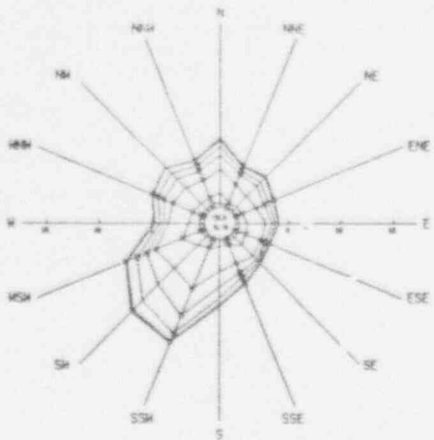
PERSISTENCE WIND ROSE
WILMINGTON, N.C., 1959–63

FIG. NO. 2.1–6

MAR APR MAY



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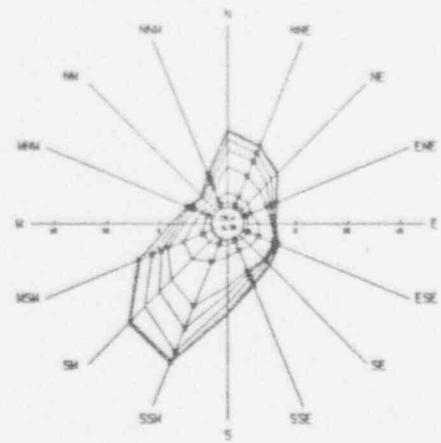
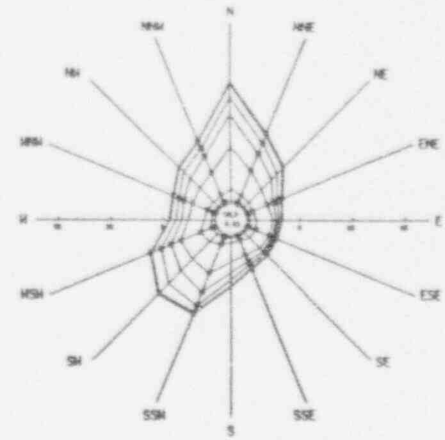
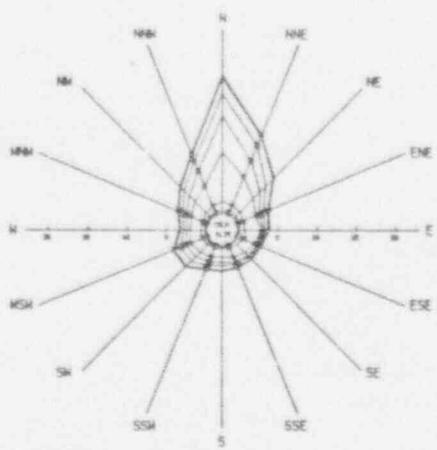


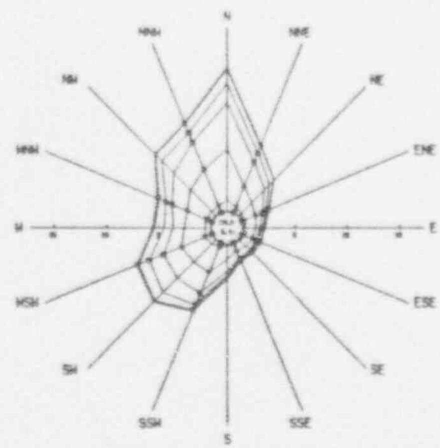
ANNUAL AVERAGE



SEP OCT NOV



DEC JAN FEB



1. Distributions are in terms of percent of totals observed.

2. Distributions represent a 4.3 year summary (9/59 – 12/63).

3. KEY:

Stability class	R	B	C	D(day)	D(night)	E	F	G
Symbol	+	⊞	X	◊	■	●	Y	▲

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BRUNSWICK STEAM ELECTRIC PLANT
UNITS 1 & 2
Environmental Report

QUARTERLY STABILITY CLASS DISTRIBUTIONS
AT WILMINGTON, N. C.

FIG. NO. 2.1–7

2.2 Plant Description

The Brunswick Steam Electric Plant will consist of two units, both of which will be boiling water reactor systems cooled and moderated by light water. Each unit is designed for an ultimate output of 2436 MWt, and 847 MWe of gross electrical power. Safety evaluations for the units are being performed for a reactor core thermal rating of 2550 MWt.

Each unit of the plant incorporates a single cycle, forced circulation boiling water nuclear steam supply system which will produce steam for direct use in the turbine-generator system. Equipment includes systems for the processing of radioactive wastes, handling of fuel, electrical distribution, cooling, power generation structures, and all other on-site facilities required to provide a complete and safely operable nuclear power plant.

2.2.1 Reactors

The two single-cycle, forced-circulation, boiling water reactors furnished by the General Electric Company for the Brunswick Plant, as shown in Figure 2.2-1, are similar to TVA's Browns Ferry Nuclear Power Station Units 1 & 2 and the Cooper Nuclear Station of the Consumer's Public Power District in Nebraska. The Brunswick nuclear steam supply systems are similar to a number of boiling water reactors which have been operating successfully and safely for years and have generated many millions of kilowatt-hours of energy both in the U. S. and abroad.

The reactor core consists of 560 fuel assemblies, 137 control rods and supporting hardware. The core is assembled in modular form, each module consisting of a square array of four fuel assemblies set at the interstices of a cruciform control rod. The reactor core fuel consists of uranium dioxide in pellet form, slightly enriched by U-235 (2 to 3 percent, by weight).

The fuel is contained in sealed Zircaloy-2 tubes, which provide the first barrier against the release of fission products.

The control rods constitute a cruciform array of 3/16 inch diameter stainless steel tubes filled with boron carbide powder. In addition to normal control, provisions are also made for the rapid simultaneous insertion of all control rods for shutdown of the reactor.

The reactor core is contained within a reactor pressure vessel which also contains jet pumps, emergency core cooling components, steam separators and dryers, and other equipment. The pressure vessel is a nominal 5-3/4 inches thick steel cylinder having an inside diameter of approximately 18-1/2 feet and an inside height between heads of approximately 69 feet. Connections to the pressure vessel are provided for control rod drives, feed water lines, reactor recirculation lines and main steam lines.

The reactor pressure vessel constitutes the second barrier against the release of fission products.

2.2.2 Reactor Coolant System

The water in the reactor core serves both as a moderator to slow down high energy neutrons generated in the fission process and as a core coolant. The water enters the bottom of the core and flows upward through the fuel assemblies, during which process it is heated to boiling. The resulting steam-water mixture flows up to the steam separator and dryers, where water is separated from the steam and returned to the core inlet; jet pumps, which are driven from two reactor recirculation loops on each unit, force the water through the core. The dried steam flows through four main steam lines from the reactor to the Turbine Building, to drive the turbine-generator. The residual steam, at a lower pressure, is condensed in the main condenser and the non-condensable gases are removed. The condensate is pumped through filters and demineralizers and returned to the reactor via feedwater heaters and feed water pumps.

2.2.3 Reactor Control

The reactor power level is controlled by movement of the control rods and by varying the flow rate of the recirculating water. The control rods are used to adjust the nuclear reaction rate, and thus the power level of the reactor over its full power range. Control rods also serve to shape the core power distribution. Near full power, the recirculation flow rate is additionally used to adjust power level over a limited range.

Automatic protection systems are tied to the control system and involve positioning of control rods and variation of flow rate. Procedural controls are also used to assure that established limits are not exceeded in reactor operation. In addition, an automatic standby liquid control system provides an independent backup to the above systems, and can be used to shut down a reactor in the remote event of a failure of other control systems.

The turbine control valves will regulate the quantity of steam admitted to the turbine in order to change the amount of electricity generated. The reactor controls will adjust reactor power in order to generate the required quantity of steam at the required pressure.

The reactor protection system overrides all operational controls and automatically initiates appropriate action. Such action includes shutting down the reactor whenever specific conditions monitored by the system approach established safety limits. All sensor wiring and other equipment associated with the safety system is maintained physically and electrically separate from the control system, in accordance with industry standards and AEC criteria.

2.2.4 Reactor Containment

The reactor pressure vessel and recirculation loops are located within the primary containment, which consists of two interconnected steel-lined reinforced concrete pressure vessels, termed the drywell and the pressure suppression chamber. In the remote event of the failure of a steam or water line in the primary containment, high-energy steam leaked into the drywell would be vented through a pool of water in the suppression chamber where the steam would be condensed and thus would give up most of its energy without raising the pressure excessively in the primary containment.

The primary containment system constitutes a third barrier to the release of fission products.

Each primary containment is located within its own Reactor Building. The Reactor Building is provided with a normal ventilation system which exhausts ventilating air through the Reactor Building vent after filtration and monitoring for any possible radioactivity. Should any radioactivity be detected in the Reactor Building atmosphere above a preset level, the Reactor Building vent is automatically closed and the ventilation air is exhausted through the standby gas treatment system which treats and filters the air prior to discharging it up the plant stack. During refueling, when the primary containment is opened, the Reactor Building serves as the primary containment for the reactor.

The Reactor Building represents the secondary containment; it constitutes a fourth barrier against the release of fission products.

2.2.5 Refueling

Fresh fuel is stored within the Reactor Buildings in a vault located adjacent to the refueling pool. Refueling takes place completely under water. The water provides the required shielding, yet permits visual observation of all operations.

During refueling, spent fuel is transferred from the reactor pressure vessel to storage racks provided for the purpose in the spent fuel storage pool. The pool is designed to permit all required fuel maintenance and inspection operations. Storage space is also provided in the pool for control rods and other core hardware which is made radioactive during residence in the reactor core. A shielded cooled cask is provided for shipping spent fuel to a fuel reprocessing plant located remote from the Brunswick Plant. The cask is loaded under water in the spent fuel storage pool.

2.2.6 Other Plant Components

The turbines for Units 1 & 2 are located in a Turbine Building common to both units. Immediately adjacent to the Turbine Building, and nestled between the two Reactor Buildings, is the shared Control Building where all major controls for the reactors and turbines and associated auxiliary equipment are located.

Next to the Control Building is the plant Radwaste Building which also serves both units for the collection, treatment and temporary storage of radioactive liquid and solid wastes, in preparation for disposal.

A gaseous radioactive waste processing system is provided to reduce radioactivity before the plant gases are discharged to the atmosphere from the 100 meter stack.

2.2.6.1 Control Building

The Control Building houses the central control room for the two units. From the control room the plant operators can monitor and control all vital plant functions. Because of its important safety function, this building is designed to survive intact the most severe earthquake specified for the site, as well as the most severe hurricane induced flood and tornado. Even following the highly unlikely event of the worst hypothetical accident, the Design Basis Accident (DBA), the control room is designed for continuous occupancy.

2.2.6.2 Service Water Intake Structure

Like the Control and Reactor Buildings, the service water intake structure is a safety related structure, because the nuclear portion of the service water system is needed to remove residual and stored energy from the reactor system after a normal reactor shutdown and also following the hypothetical Design Basis Accident. The structure is, therefore, designed to functionally survive the Design Basis Earthquake (DBE). The structure houses the ten service water pumps, and associated valves, strainers, and controls for the nuclear and conventional headers for both units.

2.2.6.3 Diesel Generator Building

Four diesel generators supply emergency power for safety related equipment which may be necessary following a DBA, if there is a loss of off-site power. The

Diesel Generator Building is designed to the AEC Class I seismic criteria and will therefore provide protection of the diesel generators and associated equipment from the effects of the Design Basis Earthquake.

The diesel generators have a capacity of 3500 KW each and the ability to accept the required load within several seconds. The four diesel fuel tanks are placed below ground immediately adjacent to the Diesel Generator Building; they are in turn supplied from the main above-ground fuel tank.

2.2.6.4 Radwaste Building

The liquid and solid radioactive waste processing systems are located in the Radwaste Building which is designed to AEC Class I seismic criteria. Liquid radwaste is collected from sumps, drain tanks and process equipment and is treated so as to remove the radioactive component by evaporating, demineralizing or filtering the liquid. The radwaste processing system is operated from a local control board in the building.

2.2.6.5 Plant Stack

The 100-meter reinforced concrete stack provides an elevated release point for effluent from the condenser air ejector, the main turbine gland seal, Radwaste Building ventilation exhaust, and from the standby gas treatment systems. The reinforced concrete stack, which is shared by both units, is designed to withstand the effects of the Design Basis Earthquake.

2.2.6.6 Turbine Building

The Turbine Building is functionally quite similar to such structures as are used in fossil fired plants. It houses the main turbines and generators for both units as well as electrical switchgear, the main condensers, auxiliary equipment necessary for the turbines, and reactor recirculating pump MG-sets.

2.2.6.7 Cooling Water Canal

A plan view of the circulating water system is shown in Figure 2.2-2. The system consists of a curved intake canal from the Cape Fear River to the Plant site, an intake bay from which the river water will be pumped through the plant condensers, a discharge canal from the plant to the Intracoastal Waterway, an inverted siphon under the Waterway, a canal from the Intracoastal Waterway to a point near the beach, and a pumping station near the beach to discharge the water at a point 2000 feet from the shore.

A typical cross section of the intake canal is in the form of an inverted trapezoid with a bottom width of 168 feet, a water depth of approximately 18 feet, and sides that slope to a width of approximately 400 feet at the water surface. Cooling water will be transported in a Southwesterly direction by gravity-flow to the plant site, 2.6 miles away.

The Service and circulating water intake structures will be constructed of reinforced concrete. Coarse bar racks and traveling screens will be provided to prevent debris from entering the condensers.

A gravity-flow open discharge canal similar to the intake canal will be utilized from a point in the vicinity of the plant to the Intracoastal Waterway. An inverted siphon will pass the discharge under the Intracoastal Waterway and empty it into an open canal on Oak Island. A typical cross section of the discharge canal is in the form of an inverted trapezoid with a bottom width of approximately 20 feet, a water depth of approximately 18 feet, and sides that slope to a width of approximately 170 feet at the water surface. This open canal will continue to a pumping station a short distance from the beach. The pumping station will discharge the cooling water in a horizontal direction at a velocity of 10 feet per second through two concrete pipes terminating 2000 feet from shore.

2.2.6.8 Laboratories and Office Space

A Service Building, placed near the Turbine Building, contains the chemistry and health physics laboratories. Some radioactive materials will be handled in the laboratories, but the level of activity will be low, commensurate with laboratory facilities. In keeping with normal practices, protective equipment and procedures will preclude the release of radioactivity from the Service Building.

The Office Building will contain plant administrative offices.

2.2.7 Plant Waste Processing System

2.2.7.1 Radioactive Waste Treatment

The radioactive waste processing systems are designed to collect, process, store, and prepare for off-site shipment or disposal, all plant wastes which contain or could contain radioactive material. The radioactive waste processing system is divided into three subsystems as follows:

1. Liquid Radwaste System
2. Solid Radwaste System
3. Gaseous Radwaste System

CP&L intends to provide the most advanced liquid, solid, and gaseous radwaste systems possible under the technology available to the industry at the present time. The liquid radwaste system will include equipment to process radioactive liquids to the degree required to meet the requirements of 10CFR50 Appendix I. The gaseous radwaste system will similarly be augmented to meet the requirements of 10CFR50 Appendix I. Through the installation of additional concentrator capacity, the solid radwaste system will be capable of handling all wet solid wastes produced by the plant for shipment off site.

As a result of the CP&L plans to provide the most advanced equipment available to the industry and to meet the requirements of 10CFR50 Appendix I, the Brunswick Plant radwaste system will limit radioactivity releases to the environment to levels which are significantly lower than variation in natural background levels at the site.

The liquid radwaste system is designed to receive and process radioactive, or potentially radioactive, liquid wastes of different purity and chemical condition to make them suitable for reuse, concentration, or disposal. Principal sources of liquid wastes are equipment drains (high purity), floor drains (medium to low purity), chemical wastes (very low purity), detergent, and oily liquid drains.

The solid radwaste system processes principally two types of solid wastes: a) wet, and b) dry. Irradiated reactor components such as spent control blades, etc., are handled separately by putting them integrally in shipping casks for off-site disposal.

Wet solid wastes are composed primarily of spent demineralizer resins, filter sludges and concentrator bottoms. Spent resins and filter sludges are dewatered before drumming in Department of Transportation (DOT) Class 17-H containers. Concentrator bottoms only require mixing with an absorbent to meet DOT shipping requirements for consistency before drumming in DOT Class 17-H containers.

Compressible dry solid wastes such as air filters, miscellaneous paper, rags, etc., are compressed into 55-gallon drums for off-site shipment.

The gaseous radwaste system will consist of an air-ejector off-gas subsystem including the standard 30-minute holdup piping, filters, and 100-meter stack arrangement. Several additional systems are now being evaluated for air-ejector off-gas treatment. The system selected for installation will result in a reduction of at least 100 in the quantities of radioactivity released from the gaseous radwaste system.

Figures 2.2-3, -4, and -5 schematically illustrate the functional objectives of the radwaste systems.

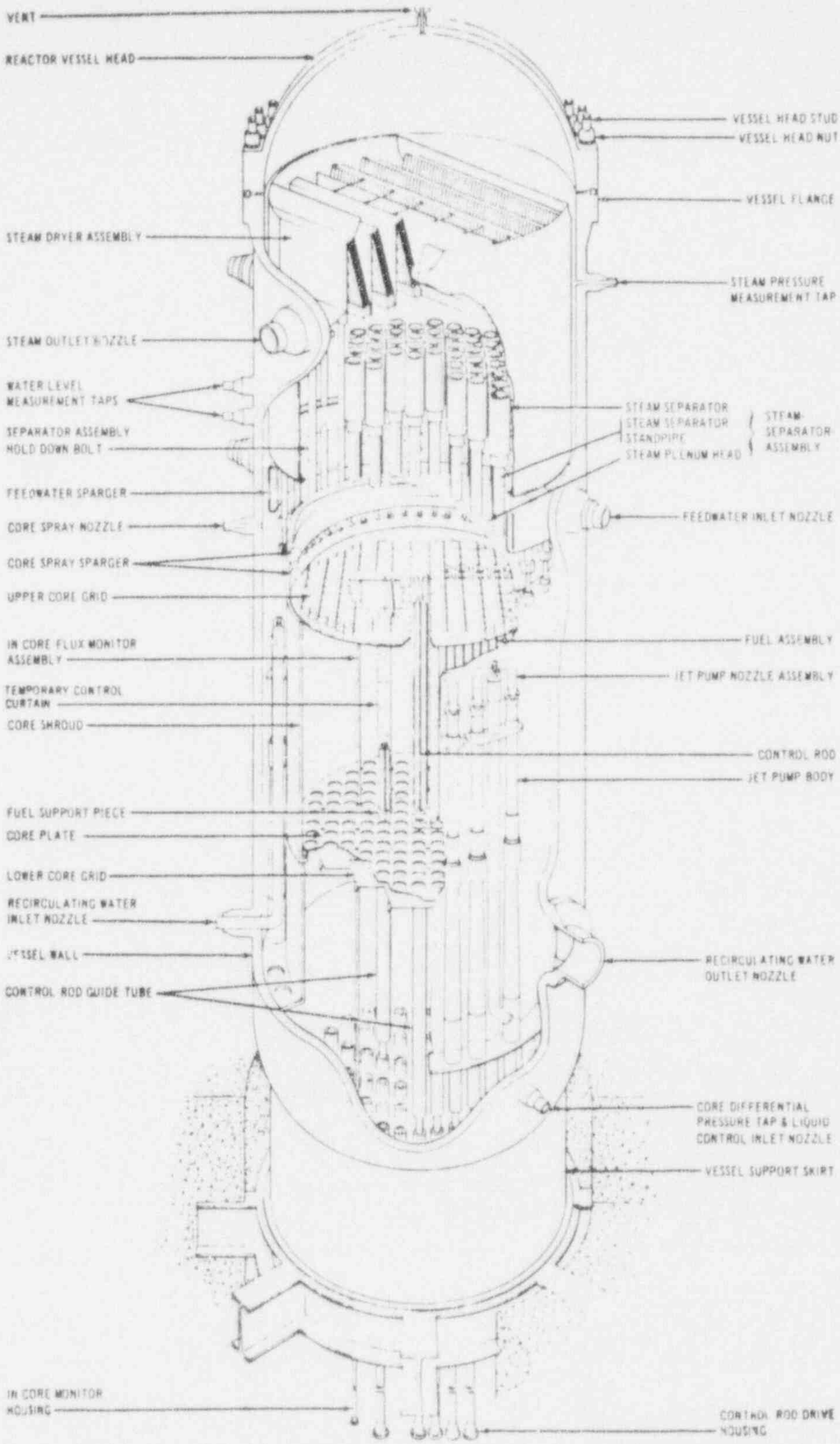
2.2.7.2 Sanitary Sewage Treatment System

Sanitary sewage will be collected and treated by the extended aeration process.

The raw domestic sewage, containing approximately 300 mg/l. of 5-day Biological Oxygen Demand (BOD), will enter the aeration tank where it will be mixed with activated sludge and continuously aerated by supplying air at a minimum rate of 2800 cubic feet of air per pound of 5-day BOD in the domestic sewage.

The mixed liquor then passes to a sludge holding tank which collects the large particles of sludge and also 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 the liquid is treated with chlorine solution and is discharged as treated effluent with a BOD less than 25 mg/l. into the circulating water discharge canal.



CAROLINA POWER & LIGHT COMPANY
BRUNSWICK STEAM ELECTRIC PLANT
UNITS 1 & 2
Environmental Report

REACTOR DESCRIPTION

FIG. NO. 2.2–1

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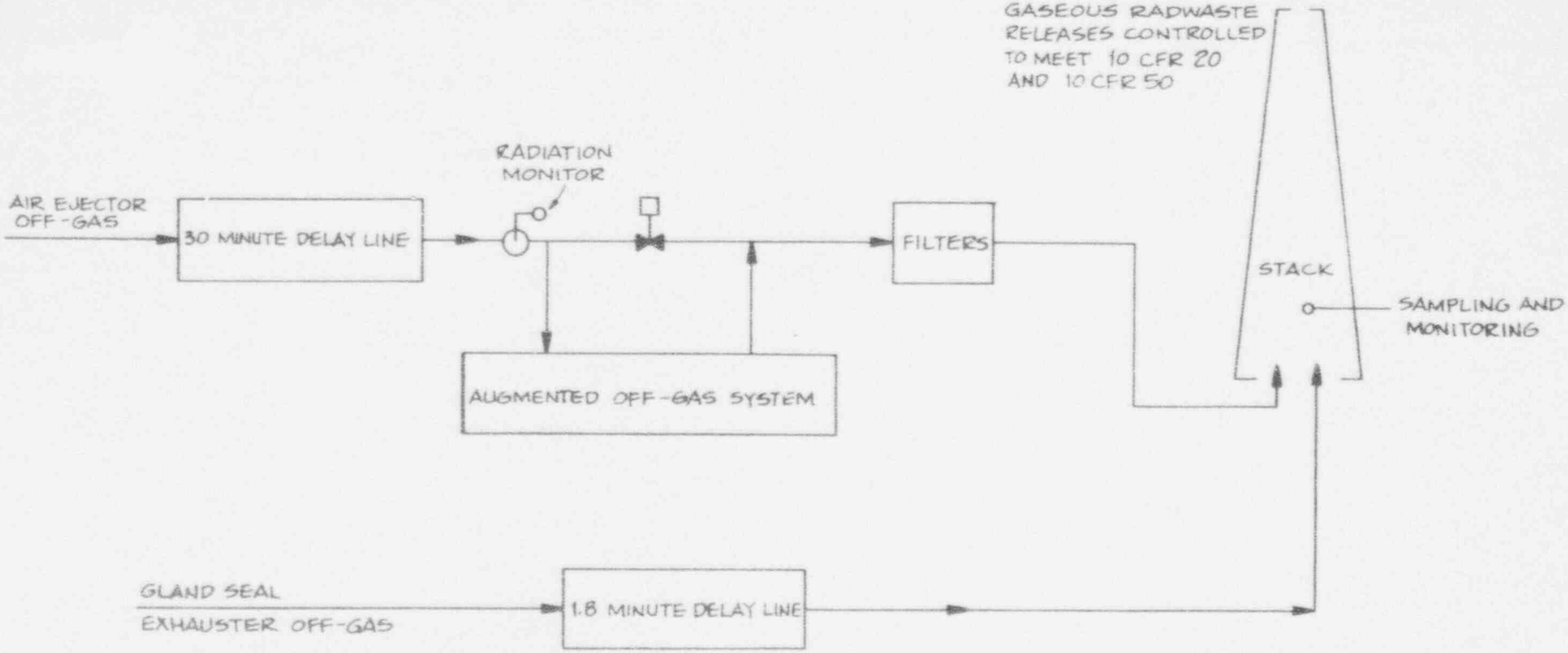


Amendment No. 5

CAROLINA POWER & LIGHT COMPANY
BRUNSWICK STEAM ELECTRIC PLANT
UNITS 1 & 2
Environmental Report

FUNCTIONAL SCHEMATIC DIAGRAM
GASEOUS RADWASTE SYSTEM

FIG. NO. 2.2-5

2.3 Permits and Environmental Approvals*

Since the inception of the Brunswick Plant, CP&L has worked diligently with numerous federal, state, and local governmental organizations in an effort to assure compatability of the plant with its environs and to assure that the plant will be capable of being operated safely. In addition to the AEC's review of plant design which preceded the issuance of construction permits, there have been a number of other permit proceedings and reviews concerned with the environmental impact of the plant. Table 2.3-1 lists the major licenses, permits, and approvals obtained by CP&L in connection with the construction and proposed operation of the Brunswick Plant.

Permits governing water use, waste water discharges, thermal effects, and various phases of construction have been received from the North Carolina Board of Water and Air Resources, the North Carolina Department of Conservation and Development, the U. S. Army Corps of Engineers, the U. S. Coast Guard, and the Federal Aviation Agency. All of these permit proceedings have included environmental impact as a major consideration in the review process and, in each case, other interested agencies, such as the North Carolina Wildlife Resources Commission, North Carolina

* Since obtaining the various state permits and approvals necessary for the Brunswick Plant, there has been a reorganization of the executive agencies of N. C. State Government. This reorganization has resulted in the creation of the Department of Natural and Economic Resources which includes as divisions the former Department of Conservation and Development, the former Department of Water and Air Resources, and the former Wildlife Resources Commission. The new divisions will carry out the basic functions of the former agencies. This section does not reflect the reorganization of State Government but is written to indicate the procedures that were followed by CP&L in obtaining the necessary state permits and approvals.

Board of Health, the Environmental Protection Agency, and the U. S. Fish and Wildlife Service were involved in the review and decision-making process.

Early in 1969, after the Brunswick Plant had been announced, the North Carolina Senate Committee on Conservation and Development held a public hearing on the possible thermal and biological effects of the proposed Brunswick Plant in an effort to determine whether existing legislation was sufficient to insure that the environmental interests of the State were being protected. CP&L appeared, along with representatives from various state agencies, to offer testimony and answer questions regarding plans and possible environmental impacts from the proposed plant. As a result of the hearing, it was concluded that additional legislation was not necessary to insure that the public interest would be protected in the design and construction of the plant.

To date, five major permits or approvals have been obtained from the North Carolina Board of Water and Air Resources. Other permits are anticipated from the Board as the design engineering of the plant progresses. Permit No. 1738 covers the discharge of heated water and low level chemical effluents into the Atlantic Ocean. Permit No. 1741 covers the discharge of effluent from the sewage treating facility now serving the construction field office at the Brunswick Plant. Permit No. 236 covers the construction and operation of the plant dewatering system. Permit No. 262 covers construction and operation of the plant water wells. In addition, Certification 2-A, as required under the Water Quality Improvement Act of 1970, has been issued by the Board of Water and Air Resources indicating that plans for the Brunswick cooling water system have been examined and that there is reasonable assurance that the proposed system will be operated in compliance with applicable water quality standards.

CP&L has worked with the North Carolina Board of Water and Air Resources to assure that all CP&L facilities are conceived, planned, designed, built, and operated in accordance with State regulations and good pollution control practices.

Long before announcing the construction of the Brunswick Plant, CP&L met with the Department of Water and Air Resources staff to discuss plans for the site as related to water use and possible thermal effects. In addition to its own review of the plans which were submitted by CP&L in support of the necessary permits to construct and operate the Brunswick Plant, the Department of Water and Air Resources solicited and coordinated the review with such other agencies as the Environmental Protection Agency, the North Carolina Wildlife Resources Commission, the North Carolina Department of Administration, the North Carolina Board of Health, the U. S. Geological Survey, and the U. S. Fish and Wildlife Service.

Under North Carolina law, the North Carolina Department of Conservation and Development has the responsibility for protecting estuarine waters, tide lands, marshlands, and State-owned lakes. In carrying out this responsibility, the Department requires a permit for all work involving dredging or filling operations in these areas. Major factors considered by the Department in its review of a permit application to dredge or fill include the effect of the proposed work on the waters of the State, the wildlife and aquatic fisheries involved, the usefulness of the project, the value and enjoyment of the property by riparian landowners, and the public health, safety, and welfare. Since the cooling water system for and railroad access to the Brunswick Plant involved estuarine waters or saltwater marshlands, permits were required from the North Carolina Department of Conservation and Development. Two permits have been issued by the

Department, one, numbered 275, for the construction of a railroad trestle over Nancy's Creek and the other, numbered 293, for construction of the circulating water system and associated structures. Prior to obtaining the construction permit for the circulating water system, CP&L had numerous conferences with the Department and other state and federal agencies. Final selection of the intake and discharge canal routes was made on the basis of these consultations with interested agencies. In providing rail access to the Brunswick site, a trestle was constructed over Nancy's Creek, a small tidal creek extending into the plant exclusion area. In addition to the permit issued by the Department of Conservation and Development, a permit was also required by the U. S. Coast Guard. A basic consideration of both agencies in reviewing the permit application was the environmental impact of the proposed construction. Both agencies coordinated their separate reviews with other state and federal agencies.

In North Carolina the State owns all vacant and unappropriated lands, swamp lands (including marshland), and lands covered by navigable waters, except those lands which may have been specifically granted and conveyed by the State to private owners. Since construction of the circulating water system for the Brunswick Plant involves work in certain lands owned or subject to claim by the State, it was necessary for CP&L to obtain an easement for the use of the lands. Prior to granting the easement, the Department of Administration (for the Governor and Council of State) reviewed CP&L's proposed circulating water system and concluded that the granting of the easement to CP&L was in the public interest.

Two permits, one for construction in navigable waters and one for discharging into navigable waters, are required from the U. S. Army Corps of Engineers in connection with the Brunswick Plant. Permit No. 19-71 has been issued by the Corps of Engineers for the construction associated with the cooling water system. Before issuing the permit the Corps obtained the approval of the State of North Carolina, the Environmental Protection Agency, and the U. S. Department of Interior. The application for a discharge permit is presently being reviewed by the Corps. Since the State certification required under the Water Quality Improvement Act of 1970 has already been forwarded to the Corps, CP&L expects that its discharge application will receive prompt Corps approval.

In the following sections, 2.3.1 to 2.3.10, a brief description is given of each major permit and the procedure that was followed in obtaining these permits.

2.3.1 AEC Construction Permit

On July 26, 1968, CP&L, in connection with its proposed construction of the Brunswick Units No. 1 and 2, submitted to the AEC a document titled "Preliminary Safety Analysis Report" (PSAR) as required by Title 10, Code of Federal Regulations, Part 50. The PSAR described all areas of the proposed plant design including its design criteria, quality assurance program and site description with regard to meteorology, climatology, geology, seismology, hydrology, topography, and population. Sections of the report described the reactor core, its cooling system, auxiliary system, power conversion system, and electrical transmission system. Other sections of the report were devoted to a description of the plant organization, the plant equipment testing program and a complete analysis of the consequences of numerous postulated abnormal occurrences. Copies of the PSAR and all amendments were submitted to the AEC. Copies of the complete filing were also sent to the Mayor of Southport and to the Chairman of the Brunswick County Commissioners. The AEC distributed copies of the PSAR to various state and federal agencies. A notice of the application was published in the Federal Register, and the AEC established Docket Nos. 50-324 and 50-325 for the Brunswick Units No. 1 and 2. Copies of the PSAR and all subsequent documents related to the Brunswick Plant were made available to the public for inspection and reproduction in the AEC's Public Document Room, 1717 H Street, N. W., Washington, D. C., filed under the appropriate docket numbers.

The Division of Reactor Licensing (DRL) conducted an extensive review and served as coordinators for the AEC review of the application. The project was assigned to a branch of DRL and a project reviewer was designated for the project. A portion of the review was conducted by specialists in the Division of Reactor Standards (DRS), a parallel division to DRL. In its review of the application, DRL called on selected outside consultants to assist them in evaluating the plant design features. These included:

1. Environmental Science Survey Administration, Air Resources Environmental Laboratory reviewed the climate and meteorological sections of the application.

2. U. S. Army Corps of Engineers, Coastal Engineering Research Center reviewed the potential storm flooding of the proposed site.

3. U. S. Geological Survey reviewed the hydrologic and geologic aspects of the proposed plant location.

4. U. S. Coast and Geodetic Survey reviewed the seismicity of the proposed site.

5. U. S. Fish and Wildlife Service reviewed the potential ecological effects on the environment of the plant site.

6. U. S. Public Health Service reviewed the radiological health aspects of the proposed plant.

7. Federal Water Quality Administration reviewed the effects of thermal and chemical discharges into public waters.

In addition, various firms and consultants not associated with the applicant were called upon by DRL to review the application. These consultants reviewed the structural adequacy and various design criteria for the plant.

Following this extensive review, the AEC reported its findings to the Advisory Committee on Reactor Safeguards (ACRS). The ACRS was composed of non-AEC personnel with recognized expertise in various disciplines who examined the entire technical aspects of the application and the AEC's review of the application. A subcommittee was formed and an on-site inspection of the proposed site was made April 30, 1969.

Based upon this on-site investigation, and its thorough review of the proposed plant, the ACRS advised the Chairman of the AEC of their findings. The ACRS findings were published, a date was set for public hearing, and an Atomic Safety and Licensing Board was appointed to conduct the hearing. A waiting period was allowed so that interested parties having objections to the proposed plant could intervene in the proceedings. Prior to the scheduled public hearing, a pre-hearing conference was held at Southport on November 13, 1969, for the purpose of establishing the agenda and order of the proceedings and to instruct all potential participants in the hearing. This pre-hearing conference was a public meeting to which all potential intervenors were invited. The public was further invited to express their sentiments (either for or against the granting of a permit to construct the plant) during the course of the hearing which was also held in Southport.

On December 2 and 3, 1969, the Atomic Safety Licensing Board, after having conducted its own review of the AEC licensing dockets, held a public hearing at which it received comments from the public and at which it closely examined witnesses for CP&L and for the AEC. The construction permits were granted February 7, 1970. A chronologically arranged listing of the AEC licensing activities to date is presented in Table 2.3-2. Figure 2.3-1 is a flow-chart which describes the normal processing by the AEC of an application for a Construction Permit.

2.3.2 Certificate of Public Convenience and Necessity

As required by N. C. Law, G.S. 62-110.1, a public utility must obtain from the N. C. Utilities Commission a Certificate of Public Convenience and Necessity prior to constructing or installing electrical generating facilities. In connection with the Brunswick Plant, CP&L filed an application with the N. C. Utilities Commission on October 25, 1968. The application included statements on the

Company's generating capability, the Company's peak load demand, a description of the proposed Brunswick generating facilities, the date when the facilities were to be completed and the anticipated cost of the facilities.

Upon receipt of this application, the Utilities Commission issued a Notice of Certificate for Generating Facilities. Beginning October 30 and ending November 20, 1968, CP&L caused copies of the notice to be published once a week in The Wilmington Morning Star, the local newspaper serving the Southport area. A public hearing was held on December 12, 1968, and on December 18, 1968, the Commission issued to CP&L a Certificate of Public Convenience and Necessity. Figure 2.3-2 shows the normal processing of an application by the Utilities Commission for a Certificate of Public Convenience and Necessity.

2.3.3 (State) Waste Water Discharge Permit (Circulating Water)

The authority to regulate and control water quality in North Carolina is vested in the N. C. Board of Water and Air Resources. The organization, powers, and general procedures of the Board are established in Chapter 143, Article 21, of the General Statutes.

The Board is responsible for the prudent utilization of the State's water resources. It is charged with the responsibility of developing a system of water classifications which recognize the best use that is to be made of various waters. It is responsible for a set of standards applicable to each of these classifications and for a program to enforce these water quality standards.

The criteria used in developing and assigning classification to the waters of the State include how the water has been used, what use is being made of it, and what use may be made of the water in the future. Primary consideration is given to domestic consumption, bathing, recreation, fish and wildlife propagation, industrial consumption, waste disposal, and fire protection. The standards of water quality corresponding to each classification are designed to protect human health, prevent injury to plant and wildlife, and prevent damage to public and private property. As a means of controlling water pollution, the Board also administers a permit program applicable to all discharges into public waters. Figure 2.3-3 describes the normal processing of an application for the Waste Water Discharge Permit.

Since the cooling water from the Brunswick Plant will be discharged into public waters under State jurisdiction, it was necessary that a waste water discharge permit be obtained from the N. C. Department of Water and Air Resources. On March 7, 1968, Carolina Power & Light Company met with the Department of Water and Air Resources to discuss water quality standards with respect to the Brunswick facility. Throughout the remainder of 1968 and in early 1969, CP&L continued to meet with several state and federal agencies to discuss plans for the plant cooling water system. On February 6, 1969, Carolina Power & Light Company met with the Department, the Federal Water Pollution Control Agency (FWPCA), the U. S. Public Health Service, and the N. C. State Board of Health to discuss studies that were being conducted by CP&L in connection with thermal discharges from the proposed plant.

On June 20, 1969, a permit application was filed with the Industrial Waste Section of the Department of Water and Air Resources covering the proposed discharge of cooling water from the Brunswick Plant into the Atlantic Ocean. Included with the permit application was an engineering report presenting plans and specifications for the proposed work. The engineering report provided details on the proposed discharge, its impact on water quality standards, and other environmental considerations. Special attention was given to stream flow, temperatures, dissolved oxygen, flood protection, safety, cost, and the protection of fish and wildlife.

On June 25, 1969, Carolina Power & Light Company met with representatives of various state and federal agencies to discuss the application. Among those agencies were the FWPCA, U. S. Fish and Wildlife, Department of Water and Air Resources, and the N. C. Department of Conservation and Development. On December 8, 1969, after supplementing the original application and after distributing copies of the revised application to various state and local agencies for their comments, Carolina Power & Light Company again met with the FWPCA, the N. C. Department of Water and Air Resources, the U. S. Geological Survey, the N. C. State Board of Health, the N. C. Wildlife Resources Commission, the Department of Conservation and Development, and the State Planning Task Force to discuss their comments. On January 16, 1970, Carolina Power & Light Company received Waste Water Discharge Permit #1738.

2.3.4 Well Construction Permit

Construction of a well in North Carolina, other than one for domestic use, or one having a maximum capacity of less than 100,000 gallons per day, requires a permit from the N. C. Board of Water and Air Resources. The organization, powers, and general procedures of the Board are established in Chapter 143, Article 21 of N. C. General Statutes.

Figure 2.3-4 discribes the normal processing of an application for a well construction permit. Application for a permit is submitted to the Board of Water and Air Resources along with detailed plans and specifications of the proposed well. The Board, in reviewing the application, considers public health and possible contamination of ground water supplies, effects on other possible uses of water, proximity to other wells, well yield, and effects on the existing water table.

In addition, the Ground Water Division of the Department of Water and Air Resources, if it feels that other interests could be affected by the proposed well, may submit copies of the application to the U. S. Geological Survey, the N. C. Department of Health, the N. C. Department of Conservation and Development, and other interested agencies for their comments.

Two applications for well construction permits have been filed by CP&L in connection with the Brunswick Plant. One, submitted October 20, 1969, was for the purpose of dewatering the plant area for excavation. This permit, #236, was granted October 26, 1969. The other application was for the construction of permanent plant operating wells, submitted to the Board on December 5, 1969. Permission to construct the permanent operating wells was granted to CP&L with the issuance of Permit #262 on December 8, 1969.

2.3.5 Waste Water Discharge Permit (Sewage Effluent)

As discussed in Section 2.3.3, a permit is required from the North Carolina Board of Water and Air Resources to discharge into State waters. In connection with the sanitary waste disposal system serving the construction office at the Brunswick Plant site, CP&L filed an application for such a permit on December 16, 1969. The application included plans and specifications describing the waste disposal system and the waste treatment process. The application was reviewed by the Department of Water and Air Resources and a permit, No. 1741, was issued by the Board on January 21, 1970. Normally, the Department's review of sanitary waste disposal systems is coordinated with the North Carolina Board of Health. Figure 2.3-5 shows the normal processing of a permit application involving effluents from a sanitary waste treatment system.

2.3.6 Permit to Obstruct Navigable Airspace

To erect a structure that exceeds the Federal Aviation Agency (FAA) standards, four copies of an application for a permit must be submitted to the Chief, Air Traffic Branch, FAA Regional Office. The FAA conducts an aeronautical study of the permit application and issues either a finding of no hazard or a finding that additional study is necessary to determine whether the proposed structure would be a hazard to air navigation. In conducting an aeronautical study, the FAA Regional Director solicits comments from interested members of the public, the Airline Pilots Association, U. S. Air Force, and local airport management. The FAA reviews these comments and all facts relevant to the proposal. The FAA then determines whether the proposed obstruction would be a hazard to air navigation.

CP&L has filed two applications with the FAA in connection with the Brunswick Plant. One, for the combination microwave and meteorological tower, was filed on June 25, 1969 and resulted in the granting of Permit #69-ATL-310-OE on June 30, 1969. The other one was filed with the FAA on March 12, 1970, for the construction of the plant stack. On March 17, 1970, the FAA stated that an aeronautical study showed that the stack would not violate any standard of Part 77, Subpart C of the Federal Aviation Regulations and would not be a hazard to air navigation. No objections were received from the aeronautical public, and the FAA granted CP&L Permit #70-SO-94-OE on April 28, 1970 to construct the stack. Figure 2.3-6 outlines the normal procedures for obtaining permits to erect structures that might obstruct navigable airspace.

2.3.7 Dredge and Fill Permit for Work in State-Owned Lake and Estuarine Waters

Work involving excavation or fill in or about estuarine waters, tidelands, marshlands, or state-owned lakes requires a permit from the North Carolina Department of Conservation and Development. The requirements and procedures for obtaining a permit are covered in North Carolina General Statutes 113-229. The construction of the Brunswick facility has necessitated the obtaining of three permits from the Department of Conservation and Development. They include permits to dredge and fill as required for construction of the circulating water system, for construction of a temporary work road across Nancy's Creek, and for construction of a railroad trestle across Nancy's Creek.

The permit application included detailed plans and specifications for conducting the proposed work. Copies of the application were filed with the Department of Conservation and Development and with adjacent riparian landowners. The adjacent landowners were invited to submit their comments to the Department of Conservation and Development. The Department of Conservation and Development transmitted copies of the application to those state and federal agencies with interest in matters which could be affected by the project. These included the State Department of Water and Air Resources, State Wildlife Resources Commission, State Board of Health, State Department of Administration, and U. S. Bureau of Sports Fisheries and Wildlife.

The Department conducted its review considering the effects of the proposed work on the use of waters by the public; the value and usefulness of the project; the value and enjoyment of the property of any riparian owner; public health, safety, and welfare; the conservation of public and private water supplies; and the protection of fish and wildlife.

On June 24, 1970, CP&L filed an application for a permit from the Department of Conservation and Development to construct a temporary work road across Nancy's Creek. Permit #222 was granted August 17, 1970, for this purpose. On October 21, 1970, an application was filed for a permit to dredge and fill as required to construct the circulating water canal. The Permit, #293, was issued on December 15, 1970. In connection with the construction of the railroad trestle over Nancy's Creek, an application was filed with the Department on September 9, 1970 and a Permit, #275, was granted on November 3, 1970. The normal processing of an application for a "Dredge and Fill Permit" is shown in Figure 2.3-7.

2.3.8 Permit to Construct Railroad Trestle - Coast Guard

To construct a bridge, trestle, or similar structure over navigable waters of the U. S., one must obtain approval from the Commandant, U. S. Coast Guard, as required by the "General Bridge Act of 1946" (60 Stat. 847; 33 U.S.C. 525). In approving the plans and location of any such bridge, the Commandant may impose any specific conditions relating to the construction, maintenance, and operation of the structure which he deems necessary in the interest of public navigation. In addition to navigation, the Commandant must consider conformance with the National Environmental Policy Act, fish and wildlife, recreation, and aesthetics.

On September 8, 1970, CP&L submitted plans and a map showing the location of a bridge to be constructed over Nancy's Creek, a small tidal creek in the vicinity of the Brunswick Plant. On January 11, 1971, Bridge Permit (194-70) was issued by the Commander, Fifth U. S. Coast Guard Division, Portsmouth, Virginia. Figure 2.3-8 shows the usual processing of an application for such a permit.

2.3.9 Water Quality Certificate

In accordance with requirements of the Water Quality Improvement Act of 1970 (Public Law 91-224) and subject to the rules of the North Carolina Board of Water and Air Resources, CP&L filed an application on October 13, 1970, for water quality certification in connection with the proposed discharge of cooling water into the surface waters of the Atlantic Ocean off Brunswick County, North Carolina. Beginning on November 4, 1970, the notice of application was published for 20 days in The Wilmington Morning Star.

In the absence of objections from State and Federal agencies and from the public, the North Carolina Board of Water and Air Resources determined that a public hearing on the application was unnecessary. On December 1, 1970, the Board issued Certificate 2-A stating "that there is reasonable assurance that the proposed activity will be conducted in a manner which will not violate applicable water quality standards".

Figure 2.3-8 shows the normal processing route for obtaining a water quality certificate.

2.3.10 Construction Permit for Work in Navigable Waters

Section 10 of the River and Harbor Appropriation Act of March 3, 1899 (33 U.S.C. 403), requires the prior approval by the Corps of Engineers for dredging operations in navigable waters. In connection with the construction of the circulating water system for the Brunswick Plant, it was necessary for CP&L to excavate materials from navigable waters.

On October 1, 1969, CP&L filed a permit application with the Army Corps of Engineers. A public notice was issued by the Corps of Engineers and comments were solicited by the Corps from interested parties, the State of North Carolina, and various Federal agencies. Comments were received from individuals, the State of North Carolina, and the U. S. Fish and Wildlife Service. Copies of the comments were transmitted to CP&L by the Corps, and on February 2, 1970, CP&L met with interested State and Federal agencies to discuss their comments.

On March 25, 1970, CP&L revised its application in an effort to accommodate the interests of the various commenting agencies, and once again, the Corps published public notice of the application. During the months of May and June, 1970, CP&L received further comments through the Corps of Engineers from the Department of Conservation and Development, the N. C. Wildlife Resources, and the U. S. Fish and Wildlife Service. Following additional discussions with these agencies, CP&L again revised its plans for the circulating water system and on October 19, 1970, filed a new application with the Corps. A permit (No. 19-71) was issued by the Corps on March 25, 1971. A description of the normal processing of the application is shown in Figure 2.3-8.

TABLE 2.3-1

MAJOR PERMITS OBTAINED BY
CAROLINA POWER & LIGHT COMPANY FOR
CONSTRUCTION AND OPERATION OF THE
BRUNSWICK STEAM ELECTRIC PLANT

Permit	Permit No.	Agency	Application Date	Permit Date
AEC Construction	CPPR-67 CPPR-68	Atomic Energy Comm.	7-26-68	2-7-70
Construction Permit for Work in Navigable Waters	19-71	U. S. Army Corps of Engrs.	10-1-69	3-25-71
Certificate of Public Convenience & Necessity		N. C. Utilities Commission	10-25-68	12-18-68
(State) Waste Water Discharge (Circulating Water)	1738	N. C. Dept. of Water & Air Resources	6-20-69	1-16-70
Dewatering in Plant Area	236	N. C. Dept. of Water & Air Resources	10-20-69	10-26-69
Well Construction	262	N. C. Dept. of Water & Air Resources	12-5-69	12-8-69
Waste Water Disposal (Sewage Effluent)	1741	N. C. Dept. of Water & Air Resources	12-16-69	1-21-70
Water Quality Certificate	2-A	N. C. Dept. of Water & Air Resources	10-13-70	12-1-70
Dredge & Fill Permit for Work in State Owned Lake and Estuarine Waters (Circulating Water)	293	N. C. Dept. of Conservation & Development	10-21-70	12-15-70
Trestle Across Nancy's Creek	275	N. C. Dept. of Conservation & Development	9-8-70	11-3-70
Road Across Nancy's Creek	222	N. C. Dept. of Conservation & Development	6-24-70	8-17-70
Brunswick Railroad Trestle	194-70	U. S. Coast Guard	9-8-70	1-11-71
Permit to Obstruct Navigable Airspace	69-ATL-310-OE 70-SO-94-OE	Federal Aviation Agency	6-25-69 3-11-70	6-30-69 4-28-70

TABLE 2.3-2

AEC LICENSING ACTIVITIES

Date	Action
July 26, 1968	Carolina Power & Light Company filed its application for a construction permit with the Preliminary Safety Analysis Report (PSAR).
September 3, 1968	Submittal of Amendment No. 1, the First Supplement containing discussion of possible effects of Sunny Point Army Terminal operations on the plant.
September 11, 1968	Initial meeting with the AEC to discuss review plan and schedule.
October 7, 1968	Meeting with the AEC to discuss site geology and potential foundation problems.
October 17, 1968	Meeting with the AEC to discuss technical qualifications and quality assurance.
November 7-8, 1968	Meeting with the AEC to discuss AEC's request for additional information.
December 6, 1968	Submittal of Amendment No. 2 which provided estimates of the cost for the plant.
December 12, 1968	AEC issued request for additional information.

TABLE 2.3-2 (cont'd)

Date	Action
December 20, 1968	Meeting with the AEC to discuss seismic design of the main steam line.
January 7, 1969	AEC issued request to applicant for information on seismic design of the main steam line and related issues.
January 17, 1969	Submittal of Amendment No. 3, the Second Supplement containing partial response to AEC's request of December 12, 1968.
January 27, 1969	Submittal of Amendment No. 4, the Third Supplement completing applicant's response to AEC's request of December 12, 1968.
January 31, 1969	Submittal of Amendment No. 5, which provided additional information on organization, technical qualifications, quality assurance, site seismic features, and missiles from munitions explosions.
February 12-13, 1969	Meeting with the AEC to discuss contents of Amendment Nos. 3, 4, and 5.
March 4-5, 1969	DRL personnel visited the site and nearby steam plants for geology and plant operations considerations.

TABLE 2.3-2 (cont'd)

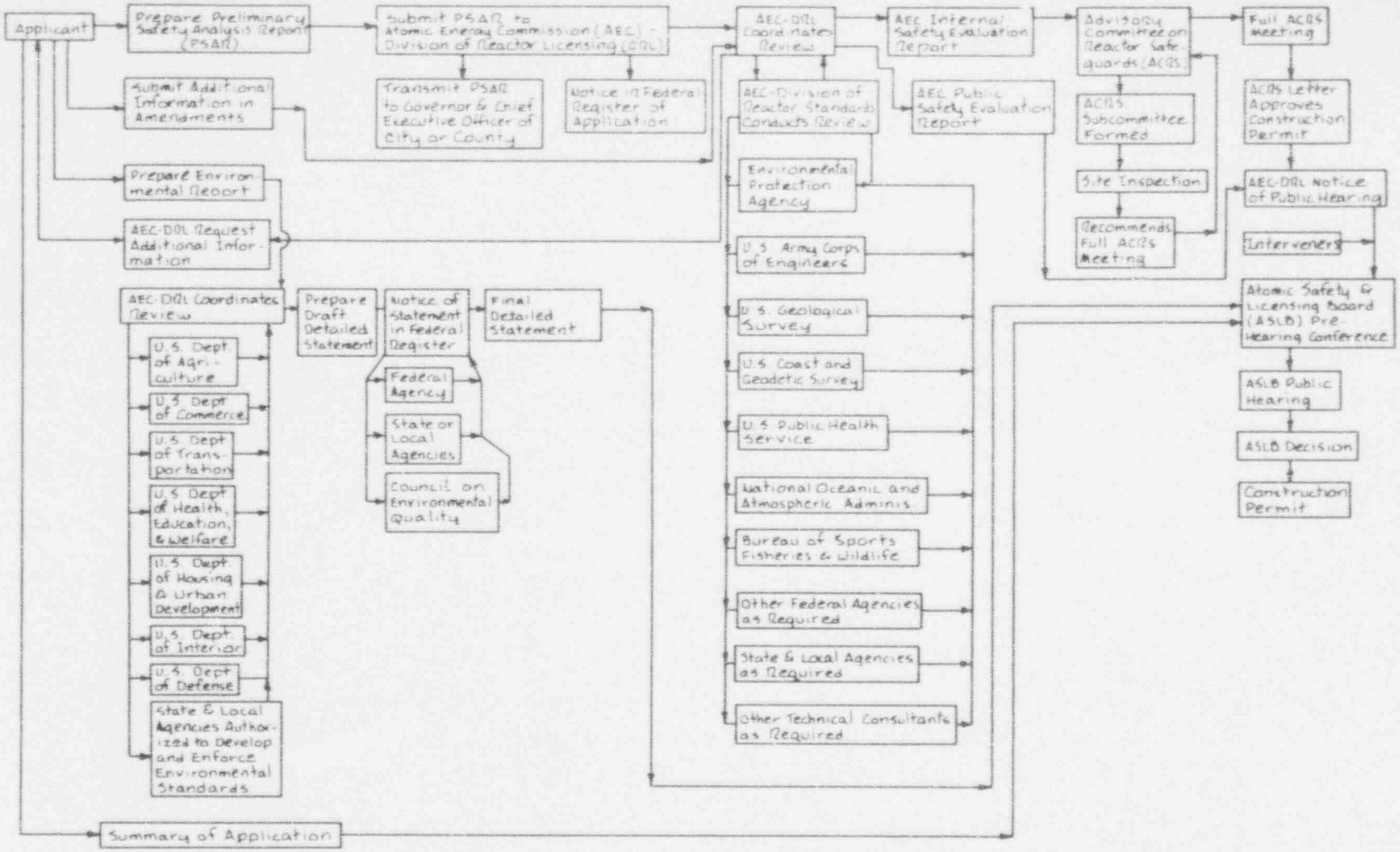
Date	Action
March 5, 1969	AEC issued third request to applicant for additional information.
March 12, 1969	Submittal of Amendment No. 6, the Fourth Supplement containing response to AEC's requests of January 7, 1969 and March 5, 1969.
March 25, 1969	Meeting with the AEC to discuss DRL position on safety issues.
April 9, 1969	Meeting with the AEC to further discuss DRL positions on safety issues and to identify remaining items requiring further information.
April 15, 1969	AEC issued fourth request for additional information.
May 2, 1969	Submittal of Amendment No. 7, the Fifth Supplement, containing the applicant's response to AEC's request of April 15, 1969.
May 7-8, 1969	First ACRS review of the Brunswick application.
May 15, 1969	ACRS letter was issued for the Brunswick plant.

TABLE 2.3-2 (cont'd)

Date	Action
May 23, 1969	Meeting with the AEC to discuss the items cited in the ACRS letter of May 15, 1969.
June 30, 1969	Submittal of Amendment No. 8, the Sixth Supplement which responds to the items cited in the ACRS letter of May 15, 1969.
July 18, 1969	Submittal of Amendment No. 9 which reports a change in schedule and costs for the Brunswick plant.
August 12, 1969	Submittal of Amendment No. 10, which reports a change in constructor with related changes in organization and quality assurance.
October 9, 1969	Second ACRS review of the Brunswick application by the full committee.
October 16, 1969	Second ACRS letter was issued for the Brunswick plant.
November 13, 1969	Pre-Hearing Conference with ASLB at Southport and Wilmington, North Carolina.
December 2-3, 1969	Public Hearing before an Atomic Safety and Licensing Board held at Southport, North Carolina.

TABLE 2.3-2 (cont'd)

Date	Action
February 7, 1970	Construction Permit issued by AEC.
October 2, 1970	Post-Construction Permit meeting of AEC and Carolina Power & Light Co.



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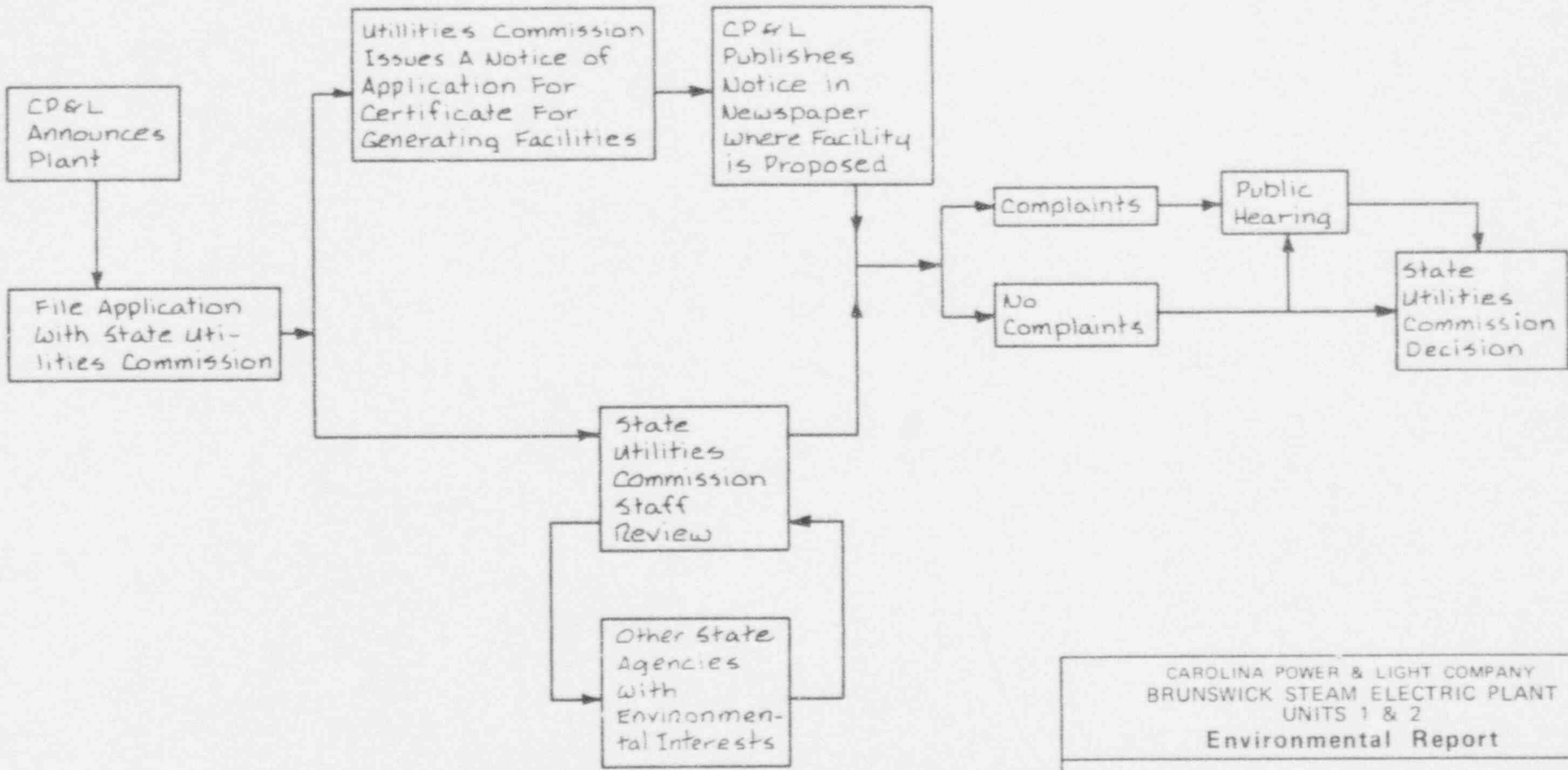
FLOW DIAGRAM OF THE NORMAL PROCESSING OF AN APPLICATION FOR THE AEC CONSTRUCTION PERMIT

FIG. NO. 2.3-1



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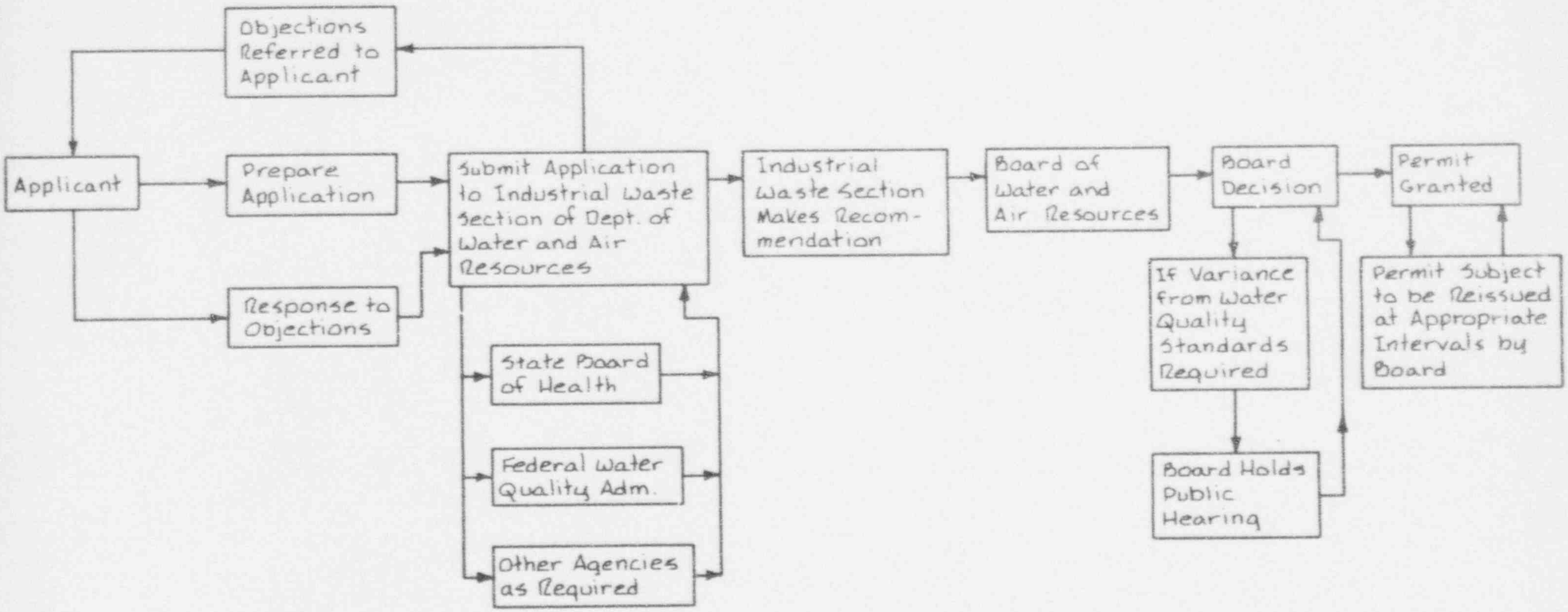
NORMAL PROCESSING OF AN APPLICATION FOR THE CERTIFICATE OF PUBLIC CONVENIENCE AND NECESSITY

FIG. NO. 2.3-2



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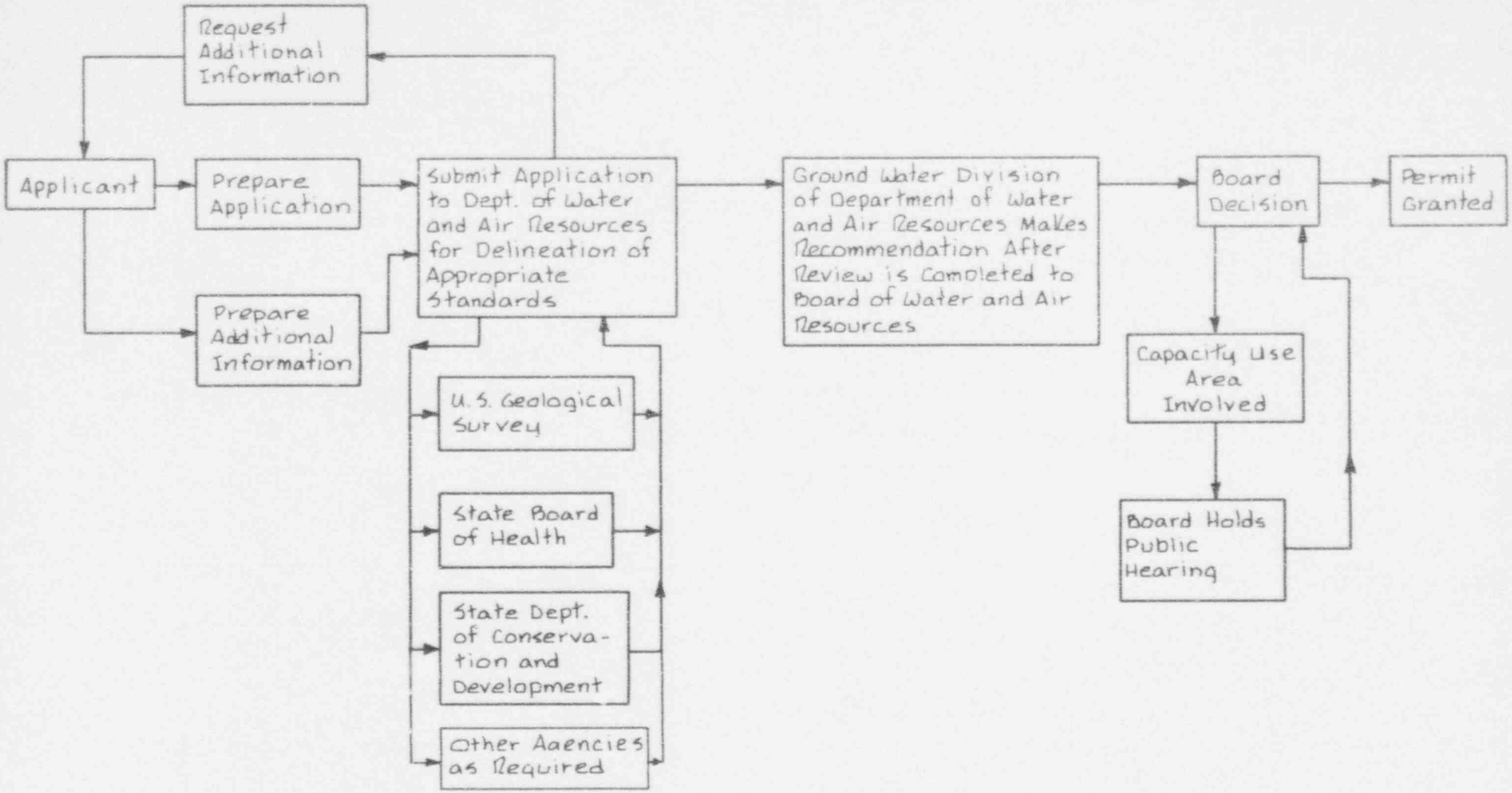
FLOW DIAGRAM OF THE NORMAL PROCESSING OF AN APPLICATION FOR THE (STATE) WASTE WATER DISCHARGE PERMIT (CIRCULATING WATER)

FIG. NO. 2.3-3



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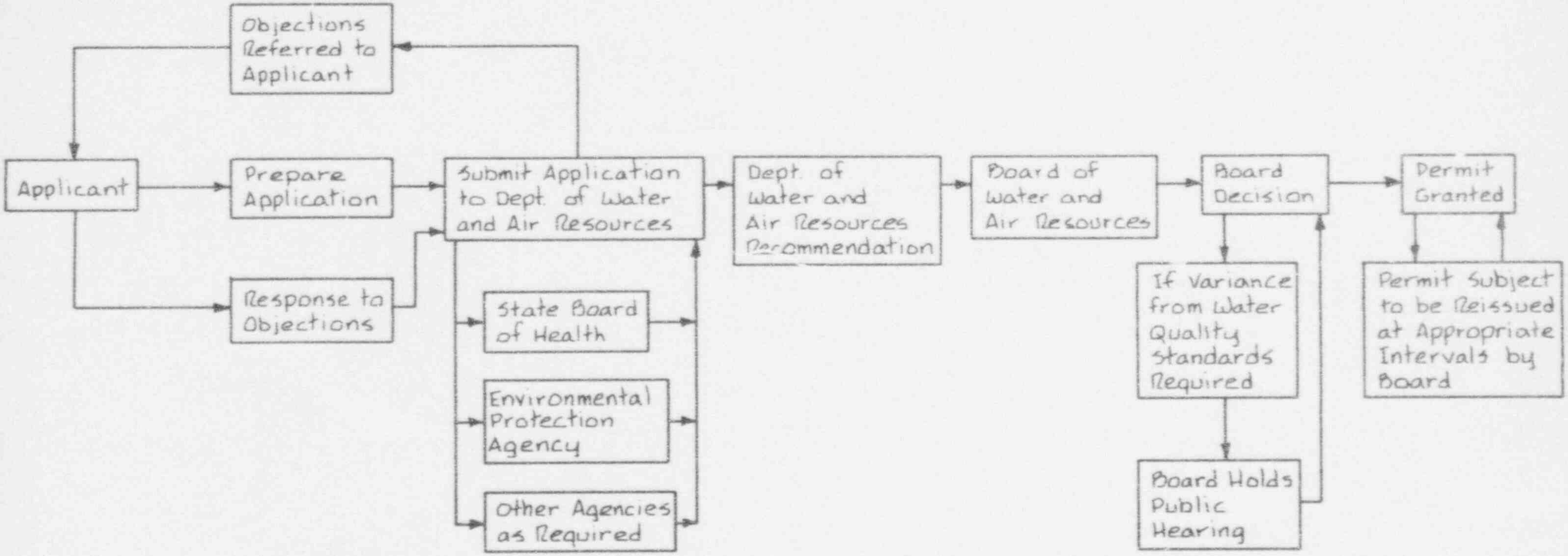
FLOW DIAGRAM OF THE NORMAL PROCESSING OF AN APPLICATION FOR THE WELL CONSTRUCTION PERMIT

FIG. NO. 2.3-4



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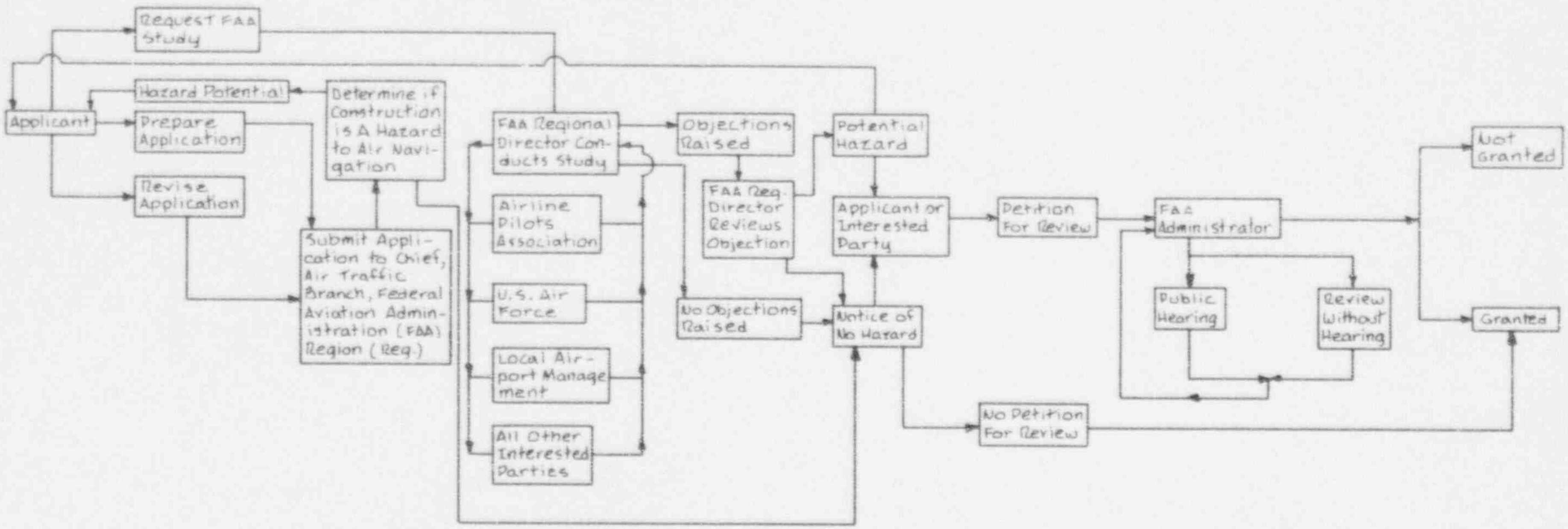
FLOW DIAGRAM OF THE NORMAL PROCESSING OF AN APPLICATION FOR THE WASTE WATER DISPOSAL PERMIT (SEWAGE EFFLUENT)

FIG. NO. 2.3-5



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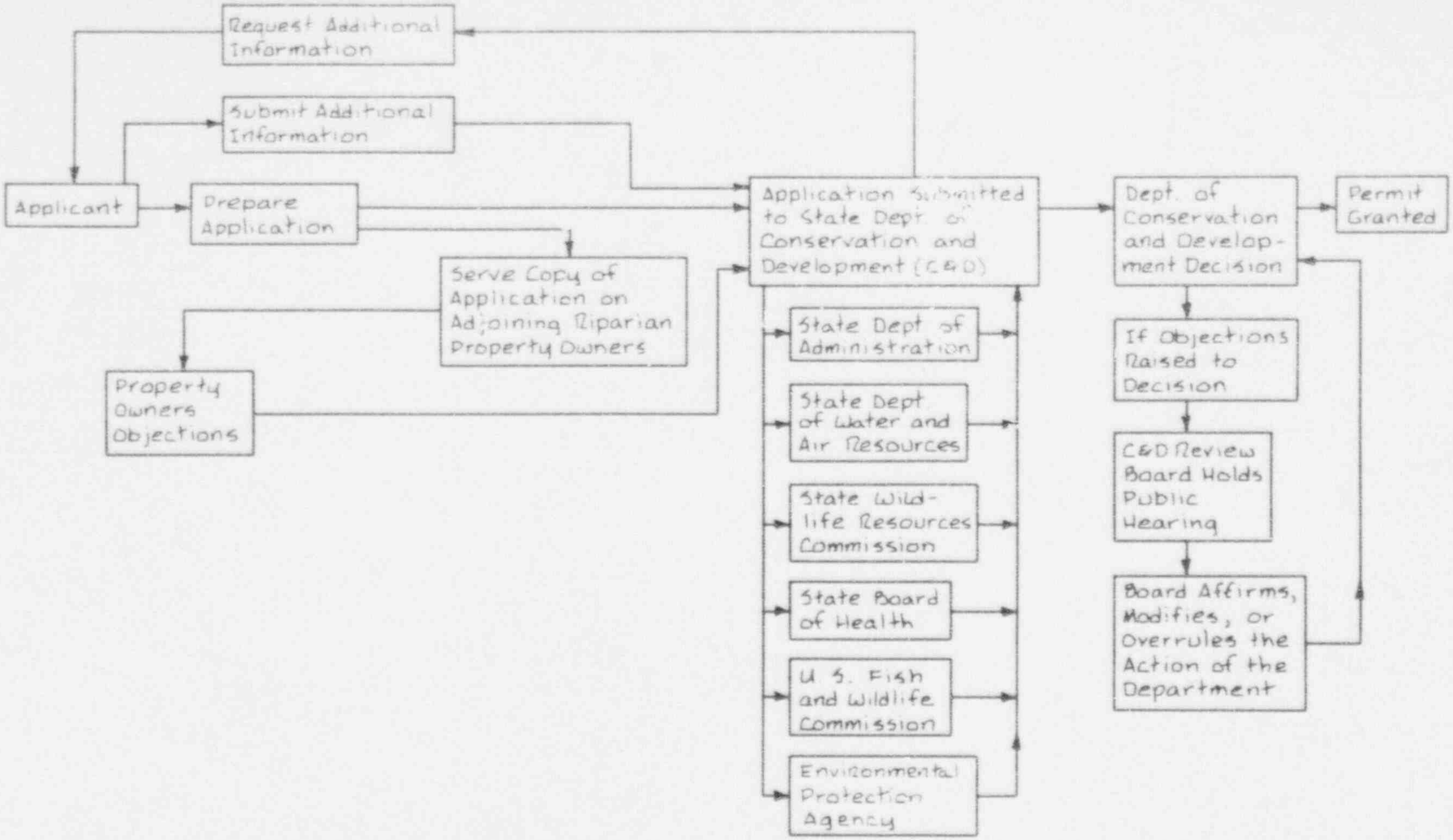
FLOW DIAGRAM OF THE NORMAL PROCESSING OF AN APPLICATION FOR THE PERMIT TO OBSTRUCT NAVIGABLE AIRSPACE

FIG. NO. 2.3–6



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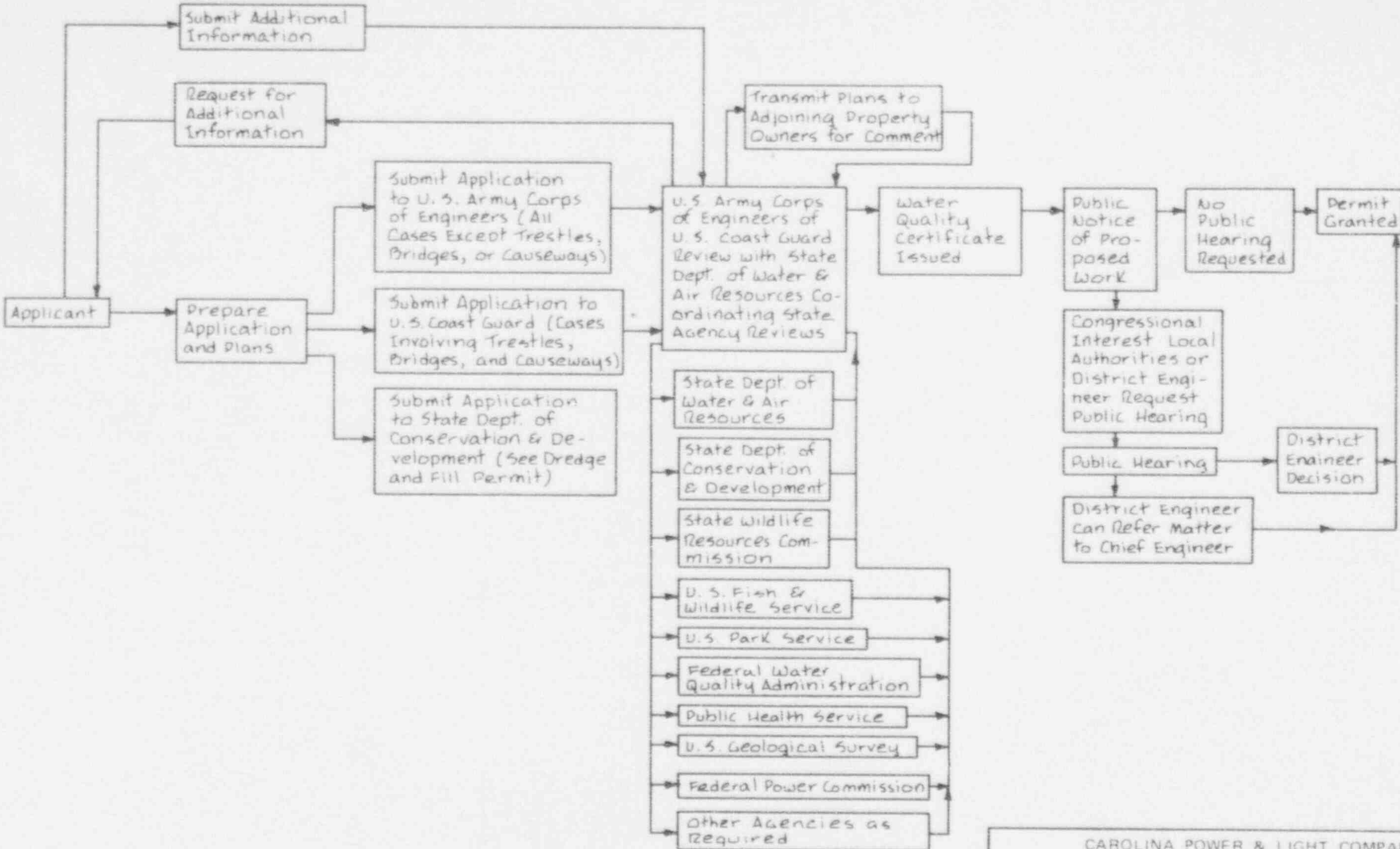
FLOW DIAGRAM OF THE NORMAL PROCESSING OF AN APPLICATION FOR THE DREDGE AND FILL PERMIT FOR WORK IN STATE-OWNED LAKE AND ESTUARINE WATERS

FIG. NO. 2.3-7



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FLOW DIAGRAM OF THE NORMAL PROCESSING OF AN APPLICATION FOR A CONSTRUCTION PERMIT FOR WORK IN NAVIGABLE WATERS

FIG. NO. 2.3-8

2.7 Environmental Radiological Monitoring

CP&L will conduct a comprehensive radiological environmental monitoring program in the vicinity of the plant to assure the design objectives of the radioactive waste control and monitoring systems are met.

Process radiation monitoring can be found in Subsection 7.12; area radiation monitoring system in Subsection 7.13; site environs radiation monitors in Subsection 7.14; and health physics laboratory radiation monitoring equipment in Subsection 7.17. Also, radioactive waste control systems can be found in Section 9.

2.7.1 Pre-operational Radiological Monitoring Program

A pre-operational radiological program was started early in 1972 and will continue until initial criticality. The program will be conducted to: determine the magnitude and nature of radioactivity in the environment surrounding the site; test the equipment, sampling and analytical procedures, and suitability of selected sampling points; and investigate the overall statistical variability of the results. The information obtained will serve as a baseline for the evaluation of any changes in environmental radioactivity levels that may result from plant operation as determined by the operational radiological monitoring program.

Table 2.7-1 describes this program by defining the types, locations, and number of samples to be taken, collection frequencies, and analyses to be performed.

Any release of radioactive materials will flow to the air, surface, ground waters or any combination thereof. Pathways to man can be direct by air inhalation, ingestion of surface and ground water, and absorption of radiation from external sources or indirectly through environmental intermediaries including soil, terrestrial animals and vegetation, and aquatic animals and vegetation. Therefore, the program has been designed to monitor critical areas in both pathways.

The close-range measurements of air are made at locations where maximum ground concentrations of airborne radionuclides are expected to occur. These locations range in distances from one to five miles from the site and in the directions of dominant winds. The one major, nearby populated area will serve for the population-related air measurements. To serve as a background (or comparison) measurement, a location has been selected at a distance of 16 miles.

Surface water measurements for the intake canal will be made at close range; discharge water at several points farther. Other surface measurements will be made at distances ranging from one to five miles from the source of possible release. At least one sampling point will be located in each of the four 90-degree sectors from the plant.

Ground water releases travel very slowly; therefore, onsite measurements will dominate in number. However, one distant measurement will be made at the Southport water supply source because of population and usage.

Measurements of direct radiation exposure are made at a variety of distances and locations; therefore, the relatively direct pathways from plant to man are well monitored. However, in direct pathways involving biological organisms and soils pose a different problem.

It is not possible to monitor every plant or animal species which might be consumed as human food. Instead, sensitive pathways (such as the air-vegetation-cow-milk-man pathway and the air and water-aquatic food-man pathway) are extensively monitored such that dominant wind directions and distance proximity to both the site and cooling water discharge are taken into account.

Milk samples are taken from the nearest possible locations, terrestrial vegetation is sampled from nearby farms in the dominant wind directions, and aquatic plants and animals are taken in close proximity to the water discharge. Where possible, more than one type of sample is taken from a given location. For example, soil and vegetation or milk and locally grown feed are sampled at common locations.

A semiannual survey will determine the locations of milk-producing animals in the area surrounding the plant. This area will be large enough to include points at which child thyroid doses (due to radioiodine in milk) are calculated to be greater than 1 mrem per year. It is anticipated that changes in milk sampling locations will be made periodically, based upon these surveys and the need for collection of larger milk volumes to achieve required sensitivities.

The program will be closely coordinated with existing state programs for monitoring radioactivity levels in the environemnt. Discussions were held with the N. C. Department of Radiological Health in formulating the program. This program (and the results to be obtained therefrom) will continue to be coordinated with this agency and other interested agencies as the program proceeds to assure maximum effectiveness for all interested parties.

2.7.2 Operational Radiological Monitoring Program

The operational radiological monitoring program is expected to closely follow the schedule developed and modified during the pre-operational program (refer to Table 2.7-1). The program will provide various background data and effluent release measurements for evaluating the environmental impact of plant operation.

Samples collected at points where effluent concentrations are expected to be greatest will be compared with samples collected concurrently at points expected to be essentially unaffected by plant effluents. The latter samples, along with the pre-operational data, will provide background measurements that will be used as a basis for distinguishing significant radioactivity introduced into the environment by plant operation from that due to natural background or other sources. If significant radioactivity is detected, the primary isotopes involved will be identified and efforts made to determine the source.

Results of the sample analyses will be evaluated to demonstrate the effectiveness of plant radiation control and compliance with the requirements of 10CFR20, the Technical Specifications, and the design objectives of the waste processing system as contained in Appendix I, 10CFR50. After one year of safe plant operation, the number of sampling frequencies and locations may undergo reductions consistent with the analytical results; however, the program will, subject to revision, continue throughout the entire period of plant operation.

TABLE 2.7-1

ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM BRUNSWICK STEAM ELECTRIC PLANT

Sample Type	Sampling Point and Description	Sampling Frequency	Sample Size	Sample Analysis
Air Samples (AS)	1. Information Center - Rt. 87 - 1 mile SW 2. Southport - 2.5 miles south at substation 3. River Road - 1.5 miles ENE 4. Caswell Beach - 5 miles SW 5. Projected maximum annual concentration point - exclusion area boundary NE 6. L. V. Sutton Plant - 16 miles NNE	Weekly	1 cfm (Continuous for operational phase)	Gross beta - weekly Iodine - weekly (2) Gross alpha - monthly gamma (1), (3) Strontium 89-90 - quarterly composite
Ground Water (GW)	1. Southport water supply (Castle Hayne) 2. Discharge canal Well C-55A (shallow) 3. Discharge canal Well C-47A (shallow) 4. BSEP on-site Well No. 1	Quarterly	2 liters	Gross beta Gross alpha Gamma (3) Tritium
Surface water (SW)	1. Intake canal at River Road 2. Ocean off Caswell Beach at distance outfall 3. Discharge canal at Hwy. 133 bridge 4. Boiling Springs Lake at Hwy. 87 bridge 5. Ocean east of discharge outfall 6. Ocean west of discharge outfall	Monthly (4)	2 liters	Gross beta - each sample Tritium - quarterly on composite Gamma - each sample (3) Strontium 89-90 quarterly composite for Stations 2, 5, 6.

Sheet 1 of 6

TABLE 2.7-1 (Cont'd)

ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM
BRUNSWICK STEAM ELECTRIC PLANT

Sample Type	Sampling Point and Description	Sampling Frequer	Sample Size	Sample Analysis
Bottom Sediment (BS)	1. Intake canal at River Road 2. Ocean off Caswell Beach at discharge outfall 3. Discharge Canal at Hwy. 133 bridge 4. Discharge Canal at stilling pond 5. Discharge Canal at 100 yds below plant discharge structure 6. Ocean east of discharge outfall 7. Ocean west of discharge outfall	Quarte)	0.5 kilogram wet	Gross beta Gamma (3) Strontium 89-90
Milk	1. Family cow - 4000 feet east of plant site (7) 2. Dairy cow - 11 miles NNW 3. Dairy cow - 13 miles NNW	Weekly (6)	2 liters	Iodine within Seven days of collection, 0.5 pCi/l sensitivity Gamma on monthly composite (3) Strontium 89-90 on quarterly composite
Soil and Beach Sand (SS)	1. Beach sand (surface) at discharge outfall	Semiannual (spring & fall)	0.5 kilogram	Gamma (3) Strontium 89-90
	2. Beach sand east of discharge outfall	Semiannual (spring & fall)		
	3. Beach sand west of discharge outfall	Semiannual (spring & fall)		
	4. At turnip sample site	Annual (spring qtr.)		
	5. At terrestrial vegetation sample 1. site	Annual (spring qtr.)		
	6. At locally grown milk cow feed sample site	Annual (spring qtr.)		
	7. Projected maximum annual concentration point-exclusion area boundary			

TABLE 2.7-1 (Cont'd)

ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM
BRUNSWICK STEAM ELECTRIC PLANT

Sample Type	Sampling Point and Description	Sampling Frequency	Sample Size	Sample Analysis
Terrestrial Vegetation (VS)	1. Grass near discharge canal at Hwy. 133 bridge	Quarterly	0.5 Kilogram	Gross beta, gamma (3) Strontium 89-90
	2. Fresh pine needles at Information Center	Quarterly		Gross beta, gamma (3)
	3. Turnips at nearby farms	3 times during growing season		Gross beta, gamma (3) Strontium 89-90 on composite
	4. Collard greens at nearby farms	3 times during growing season		Gross beta, gamma (3) Strontium 89-90 on composite
	5. Grass near intake canal at River Road	Quarterly		Gross beta, gamma (3) Strontium 89-90
	6. Fresh pine needles near intake canal at River Road	Quarterly		Gross beta, gamma (3)
	7. Locally grown milk cow feed	Monthly during growing season		Gross beta, gamma (3) Strontium 89-90 on quarterly composite
External Radiation Dose (TLD)	1. Junction of Hwys. 87 & 211 (1-2 mi.)	Quarterly	Not applicable	TLD readout
	2. Information Center (1-2 mi.)			
	3. Junction of Hwys. 211 & 133 (2-3 mi.)			
	4. Standard Products access road off Hwy. 133 (about 4 mi.)			
	5. Caswell Beach at pump station (about 5 mi.)			
	6. Sunny Point access road off Hwy. 133 at railroad tracks (2-3 mi.)			
	7. Entrance to Old Brunswick Town (5-6 mi.)			
	8. Hwy. 87 at Boiling Springs Lake (5-6 mi.)			
	9. Perimeter, dirt road off Hwy. 87			

TABLE 2.7-1 (Cont'd)

ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM
BRUNSWICK STEAM ELECTRIC PLANT

Sample Type	Sampling Point and Description	Sampling Frequency	Sample Size	Sample Analysis
External Radiation Dose (TLD) (cont.)	10. N Perimeter, off state road 1525 11. N Perimeter, off state road 1525 12. S Perimeter, construction access road 13. River Road at intake canal (1-2 miles) 14. SE Perimeter, River Road 15. SE Perimeter, state road 1534 16. River Road at green colored house (1-2 mi.) 17. Southport ferry slip access road (1-2 mi.) 18. Near Southport hospital (2-3 mi.) 19. Fort Fisher ferry slip (about 5 mi.) 20. Kure Beach (about 5.5 mi.) 21. Carolina Beach (about 7 mi.) 22. Sutton Plant access road (about 11 mi.) 23. Projected maximum annual concentration point - NE	Quarterly	Not applicable	TLD readout
Aquatic Vegetation (AV)	1. Ocean off Caswell Beach at discharge (if available) 2. Ocean off Caswell Beach 1/2 mile east of discharge (if available) 3. Ocean off Caswell Beach 1/2 mile west of discharge (if available) 4. Background location away from influence of plant discharge (if available)	Quarterly	0.5 kilogram wet	Gamma (3) Strontium 89-90

TABLE 2.7-1 (Cont'd)

ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM
BRUNSWICK STEAM ELECTRIC PLANT

Sample Type	Sampling Point and Description	Sampling Frequency	Sample Size	Sample Analysis
Zooplankton (ZO)	1. Ocean off Caswell Beach at discharge (if available) 2. Ocean off Caswell Beach 1/2 mile east of discharge (if available) 3. Ocean off Caswell Beach 1/2 mile west of discharge (if available) 4. Background location away from influence of plant discharge (if available)	Quarterly	10 cc wet	Gamma (3) Strontium 89-90
Benthic Organisms (BO)	1. Ocean off Caswell Beach at discharge (if available) 2. Ocean off Caswell Beach 1/2 mile east of discharge (if available) 3. Ocean off Caswell Beach 1/2 mile west of discharge (if available) 4. Background location away from influence of plant discharge (if available)	Quarterly	10 cc wet	Gamma (3) Strontium 89-90
Fish (FI)	1. Ocean off Caswell Beach at discharge 2. From discharge canal	Quarterly	0.5 kilogram	Gross beta on flesh Gamma (3) on flesh Strontium 89-90 on flesh
Shrimp (SH)	1. Purchases locally	Quarterly	0.5 kilogram	Gross beta Gamma (3) Strontium 89-90

Sheet 5 of 6

TABLE 2.7-1 (Cont'd)

ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM
BRUNSWICK STEAM ELECTRIC PLANT

Sample Type	Sampling Point and Description	Sampling Frequency	Sample Size	Sample Analysis
Oysters (OY)	1. Mouth of Cape Fear River	Quarterly	4 liters in shell	Gamma (3)
Precipitation	1. Near discharge canal at Hwy. 133 bridge 2. Information Center Rt. 87 - 1 mile SW 3. Projected maximum annual concentration point - exclusion area boundary NE 4. L. V. Sutton Plant 16 miles NNE	Monthly	Variable	Gross beta each sample

NOTES:

(1) Air samples will be composited quarterly for gamma spectrum. Individual gamma spectra will be run on samples exceed 10 pCi/m^3 gross beta

(2) Charcoal cartridges will be installed at air sampling locations 1 and 6 one year prior to startup and at the remaining locations three months prior to startup

(3) Gamma analysis consists of identifying of major gamma emitters and a quantitative interpretation

(4) Surface water samples 5 and 6 will not be collected until startup

(5) Bottom sediment samples 4 thru 7 will not be collected until startup

(6) Monthly prior to startup

(7) Frequency of sampling, sample volume, and attendant sensitivity will depend on availability

3. PROBABLE ENVIRONMENTAL IMPACT OF THE PLANT

3.1 Land Use Compatibility

The existence and operation of the plant will have an effect on the utilization of nearby land. Temporary effects caused by construction activities will be discussed in Section 3.7. This section will address itself to effects on land use caused by the existence and operation of the plant.

3.1.1 Public Water Supplies

As previously indicated, the Castle Hayne aquifer is the only source of public water supplies in the vicinity of the Brunswick Plant. In the design of the plant, the following concerns were addressed with respect to the public water supplies:

1. The effect of the plant fresh water requirements on the Castle Hayne aquifer and on other wells set in the aquifer.
2. The possible loss of water from the Castle Hayne to the cooling water canals because of upwelling.
3. The possible intrusion of saline water into the aquifer.
4. The contamination of the Castle Hayne aquifer with chemicals, radioactive, or sewage effluents from the plant.

Plant fresh water requirements will be supplied from two 300 gpm deep wells set in the Castle Hayne aquifer at a typical depth of 150 feet. The calculated daily requirement is not a significant load on the aquifer which can supply better than 1000-3000 gallons per minute at the site, seasonally averaged. A study has been conducted to determine the radius of influence of these wells, and to establish operating limits so as to have a negligible effect on the ground water level.

A detailed investigation has been conducted by CP&L to determine the effects of the plant on public and private wells within a ten-mile radius of the plant. As part of this investigation, use of numerous piezometers, standpipes, abandoned wells, borings, pump tests, etc. were made to establish baseline data, and to study existing groundwater conditions. This investigation has shown that only a few shallow wells will be affected by the plant, none of which are public water supplies. Where necessary and appropriate, some alternative form of water supply will be provided by CP&L as replacement for those shallow wells reduced significantly in flow by the canal excavation. The intake and discharge canals may lower the watertable in the immediate vicinity of the canals; however, at a distance of about 1000 feet from the canal the piezometric surface should only be lowered five to six feet.

A major part of the detailed investigation involved studies to determine what effect, if any, the excavation for the canals might have on local water supplies. The main considerations are the possibility of downwelling of saline water from the canal to the aquifer, or the upwelling of water from the aquifer into the canal. Whether a potential for upwelling or downwelling exists is dependent on the differential head between the canal water surface and the artesian head, adjusted for difference in specific gravity. With the data obtained from the study, it has been possible to select the canal water surface so that an optimal type arrangement exists whereby some minimal amount of upwelling is permitted, and some downwelling is permitted in areas where the chloride content is already high. As shown in Figure 3.1-1, there is a net upwelling force all along the intake and discharge canals, except for a small section near the Intracoastal Waterway where the net force is downward. This variation in the net head differential along the canal is due to the variation in the artesian pressure over the canal path. Where there is an upwelling force, this force may cause a flow of water from the Castle Hayne aquifer into the canals, similar to an artesian well. The optimum design level of the canal water level is El (+) 4.5 feet MSL in the discharge canal at the weir, and this level will be continuously controlled to assure optimum conditions. With the canal water level held at this design level, it has been calculated that the total flow of ground water into the canal will be 0.85 cubic feet per second (cfs). Since the total flow available from the Castle Hayne aquifer in the area of Southport is approximately 15 cfs, the potential loss from upwelling is only six percent of that flow.

In the small area near the Intracoastal Waterway there exists a net downward hydraulic force, so this area may experience some intrusion of saline water into the aquifer. This intrusion is small, however, and will not affect the water supply of Southport. The maximum downward head differential varies from about 1.5 feet to zero along this beach on Oak Island, and an estimate for downwelling is about 0.01 cfs. Canal water which might downwell would move toward the Elizabeth River, approximately parallel to Dutchman Creek, where the Castle Hayne aquifer presently has a high chloride content and is not used as a source of potable water. Thus, the water supply of Southport and the surrounding area will not be affected by this localized zone of downwelling. In this area of Oak Island where downwelling might occur due to the canal, intrusion of salt water has been occurring for some time already. Salinity measurements show a chloride content of the water of 1400 ppm at El (-) 110. Abandoned wells at Fort Caswell, to the east of the discharge canal route, show chloride contents of 1550 and 8100 ppm, at depths of 221 and 1543 feet, respectively. The relatively high salinity indicates that salt water is moving shoreward into the Castle Hayne aquifer in this area.

Although the generally upward flow of water from the Castle Hayne aquifer into the canal prevents a direct salt water seepage from the canal down into the aquifer, there is a difference in the chemical potential between the two waters, and this difference could serve as a motive force for diffusion or migration of salt particles in a direction opposite to the direction of the flow. Analysis shows that up to 0.1 percent of the salt in the canal, or up to 20 lbs/day, could reach the Castle Hayne under steady-state conditions. The transit time when the salt would begin to penetrate the aquifer, at the maximum diffusion rate and over minimum distance between canal bottom and the aquifer, is approximately 54,000 years. It would then take many more years before an equilibrium is attained between the infusion of salt and the leaching of salt from the aquifer.

Small amounts of chemical or radioactive effluents will be released to the discharge canal under controlled conditions. The plant radwaste system will extract and remove most of the radioactive liquid waste from the plant. The small and controlled discharge of liquid radwaste into the canal will be circumscribed by appropriate federal regulations, will be constantly monitored, and will be only slightly more radioactive than the ocean water itself. Because of the upwelling conditions that exist along most of the canal, the possibility for intrusion into the aquifer is very limited. In the area of Oak Island where the net hydrological head is negative, the downwelling of radioactive material will have a negligible effect since the material will be very diluted in the canal water. The same conditions apply to any chemicals in the discharge canal, since they too will be very small amounts, and be highly diluted in the canal.

3.1.2 Effects on Recreational Land Use

Recreation in the vicinity of the plant consists generally of boating, fishing, golfing, some hunting, and beach recreation.

The significant nearby recreational areas are beaches along the Atlantic seaboard, ranging from six to twenty miles from the plant. During the peak summer season, the population in the vicinity of these beaches increases by about 10,000 persons who seek ocean beach recreation. The Brunswick plant will not affect these activities. With its visitor facilities, the plant will likely become a sightseeing attraction.

An existing golf course on Oak Island is in proximity to the discharge canal. At its nearest point, the edge of the canal dike lies 350 feet east of the nearest green. The utilization of the course will not be affected by the presence of the canal.

Recreational fishing, hunting, and boating will also be unaffected by the presence of the plant.

The lands adjoining the cooling water system canals will be open to public use, including hunting and fishing, except in those areas within the plant exclusion area, adjacent to the pumping station on Oak Island, and adjacent to the inverted siphon under the intracoastal waterway. The presence of the Brunswick Plant will thus have little undesirable effects on the local recreational facilities.

3.1.3 Effects on Non-Recreational Land Use

3.1.3.1 Farming Use

The operation of the plant will have negligible effect on the farms in the Brunswick and New Hanover Counties since most of the farming is outside the influence of the plant.

3.1.3.2 Industrial Use

No direct effect is anticipated on the industrial activity in the area, as a result of the operation of the Brunswick Plant.

The U.S. Army Ammunition Transshipping Terminal at Sunny Point, which is located some 4½ miles north of the Brunswick Plant, has been determined to have no significant interaction with the Brunswick Plant. The interactions between the activities of Sunny Point and the Brunswick Plant have been fully reviewed by the AEC as part of the evaluation of the CP&L application for a construction permit for the Brunswick Plant.

3.1.3.3 Transportation Use

Sunny Point Terminal and the Wilmington industries rely heavily upon sea transport. The presence of the plant will have no effect on sea transportation.

Two bridges will be constructed where the discharge canal intersects State highways 87 and 211 to maintain existing connections. The bridges will be designed in accordance with the N. C. State Highway Commission's current standards.

3.1.4 Effects on Historical Landmarks

The plant vicinity has been investigated in relation to the National Historical Preservation Act of 1966. There are several historical markers located in Southport, North Carolina, along the local beaches and approximately 4.5 miles north of the plant in the vicinity of the ruins of Old Brunswick Town, an early settlement (founded in 1725) on the Cape Fear River. There are two historical sites in this area that are in the Federal Register of Historic Places: The ruins of St. Phillips Church which is located at Old Brunswick Town approximately 4.5 miles north of the plant, and the remnants of Fort Fisher located on the beach approximately 5 miles east of the plant. Construction and operation of the plant will have no effect on these areas of historical interest.

3.1.5 Effects on Archaeological Activities

Archaeological investigations have been made in the vicinity of Old Brunswick Town and in the vicinity of Fort Fisher. These investigations may be continued from time to time; however, the plant will have no effect on these archaeological activities.

3.1.6 Alteration of Terrestrial Environment

The alteration of the terrestrial environment will have either temporary effects associated with the construction activities, or permanent effects - within the context of the life of the plant. The construction effects are discussed in Section 3.7. The permanent effects are discussed in this Section under their respective headings, and in Section 5. These effects have undergone careful scrutiny by federal, state, and local authorities and extensive communications between these agencies and CP&L in the processing of permits and licenses necessary for the various construction activities, as discussed in Section 2.3.

3.2 Biological Impact

3.2.1 Biological Effects

The Brunswick Plant and supporting structures will have a limited physical impact on the terrestrial and aquatic environment. The land cleared for the plant site was covered with old-field vegetation and second-growth pine trees. Neither of these vegetation types constitute significant wildlife habitat. Most of the areas cleared for construction activities and not utilized as part of the canal system will be replanted and will eventually provide cover for wildlife. Care is being taken to minimize utilization of marsh areas required for the construction of the cooling water canals. Utilization of river water for cooling the plant condensers and disposal of waste heat will have a slight impact on the aquatic environment. However, the total impact of the plant on the environment will be minimal.

3.2.1.1 Effects of Canals

North Carolina has an extensive estuarine system, ranking third among the fifty states in total acreage with over 2 million acres of estuarine waters. Over 75% of the total estuarine area of North Carolina is located in seven major sounds: Currituck, Albemarle, Croatan, Roanoke, Pamlico, Core, and Bogue. Coastal marshlands are abundant and North Carolina, with over 200,000 acres, probably has more such acreage than any of the other eastern states. About 8,000 of these acres are located behind Smith Island at the mouth of the Cape Fear River. In addition, Brunswick County, which extends from the Cape Fear River to the South Carolina line, contains approximately 18,000 acres of marshlands. These estuarine areas are a valuable resource to coastal North Carolina. Consequently, the Brunswick Steam Electric Plant, including its cooling water system, has been designed to minimize its impact on the estuarine ecosystem.

Several meetings were held with various State agencies, including the North Carolina Department of Conservation & Development, the N.C. Wildlife Resources Commission, and the N.C. Department of Water & Air Resources, during which their comments were received and incorporated into the design of the plant. Some of the considerations were: selective routing of the intake and discharge canals to minimize the utilization of marshland, elimination of the possibility of undesirable results from calefaction of the estuary, and rapid cooling of the condenser cooling water upon discharge into the ocean.

As shown in Figure 2.2-2, the intake canal is routed through an existing channel which reduced the amount of marshland required. To minimize the amount of marsh required for construction of the discharge canal, the canal is routed to the west of Dutchman Creek on the mainland and on Oak Island the canal is routed through high ground next to the golf course. Total marsh utilized is less than 25 acres for the intake canal and 120 acres for the discharge canal. All spoil resulting from dredging operations is being deposited on the mainland away from the marsh. These spoil areas are all diked and weirs are being used to control discharges from these areas in a manner that will protect the marshes and public waters against siltation. The discharge canal will intercept some of the fresh water runoff to Dutchman Creek and divert it to the Intracoastal Waterway. The effect of diverting part of the fresh water inflow is being investigated during the ecological study discussed in Section 3.3.1.8.

Though fish will be blocked from the plant intake structures by traveling screens, plankton will pass through the fish screen and be pumped through the plant condensers. The percent mortality of plankton passing through the condensers is not known at the present time; however, this will be determined as part of the ecological investigation of the site. The amount of water pumped through the plant condensers is only a small part of the net drift of water past the plant intake toward the ocean. The estuary is characterized by rapid movement of large volumes of tidal flow, and surface water in the vicinity of the plant intake at low slack tide will be lost to the ocean during the next ebb tide. The length of the discharge canal is of significant concern in terms of survival of entrained organisms. Planktonic organisms will pass through the condenser tubes and down the discharge canal. The length of the discharge canal is such that the entrained organisms will be held at elevated temperature for five or six hours. This length of time may cause significant mortality. However, assuming the mortality is 100% for plankton passing through the condensers, this is not considered to represent a significant loss from the estuary due to the small percentage of water from the estuary that will be diverted through the plant. Work at other locations indicates that mortality in the plant condensers will not be this great.(1)

3.2.1.2 Effects of Thermal Discharge

The original design of the circulating water system included discharging waste heat into the estuary. As the hydrology studies progressed, it became apparent that such an arrangement on occasions might result in thermal accumulations in the estuary that might exceed the evolving federal and state water quality standards. Therefore, the discharge canal was routed to the ocean.

Several routes for the discharge canal were considered as discussed in Section 4.5 and ultimately rejected, including one that utilized Dutchman Creek. The final route selected (Figure 2.2-2) preserves the more productive marshland along the canal and at the same time protects ground water supplies in the Southport area. On Oak Island, the canal was routed to utilize high ground adjacent to the golf course to further reduce the utilization of marsh.

Discharge of condenser cooling water into the ocean eliminates concern over possible detrimental effects associated with calefaction of the estuary. However, discharging water which has been warmed up to 18°F above ambient, depending on plant load, into the ocean will have some impact on the oceanic environment. Dissipation of waste heat is discussed in Section 3.4. The cooling water, which will have lost some of its heat to the atmosphere along the way, will be discharged in a horizontal direction at 10 feet per second. This discharge will be made approximately perpendicular to the natural drift in the area which averages about 0.7 feet per second. This discharge arrangement provides for quick dilution and cooling. Based on field dye experiments, the discharged water will mix rapidly with the ocean water and cool.

The species composition of plankton may change in the area immediately in front of the discharge but the rapid mixing of the cooling water with the cooler ocean water is expected to limit this effect to a small area. Some species of shellfish and fish may avoid the area in the summer and be attracted to the warm waters in the winter. The ecological study being performed by North Carolina State University will document any changes in species composition and numbers in the discharge area.

3.2.1.3 Migration

The possibility that migrating animals will orient on the discharge water and thus be prevented from entering the Cape Fear River Estuary has been considered. Recent studies have shown that postlarvae enter estuaries from the sea by following a "scent" of organic materials (principally amino acids) flowing out of the estuaries. Since the discharge will be large and the water is from the estuary, it is possible that some migrating postlarvae might orient on the discharge. However, flow measurements and aerial photographs reveal that the discharge is located within the plume of effluent from the Cape Fear Estuary and thus will not interfere with migrations. This possibility will be included within the ecological studies already in progress in the area.

The discharge is designed so that fish cannot be trapped. The high water velocities in the immediate discharge area will make it difficult for fish to remain in the warmest water. No significant detrimental effects are expected either while the units are operating or if the units stop operating and the warm water discharge ceases.

The warm water discharge may scour the bottom in a small area adjacent to the end of the discharge pipe. This scouring action, which will be limited to less than two acres, will result from friction as the water flows over the bottom. The warmer water will rise to the surface and is not expected to affect benthic organisms outside the two acre area. A comprehensive study of benthic organisms in the area is underway, and any effect of plant operations on benthic organisms will be documented.

3.2.1.4 Fish Diversion

Condenser cooling and service water for the Brunswick Steam Electric Plant will be supplied by a canal which extends from the vicinity of Horseshoe Shoals in the Cape Fear River to the plant, a distance of approximately two miles. The canal will have an average width of approximately 300 feet at the surface, a depth of (-) 18 feet MSL, and a shape that is trapezoidal. Concrete intake structures will be located adjacent to the canal in the plant vicinity. Water from the canal will enter the intake structures and be pumped through the plant circulating and service water systems. Vertical traveling screens of 3/8 inch mesh will be provided in the intake bay to screen trash and debris from the condensers.

Water velocities in the intake canal will vary with the tide, the number of pumps operating, and other factors, and will range between 0.08 to 0.6 feet per second for one unit operating, and 0.41 to 0.95 feet per second with both units operating. These velocities are considerably less than velocities encountered in the Cape Fear River during ebb tide which frequently reach 5 to 6 feet per second.

Recognizing that there still may be a potential attraction for fish at the intake structure, Carolina Power & Light Company has undertaken a study of existing fish diversion systems. This study included a literature search and on-site visits to existing fish diversion installations. The literature search determined types of fish diversion devices, where they were employed and how successful each was in diverting certain species of fish. From this information, on-site visits were scheduled to several facilities operating fish diversion systems. The on-site visits provided valuable insight into the design and operation of fish diversion systems. However, little of the experience on fish diversion uncovered to date is directly applicable to the Brunswick facility. In order to construct a fish diversion device with reasonable assurance of success, Carolina Power & Light Company is considering a test facility at the Brunswick Plant to study the efficiencies of various devices in diverting fish indigenous to the lower Cape Fear River. It is anticipated that the test facility will consist of a cell constructed next to the intake canal at a point near the Cape Fear River. The test cell will be designed to permit the possible evaluation of horizontal and vertical louver arrays, drum screens, bubble barriers, the electric fence, and stationary screens. Fish will be diverted from the main flow of water and be returned to the Cape Fear River. Optimum design of a full sized installation, should experience indicate its need, will be accomplished with the test facility.

3.2.2 Radiological Effects

The radiological effects analysis is a systematic examination of the normal steady state, abnormal transient, or postulated accident occurrences of all modes of the Brunswick Steam Electric Plant operation. This analysis includes both reactor facility operation and reactor material transportation, with events in the operational mode placed into AEC-classification categories. Radiological effects from normal radioactive effluents are discussed in detail in Section 3.6 and Section 8.4; transportation effects are discussed in Section 3.10; and the radiological significance of abnormal transient and postulated accident occurrences are discussed in detail in Section 8. Radiological effects are determined for the appropriate events in each category. The radiological effects determination was conducted utilizing reasonable assumptions, justifiable calculational models and techniques, and realistic assessments of environmental effects. The radiological impact is a measure of the relative radiological influence of the BSEP compared to the natural radiation background expressed in man-rem exposure to the population within a 50-mile radius of the site. Residence background characteristics are assumed to be a combination of the radiation received by the population from natural radiation background and man-made exposure sources, such as medical X-rays. A summary of the integrated dose, in man-rem, for each of the above categories is given in the following sub-sections.

3.2.2.1 Man-Rem Integrated Dose Concept

The integration of radiation exposure over a group of people, exemplified by the unit of man-rem as contrasted with dose to an individual in rem, is undertaken because of genetic considerations. It is apparent that summation of exposures to individuals at these low dose levels has no somatic effect on a population group or individual. These low exposure levels could, however, represent a genetically significant dose. For this reason the man-rem unit is associated with, and limited to, a sufficiently large group of people to be considered of genetic significance.

As is shown in Section 3.6, the most signifi[illegible]t mode of exposure to the general population from the BSEP is caused [illegible]rect external radiation from the elevated plume of noble gases emitted from the stack, with only a minor contribution from the consumption of seafood using conservative pathway assumptions. These levels of exposure, calculated for the nearest neighbors are shown to be only a small fraction of the permissible dose. Calculations indicate that the actual dose beyond the nearest neighbors decreases rapidly so that average doses to all inhabitants within the 50-mile radius are lower than the nearest neighbor estimates by about two orders of magnitude. This is so because of the extensive diffusion capacity of the atmosphere, the fact that radioactive gas is decaying significantly with atmospheric travel time (this, however, was conservatively not taken into consideration in the calculation of man-rem doses), and the fact that the number of occupants in the immediate environs is low.

Most of the man-rem dose received by the public via the gaseous effluents pathway is to the few thousand people within a few miles of the site, and the several thousand people within twenty miles of the site. Thus, any man-rem integration requires consideration of whether this population group is of a genetically significant size. Also, for an exposure to groups in a nearby town (Southport) or a small city (Wilmington), it must be considered whether or not the group remains intact for a time period of genetic significance, such as the human generation time of thirty years, in view of present-day population mobility.

Some insight into genetically significant population groups is available in the publications of the internationally recognized expert group, the International Commission on Radiological Protection. A review of publications from this group, through Publication #16, shows general and repeated use of phrases such as: "whole populations", "population at large", "large populations", "practices in some countries", and "circumstances which vary from country to country". One might conclude that basic thinking is oriented to the population of a small country or to the population of a significant section of a large country, which in either case would be in the range of 10^6 to 10^7 people or more. At the BSEP, a 50-mile radius from the site encompasses a population (1996 projection) of slightly over 300,000 people. The low probability of detecting a statistically significant genetic effect is applicable in considering a population of this size. For example, ICRP Publication No. 8 considers the probability of a dominant genetic effect being experienced by the children of a generation of exposed parents. The estimate (acknowledged as may well be high for a number of reasons) was that "the effects of a few rads would not be detected in the annual statistical returns of a population of 50 million". From this, perspective may be gained on the probable effects of a few rads per year to a few thousand people near the BSEP. Due to the small genetically significant population around the BSEP and the low population dose, the only meaningful assessment of the radiological impact of the BSEP is a comparison between the dose received from operation of the plant and that received from residence background.

The whole body dose is the only important contribution to a genetically significant exposure, expressed in man-rem. Critical organ doses have been calculated but are not considered in the evaluation of the radiological impact from plant operations as the effect on the critical organ is not of genetic significance. Since the critical organ, such as the thyroid, can tolerate a much greater dose than the whole body, the effect of a gross body exposure on the critical organ is less than the effect on the whole body.

3.2.2.2 Natural Radiation Background

Radiation in various forms is a normal part of man's natural environment; it has been present throughout his development, and man has demonstrated the ability to develop in the presence of this natural radiation. Every day we receive radiation from the sky, the ground, the air around us, and the food we eat. The magnitude of this radiation level is strongly influenced by where we live, what we do, and even in what kind of house we live. For most locations around the United States, natural radiation level averages about 140 mrem per year. The various component contributions of this typical value are discussed below.

Cosmic rays provide one of the most significant natural radiation sources. Cosmic radiation is, to some extent, dependent on latitude and, to a large extent, dependent on altitude. In the mid-latitudes, the cosmic radiation varies from about 40 mrem per year at sea level to about 3800 mrem per year at altitudes used by jet aircraft (35,000 feet). This does not mean that all commercial jet airliner crews receive 3800 mrem per year, since this would imply that they were continuously airborne. Assuming, for instance, that these crews stay aloft a tenth of the year, then their occupational radiation exposure due to cosmic radiation alone would be in the range of 300 to 400 mrem per year. Even one transcontinental roundtrip per year would give the business man or vacationer about 4 mrem. The average cosmic radiation of 40 mrem per year will increase to about 150 mrem per year in some mile-high locations, such as Denver or Salt Lake City. It is assumed that 50 mrem per year from cosmic radiation is an average for people within a 50-mile radius of the BSEP.

Another source of radiation in nature is the ground inself, because it contains many radioactive minerals, particualarly the uranium and thorium series, together with the important uranium decay product, radium. Another significant radioisotope in the ground is potassium-40, the naturally radioactive isotope of the element potassium. The incidence of radioactive materials in the ground causes the earth to act as a large plane radiation source with respect to an individual. The resultant average radiation exposure in the continental United States is about 60 mrem per year. Assuming that the average person spends about one-fourth of this time outside of buildings, this 60 mrem per year contribution would reduce to 15 mrem per year. There are a number of locations in the world where the radiation exposure from the ground is actually much higher. In various locations in Brazil, India, and in the French mountains, the exposure may range from 180 to as high as 1600 mrem per year, largely due to the presence in these locations of deposits of thorium near the surface of the ground. There have been reports of exposure even higher than these.

The fact that these radioisotopes exist in the ground gives rise to a secondary source of radiation, since the natural decay of the uranium and thorium series each contains a natural radioactive gas. These radio-gases evolve from the ground at a fairly constant rate and thus cause equilibrium concentrations of natural radiogases in the air. The principal constituent of this source of radiation in nature is the radiogas radon, which has a 3.8-day radioactive half-life. This element, together with its daughter decay products, causes a world average whole body external exposure of about 5 mrem per year. Actually the inhalation of these radiogases and the deposition of their radioactive daughters in the lung may cause a lung dose of as high as 200 mrem per year.

Since man takes materials from the ground to build homes and offices, natural radioisotopes from the ground are transferred to these structures. A signficant variation will result from the use of different building materials. A wooden structure may emit radiation leading to a dose rate of about 50 mrem per year, while concrete may give 70, and brick as high as 100. Even these may vary within the material originated. For example, there are some types of stone (such as some granite and marble) that will produce an exposure of 350 to 500 mrem/year.

All liquids in the world are now, and have always been, radioactive due to the presence of many naturally radioactive materials in solution, such as uranium, thorium, radium and carbon-14, all of which have very slow decay rates ranging from thousands to billions of years. Ocean water that is used for cooling water at the BSEP is a good example of such natural radioactivity. The measure of radioactivity in liquids is usually stated in units of picocuries (1×10^{-12} curies) per liter. Radioactive liquid waste discharges from the BSEP will average about 2 pci/liter. In ocean water the natural radioactivity is about 350 picocuries per liter. Most of this is due to the naturally radioactive isotope potassium - 40, which has a decay rate (half-life) of 1.3 billion years. River water radioactivity usually averages between 10 and 100 picocuries per liter.

Due to these activities in liquids used for human consumption, the average concentration in the liquids of the human body is about 300 picocuries per liter. The general average radiation exposure from food and water is about 25 mrem per year, due to the deposition and retention of these radioactive materials within the body. In a typical case, about 20 mrem per year of this exposure comes from the natural radioisotope potassium-40, which is found particularly in protein type foods.

3.2.2.2.1 Total Radiation From Nature

The following table summarizes the various contributions in arriving at an average natural radiation background of 140 mrem per year for people living in a 50-mile radius of the Brunswick Steam Electric Plant.

Cosmic Rays	50
Ground (1/4 time)	15
Buildings (3/4 time)	45
Air	5
Food and Water	25
	140 mrem per year

3.2.2.2.2 Man-Rem From Natural Radiation Background

Calculations of the total exposure to the population as a result of natural background radiation have been made. Obviously, if every person in the United States receives an average of 140 mrem/year, then the total population exposure would be about 30 million man-rem per year. However, it is not appropriate to compare the radiological effects of the operation of any one nuclear power plant, as negligible as they are, with the total man-rem/year to the entire U. S. population. Therefore, the man-rem comparisons are made for the population within a 50-mile radius. If the projected (1996) population within a 50-mile radius of the BSEP is 302,841, the natural background radiation will result in about 42,400 man-rem/year.

3.2.2.3 Man-Made Radiation Background

Total population exposure from man-made sources is more difficult to evaluate because, unlike the case with natural radiation, an individual can make a choice whether to receive such radiation or not. However, reasonable assumptions can be made in order to make estimates of man-rem per year.

The dose to a sample population of one million people as a result of viewing television can be estimated. Typically an individual would receive about 1-10 mrem/year from watching TV. If the average dose received is 5 mrem/year, then this results in 5000 man-rem/year. Looking at this same population, one can determine the man-rem as a result of exposure from luminous-dial watches. If only 10 percent of this sample population receives a dose from their watches of 2 mrem/year, then the resultant population dose is 200 man-rem/year.

The use of medical X-rays is by far the largest contributor to population exposure from a man-made source. Again considering the sample million-person population, diagnostic X-rays would result in about 100,000 man-rem/year assuming that each person received an average of 100 mrem/year. However, if only 10 percent of this sample population received an annual chest X-ray of 200 mrem per examination, the result would be 20,000 man-rem/year.

In summary, medical exposure results in the largest man-rem per year contribution from man-made sources. However, the examples of television viewing and wearing luminous dial watches do contribute to population exposure and should be included when comparing the impact on man from these and other man-made sources. For the purposes of comparison a value of 60 mrem/year due to all man-made sources has been used for determining man-rem exposures to the population within a 50-mile radius of the BSEP.

3.2.2.4 Total Average Radiation Background

The total background radiation exposure received by the average citizen within a 50-mile radius of the BSEP is the sum of the contributions received from natural background and man-made sources. The resultant total is the 140 mrem/year from natural sources and the 60 mrem/year from man-made sources giving a total of 200 mrem/year to the average resident of this area.

3.2.2.5 Variations in Radiation Background

So far, only average radiation background has been discussed; however, it is well established that variations do occur from place to place and from year to year. The following information substantiates this.

Airborne radioactivity surveys conducted by the U. S. Geological Survey on behalf of the Division of Biology and Medicine of the USAEC have shown the variations of radioactivity level from place to place. These surveys are a part of the Aerial Radiological Measurement Surveys (ARMS) program, a program of airborne radioactivity surveys of nuclear installations.

Measurements consisted of whole body gamma dose from the ground, air, and cosmic-ray sources. From the standpoint of airborne activity, only three naturally occurring radioactive elements are important: uranium, potassium-40, and thorium. The relative amounts vary with the type of geological formation. In fact, measurements have shown variations of natural background of up to four to six times within a 10-mile distance. This mears that values between 50 to 200 mrem/year have been measured. Some areas that have certain types of granite and marble will produce exposures of 350 to 500 mrem/year. As stated earlier, this material has been used as building material for some of our most stately public structures. Variations can also occur from year to year even at the same location. For example, an annual variation of up to 10 mrem is not unexpected for some locations. The point is that spatial and temporal changes do exist in nature, though it is not obvious unless one is trying to measure such differences. Such variations are much greater than the total radiological effect from nuclear power plant operation.

3.2.2.6 Considerations in Minimizing One's Radiation Background

An appreciable fraction of man-made radiation is voluntarily self-imposed. Man-made radiation sources such as medical X-rays, television, luminous features on watches and appliances, and micro-wave ovens add to an individual's background exposure, depending on the frequency of usage. None of these are uniquely necessary for life support, and the exposure could be curtailed.

The largest man-made radiation source is from medical exposure, as stated earlier. Certainly, if no diagnostic medical or dental X-rays are received, there would be no exposure. However, many of us have received much benefit from diagnostic X-rays to aid in medical treatment. Therapeutic X-ray treatments have also resulted in many lives being saved or prolonged even though massive doses of radiation have been received. Not receiving such X-ray treatments would minimize one's exposure but the risk to the patient could be quite detrimental.

The radiation exposure from viewing television can be minimized by sitting farther away from the set or reducing the number of viewing hours per year. This could lower one's exposure by a few mrem/year. An additional few mrem/year reduction could be realized by wearing a wrist-watch without a luminous dial.

To summarize the many choices that each person has in order to minimize his background radiation exposure, let us postulate two individuals:

One lives near sea level, in a wooden house; does not receive medical X-ray examinations; does not smoke or drink alcoholic beverages; works on the first floor of a wooden building; and does not watch television. The second person lives in a stone house, in a mile-high city; receives his yearly chest X-ray and dental X-ray examinations; smokes cigarettes and drinks alcoholic beverages; works on the 20th floor of a granite building; and watches television regularly. The difference in the background radiation exposure between these two people could easily be several hundred mrem/year. They represent the range of possible exposures experienced by typical individuals. Most people would fall between these two extremes depending on the choices made, knowingly or unknowingly, to determine the background exposure received.

With the numerous ways that man could reduce his background radiation, it would appear that if radiation were of concern to man he would regulate his behavior to take advantage of the lowest possible level of natural radiation. Nowhere does he appear to have seen fit to regulate his behavior to this extent. Thus, it could be concluded that this particular low level of natural radiation has not been, and currently is not, a significant criterion to man, even though these levels of exposure are several orders of magnitude greater than that received from the operation of, for example, the Brunswick Steam Electric Plant.

3.2.2.6 Man-Rem From Nuclear Power Plants

The radiological impact of nuclear power plants may be compared with the already radioactive environment in which we live. There is a basic difference between the man-rem received from natural and man-made radiation background and that from the nuclear power plants. That is, everyone within a 50-mile radius is assumed to receive the average background exposure, whereas everyone does not receive the same dose contribution from the power plant. The reason is that the natural atmospheric dispersion effects reduce the radiation source the farther one is from the plant. Over the year, the wind directions, wind speeds and atmospheric stability change to disperse an airborne source so that out to 50 miles from the release location, the radiological effect is not measurable but only estimated by means of a calculation.

Liquid sources are treated similarly to the gaseous ones in that only a portion of the total population out to 50 miles acutally could be influenced from small amounts of radioactivity discharged from the plant. Considering the consumption of fish as the primary mode of exposure to man from this source, several factors affect the result. For example, some of these are effects of water dilution and dispersion in the ocean as compared to concentrations in the discharge canal and of the actual number of people in the 50-mile radius who consume fish.

The total man-rem to the population out to 50 miles from the plant for the various conditions evaluated in the nuclear environmental effects determination are summarized in Sections 3.6 and 8. This list includes the man-rem results for normal plant operation considerations, transportation considerations, various abnormal conditions and postulated design basis accident conditions. One should not add the man-rem from each condition since the probability of occurrence was not applied to all conditions.

3.2.2.7 Radiological Impact

The general conclusion drawn from the total population exposure for each condition discussed in Section 3.6 and Section 8 is that there is a negligible contribution from BSEP compared to the natural and other man-made exposures received by the population. In fact, the highest dose to an individual near the plant is usually less than a few percent of natural background. This dose would approach negligible proportions at a distance of 50 miles (two to three orders of magnitude less).

As observed earlier, the many spatial and temporal changes in natural background and certain man-made sources more than mask out the contribution from normal operation of BSEP.

From a radiological viewpoint, BSEP will be a good neighbor, one that has a negligible impact on the environment.

3.3 Ecological Studies

3.3.1 Biological Monitoring

3.3.1.1 Preliminary Ecological Investigation

A preliminary investigation of the ecology of the lower Cape Fear River was initiated during August of 1968. In March of 1969, this investigation was expanded to include an area of the ocean off Oak Island in the vicinity of the cooling water discharge.

As shown in Figure 3.3-1, five stations were established in the lower six miles of the Cape Fear River and one station was established in the ocean. All samples were collected monthly with the exception of benthic samples which were collected quarterly. Temperature and salinity were measured with depth during both low and high tide. Dissolved oxygen was measured at the surface and at the bottom during both low and high tide. Phytoplankton, zooplankton, and fish larvae were collected at four stations (23A, 18, Oak Island, and Ocean). Fish trawls were made in the vicinity of the plant intake, near Oak Island and in the ocean. Benthic samples were collected at thirty locations in the vicinity of the ocean station as shown in Figure 3.3-1.

3.3.1.2 Hydrology

At station 19, near the plant intake, salinity ranged from 2.45 to 33.86 ppt although greater than 81% of the measurements were in excess of 15 ppt as shown by Table 3.3-1. The lowest salinity recorded during the year was 1.72 ppt at station 23A upstream from the plant intake. These low salinities were always at the surface and were a reflection of high rainfall upstream. Isohalines constructed from salinity date (Figure 3.3-2) suggest that saline water moves upstream near the river bottom while the fresh water moves toward the ocean in the surface layers; however, turbulence from the rapid water movement causes significant mixing between layers. Temperature of the surface water during high tide at station 19 ranged from 38°F to 87°F. Temperature measurements at station 19 are included along with temperature at the ocean station as Figure 3.3-3. Dissolved oxygen was close to saturation most of the year; however, during the spring and early summer, oxygen levels were somewhat less. The minimum oxygen level of 33% of saturation was measured in April at the river bottom at station 23A which is just upstream from the plant intake point. Monthly dissolved oxygen measurements at station 23A over a period of one year are included in Table 3.3-1. The lower oxygen levels such as those recorded in April are caused by upstream discharges of organic matter.

As shown in Figure 3.3-2, there generally is a 40% change in salinity between high and low tides at the intake site (Station 19). This means that there is at least a 40% exchange of water at the intake site on each tidal cycle; thus, withdrawing water should have little effect because of the massive interchange of water that occurs in the estuary at the plant site.

3.3.1.3 Phytoplankton

As in most estuaries located on the east coast, the phytoplankton were dominated by diatoms (Riley 1967). A total of 203 species were collected in the estuary and they included 134 diatoms, 25 chlorophytes, 9 cyanophytes, 3 chrysophytes, 15 dinoflagellates, 2 haptophytes, 9 cryptomonads, 3 xanthophytes, 1 euglenoid flagellate, and 2 loricate flagellates. Total number of species was highest in the ocean and decreased slightly upstream as shown by Table 3.3-2. Diatoms increased from upriver to downriver and chlorophyte algae increased in the opposite direction.

Three of the six dominant species were diatoms. One of these, Skeletonema costatum, averaged 29% of all phytoplankton sampled during the year which is typical of east and gulf coast estuaries. The other dominant species included a cryptomonad, a dinoflagellate, and a loricate flagellate. Peak populations of phytoplankton occurred in May and June when up to 7.3 million cells per liter were found and 75% of these were of the diatom Skeletonema. Average cell numbers per liter for each station during the year was 2.10×10^6 at the ocean; 1.75×10^6 at Oak Island; and 1.44×10^6 at station 23A.

The Shannon-Weiner formula (Odum, 1969) was used to calculate species diversity and the results are included in Table 3.3-3. Diversity was slightly higher at the estuary mouth and lower upstream and at ocean station. Average diversity was lowest in January and February and higher through the rest of the year.

3.3.1.4 Zooplankton

The zooplankton were dominated by copepods. The most abundant copepod, Acartia tonsa, had a population peak in April and May when up to 7,500 per cubic meter were collected. Other abundant copepods included Paracalanus, Centropages, and Oithona. Larvae of attached or benthic forms (such as barnacles, polychaetes, and molluscs) made up 25% of the total zooplankton. A total of 37 different forms were collected, but many of the larvae could not be identified beyond family. Seasonal distribution of zooplankters is included as Figure 3.3-4. The peak of abundance at the Ocean Station was 19,100 per cubic meter in March while at the Oak Island Station, the peak was 13,292 per cubic meter in July. Very low numbers of zooplankters were present in December and January.

3.3.1.5 Larval Fish

Larval fish were present throughout the year in the estuary, but fewer numbers were caught in September and October than during the remainder of the year. The Ocean Station yielded fewer individuals and species than did any of the three estuarine stations. Anchovies were the most abundant larvae at the ocean and Oak Island stations. Croaker was the most abundant at the upriver stations. Gobies, however, were abundant at all stations. The only other abundant species was spot, which was found in moderate numbers at all stations. Flounders, seatrout and striped mullet were all of minor importance.

There appeared to be extended summer spawning of the anchovies and gobies. Larval croaker appeared in October and were abundant through February. Spot, however, was not present in significant numbers until January. Bivalve larvae first appeared in October in the estuarine samples, but were collected only in January in the ocean samples.

3.3.1.6 Fish

The most abundant fish caught by otter trawling was the gray seatrout which was present from July through October. Spot was also abundant and was present throughout the year except for the months of January and February. The croaker reached its peak of abundance in January, but these appeared to be young of the year. Other important fish are the summer flounder, the windowpane, and the blackneck tonguefish. Shrimp were abundant in July, August, and September, but were found only at the ocean station in May and June.

Fish were collected with a 10-minute tow of a six-foot otter-trawl which had a mesh size of 5/8 inches and a 1/8 inch mesh cod end. All samples from the river were taken on the Western side of the river channel in water from three to ten feet in depth. Analyses may be influenced by the fact that large fish avoid the net and small fish may pass through the 5/8 inch mesh. Any judgment of the fish population of the Cape Fear is influenced by the fact that only one habitat was sampled. For these reasons, the fish survey provided only qualitative data on the kinds and abundance of fish in the estuary.

3.3.1.7 Benthic Organisms

Four times throughout the year, benthic organisms were sampled near the ocean discharge site. Sediments in the area are mud to the west of the discharge site, and sand to the south and east. Some 56 different species of animals were collected, but a snail, *Retusa canaliculata*, and a brittlestar, *Ophiophragmus wurdemani*, were the two dominant species and both were present throughout the year. Other animals were prominent at various times of the year, such as polychaetes in the fall. Other important animals were the sea pansy, Renilla reniformis, and several clams.

The sampling area in the ocean includes three transects of ten sampling points each as shown in Figure 3.3-1. Diversity was calculated for samples from each of the 30 points and the results included as Table 3.3-4. The diversity index indicated that there was reduced diversity close to shore, and at the eastern transect closest to the mouth of the river. There was a decline in the number of organisms during the winter and spring, and also fewer organisms in the sand sediments of the transect nearest the mouth of the river.

3.3.1.8 Ecological Investigation

Results from the preliminary biological investigation of the lower Cape Fear River and ocean off Oak Island were utilized in planning an expanded study of the area. In February of 1971, Carolina Power & Light Company extended its support of North Carolina State University for an additional five year study of the ecology of the lower Cape Fear River and ocean off Oak Island. The study is under the direction of Dr. B. J. Copeland, Director of the NCSU Pamlico Marine Laboratory, and Dr. J. E. Hobbie, Professor of Zoology at NCSU, and will be performed by personnel at the Pamlico Marine Laboratory.

The study is composed of both field and laboratory effort and is designed to document any significant changes in the local estuarine and marine environments. Results of the study will be used to determine whether or not there are changes resulting from either plant construction or operation, and if they are beneficial, harmful, or of no consequence. In addition, the study will provide laboratory data concerning the response of important aquatic organisms to thermal changes.

3.3.1.9 Field Investigation

Several sampling locations in the Walden, Nancy, Dutchman, Denis, Piney Point Creek areas and in the Cape Fear River, as shown in Figure 3.3-5 have been established for the field program. Samples at these stations include trawling zooplankton, phytoplankton and benthos, as well as temperature, dissolved oxygen, turbidity, and salinity.

In recognition of the possibility that construction of the plant could have an impact on the aquatic environment, precautions were instituted to protect the creeks and marsh. The major effect that could occur is silting by runoff from spoil areas that are set aside to contain excavation materials. Safeguards that were established include channeling of runoff from the spoil areas into settling pools where most of the solids settle before the water is permitted to enter the natural flow of the creeks. Spoil from dredging in the river is being placed in spoil areas on the mainland to avoid any possible harmful effects on the estuarine biota and to reduce the amount of marsh acreage required for construction. In addition to these precautions, CP&L will conduct investigations of possible effects of construction by field studies of the creeks in the area. Other items that will be investigated during the field study include:

1. Larval and adult fish migrations past the plant intake site with primary emphasis on timing and location of the migrations in the estuary.
2. Population diversity of the larval and adult fish, phytoplankton, zooplankton and other organisms in the Cape Fear River estuary near the plant intake and in the ocean in the vicinity of the cooling water discharge with emphasis on quantitative determination of kinds and numbers present.
3. Population diversity of the benthic community in the ocean discharge area and in the estuary will be determined. Samples will be collected in the immediate discharge area and outside the area of influence.
4. Organisms will be collected for laboratory studies of response to thermal changes.

After the plant begins operation, the field investigation will be expanded to include the following:

1. A detailed study of the fish diversion system.
2. Sampling of organisms in the intake and discharge canals to determine the effect on these organisms of being transported through the plant condensers. Time of day and seasonal differences in the effect will be investigated.

3.3.1.10 Laboratory Investigation

Identification and quantification of organisms collected in the field will be performed in the Pamlico Marine Laboratory as will chemical analysis of water samples. There will be laboratory investigations of the heat tolerance of important estuarine organisms by simulating the increase in temperature experienced by organisms being transported through the plant condensers. The effects of temperature acclimation and of life-history stage on temperature tolerance will be determined. In addition, the effect of holding the organisms at elevated temperatures for time periods extending to several days will be investigated.

In addition to heat mortality studies, the effect of elevated temperatures on metabolism will be studied. An attempt will be made to correlate metabolic indices of thermal stress with the tolerance limit. The behavior and physiological criteria of organisms will be investigated with respect to elevated temperatures.

3.3.2 Environmental Radiological Monitoring

Maximum engineering and design efforts have been made in the design and construction of the Brunswick Steam Electric Plant to minimize the release of radioactive materials to the environment. The detailed design of the radioactive waste processing system, along with the design objectives of this system, are presented in Section 3.6 of this report. As a further awareness of its responsibilities to protect the environment, the Carolina Power & Light Company will conduct a comprehensive radiological environmental monitoring program in the vicinity of the plant to insure that these design objectives are met.

3.3.2.1 Pre-operational Radiological Monitoring Program

A pre-operational radiological monitoring program will be conducted to determine the magnitude and nature of radioactivity in the environment surrounding the site, to test the equipment, sampling and analytical procedures, the suitability of selected sampling points, and investigate the overall statistical variability of the results. The information obtained will serve as a baseline for the evaluation of any changes in environmental radioactivity levels that may result from plant operation as determined by the operational radiological monitoring program. The pre-operational radiological monitoring program will start early in 1972 and will continue until initial criticality.

The initial pre-operational monitoring program is described in Table 3.3-5. This table defines the type of samples, the number of samples to be taken, and the location, the collection frequency, and the analysis to be performed. As shown by this table, radioactivity will be determined in samples of water, air, farm and dairy products, fish and other organisms and bottom sediments.

The sample media and location of sampling points were established on the basis of population density and distribution, meteorological, hydrological, ecological and topological conditions, critical pathways to man, and expected radiological effluents from the facility. It is expected that there will be some alterations in this sampling program as experience is obtained during the pre-operational program.

The pre-operational environmental radiological monitoring program will be closely coordinated with existing state programs for monitoring radioactivity levels in the environment. Discussions were held with the N.C. Department of Radiological Health in formulating the pre-operational program. This program, and the results obtained, will continue to be coordinated with this state agency and other interested agencies as the program proceeds, to assure maximum effectiveness for all interested parties.

3.3.2.2 Operational Radiological Monitoring Program

During the first year of operation, operational radiological monitoring will follow the schedule developed during the pre-operational program. It is expected that this program will follow closely the program outlined in Table 3.3-5, with only minor modifications which are found to be necessary or desirable during the pre-operational phase.

The sampling program has been designed to incorporate measurements to provide background data and to measure possible Brunswick Steam Electric Plant effects on the environment. Samples collected at points where concentrations of effluents in the environment are expected to be greatest will be compared with samples collected concurrently at points expected to be essentially unaffected by plant effluents. The latter samples, along with the pre-operational data, will provide background measurements that will be used as a basis for distinguishing significant radioactivity introduced into the environment by the operation of the plant from that radioactivity due to natural background or from other sources. If significant radioactivity is detected, the primary isotopes involved will be identified and efforts made to determine the source of the radioactivity.

Results of the sample analyses will be evaluated to demonstrate the effectiveness of plant radiation control and compliance with the requirements of 10CFR20, the technical specifications, and the design objectives of the waste processing system as contained in Appendix I, 10CFR50.

It is expected that after the first year of operation the Brunswick Steam Electric Plant will have demonstrated the capability of operation within the design objectives as stated in 10CFR50, Appendix I. At this time there will be a reduction in the number of sampling locations and the sampling frequency. This reduced environmental radiological monitoring program will continue as long as the plant continues to operate within design objectives.

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TABLE 3.3-1

DISSOLVED OXYGEN FROM STATION 23A(ppm) AND SALINITY FROM STATION 19(ppt) IN THE CAPE FEAR RIVER FROM MARCH OF 1969 THROUGH FEBRUARY OF 1970

Date	Tide	Depth	Dissolved Oxygen ppm	Dissolved Oxygen % Saturation	Salinity ppt
3/15/69	High	Surface	6 53	81	9.46
		Bottom	5.84	102	26.52
	Low	Surface	6.18	69	5.00
		Bottom	5.79	79	14.62
4/19/69	High	Surface	2.00	35	22.19
		Bottom	1.86	33	27.60
	Low	Surface	5.58	95	12.40
		Bottom	5.21	89	17.34
5/12/69	High	Surface	5.23	91	26.69
		Bottom	5.05	89	30.18
	Low	Surface	5.23	92	16.48
		Bottom	4.97	91	24.03
6/5/69	High	Surface	4.41	89	26.21
		Bottom	4.20	83	24.59
	Low	Surface	3.45	67	25.77
		Bottom	3.71	77	25.86
7/8/69	High	Surface	4.17	87	21.70
		Bottom	3.82	84	32.58
	Low	Surface	3.29	65	12.30
		Bottom	3.38	72	20.09
8/5/69	High	Surface	3.49	65	6.51
		Bottom	2.00	43	29.05
	Low	Surface	3.71	68	2.45
		Bottom	3.35	65	9.56
9/9/69	High	Surface	4.42	92	28.10
		Bottom	4.41	96	33.85
	Low	Surface	4.83	100	23.02
		Bottom	3.90	83	26.98
10/7/69	High	Surface	4.99	89	22.90
		Bottom	4.45	86	32.50
	Low	Surface	4.80	88	17.80
		Bottom	4.52	87	26.10
11/8/69	High	Surface	5.57	82	13.92
		Bottom	5.59	95	30.72
	Low	Surface	5.51	85	11.52
		Bottom	5.88	88	20.36
12/7/69	High	Surface	6.58	96	31.52
		Bottom	6.56	100	33.80
	Low	Surface	6.41	93	24.00
		Bottom	6.50	94	26.18
1/10/70	High	Surface	8.10	95	19.33
		Bottom	8.07	111	32.50
	Low	Surface	7.83	90	14.44
		Bottom	7.93	99	21.78
2/7/70	High	Surface	7.27	93	19.26
		Bottom	6.51	94	32.50
	Low	Surface	8.09	100	7.66
		Bottom	7.49	96	19.00

TABLE 3.3-2

TOTAL NUMBER OF SPECIES BY PHYLUM COLLECTED DURING THE PERIOD FROM MARCH OF 1969 THROUGH FEBRUARY OF 1970

Station	23A Low Tide	23A High Tide	OI Low Tide	OI High Tide	Ocean
Bascillariophyceae	56	66	73	70	76
Chlorophyceae	17	16	15	11	10
Cyanophyceae	3	4	5	3	1
Haptophyceae	2	2	2	2	2
Dinophyceae	4	8	5	11	11
Cryptophyceae	7	6	7	7	6
Chrysophyceae	2	3	2	2	2
Euglenophyceae	1	1	1	1	1
Flagellata	2	2	2	2	2
Total	94	108	112	109	111

TABLE 3.3-3

PHYTOPLANKTON DIVERSITY AT STATION 23A, OAK ISLAND (OI), AND THE OCEAN DURING HIGH AND LOW TIDE OVER A PERIOD OF ONE YEAR. DIVERSITY IS SLIGHTLY HIGHER AT THE ESTUARY MOUTH THAN EITHER THE OCEAN OR THE RIVER.

	23A Lo	23A Hi	OI OI Lo	OI OI Hi	Ocean
Jan	3.12	3.24	3.14	3.29	2.68
Feb	3.00	1.87	1.62	1.60	2.04
Mar	3.69	3.23	3.77	2.37	2.48
Apr	3.93	3.29	4.21	3.85	3.33
May	4.01	3.66	3.68	3.14	1.72
June	1.99	3.34	3.81	2.61	1.80
July	3.76	3.45	3.27	4.29	3.73
Aug	3.20	3.42	4.03	3.77	3.68
Sept	2.81	3.41	3.58	3.33	3.43
Oct	2.37	1.64	3.22	4.18	3.99
Nov	2.54	3.25	2.86	3.51	4.30
Dec	2.39	4.03	3.80	3.69	3.66
Total	36.81	37.83	40.99	39.63	36.84
Average	3.07	3.15	3.42	3.30	3.07

TABLE 3.3-4

SAMPLE SIZE AND DIVERSITY OF BENTHIC ORGANISMS COLLECTED AT EACH OF THE 30 SAMPLING POINTS OF THE OCEAN STATION. TRANSECT C IS NEAREST THE RIVER MOUTH (FIGURE 3.3-1) AND POINTS 1 THROUGH 10 EXTEND FROM 1/4 MILE OFFSHORE TO 1-3/8 MILES OFFSHORE.

Diversity:

Station		Summer	Fall	Winter	Spring	Station		Summer	Fall	Winter	Spring	Station		Summer	Fall	Winter	Spring
A	1	1.39	1.25	1.79	1.23	B	1	2.60	1.45	0.98	1.30	C	1	1.84	1.81	0000	1.58
	2	1.69	1.51	0.39	0.72		2	3.12	1.67	1.67	2.20		2	1.79	1.50	0000	1.50
	3	1.48	1.81	1.25	0.73		3	3.34	1.90	2.58	2.58		3	2.95	1.50	1.92	1.38
	4	2.26	3.01	1.60	0.18		4	3.83	3.23	2.61	1.93		4	3.10	2.44	2.96	2.95
	5	3.09	2.61	1.46	1.17		5	4.75	2.70	1.09	2.10		5	3.18	2.58	0.97	2.58
	6	2.50	2.84	1.97	2.20		6	3.70	3.08	1.56	2.75		6	2.64	2.29	3.56	2.20
	7	2.83	2.29	2.43	1.97		7	3.66	2.44	2.95	2.81		7	2.64	0.72	1.46	2.40
	8	3.42	3.20	2.36	3.19		8	3.09	2.67	3.29	2.04		8	2.42	1.95	1.81	1.37
	9	3.00	2.41	2.42	2.46		9	2.42	2.35	5.44	2.52		9	0.92	0.92	2.94	1.62
	10	3.52	2.82	1.39	3.04		10	3.14	3.08	2.0[illegible]	5.16		10	2.17	2.40	1.79	2.32
	Av	2.52	2.37	1.71	1.69		Av	3.30	2.46	2.42	2.54		Av	2.36	1.81	1.74	1.89

Sample size:

Station		Summer	Fall	Winter	Spring	Station		Summer	Fall	Winter	Spring	Station		Summer	Fall	Winter	Spring
A	1	48	134	62	18	B	1	15	7	9	8	C	1	7	8	2	3
	2	44	106	65	25		2	23	11	13	9		2	23	4	2	4
	3	52	85	74	44		3	17	17	22	12		3	16	4	6	7
	4	111	58	108	79		4	29	13	22	21		4	17	10	10	9
	5	84	35	91	84		5	43	14	53	17		5	26	22	5	6
	6	60	47	59	16		6	44	52	15	22		6	23	19	14	9
	7	60	27	34	22		7	[illegible]	40	31	24		7	10	5	6	14
	8	47	37	42	29		8	[illegible]	51	39	15		8	9	12	8	5
	9	15	54	39	18		9	[illegible]	39	41	26		9	3	3	17	11
	10	27	56	45	26		10	[illegible]	3	14	42		10	10	19	6	5
	Av	54.7	63.9	61.9	36.1		Av	[illegible]	7.7	25.9	19.6		Av	14.4	10.6	7.6	7.3

ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM

Location	Analysis - Frequency by Sample Types								
	Air Filter	Charcoal Cartridge	Radiation TLD	Surface Water	Well Water	Bottom Sediment	Fish & Shrimp	Milk	Fruits & Vegetables
Information Center Route 87 1 mile SW of Plant	A-M B-W G-Q (composite)	I-W	R-M & Q						
Southport, 2.5 Miles South of Plant	A-M B-W G-Q (composite)	I-W	R-M & Q						
River Road, 1.5 Miles ENE of Plant	A-M B-W G-Q (composite)	I-W	R-M & Q						
Point of Projected Maximum Annual Average Exposure	A-M B-W G-Q (composite)	I-W	R-M & Q						
Caswell Beach 5 Miles SW to SSW of Plant	A-M B-W G-Q (composite)	I-W	R-M & Q		G-Q →				
Perimeter Stations (5) See Map			R-M & Q						
Stations 2-3 Miles From Plant (6) See Map			R-M & Q						
Boiling Spring Lake 6 Miles NNW from Plant			R-M & Q						
Fort Fisher, 5.4 Miles E to ENE From Plant			R-M & Q						
Kure Beach, 6 Miles NE to ENE From Plant			R-M & Q						
Carolina Beach, 7 Miles NE to ENE From Plant			R-M & Q						
Wilmington, 16 Miles NNE From Plant	A-M B-W G-Q (composite)	I-W	R-M & Q						

TABLE 3.3-5 (Cont'd)

ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM

Location	Analysis - Frequency by Sample Types								
	Air Filter	Charcoal Cartridge	Radiation TLD	Surface Water	Well Water	Bottom Sediment	Fish & Shrimp	Milk	Fruits & Vegetables
Intake Canal				B-M T&G-Q (composite)					
Discharge Canal				B-M T&G-Q (composite)		G-Q			
Wells (2) Along Discharge Canal				A,B&T-Q					
Wells On-Site				A,B&T-Q					
Ocean Near Discharge Canal Outfall					G-Q	G-Q			
G. K. Lewis Dairy 11 Miles NNW of Plant							I-S		
Vegetable Stand on State Highway 211 Approximately 3 Miles SW of Plant								B & G-Q	

Analysis Codes:

A - Gross Alpha
B - Gross Beta
G - Gamma Spectrum, Identification of Major Emitters and Quantitative Interpretation
I - Iodine 131, Begin 3 Months Before Startup
R - Radiation Dose in rem
T - Tritium

Frequency Codes:

H - At Time of Harvest
M - Monthly
Q - Quarterly
S - Special Based on Effluent Data
W - Weekly

3.4 Heat Dissipation

3.4.1 Production of Waste Heat

In nuclear powered plants as in fossil fired plants, the conversion of heat energy to electrical energy is limited by the thermodynamics of the Rankine cycle; i.e., a part of the heat energy cannot be recovered and must be removed to some heat sink. In the case of the Brunswick Plant most of the unrecovered energy is transferred to the condenser cooling water as waste heat.

3.4.2 Cooling Water System

The temperature rise across the main condenser is limited to 18 F through use of a water flow rate of 624,000 gpm. The temperature rise of the service water for the two reactor building closed cooling water systems is kept to about 10 F, before releasing it to the discharge canal, as the result of providing a 24,000 gpm flow rate.

Cooling is accomplished by taking raw water from the lower Cape Fear River, channeling it to the plant, and releasing it, via the discharge canal and pumping station, to the Atlantic Ocean, some 2000 feet off-shore from Oak Island. A fraction of the stored energy is radiated to the atmosphere from the discharge canal before the final discharge off-shore, where the remaining heat is dissipated by rapid mixing with the ocean water.

3.4.3 Thermal Plume

It is desirable to dilute the discharge water by ten fold as soon as possible in order to reduce the temperature difference to about 2 F above ambient.

Mixing of the discharge into the seawater is attained by jet discharge. The resulting plume is bounded by the free water surface above and by a variable density layer below. With a spread angle of 1:6 for the jet, and a depth of ten feet, the area of increased temperature is approximately 1000 by 300 yards or approximately 60 acres.

The distortion of the plume shown in Figure 3.4-1 is caused by the tidal drift of water in the discharge area (which does not, however, move into the Cape Fear estuary) and by a large eddy in the region which drifts westward one to two miles off the shoreline. Although the drift currents have an average speed of only 0.7 feet per second, the large cross section of the body of water provides an extensive diluent mass.

The submerged off-shore outfall will not affect the movement of sand or marine organisms along the shore. The outfall area has no features which would tend to trap organisms and then expose them to elevated temperatures. Because of the free access to the mixing zone, it is expected that organisms may avoid the mixing zone during the summer months and seek it out during the colder seasons.

3.5 Chemical Discharges

Some non-radioactive chemical wastes are produced in the processing of the high quality reactor make-up water, in the operation of some auxiliary systems, and by the two oil-fired systems: the auxiliary boilers and the emergency diesel generators.

3.5.1 Water Treatment

Non-radioactive liquid chemical discharges will be those associated with the chlorination of the main condenser cooling water and service water as well as those associated with the regeneration of the non-radioactive demineralizers. Non-radioactive regenerant chemicals will be neutralized before release to the discharge canal. The resulting salts are a negligible added inventory to the saline estuarine cooling water.

The discharge into the ocean will have essentially the same chemical analysis as the river. The chlorination system for control of algae and slime growth in the plant condensers and circulating water tunnels, will normally operate for only two 30-minute cycles per day. Chlorine residuals in the water leaving the condenser will be no more than 0.5 ppm and should be no more than a trace at the discharge into the ocean.

The closed cooling water systems may contain chemical additives for corrosion protection. Provisions have been included to collect waters containing chemical additives for processing prior to discharge or off-site disposal.

3.5.2 Gaseous Discharges

The two auxiliary boilers are fired with No. 2 fuel oil, but have a capability of operating with No. 6 oil as well, when No. 2 oil is not available. Each boiler is capable of generating 55,000 pounds of steam per hour. The combustion gases are vented from stub stacks some 35-40 feet above plant grade which will adequately diffuse any possible concentrations. Because of the high quality fuel, the diesel generators and the auxiliary boilers are not considered to contribute significant chemical gaseous wastes. Both systems will operate within the limits of chemical emission standards for the State of North Carolina.

3.5.3 Spills and Leakage of Oil

In areas where oil or grease can enter floor drains, the pipe lines from these drains are equipped with traps which collect the oil or grease and the material is periodically removed for disposal.

The turbine lube oil tanks, located just outside the Turbine Building, are placed in concrete moats which are equipped with a sump to permit collection for disposal as necessary.

The above ground storage tank for fuel oil for the diesel generators and the auxiliary boilers is protected by surrounding dikes that are capable of containing the full contents of the tanks.

3.6 Radioactive Discharges

3.6.1 Radioactive Waste Processing System - Summary Description

The radioactive waste processing system is designed to collect, process, store and prepare for off-site shipment or disposal, plant wastes which contain or could contain radioactive material. It is composed of the following:

(1) Liquid Radioactive Waste Processing System

(2) Solid Radioactive Waste Processing System

(3) Gaseous Radioactive Waste Processing System

The functional objectives of these three systems are shown in Figures 2.2-3, 2.2-4 and 2.2-5 respectively. The design objective of these systems is to minimize the release of radioactivity to the environs as much as is practicable. Activity releases are made only after proper sampling, analysis and monitoring to assure that predetermined release indicators (activity levels and discharge rates) are not exceeded. The cumulative effect of off-site exposures will be within the requirements of 10CFR20 and Appendix I of 10CFR50 (maximum off-site dose to a single individual due to normal gaseous releases will not exceed 10 mrem/year, whole body; integrated liquid effluent activity will not exceed 5 curies per year per unit excluding tritium while maintaining a discharge canal activity of less than 2×10^{-8} μCi/ml due to these releases, and the maximum integrated dose to an individual will not exceed 5 mrem due to these liquid releases). Accidental release of radioactivity will be safeguarded so that the likelihood of occurrence is very remote, and, if such releases do occur, the radiological consequences will be well within the AEC guidelines.

3.6.1.1 Liquid Radioactive Waste Processing System

Liquid wastes which are subject to possible radioactive contamination are collected in the liquid radwaste system where they are monitored, stored, and processed for re-use or for discharge to the circulating water system.

The liquid radwaste system is 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 are processed on a batch basis, and each batch is sampled to determine that all discharge requirements are met prior to release from the waste system.

The liquid radwaste system is divided into several subsystems so that the liquid wastes from various sources can be kept segregated and processed separately. Cross connections between these subsystems provide additional flexibility for processing of wastes by alternate methods. The liquid radwastes are classified, collected and treated as high purity, low purity, chemical, detergent, sludges or concentrated wastes. The terms "high purity" and "low purity" refer to the conductivity and not radioactivity.

High purity (low conductivity) liquid wastes are collected in the Waste Collector Tank and are processed by filtration and ion exchange through the waste filter and waste demineralizer. After processing, the waste is pumped to a waste sample tank where it is sampled. If this liquid meets plant water quality standards, it is then pumped to the condensate storage tank to be used as make-up water. If it does not meet water quality standards, it is returned to the system for reprocessing. High purity wastes will always be recycled.

Medium and low purity (high conductivity) liquid wastes are those having a conductivity greater than 50μ-mho and are collected in the floor drain collector tank. These wastes normally have low concentrations of radioactive impurities; thus, processing consists of filtration and subsequent transfer to the floor drain sample tank for sampling and analysis. Although it is the intent to recycle these liquids by additional filtration and demineralization or concentration, ooccasionally, when water inventory in the plant dictates and activity levels permit, these liquids will be released to the discharge canal where they are diluted by the circulating water flow. Such discharges will be made only if plant water inventory demands it and if the activity levels are sufficiently low to meet predetermined release parameters so that compliance with 10CFR20 and 10CFR50 will always be maintained.

Chemical wastes are collected in one of the four waste neutralizer tanks. These chemical wastes are of such high conductivity as to preclude treatment by ion exchange. The radioactivity concentrations are variable. Normally the chemical wastes will be neutralized in the waste neutralizer tank and subsequently processed in the waste concentrator after which the concentrates are drummed and the condensate is recycled through filters and demineralizers for reuse. Occasionally a batch of chemical waste may be released to the circulating water system if water inventory demands and if chemical purity and radioactive contents are sufficiently low to meet all regulatory requirements.

Detergent wastes are collected in the detergent drain tanks. These wastes are primarily radioactive laundry and decontamination solutions and are of low radioactive content (normally 1×10^{-5} μCi/ml). Because of the tendency of these liquids to foul ion exchange resins and other process equipment, they will normally be discharged, after sampling for compliance with discharge standards, through the detergent drain filter to the discharge canal where it is diluted by circulating water. Under abnormal conditions, the detergent wastes will be processed as required to meet regulatory requirements. The detergent drains are the only liquids which are routinely discharged from the plant.

Clean-up, condensate and radwaste demineralizer systems sludges are collected in backwash receiving tanks, then fed to phase separators where excess backwash water is decanted to the waste collector tank and the sludge is accumulated. The fuel pool filter-demineralizer and waste filters are backwashed to the waste sludge tank. The accumulated resins and sludges are processed through the solid radwaste system after a suitable decay period.

Oily drains such as shop drains and the turbine building oil drains are piped to a centrifuge where the oil and water are separated. The oil will be sealed in DOT approved 55-gallon drums and shipped off-site. The waste water is routed to the detergent drain tank and subsequently disposed of as described above.

3.6.1.2 Solid Radioactive Waste Processing System

The objective of the solid radwaste system is to provide a practicable means to collect, process, store, package and prepare for off-site shipment solid radioactive waste materials produced from the operation of both nuclear units.

Wet solid wastes such as spent resins, filter sludges, and highly concentrated concentrator bottoms are dewatered in one of the two centrifuges before being packaged in DOT approved 55-gallon drums for off-site shipment to a licensed burial facility.

Concentrator bottoms may be permitted to undergo radioactive decay in the concentrated waste tank prior to further processing. After a decay period, concentrator bottoms are mixed in a mixer with "Microcel-E" for solidification and packaged in DOT approved 55-gallon drums.

Dry solid wastes consisting of air filters, paper, rags and contaminated clothing will be collected. Compressible wastes will be compacted into DOT approved 55-gallon drums in a hydraulic press-bailing machine to reduce the volume. Noncompressible wastes are packaged in 55-gallon drums or other DOT "specification" containers for shipment to an off-site disposal facility.

3.6.1.3 Gaseous Radioactive Waste Processing System

The gaseous radwaste system collects and processes radioactive gaseous wastes from the main condenser air ejectors, the standby gas treatment system, the start-up vacuum pumps, the gland seal condenser and various building ventilation exhaust systems, and controls their release to the atmosphere through the plant stack in compliance with the standards and design objectives of 10CFR20 and 10CFR50, Appendix I.

The air ejector off-gas is passed through the standard 30-minute hold-up piping and the augmented off-gas treatment system prior to passing through filters and being discharged up the 100-meter stack. The augmented off-gas treatment system uses cryogenic distillation to liquify and concentrate xenon and krypton isotopes and effectively remove them from the off-gas. The system is expected to essentially eliminate I-131 releases from the air ejector. The air ejector off-gas system results in a reduction of at least 1000 in the quantities of noble gas radioactivity that would be released from the system with only the standard 30-minute holdup.

The activity release from the gland seal condenser is significantly smaller than the release that would result from untreated air-ejector off-gas. The turbine sealing system is a bleed-off from the main steam. The activity input to the gland seal condenser system is about 0.1% of the total activity contained in the main steam from the reactor. The gases from the gland seal off-gas system are monitored and discharged through the 100-meter stack after passing through a 1.8 minute holdup to allow decay of N-16 and 0-19.

The potential levels of activity from the Radwaste Building ventilation and various tank vents are expected to be extremely low. The collection and control of the release of these gases is a measure to ensure that every potential radioactive pathway is monitored, and provides the extra measure of safety due to the additional dispersion from the elevated release.

The Reactor Building ventilation exhausts through the building vents while being continuously monitored. If radioactivity is detected above a pre-set level in this ventilation system, the exhaust is automatically diverted to the standby gas treatment system where it passes through charcoal and absolute filters before being discharged to the 100-meter stack.

3.6.2 Radioactive Releases

During normal operation of the Brunswick Steam Electric Plant, small amounts of radioactive materials will be discharged to the environment on a controlled basis. Although the resultant doses from both the gaseous and liquid radioactive discharges are considered insignificant when compared to the dose received from natural background, they are assumed to impose a theoretically calculable radiation dose to the local population. These calculations and results are discussed in the following sections.

3.6.2.1 Radioactive Liquid Discharges

The design of the liquid radwaste system as described in Section 3.6.1 has undergone a continuous re-evaluation due to evolving regulatory standards to ensure compliance with those standards. Although the system as originally designed would have limited radioactive liquid releases to a small fraction of 10CFR20 criteria, there have been numerous improvements in the system, such as the provision of additional tankage capacity, the installation of additional concentrator capacity, changing the design of the building to AEC seismic Class I, and numerous smaller changes. At the present time additional treatment is being evaluated to ensure that the plant complies with an annual per unit discharge limit of 5 curies exclusive of tritium and an average annual concentration in the discharge canal of 2×10^{-8} μCi/ml. Additional storage and clean-up capacity has been installed for this system to permit the re-use of liquids that had previously been designated for release to the discharge canal. Since the construction permit was granted, an auxiliary surge tank has been added and an additional waste concentrator and waste concentrator condenser have also been added to the radwaste system. With this additional equipment it is expected that radioactive releases will be less than the 5 curies per year limit exclusive of tritium.

There is a good correlation between the gaseous radwaste system and the liquid radwaste system for setting the administrative constraints and procedures for disposal. With no defective fuel both systems would see only activation products, and discharges from the liquid radwaste system, with both detergent drains and floor drains discharged routinely, would be about 0.03 curies per year. However, should fuel defects occur, fission products would be present in the liquid radwaste system, with the amount of fission products proportional to the amount of defective fuel.

Since it is impossible at this time to predict the exact rate of fuel failure, it is impossible to determine the actual ratio of fission products to corrosion products in the liquid releases and determine an exact isotopic distribution of liquid releases. However, to evaluate the maximum impact of liquid releases on the environment, we have evaluated two postulated circumstances; (1) that 5 curies per year of 10 day old corrosio products are released and (2) that 5 curies per year of a 10 day old recoil-equilibrium fission product mixture are discharged. The total annual release of each isotope to make-up the two 5 curie categories described above is shown in Tables 3.6-1 and 3.6-2. It should be noted that this is a conservative case, since the release will not exceed 5 Ci/yr/unit in accordance with 10 CFR 50.

Although releases of radionuclides from the BSEP will be extremely small, it is important to know their ultimate radiological consequences to man. Of the possible pathways to man for isotopes in the liquid waste, only the water-fish-man pathway is considered important. Other pathways considered and determined to be of lesser importance or of no significance are:

(1) Ingestion from drinking water - Since this is an ocean site, there is no source of drinking water from the plant liquid effluents. The possibility of radioactive materials from the discharge canal entering ground water streams and subsequently into local wells is so remote and the concentrations would be so small that this pathway is considered to be of no significance.

(2) External exposure from deposits on beaches - The method of discharge and direction of drift from the point of discharge is expected to minimize any sedimentary deposits on the beaches[1]. Since liquid wastes will be treated prior to discharge, those radionuclides that tend to deposit will not be present in significant amounts. Furthermore, the concentration in the discharge canal water will be extremely low (less than 2×10^{-8} μCi/ml). Under these conditions, exposure from sediment deposits on the beaches is considered to be of no significance.

(3) Ingestion of small game and waterfowl. There is some limited taking of small game and waterfowl on a seasonal basis. However, due to the extremely low concentrations in the canal (seawater) and the limited seasonal activity, this pathway is considered of no significance.

(4) Ingestion of oysters from the Cape Fear Estuary - Because of pollution resulting from the release of sanitary wastes, oysters from the Cape Fear estuary are not presently used for direct consumption, but are presently utilized for transplanting to other areas. These oysters exist only in the Cape Fear estuary and not in the area of the discharge

canal. The direction of water movement from the point of discharge of the circulating water system has been evaluated using a tracer material[1]. Normal movement of the water at this point is to the west, away from the Cape Fear estuary. Even with a continuous strong southwest wind, the direction of drift was still to the west during ebb tide and early flood tide. For the last half of flood tide, eastward drift was observed, which moved some of the tracer material to the area east of Oak Island at the end of flood tide but ensuing ebb tide moved the material seaward. Under these conditions, radioactive material from the discharge canal is not expected to reach the Cape Fear estuary. For these reasons, the ingestion of radioactive material via consumption of shellfish from the Cape Fear estuary is considered to be of no significance.

Fish and shrimp are taken from the ocean in the area of the discharge canal. However, the commercially important species of fish (including shrimp) do not remain in this area for long periods of time and would be expected to show no increase in radioactivity due to the low levels of radioactivity discharged with the circulating water. Nevertheless, an evaluation has been made assuming these fish spend 100% of their time in the discharge water. In essence, this assumes that the fish live in the discharge canal and are taken from the canal.

Average per capita consumption of fish and seafood in the Middle Atlantic Region is 14.3 pounds per year but more than one third of this amount is canned or frozen fish not locally produced[2]. The average per capita consumption of seafood from the ocean would be unlikely to exceed 9 pounds per year (12 grams/day), although a commercial fisherman may eat as much as 40 pounds/year (50 grams/day)[3]. For calculational purposes 50 grams/day was used in determining individual doses as the result of liquid releases.

Fish living in water that contains low concentrations of radionuclides may concentrate some of these radionuclides through the micro-organism-small invertebrate-fish food chain. The collective effect of these concentration mechanisms may be estimated from stable element concentrations in water and fish. An extensive review of stable element data available in literature has been made[4]. Concentration factors, C_f, for fish in the discharge water are based on data provided by this review. The concentration factor is the expected ratio of the concentration of a radionuclide in fish to that in the ambient water.

The dose to an individual from ingestion of fish containing radioactivity is determined from the rate of intake of each component radionuclide and the application of the appropriate computational method of the ICRP[5]. The ICRP dose conversion values used were those for the whole body and for an exposure to an individual in an unrestricted area.

Tables 3.6-1 and 3.6-2 list the concentrations of radioactive materials in the discharge canal based on the two isotopic distributions as noted above. Also included in these tables are the total annual whole body dose received by an individual who eats 50 grams of fish flesh per day, 365 days per year, taken from the discharge canal. These doses assume that fish have lived in the discharge canal for a sufficient length of time to reach a maximum concentration in the fish with no depletion by radioactive decay.

The above assumptions and relationships have been used to calculate upper level estimates of individual doses resulting from liquid releases via the seafood pathway. As seen by the doses presented in Tables 3.6-1 and 3.6-2, this pathway is of only minor significance and could be considered of no significance when compared to the dose a person receives from natural background and other man-made sources of radiation.

3.6.2.2 Radioactive Gaseous Discharges

During normal operation of the Brunswick Steam Electric Plant Units 1 and 2, radioactive gaseous effluents are expected to be released. The quantity of radioactivity released is principally dependent upon the degree of fuel failure in the core. Without fuel failures, the principal activity source would be the activation products. If perforations exist in the fuel cladding, fission gases are released to the coolant and subsequently are released to the environs at a controlled rate. All systems are designed to ensure that all radioactive releases are in accordance with the allowable limits that are specified in the Code of Federal Regulations.

The principal mechanisms of activity release are:

1) Air ejector off-gas
2) Gland seal condenser off-gas
3) Containment purge
4) Leakage in Turbine Building
5) Startup mechanical vacuum system

The air-ejector off-gas is the dominant contributor to activity release, with the gland seal condenser off-gas of secondary importance. The other three sources have substantially smaller contributions.

In order to minimize environmental impact due to normal operation activity releases, a processing system will be installed to remove the fission noble gases from the air-ejector off-gas and store them for decay. With the augmented off-gas processing system and a postulated fuel failure rate corresponding to 25,000 μCiNG/sec/unit at 30-min decay, the release rate at the stack, from the first two sources, will be in the order of 259 μCiNG/sec/unit, resulting in a whole body dose, for the worst 22-1/2 degree sector, of 0.086 mrem/yr at the exclusion distance (0.915 Km). The contribution from the augmented off-gas system is less than 2.0 percent of this dose. The doses due to containment purge and the other sources were found to add less than 3.0 percent of the above dose. The total calculated doses are thus well below the limits set forth in 10CFR50, proposed Appendix I, concerning yearly doses from gaseous effluent release.

The I-131 concentration off-site calculated for the worst 22-1/2 degree sector for the postulated fuel failure rate is 1.84×10^{-16} μCi/cc. These calculations are based upon the operation of one unit of the Brunswick plant.

Whole body doses and iodine concentrations are summarized in Table 3.6-3.

3.6.2.2.1 Activity Sources

Air Ejector Off-Gas

The air-ejector off-gas draws non-condensible gases from the main condenser hotwell to maintain vacuum. Consequently, the radioactive releases are principally fission (noble) and activation gases. The air ejector augmented off-gas processing system reduces the noble gas activity by an expected factor of 10^4, minimum of 10^3. Two levels of gaseous effluents have been evaluated: (1) the postulated fuel failure rate resulting in a noble gas diffusion mixture activity of 50,000 μCi/sec (25,000 μCi/sec/unit) as measured after 30 minutes decay and which will be 25 μCi/sec/unit after treatment and (2) the design basis maximum fuel failure rate equivalent to 500,000 μCi/sec noble gas diffusion mixture rate as measured after 30 minutes decay. The design basis noble gas rate is the basis on which other design decisions should be made and would not be expected to be reached during the life of the plant; a lower value is, therefore, appropriate to estimate effects on the environs as averaged over the years of plant operation. Past BWR experience for about 10 plants, with hold-up systems providing less than one hour delay, has shown average annual emission rates between 1,000 and 30,000 μCi/Sec. These include plants with thermal power levels between 200 and 2,400 MWt[(6)]. Therefore, based on BWR experience to date, an average activity rate over the years of the order of 50,000 μCi/sec for two units before treatment is more representative for estimating the long term dose. This activity rate of 50,000 μCi/sec as measured after 30 minutes decay has been selected for the purpose of evaluating the dose to the population within a 50-mile radius of the plant.

In order to make a conservative estimate, a reduction factor of only 10^3 has been assumed, and calculations in this Section are based on the resulting value of 25 μCiNG/sec/unit.

Table 3.6-4 shows the release rate of fission and activation gases as they enter the turbine plant and after they leave the augmented off-gas processing system. For the expected fuel failure rate corresponding to 25,000 μCiNG/sec at 30-min decay, the release rate from the augmented off-gas system is expected to be 25 μCi/sec.

Gland Seal Condenser Off-Gas

The turbine thermodynamic cycle is designed to divert a maximum of 0.05 percent main steam for use in the sealing system. Thus, the noble gas activity from the gland seal condensers should correspond to this value. For conservatism, 0.1 percent of the main steam activity is assumed to be diverted and released through the gland seal condenser off-gas.

Table 3.6-5 shows the release rate of fission and activation gases from the gland seal condenser off-gas. The total activity release rate after 1.8 min. delay is 234 μCi/sec for a fuel failure rate corresponding to the expected average value of 25,000 μCi NG/sec at 30-minutes decay.

The combined release rate from the processed air-ejector and the gland seal condenser off-gases is shown in Table 3.6-6. The combined release rate is 259 μCi/sec for the expected average fuel failure rate.

Containment Purge

A small amount of leakage from the reactor plant systems inside the primary containment (drywell) will occur during normal operation. The leakage of reactor coolant water is collected in equipment and floor drain sumps which feed to the liquid radwaste system.

In analyzing the radioactive releases from containment purge, all primary fission products, e.g., halogens, etc. and their daughter products have been examined and their accumulation calculated. Table 3.6-7 shows the parent-daughter relationship and characteristics for the isotopes considered. Table 3.6-8 shows the activity levels in the drywell before and after purge as well as the activity released during the purging period. To establish the total activity released during containment purge, an average of two purges per year is assumed. Purge releases are through the plant stack.

Leakage in Turbine Building

Reactor steam in the Turbine Building follows essentially two paths; a) from the reactor to the turbine and b) extraction steam from the turbine to the feedwater heaters. The steam leakage from the components in the first path is collected by means of packing gland leakoffs to either the Reactor Building equipment drain tank or to the condenser. The potential leakage source in the second path are the feedwater heater isolation valves. These valves are back seated and have lantern type gland packings. While these are the only components that do not have the controlled gland leakoff feature, their limited usage and back seating should provide essentially leak-free operation. Operating experience suggests that valves operating in a normal fashion give undetectable leakage while a failed valve is expected to leak at a rate of 0.4 gpd. This value of 0.4 gpd was used conservatively for steam leakage in the Turbine Building.

In analyzing the radioactive release due to Turbine Building water leakage, it is assumed that the principal activity contained in the water are halogens, the noble gases having already been removed by the off-gas systems. The activity in the condensed steam is a small fraction of the activity in the reactor coolant because the steam production limits the carryover.

Startup Mechanical Vacuum System

The mechanical vacuum pump is used to produce vacuum in the condenser during startup when steam production is not adequate to operate the steam jet air ejectors. The only possible release of activity could be from the residual activity in the condenser hotwell and the turbine vapor space.

3.6.2.2.2 Whole Body Dose Calculations

Air Ejector and Gland Seal Condenser Off-gas Doses

The whole body dose calculations were carried out by the use of the RADOS code described in Section 14 of the FSAR. The use of RADOS is conservative because it calculates centerline doses, thus the resulting whole body doses for the annual meteorological data for each sector is the sum of properly weighted centerline doses. This yields doses higher than expected. A sector-averaged calculation would be more representative of the annual-averaged doses.

Elevated release at 100 meters was used. The stability index and average wind speed distribution used is based on annual site meteorological data presented in Amendment 1 of the Environmental Report, Response VI.1.

Containment Purge Doses

The contribution to the operational doses from containment purge has also been calculated using RADOS. The meteorological aspect of the calculations was approached assuming that the containment purge is conducted in short periods, i.e., four hours or less, such that the release could occur coincidentally with a stability regime persisting for that period, and that all purges during any given year have identical meteorological regimes. Thus, the total activity release from containment purges could be made during a Pasquill F, or any other stability, for any given year. The resulting dose can be added to the dose in any of the sixteen sectors to reflect some degree of control in the timing of the purge operation. For conservatism, the purge dose from the worst stability was added to the worst sector annual dose to determine degree of compliance with the proposed Appendix I of 10CFR50.

Results of the calculations show that the whole body dose for each unit is 4.20×10^{-4} mrem/yr at the exclusion distance for two containment purges/year. This value is less than 1.0 percent of that from the air-ejector and gland seal for a failure rate of 25,000 μCiNG/sec at 30-minutes decay.

Turbine Building Leakage Doses

For conservatism, the dose resulting from the release rate of halogens was calculated on the basis of ground release using the semi-infinite cloud approximation. The annual average dispersion factor for the "worst" wind direction was used, based on annual site meteorological data presented in Response VI.1 of Amendment 1 and shown in Figure 3.6-1.

The total dose is 9.5×10^{-4} mrem/yr at the exclusion distance, which is approximately 2 percent of the off-gas doses calculated for 25,000 μCiNG/sec equivalent fuel failure rate.

3.6.2.2.3 Off-Site Iodine-131 Concentrations

Sources

The potential pathways for release of I-131 are as follows:

a) Air-ejector condenser off-gas

b) Gland-seal condenser off-gas

c) Turbine Building leakage

d) Normal containment purge

Assumptions for Release Calculations and Results

The assumptions used to calculate the I-131 release due to the above sources are as follows:

a) I-131 concentration in primary coolant is based on sufficient fuel cladding defects to result in a noble gas activity rate of 25,000 μCi/sec at 30-minutes decay.

b) Carry-over fraction to the steam is 2.0 percent by weight.

c) Steam mass flow rate is 10,460,000 lb/hr.

d) 0.1 percent of activity carryover is routed to gland-seal condenser off-gas.

e) Retention of I-131 in the main condenser and gland seal condenser water is 99 percent.

f) Leakage of primary coolant to containment equal to 2.0 gpm.

g) Leakage into the Turbine Building equal to 1000 gpd water and 0.4 gpd steam.

h) Retention factor in the turbine plant water leakage is 1000. No retention for steam leakage.

The air-ejector augmented off-gas system (AOGS) is designed to remove essentially all of the halogens through a combination of low-temperature and charcoal filtration processes, thus the contribution to the release from this source will be relatively negligible.

The release rates are shown below:

Source	Release Rate of I-131 (μCi/sec)
Air-Ejector	negligible, removed by AOGS
Gland-Seal	1.31×10^{-3}
Turbine Building Leakage	5.42×10^{-6}
Purging(*)	1.39×10^{-3}

Assumptions for Concentration Calculations and Results

For the concentration calculations, the annual average dispersion factor (X/Q) used corresponds to the worst wind direction at the site boundary. Elevated release with an effective stack height of 117 meters (**) was used for the air ejector and gland-seal sources while ground release was used for the turbine plant leakage source. The annual average dispersion factor for the worst wind direction for elevated and ground release is shown in Figure 3.6-1. Several conditions for containment purging were examined with two stabilities emerging significant: day purging with C Pasquill type stability, and night purging with E Pasquill type stability, each one the conservative assumption for each period in light of exclusion distance and purge duration.

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* 2 purges per year of 4 hr. duration each for a total release of 4.36×10^{-2} curies.

** The physical stack height is 100 meters. The additional 17 meters is due to the jet effect at the stack, provided by the 46,200 CFM air flow from the Radwaste Building.

For the duration of the four hours for each purge, under day purging (C type stability) the concentration peaks at 1200 meters and is equal to 5.20×10^{-15} µCi/cc; under night purging (E type stability) the concentration peaks at approximately 5000 meters and is equal to 2.38×10^{-15} µCi/cc. Averaged over one year these concentrations become 4.72×10^{-18} µCi/cc and 2.13×10^{-18} µCi/cc, respectively. Thus, the total annual contribution to the I-131 concentration at the exclusion distance from containment purge is 5.0×10^{-18} µCi/cc.

The results are shown below:

Source	Concentration at 3000 ft (µCi/cc)
Air-Ejector	Negligible
Gland-Seal	9.16×10^{-17}
Turbine Building	8.70×10^{-17}
Purging(*)	5.0×10^{-18}
Total	1.84×10^{-16}

3.6.3 Maximum Exposed Individual

Based on the analysis of one year's wind data at the site, the maximum value calculated for the annual average for the atmospheric dispersion parameter, X/Q, is 7×10^{-8} sec/m^3. The maximum occurs at the site boundary

*The concentration due to purging (C Stability) has been averaged over one year period.

to the northeast. The maximum exposed individual is considered to be a person standing at this point 365 days per year. As noted previously, the off-gas treatment installed reduces the discharge rate by at least a factor of 1000. Assuming that the off-gas rate from the plant is the maximum postulated rate of 50,000 μCi/sec at 30-minute decay prior to processing by the augmented off-gas system, this individual would receive an annual whole body dose of 0.18 mrem. In addition, this maximum exposed individual is assumed to consume 50 grams/day of fish taken from the discharge canal; this would add an annual exposure of 0.215 mrem, assuming that a total of 5 curies of fission products and 5 curies of activation products are discharged annually. Since the 50 grams/day fish consumption could be in the form of shrimp, and because the reconcentration factor is higher for shrimp than for fish, this dose might increase by a factor of about 2. This ingestion dose to a maximum exposed individual is considered to represent an unrealistically high situation which in practice would never be achieved.

3.6.4 Population Dose

Integrated radiation doses to the population within a 50-mile radius were calculated using the 1996 population projections shown in Figures 2.1-1 and 2.1-2. Doses were calculated as described in Section 8.4.3.1.

Radiation doses as a function of direction and distance are summarized in Table 8.14-1. Also included for comparison purposes, in Table 8.14-1, are the population doses estimated to result from natural background and other man-made sources in the absence of BSEP. It can be concluded from these data that the population dose due to gaseous effluents will, under the most severe operating conditions, be only a small fraction of the natural background and that the plant can be safely operated within the limits of 10CFR20 and Appendix I, 10CFR50.

As shown in Table 8.14-1, the total dose to the population within a 50-mile radius of the plant is 1.06 man-rem/year, assuming the maximum expected off-gas rate of 50,000 μCi/sec prior to processing by the augmented off-gas system.

As discussed in Section 2.1.3.3, 39 million lbs. of fish and shellfish (mostly shrimp) were landed in Brunswick County which were taken from offshore and from deep ocean waters. Of the fish landed, 87 percent or 33.5 million pounds were menhaden which are used for fertilizer and livestock feed; the remaining 5.5 million pounds are assumed to be for personal consumption. For fish, it is estimated that only one-third of the live weight is edible. For purposes of estimating the population dose to the public, it is assumed that all of this edible portion of the fish (1.83 million pounds) is consumed by the population within a 50-mile radius of the plant. It is further assumed that all of these fish are grown in, and taken from, the BSEP discharge canal, a very unrealistic assumption. Using both the above assumptions, the annual dose to the population within a 50-mile radius of the plant would be 10 man-rem/year.

Considering the above unrealistic assumptions, 50,000 μCi/sec off-gas rate and all fish landed in Brunswick County are taken from the discharge canal and consumed by the population within a 50-mile radius of the plant, the total population dose resulting from plant operations in only .02 percent of that estimated to be received from natural background and from other man-made sources. This is reduced significantly when using more realistic assumptions. In actual practice, the population dose due to liquid discharges would be expected to approach zero and the population dose due to gaseous effluents would be expected to be lower by at least a factor of 10, since the augmented off-gas system is expected to have a reduction of at least 10^4, rather than the 10^3 that was assumed in these calculations. As shown in Table 8.14-1 and discussed in Section 3.2.2, this same population receives 60,568 man-rem/year from natural and other man-made radiation.

It is concluded that the man-integrated dose to the population residing within 50 miles from the plant is negligible compared with the dose received from exposure to natural background and from other man-made sources.

3.6 REFERENCES

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7. Kahn, B., el al., "Radiological Surveillance Studies at a Boiling Water, Nuclear Power Reactor," Division of Environmental Radiation, Bureau of Radiological Health, U. S. Dept. of Health, Education, and Welfare, March, 1970.

8. Personal Communication with Brunswick County Agent, Mr. Martin.

TABLE 3.6-1

WHOLE BODY DOSE (MRem/Year)
FROM EXPECTED BRUNSWICK DISCHARGES
OF FISSION PRODUCTS*

Isotope	Annual Discharge (μCi)	C_w Annual Average Canal Discharge Concentration (μCi/mℓ)**	MPC Water Total Body MPC_w(μCi/mℓ)	Concentration Factor C_f	Dose = $\frac{50}{2200} X \frac{C_w C_f}{MPC_w} X 500 \frac{mRem}{Year}$
SR-92	$1.5 X 10^{3}$	$6.27 X 10^{-13}$	$7 X 10^{-3}$	$5 X 10^{-1}$	$5.1 X 10^{-10}$
Y-92	$7 X 10^{3}$	$2.93 X 10^{-12}$	$3 X 10^{1}$	$1 X 10^{2}$	$1.1 X 10^{-10}$
La-141	$1.2 X 10^{4}$	$5.02 X 10^{-12}$	$2 X 10^{0}$	$1 X 10^{2}$	$2.85 X 10^{-9}$
Tc-99m	$4.3 X 10^{4}$	$1.8 X 10^{-11}$	$8 X 10^{-2}$	$1 X 10^{1}$	$2.55 X 10^{-8}$
I-135	$5.5 X 10^{4}$	$2.3 X 10^{-11}$	$4 X 10^{-4}$	$1 X 10^{1}$	$6.50 X 10^{-6}$
Sr-91	$1.04 X 10^{5}$	$4.35 X 10^{-11}$	$2 X 10^{-3}$	$5 X 10^{-1}$	$1.24 X 10^{-8}$
Y-93	$1.14 X 10^{5}$	$4.76 X 10^{-11}$	$9 X 10^{1}$	$1 X 10^{2}$	$5.92 X 10^{-10}$
I-133	$2.38 X 10^{5}$	$9.95 X 10^{-11}$	$9 X 10^{-4}$	$1 X 10^{1}$	$1.25 X 10^{-5}$
Ce-143	$2.58 X 10^{5}$	$1.08 X 10^{-10}$	$5 X 10^{0}$	$1 X 10^{2}$	$2.45 X 10^{-8}$
Y-90	$2.89 X 10^{5}$	$1.21 X 10^{-10}$	$3 X 10^{0}$	$1 X 10^{2}$	$4.57 X 10^{-8}$
Mo-99	$3.12 X 10^{5}$	$1.31 X 10^{-10}$	$8 X 10^{-4}$	$1 X 10^{1}$	$1.86 X 10^{-5}$
Te-132	$2.28 X 10^{5}$	$9.54 X 10^{-11}$	$5 X 10^{-4}$	$1 X 10^{1}$	$2.16 X 10^{-5}$
I-131	$1.66 X 10^{5}$	$6.94 X 10^{-11}$	$1.33 X 10^{-5}$	$1 X 10^{1}$	$5.90 X 10^{-4}$
Nd-147	$1.22 X 10^{5}$	$5.10 X 10^{-11}$	$1 X 10^{0}$	$1 X 10^{2}$	$5.80 X 10^{-8}$
Ba-140	$3.56 X 10^{5}$	$1.49 X 10^{-10}$	$5 X 10^{-4}$	$1 X 10^{1}$	$3.38 X 10^{-5}$
Cs-136	$3.43 X 10^{5}$	$1.44 X 10^{-6}$	$6 X 10^{-5}$	$3 X 10^{1}$	$8.21 X 10^{-4}$
Pr-143	$3.32 X 10^{5}$	$1.39 X 10^{-10}$	$1 X 10^{0}$	$1 X 10^{2}$	$1.58 X 10^{-7}$
Eu-156	$7 X 10^{2}$	$2.92 X 10^{-13}$	$8 X 10^{-3}$	$1 X 10^{2}$	$4.15 X 10^{-8}$
Ce-141	$3.66 X 10^{5}$	$1.53 X 10^{-10}$	$1 X 10^{0}$	$1 X 10^{2}$	$1.74 X 10^{-7}$
Y-90	$2.89 X 10^{5}$	$1.21 X 10^{-10}$	$3 X 10^{0}$	$1 X 10^{2}$	$4.57 X 10^{-8}$
Mo-99	$3.12 X 10^{5}$	$1.31 X 10^{-10}$	$8 X 10^{-4}$	$1 X 10^{1}$	$1.86 X 10^{-5}$
Te-132	$2.28 X 10^{5}$	$9.54 X 10^{-11}$	$5 X 10^{-4}$	$1 X 10^{1}$	$2.16 X 10^{-5}$
I-131	$1.66 X 10^{5}$	$6.94 X 10^{-11}$	$1.33 X 10^{-5}$	$1 X 10^{1}$	$5.90 X 10^{-4}$
Nd-147	$1.22 X 10^{5}$	$5.10 X 10^{-11}$	$1 X 10^{0}$	$1 X 10^{2}$	$5.80 X 10^{-8}$
Te-129M	$2.02 X 10^{4}$	$8.45 X 10^{-12}$	$2 X 10^{-4}$	$1 X 10^{1}$	$4.81 X 10^{-6}$
Nb-95	$3.68 X 10^{5}$	$1.53 X 10^{-10}$	$4 X 10^{-1}$	$3 X 10^{4}$	$1.30 X 10^{-4}$
Ru-103	$1.79 X 10^{5}$	$7.50 X 10^{-11}$	$8 X 10^{-3}$	$1 X 10^{2}$	$1.06 X 10^{-5}$
Sr-89	$2.68 X 10^{5}$	$1.12 X 10^{-10}$	$7 X 10^{-5}$	$5 X 10^{-1}$	$9.13 X 10^{-6}$
Y-91	$3.33 X 10^{5}$	$1.39 X 10^{-10}$	$2 X 10^{-1}$	$1 X 10^{2}$	$7.85 X 10^{-7}$
Zr-95	$3.64 X 10^{5}$	$1.45 X 10^{-10}$	$1 X 10^{-1}$	$1 X 10^{2}$	$1.65 X 10^{-7}$
Ce-144	$1.81 X 10^{5}$	$7.55 X 10^{-11}$	$3 X 10^{-2}$	$1 X 10^{2}$	$2.89 X 10^{-6}$
Eu-155	$5 X 10^{2}$	$2.09 X 10^{-13}$	$1 X 10^{-1}$	$1 X 10^{2}$	$2.37 X 10^{-9}$
Sr-90	$8 X 10^{2}$	$3.35 X 10^{-13}$	$4 X 10^{-1}$	$5 X 10^{-1}$	$4.76 X 10^{-13}$
Cs-137	$7 X 10^{2}$	$2.93 X 10^{-13}$	$2 X 10^{-5}$	$3 X 10^{1}$	$5 X 10^{-6}$
TOTAL	$5 X 10^{6}$	$2 X 10^{-9}$			$2.41 X 10^{-3}$

* Based on the consumption of 50 grams of fish/day
** Based on a circulating water flow of $1.2 x 10^{6}$ gpm

TABLE 3.6-2

WHOLE BODY DOSE (mRem/Year)
FROM EXPECTED BRUNSWICK DISCHARGES
OF MAIN COOLANT ACTIVATION PRODUCTS*

Isotope	Annual Discharge (μCi)	C_w Average Annual Discharge Canal Concentration (μCi/mℓ)**	MPC Water Total Body MPC_w (μCi/mℓ)	Concentration Factor C_f	Dose (mRem/year) = $\left(\frac{50}{2200}\right) X \left(\frac{C_w X C_f}{MPC_w}\right) X \frac{500\ mRem}{Year}$
CO-58	$3.5 X 10^{6}$	$1.46 X 10^{-9}$	$4 X 10^{-4}$	$5 X 10^{2}$	$2.8 X 10^{-2}$
CO-60	$4 X 10^{4}$	$1.67 X 10^{-11}$	$1 X 10^{-4}$	$5 X 10^{2}$	$9.5 X 10^{-4}$
Fe-59	$1.7 X 10^{3}$	$7.11 X 10^{-13}$	$2 X 10^{-4}$	$3 X 10^{3}$	$1.21 X 10^{-4}$
P-32	$1.2 X 10^{5}$	$5.01 X 10^{-11}$	$9 X 10^{-5}$	$2.86 X 10^{4}$	$1.8 X 10^{-1}$
Cr-51	$7.7 X 10^{5}$	$3.21 X 10^{-10}$	$2 X 10^{-2}$	$4 X 10^{2}$	$7.3 X 10^{-5}$
Ag-110M	$5.8 X 10^{5}$	$2.42 X 10^{-10}$	$7 X 10^{-3}$	$3.33 X 10^{3}$	$1.3 X 10^{-3}$
Mn-54	$1.9 X 10^{4}$	$7.95 X 10^{-12}$	$8 X 10^{-4}$	$3 X 10^{2}$	$3.38 X 10^{-5}$
Zn-65	$1.0 X 10^{4}$	$4.18 X 10^{-12}$	$1 X 10^{-4}$	$2 X 10^{3}$	$2.85 X 10^{-3}$
TOTALS	$5 X 10^{6}$	$2 X 10^{-9}$			$2.13 X 10^{-1}$

* Based on the consumption of 50 grams of fish/day
** Based on a circulating water flow of $1.2 X 10^{6}$ gpm

TABLE 3.6-3

SUMMARY OF EXPECTED ANNUAL WHOLE BODY DOSES AND I-131 CONCENTRATIONS AT THE EXCLUSION DISTANCE* FOR EACH UNIT OF THE BRUNSWICK STEAM ELECTRIC PLANT

Source	Radioactive Gas Release** Whole Body Dose (mrem/yr)	I-131 Concentration (μCi/cc)
Air Ejector	5.0×10^{-4}	Negligible, removed by AOGS**
Gland Seal	8.6×10^{-2}	9.16×10^{-17}
Turbine Building	9.5×10^{-4}	8.70×10^{-17}
Containment Purge	4.2×10^{-4}	5.0×10^{-18}
Startup	4.7×10^{-4}	-
Total	8.78×10^{-2}	1.84×10^{-16}

* Exclusion distance is 3000 ft.

** Doses based on the expected average fuel failure rate corresponding to 25,000 μCi/sec of noble gases at 30-minutes decay to determine inputs to the air ejector augmented off-gas system (AOGS) and the gland seal off-gas. The AOGS is expected to reduce the noble gas activity by a factor of 1.0×10^3 and essentially remove all the halogens.

TABLE 3.6-4

RELEASE RATE OF FISSION AND ACTIVATION GASES FROM AIR EJECTOR WITH THE AUGMENTED OFF-GAS SYSTEM*

Isotope	Time=0 (μCi/sec)	Augmented Off-Gas Release (μCi/sec)
Noble Gases		
Xe 131m	3.868×10^{0}	3.8636×10^{-3}
Xe 133m	4.715×10^{1}	4.6862×10^{-2}
Xe 133	1.264×10^{3}	1.2609×10^{0}
Xe 135m	7.725×10^{3}	2.3091×10^{0}
Xe 135	4.493×10^{3}	4.3257×10^{0}
Xe 137	5.064×10^{4}	2.4580×10^{-2}
Xe 138	2.261×10^{4}	6.6100×10^{0}
Xe 139	9.639×10^{4}	0.0
Xe 140	1.214×10^{5}	0.0
Kr 83m	7.610×10^{2}	6.3450×10^{-1}
Kr 85m	1.571×10^{3}	1.4516×10^{0}
Kr 85	2.189×10^{0}	2.1895×10^{-3}
Kr 87	5.182×10^{3}	3.7452×10^{0}
Kr 88	4.866×10^{3}	4.2941×10^{0}
Kr 89	4.372×10^{4}	6.3540×10^{-2}
Kr 90	1.188×10^{5}	0.0
Kr 91	1.553×10^{5}	0.0
Total Noble Gases	6.35×10^{5} μCi/sec	2.5×10^{1} μCi/sec
Activation Gases		
N-17	6.0×10^{4}	0.0
N-16	2.0×10^{8}	0.0
O-19	1.0×10^{6}	0.0
N-13	2.0×10^{3}	2.49×10^{-2}
A-41	5.0×10^{0}	4.14×10^{-4}
A-37	1.0×10^{-4}	1.00×10^{-8}
H-3	6.0×10^{-1}	6.00×10^{-5}
Total Activation Gases	2.0×10^{8} μCi/sec	2.53×10^{-2} μCi/sec

* Based on a fuel failure corresponding to 25,000 μCi NG/sec release rate (30 minute decay).

TABLE 3.6-5

RELEASE RATE OF FISSION AND ACTIVATION GASES FROM GLAND-SEAL CONDENSER OFF-GAS*

Isotope	Activity at Time=0 (μCi/sec)	Activity after 1.80 min. (μCi/sec)
Noble Gases		
Xe 131m	3.868×10^{-3}	3.86×10^{-3}
Xe 133m	4.716×10^{-2}	4.71×10^{-2}
Xe 133	1.264×10^{0}	1.26×10^{0}
Xe 135m	7.725×10^{0}	7.15×10^{0}
Xe 135	4.493×10^{0}	4.48×10^{0}
Xe 137	5.064×10^{1}	3.71×10^{1}
Xe 138	2.261×10^{1}	2.10×10^{1}
Xe 139	9.640×10^{1}	1.55×10^{1}
Xe 140	1.215×10^{2}	1.13×10^{0}
Kr 83m	7.611×10^{-1}	7.50×10^{-1}
Kr 85m	1.572×10^{0}	1.56×10^{0}
Kr 85	2.190×10^{-3}	2.18×10^{-3}
Kr 87	5.182×10^{0}	5.10×10^{0}
Kr 88	4.866×10^{0}	4.83×10^{0}
Kr 89	4.372×10^{1}	2.95×10^{1}
Kr 90	1.189×10^{2}	1.21×10^{1}
Kr 91	1.553×10^{2}	7.40×10^{0}
Total Noble Gases	6.35×10^{2}	1.49×10^{2} μCi/sec
Activation Gases		
N-17	6.0×10^{1}	0.0
N-16	2.0×10^{5}	7.55×10^{0}
O-19	1.0×10^{3}	7.56×10^{1}
A-41	5.0×10^{-3}	0.0
A-37	1.0×10^{-7}	1.0×10^{-7}
N-13	2.0×10^{0}	1.76×10^{0}
H-3	6.0×10^{-4}	6.00×10^{-4}
Total Activation Gases	2.0×10^{5}	8.5×10^{1} μCi/sec
	Total Release Rate	234 μCi/sec

* Based on a fuel failure corresponding to 25,000 μCi NG/sec release rate (30 minute decay).

TABLE 3.6-6

RELEASE RATE OF FISSION AND ACTIVATION GASES FROM
GLAND SEAL CONDENSER AND AIR EJECTOR WITH AUGMENTED SYSTEM*

Noble Gases

Isotope	Release rate (μCi/sec)
Xe 131m	7.723×10^{-3}
Xe 133m	9.396×10^{-2}
Xe 133	2.520×10^{0}
Xe 135m	9.459×10^{0}
Xe 135	8.805×10^{0}
Xe 137	3.712×10^{1}
Xe 138	2.761×10^{1}
Xe 139	1.550×10^{1}
Xe 140	1.130×10^{0}
Kr 83m	1.384×10^{0}
Kr 85m	3.011×10^{0}
Kr 85	4.369×10^{0}
Kr 87	8.845×10^{0}
Kr 88	9.124×10^{0}
Kr 89	2.956×10^{1}
Kr 90	1.210×10^{1}
Kr 91	7.400×10^{0}
Total	1.74×10^{2} μCi/sec

Activation Gases

Isotope	
N-13	1.76×10^{0}
N-16	7.55×10^{0}
O-19	7.56×10^{1}
Total	8.50×10^{1}

Total Release Rate 259 μCi/sec

* Based on a fuel failure corresponding to 25,000 μCi NG/sec rate at (30 minute decay) and AOG system decontamination factor of 10^3.

TABLE 3.6-7

PARENT - DAUGHTER ISOTOPIC RELATIONSHIPS AND CHARACTERISTICS USED IN CALCULATING CONTAINMENT ACTIVITY ACCUMULATION

Parent	$\lambda (hr^{-1})$	Daughter	$\lambda (hr^{-1})$
I-131	3.6×10^{-3}	1% - Xe 131m	2.4×10^{-3}
I-132	2.88×10^{-1}	-	-
I-133	3.3×10^{-2}	2.4% Xe 133m 97.6% Xe 133	1.62×10^{-2} 5.50×10^{-3}
I-134	8.0×10^{-1}	-	-
I-135	1.04×10^{-1}	30% Xe 135m 70% Xe 135	2.66×10^{0} 7.60×10^{-2}
I-136	2.9×10^{1}	-	-
I-137	1.14×10^{2}	94% Xe 137	1.07×10^{1}
I-138	4.2×10^{3}	100% Xe 138	2.45×10^{0}
Br-83	3.0×10^{-1}	100% Kr 83m	3.65×10^{-1}
Br-84	1.30×10^{0}	-	-
Br-85	1.40×10^{1}	80% Kr 85m 20% Kr 85	1.6×10^{0} 7.7×10^{-6}
Br-86	4.50×10^{1}	-	-
Br 87	1.60×10^{1}	100% Kr 87	5.3×10^{-1}

TABLE 3.6-8

ISOTOPIC CONCENTRATIONS BEFORE AND AFTER CONTAINMENT PURGING AND ACTIVITY RELEASED DURING PURGE PERIOD*

Isotope	Containment Concentration at Start of Purge (μC/cc)	Containment Concentration After Purge (μCi/cc)	Total Activity Released Per Purge (Ci)
I-131	4.34×10^{-6}	4.50×10^{-9}	2.18×10^{-2}
I-132	2.91×10^{-7}	1.09×10^{-10}	1.28×10^{-3}
I-133	2.78×10^{-6}	2.60×10^{-9}	1.38×10^{-2}
I-134	1.55×10^{-7}	1.04×10^{-11}	5.60×10^{-4}
I-135	1.15×10^{-6}	8.40×10^{-10}	5.50×10^{-3}
I-136	3.49×10^{-10}	0.0	1.23×10^{-7}
Br 83	3.36×10^{-8}	1.26×10^{-11}	1.48×10^{-4}
Br 84	9.5×10^{-9}	1.15×10^{-13}	2.92×10^{-5}
Br 87	4.18×10^{-11}	0.0	0.0
Xe 131m	6.50×10^{-8}	6.70×10^{-11}	3.28×10^{-4}
Xe 133m	1.75×10^{-7}	1.29×10^{-10}	8.8×10^{-4}
Xe 133	1.63×10^{-5}	1.69×10^{-8}	8.2×10^{-2}
Xe 135m	1.35×10^{-8}	0.0	8.20×10^{-6}
Xe 135	1.10×10^{-6}	8.90×10^{-10}	5.35×10^{-3}
Xe 137	6.85×10^{-10}	0.0	0.0
Xe 138	1.15×10^{-9}	0.0	1.79×10^{-6}
Kr 83m	2.77×10^{-8}	0.0	6.40×10^{-5}
Kr 85m	2.98×10^{-8}	1.30×10^{-13}	0.0
Kr 85	7.45×10^{-8}	7.80×10^{-12}	7.45×10^{-3}
Kr 87	1.21×10^{-8}	2.06×10^{-12}	4.86×10^{-5}

Total Activity Released 1.39×10^{-1} Curies/purge

* Based on primary system leakage to containment of 123 gph and fuel failure rate corresponding to 25,000 μCi/sec at 30-min. decay.

3.7 Construction Effects

The major environmental impacts from construction of the Brunswick Plant are associated with clearing operations, dewatering of the plant excavation, and construction of the circulating water system canals. These impacts for the most part have taken place and continued construction will not significantly alter the impact. Scheduled completion of the plant will mitigate the construction effects at the earliest possible date.

The change in some wildlife habitat, as a result of clearing operations, was an unavoidable impact in the construction of the Brunswick Plant. Efforts, however, have been made to minimize the impact. Except where necessary for construction and physical erection of the various structures, the woodlands have been preserved. Construction and spoil areas have been diked to control erosion and siltation into water courses. Many of those areas which have been cleared for construction, including areas for borrowing and spoiling materials, will be reseeded to control erosion, and this, in turn, will provide new cover for wildlife.

Dewatering required for excavations in the plant area has lowered ground water levels in the immediate vicinity of the plant. A limited number of shallow domestic wells have been influenced by the dewatering. However, CP&L, through a combination of pump replacements and redrilling or deepening of the wells, has provided those affected homeowners with a dependable and acceptable water supply. Dewatering and the resulting ground water conditions have been monitored and reported to the Department of Water and Air Resources on a periodic basis. Except for the temporary depression in ground water levels, the dewatering has in no way jeopardized local ground water supplies. As soon as the below grade work in the plant area is complete, the dewatering operation will be discontinued. Already, pumping rates are being reduced and it is estimated that complete shutdown of dewatering system will take place around June 1972 if construction continues as scheduled.

In constructing the canal system material required to be removed will be either excavated or dredged. Structural grade material will be used for maintenance roads, dikes, and backfill along various weirs, head wall and pumping bays. Spoil materials are being deposited on high land adjacent to the canal or on other Company-owned land. These materials are being placed in a way that will preserve natural creeks and marshes.

Dredged materials for the discharge pipe trench in the ocean will be placed around and over the discharge pipes except for the excess which will be deposited either on Company-owned land or on the beach as requested by local authorities to rebuild areas marred by tidal and hurricane induced erosion.

Turbidity as a result of dredging is being controlled by the use of dikes and temporary weirs which are decanting the water from the disposal are . only after most of the solid material has settled. CP&L is monitoring effluent water quality from the spoil areas to assure compliance with state requirements.

Construction of the railroad trestle across Nancy's Creek to provide rail access to the plant has been completed, and in cooperation with the N. C. Department of

Conservation and Development steps have been taken to restore the small amount of marshland which was disturbed during trestle construction.

Plant make-up water will be obtained from deep wells for which a permit has been issued by the N. C. Department of Water and Air Resources. The first of the two approved wells is complete and is supplying water for construction. The amount of water from this and the second production well, which will be drilled at some later date, is a small fraction of the aquifer capacity and will have no significant effect on other wells in the Southport area.

Provisions have also been made to minimize other possible environmental impacts of construction such as result from dust and disposal of sanitary wastes. Temporary construction roads are being watered as necessary to control dust along these roads and chemical toilets have been provided throughout the construction site. In addition, an aerobic treating system having the capability to process approximately 4,000 gallons of sewage per day has been installed at the site to handle the sanitary wastes from the construction office. The effluent from the aerobic treating system is collected, chlorinated and released to the environment by way of a small tributary to the Cape Fear River. This treatment facility provides the equivalent of secondary treatment and is covered by Permit No. 1741 issued by the N. C. Board of Water and Air Resources.

3.8 Transmission Lines

The power generated at the Brunswick Nuclear Plant will be transmitted over 8 new transmission lines extending to the existing transmission grid.

Appropriate considerations of the recommendations in "Environmental Criteria for Electric Transmission Systems" published by the Departments of Interior and Agriculture were used in the design and locations of the proposed lines.

3.8.1 Description of Transmission Lines

The transmission system in 1975, including the lines necessary for the operation of the Brunswick Plant, is shown in Figure 3.8-1.

The lines to be constructed with the Brunswick Plant are as follows:

Brunswick-Fayetteville 230 KV - 103 miles

Brunswick-Weatherspoon 230 KV - 31 miles (connects to existing line near Delco)

Brunswick-Delco East 230 KV - 31 miles

Brunswick-Delco West 230 KV - 31 miles

Brunswick-Wallace 230 KV - 54 miles

Brunswick-Jacksonville 230 KV - 76 miles

Brunswick-Barnards Creek East 230 KV - 16 miles

Brunswick-Barnards Creek West 230 KV - 16 miles

The location of the transmission lines extending from the Brunswick Plant are shown superimposed on a portion of a N.C. State Highway Road Map in Figure 3.8-2.

Each of the transmission lines is for 230 KV operation, consisting of wood two pole H-Frame structures, except for the structures crossing the Cape Fear River. The wood structures are shown on Figure 3.8-3. The basic structure will be two 75 foot wood poles extending 65-1/2 feet out of the ground. Span lengths will average 650 feet. Except as noted, the conductor will be one 1,272,000 45/7 ACSR (diameter = 1.345 inches) per phase and 2 - 7 #10 alumweld overhead ground wires (diameter = 0.306 inches). Conductor size on the Brunswick-Barnards Creek East and West 230 KV lines will be 2,515,000 76/19 ACSR (diameter = 1.88 inches).

The Brunswick-Barnards Creek East and West 230 KV lines will cross the Cape Fear River south of Wilmington, N. C. to the Barnards Creek Substation on the east side of the river. The river crossing structures will be two self-supporting double circuit galvanized steel lattice type towers. These two towers will be installed on each side of the river channel. Two guyed steel terminal towers will be installed on each bank of the river - one for each circuit. The river crossing will comply with all applicable regulations. An analysis of the different alternate towers for the crossing is contained in subsection 9.7.

To minimize the environmental impact, a section of the line extending to Jacksonville from the Brunswick Plant will be constructed on the right-of-way of an existing 115 KV transmission line. Of the total distance of 76 miles, 35 miles will be constructed on the existing right-of-way. In this section of line the existing 115 KV H-Frame structures and conductor will be removed and replaced with the new 230 KV structures and conductor.

The Brunswick-Weatherspoon 230 KV line will be constructed by extending the Weatherspoon-Delco 230 KV line from a point near Delco to the Brunswick Plant.

Of the total distance of 78 miles, 31 miles will be the new section between Delco and Brunswick and 47 miles will be the existing line between Delco and Weatherspoon.

The regulatory agencies involved in the review of the transmission lines are:

I. U.S. Army Corps of Engineers - Issues permits for crossings of navigable waters.

II. Federal Aviation Administration - Issues permits to obstruct navigable airspace.

III. North Carolina Highway Commission - Issues permits to cross highways.

IV. State of North Carolina - Issues right-of-way easements over state-owned lands.

3.8.2 Environmental Impact of Transmission Lines

The construction and operation of the lines are designed to have a minimum effect on the environment.

Appropriate considerations of the recommendations in "Environmental Criteria for Electric Transmission Systems" published by the Departments of Interior and Agriculture were used in the design and locations of the proposed lines.

The lines will cause no change in population patterns and a minimum change in land use in future years. No residences will be removed or affected. The only lands committed to the lines are the areas they will traverse. Ownership of the land is retained by the property owners who will be able to continue to use it for agricultural, recreational or other purposes not inconsistent with the operation of the lines.

The Company will continue to cooperate with state and local agencies, property owners and other individuals in creating recreational and wildlife opportunities along portions of the right-of-way. The Company will also continue to prepare the land, in cooperation with the property owners, for other uses such as pasture land and agricultural uses.

The right-of-way affords excellent potential for game food plots and game cover, recreation areas, parks, golf courses, orchards, picnic areas, parking areas, Christmas tree and other types of nurseries, wildlife sanctuaries, refuges and management areas, and either private or public access roads.

Forest fires are a constant threat and can cause extensive damage to the forests and wildlife. Where the right-of-way crosses wooded areas, it provides an excellent fire break to help limit and confine forest fires to the immediate area. The right-of-way also provides a ready means of access for fire fighting equipment.

To reduce the visual impact of the lines, H-Frame structures using wood poles of minimum height will be employed. The poles will blend in with the extensive forested area and, because of their low height, will not be generally visible from a distance above the tree tops.

At locations where the lines cross areas of public access, such as roads, rivers, and streams, the existing growth in the right-of-way will be left in its natural state to provide a screen for the structures. Here clearing will be limited to material which poses a hazard to the line. Where necessary to remove large trees and other growth, special clearing techniques will be used to reduce any possible damage to the remaining growth. Native types of plants, low growing trees, etc. will be planted in areas where needed for effective screening. The wood pole structures will be placed behind the screening to blend with the trees, and this, together with their low profile, will provide a very effective means of reducing the visibility of the structures. Access to the right-of-way behind the screening will be obtained by providing an access road at an angle to the screening. It is the intent of the Company to preserve and enhance the natural growth in these areas.

The wood pole structures will be transported to each site and constructed with a minimum disturbance to the environment. Their foundations, two per structure, require an absolute minimum of excavation, since the pole butt will be buried directly in the ground. Excess soil removed from the pole hole will be evenly distributed over the surrounding area. Pole holes will be 36 inches in diameter and 9½ feet deep. Each tangent structure only occupies an area of approximately 4½ square feet after erection.

Normal operation and maintenance of the lines will require only infrequent traversing of the right-of-way. Airplane patrol of the lines will be conducted on a regular basis. Maintenance personnel will be directed to the precise area requiring attention as a result of the airplane patrol. Once a year 2 or 3 men will travel the entire length of the lines in a suitable vehicle closely inspecting the condition of structures and right-of-way. This infrequent traveling of the right-of-way will have a minimum effect on the land and growth. Right-of-way maintenance will be scheduled on a 4-to-5 year cycle to control vegetation growth. Areas such as major road and stream crossings will be maintained and improved so as to preserve the effects obtained by special clearing. The screening at these crossings will improve each year as selective pruning will enhance the growth and thickness of the vegetation. Right-of-way maintenance will also take into account any uses of the land for recreation and wildlife purposes.

The lines will not cross any designated historical sites, recreation areas, or wildlife management areas, with the following minor exceptions:

The Brunswick-Jacksonville 230 kV line will be constructed through the Holly Shelter Wildlife Management Area by rebuilding the existing 115 kV line for 230 kV operation as previously described. The use of the 115 kV line right-of-way avoids the construction of an additional line through the area. See Figure 3.8-4 for location in the line in this area.

The Brunswick-Barnards Creek East and West 230 kV lines, the Brunswick-Wallace, and the Brunswick-Jacksonville 230 kV lines will cross the extreme westernmost edge of the Orton Plantation Waterfowl Impoundment Area in a wooded area along the western boundary as shown in Figure 3.8-5 for a distance of only 0.1 mile.

3.8.3 Environmental Effects Which Cannot Be Avoided

The visibility of the lines in some areas, and the curtailed use of the land for timber production in the right-of-way, are the only environmental effects which cannot be avoided in the construction and operation of the transmission lines.

The visibility will be reduced to a minimum through the use of low structures which do not generally project above the tree tops of mature timber, and through selective clearing at points of high visibility such as road and river crossings.

The curtailed timber production capacity of those lands in the cleared portion of the right-of-ways will be replaced by areas that will provide food and better habitat for many species of wildlife.

The environmental effects associated with the construction of the transmission lines are temporary in nature. Should it become necessary to remove the transmission lines, the right-of-ways could be restored to their natural state in time and materials of construction such as poles, wire and associated hardware could be reused.

3.9 Aesthetics

3.9.1 Appearance

The Brunswick Plant will have a pleasing landscaped appearance, as shown in Figure 1.2-4, that will enhance all aesthetic attributes of the site. The overall picture of the plant will present an impressive grouping of structures that blend in rather than stand out on the site.

During construction the site area has a typical construction appearance which cannot be avoided. However, when completed, the plant will present an attractive appearance.

3.9.2 Noise

The Brunswick Plant will be quiet, both because of the intrinsic nature of a nuclear plant, and because the design for this plant includes provisions which minimize plant noise, e.g., the turbine-generators are surrounded by heavy concrete shielding walls and the entire complex is further housed in a fully enclosed building.

Since most of the BSEP facilities are housed within the plant structures, the plant communications systems will be primarily within the structures and therefore the usual communications system sounds will be reduced substantially.

3.10 Transportation

The generation of electrical energy in a nuclear power plant requires the periodic shipment of new fuel assemblies to the plant, spent fuel assemblies to a fuel reprocessing facility, and packaged low level radioactive materials to licensed waste burial grounds. The shipments are made in compliance with federal and state requirements pertaining to the proper packaging and transportation of the materials.

New fuel (UO_2 pellets clad in Zircaloy) for the Brunswick Plant will be shipped by truck from the fabricator's plant in packages designed to protect them from physical damage due to the normal handling and vibration of transportation and in accordance with U. S. Department of Transportation (DOT) regulations for the transportation of fissile materials. Each package will be a right rectangular box consisting of a wooden outer container and metal inner container separated by cushioning material. The inner metal container has an outer shell and a perforated inner basket. Because new fuel contains no fission products or radioactive gases, an accident involving new fuel shipment in which the package and fuel assemblies are damaged would result in no release of radioactivity and would, therefore, have no environmental effect. The only effect would be an economic loss for replacement of the damaged fuel assemblies.

Inherent in the generation of power with a nuclear reactor is the fact that fissionable isotopes in the nuclear fuel are depleted to the extent that they need to be replaced with new fuel. However, the spent fuel still contains residual fissionable uranium and plutonium. This recovery operation can most safely and economically be carried out at a separate fuel reprocessing facility serving many individual reactors. The spent fuel must, therefore, be transported to a recovery facility where the valuable uranium and plutonium can be recovered and residual wastes packaged for safe disposal.

Each BSEP unit will discharge approximately 140 spent fuel assemblies each year. The spent fuel will be stored in the plant fuel storage pools for at least three months prior to shipment, during which time many of the isotopes present at the time of removal from the reactor will decay. After storage, the spent fuel will be packaged in containers designed and constructed to meet rigorous requirements of the USAEC and U. S. Department of Transportation. These requirements provide for protection of the public in case of abnormal and accident conditions as well as normal conditions of transport. The normal shipping conditions require that the package be able to withstand temperatures ranging from -40°F to 130°F and to withstand the normal vibrations, shocks, and wetting that would be incident to normal transport. The accident conditions for which the package must be designed include, in sequence, a 30-foot free fall onto a completely unyielding surface, a 40-inch drop onto a 6-inch diameter pin, 30 minutes in a 1475°F fire, followed by 8 hours immersion in 3 feet of water. The permissible radiation levels and releases under these shipping conditions are given in Table 3.10-1. The radiation levels shown in Table 3.10-1 represent limits established by AEC regulations. The containers will exhibit radiation levels and releases under accident conditions less than those permitted by the regulations.

Prior to their use, container designs and the transport system will be reviewed and approved by USAEC and USDOT, and transportation will be authorized by a license issued by the USAEC. License provisions will include adequate quality assurance and testing programs to assure the equipment is constructed and used in accordance with approved designs and procedures. When loaded, containers will be decontaminated and carefully surveyed and inspected to assure that they have been properly prepared for shipment and are in full compliance with license provisions governing transportation. Shipments will also be labeled in accordance with federal regulations.

CP&L has a long-term contract under which Allied-Gulf Company will reprocess the BSEP spent fuel. Spent fuel will be transported by both rail and exclusive-use truck. By rail 20 to 24 fuel assemblies can be handled in one shipment; by truck, capacity is limited to one fuel assembly per shipment. Since rail service is available at the Brunswick Plant, most spent fuel will be shipped by rail. Truck shipment will be used only for odd numbers of assemblies left over from full rail shipments.

Based on this plan, approximately 6 rail shipments and approximately 2 truck shipments per unit will be made each year. Destination for these shipments will be Allied-Gulf Nuclear Services in Barnwell, South Carolina. Rail routing will be via Leland, N. C., Florence, S. C. and Orangeburg, S. C., a distance of 234 miles, which will require approximately 48 hours, via direct movement over the Seaboard Coastline Railroad. Truck routing will be via highways NC 211, US 17, SC 90, US 378, I 95, US 301, SC 70, and SC 64, a distance of 227 miles, which will require 7½ hours.

The total yearly spent fuel shipping program will be carried out in approximately one month. In all cases, truck shipments will be routed to avoid heavily populated and congested areas as well as tunnels, bridges or toll roads which prohibit such shipments. Progress of truck shipments will be frequently reported to the reprocessor while enroute and each truck will have two specially trained drivers. Instruments for detection of abnormal conditions and instructions for immediate action will accompany all truck shipments and will be available at rail connection and interchange points. Progress of rail shipments will be monitored and reported at all connections and interchange points.

A formal Accident Control and Recovery Plan will be developed, prior to the first shipment, which will provide for rapid and orderly utilization of utility, carrier, Allied-Gulf, USAEC, State and local Radiological Assistance Personnel as required in event any abnormal condition or accident is encountered. The plan will include salvage and recovery as well as control of bodily injury and property damage.

It is believed that there will be no significant adverse environmental effects associated with the transportation of spent fuel from the Brunswick Plant. This conclusion is based on the following:

(1) The volume of rail and truck traffic added in the region of interest is an insignificant part of existing traffic.

(2) The packaging and vehicle will be designed to withstand both normal and accident conditions without release of radioactive spent fuel or harmful radiation exposure to the public.

(3) The hazards associated with possible accidents are largely those associated with conventional heavy object shipments, not radiological hazards.

(4) The probability of accidents is lower than comparable heavy object shipments because of the additional equipment design and operational safety requirements brought about by thorough driver screening and training.

Shipment of solid waste containers of low level radioactive material between the plant and a disposal location will be done periodically. Regulations pertaining to such packaging and shipments prescribed by the AEC and U. S. Department of Transportation will be met. Approximatley 1000 drums of solid waste will be shipped from the plant each year. Each shipment will consist of from 15-100 drums.

The only exposure to people from routine shipments is for the brief period such a shipment is in direct view. A person standing along the roadway while a solid waste shipment passes would receive an insignificant direct dose.

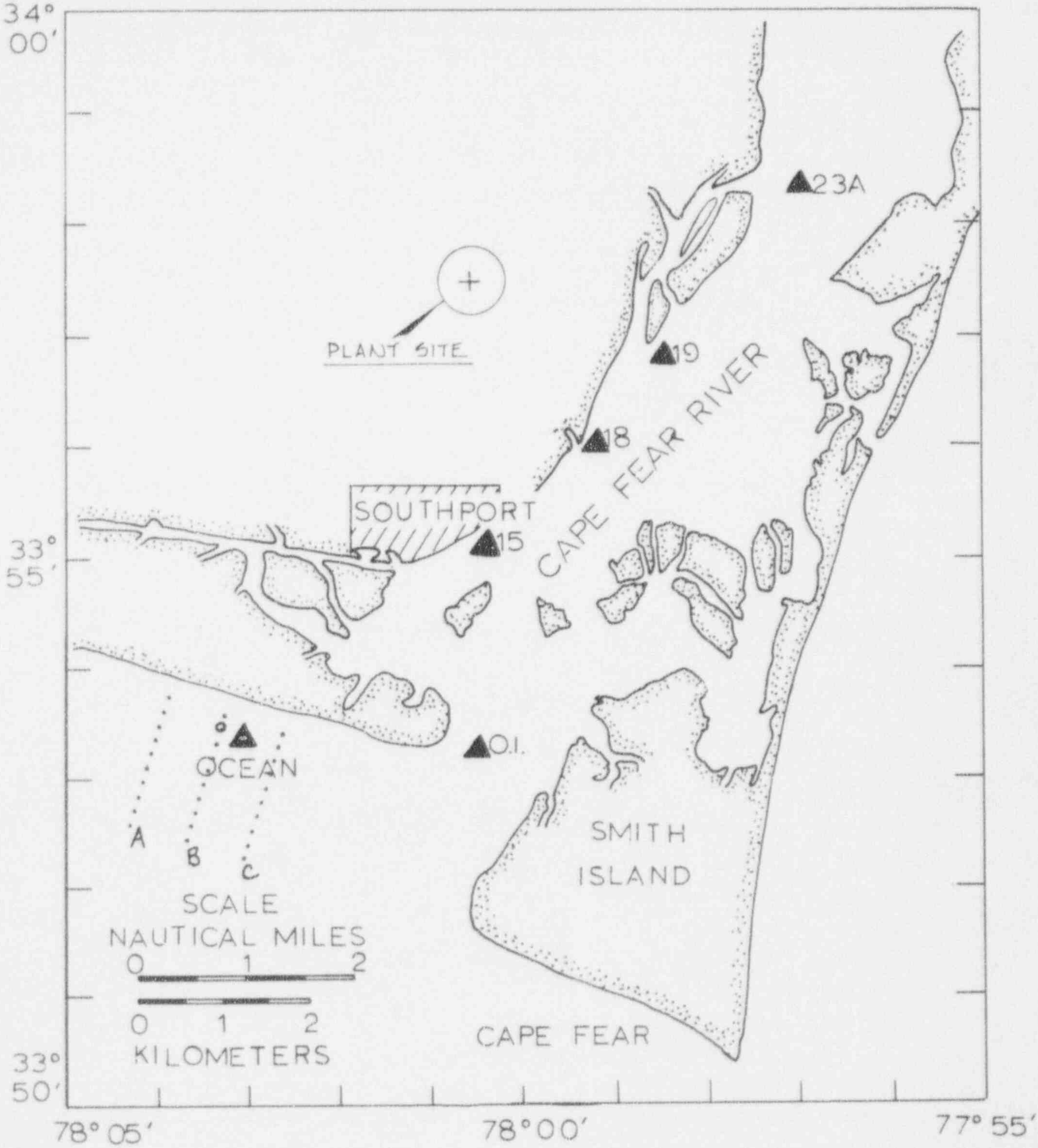
The radiation exposure to the public in transporting new fuel, spent fuel, and low level radioactive wastes from the plant, will result in no significant environmental effect and constitute no hazard to the general public.

The principal normal environmental effect from these shipments would be the direct radiation dose from the shipments as they move from the plant to the reprocessing plant. In this regard, it has been assumed that the shipments were made at the maximum permitted level of 10 mrem per hour at six feet from the nearest accessible surface. Based on this, and with the nearest person assumed to be 100 feet from the centerline of the tracks (because of railroad right of way) it is estimated that the dose rate at that point would be 0.2 mrem per hour. This would fall off to 0.01 mrem per hour at approximately 300 feet, beyond which the exposure received by the population is considered to be negligible.

TABLE 3.10-1

CONTAINER DESIGN REQUIREMENTS

	Normal Conditions	Accident Conditions
External Radiation Levels		
Surface	200 MR/hr	
3 Ft. from surface		1000 MR/hr
6 Ft. from surface	10 MR/hr	
Permitted Releases		
Noble Gases	None	1000 Ci
Contaminated Coolant	None	.01 Ci alpha, 0.5 Ci mixed fission products 10 Ci Iodine
Other	None	None
Contamination Levels		
Beta and Gamma	2200 dpm/100 cm^2	
Alpha	220 dpm/100 cm^2	



1. One-year survey was conducted from March 1969 through February 1970.
2. Stations are indicated by "▲" symbol.
3. The ocean station contains thirty (30) sampling points (denoted by three lines of ten dots each, labeled A, B and C).

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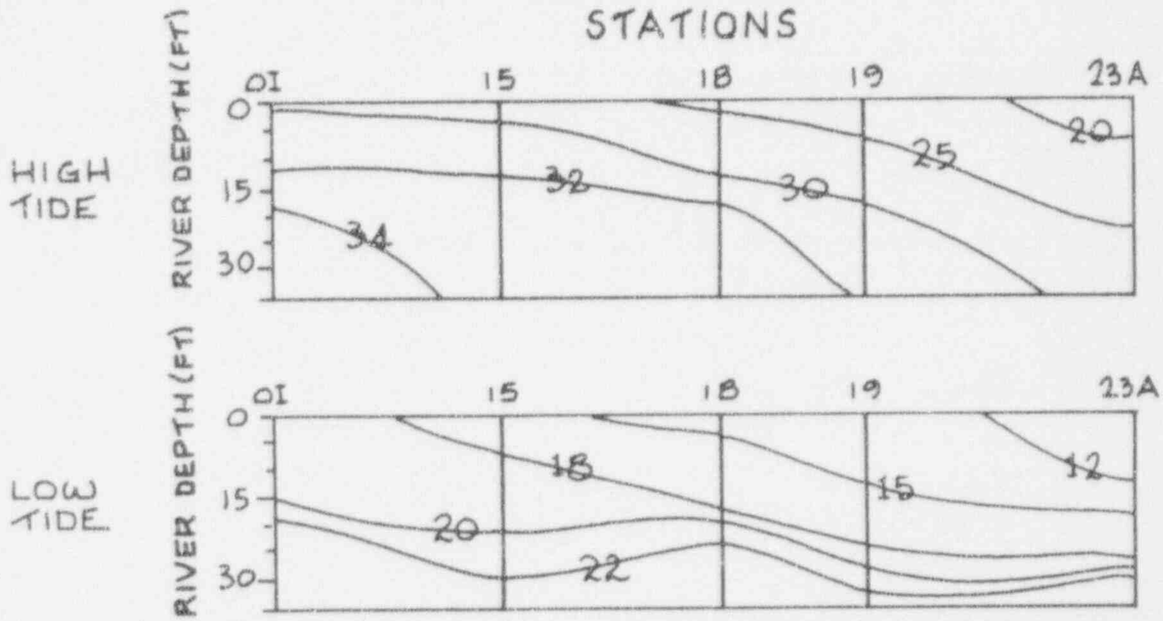
LOCATIONS OF ECOLOGICAL SURVEY SAMPLING STATIONS

FIG. NO. 3.3-1



1. Isohalines are specified in parts per thousand (PPT).

2. Isohalines extend along a transect from Oak Island (OI) to Station 23A, which is about six (6) miles upstream.

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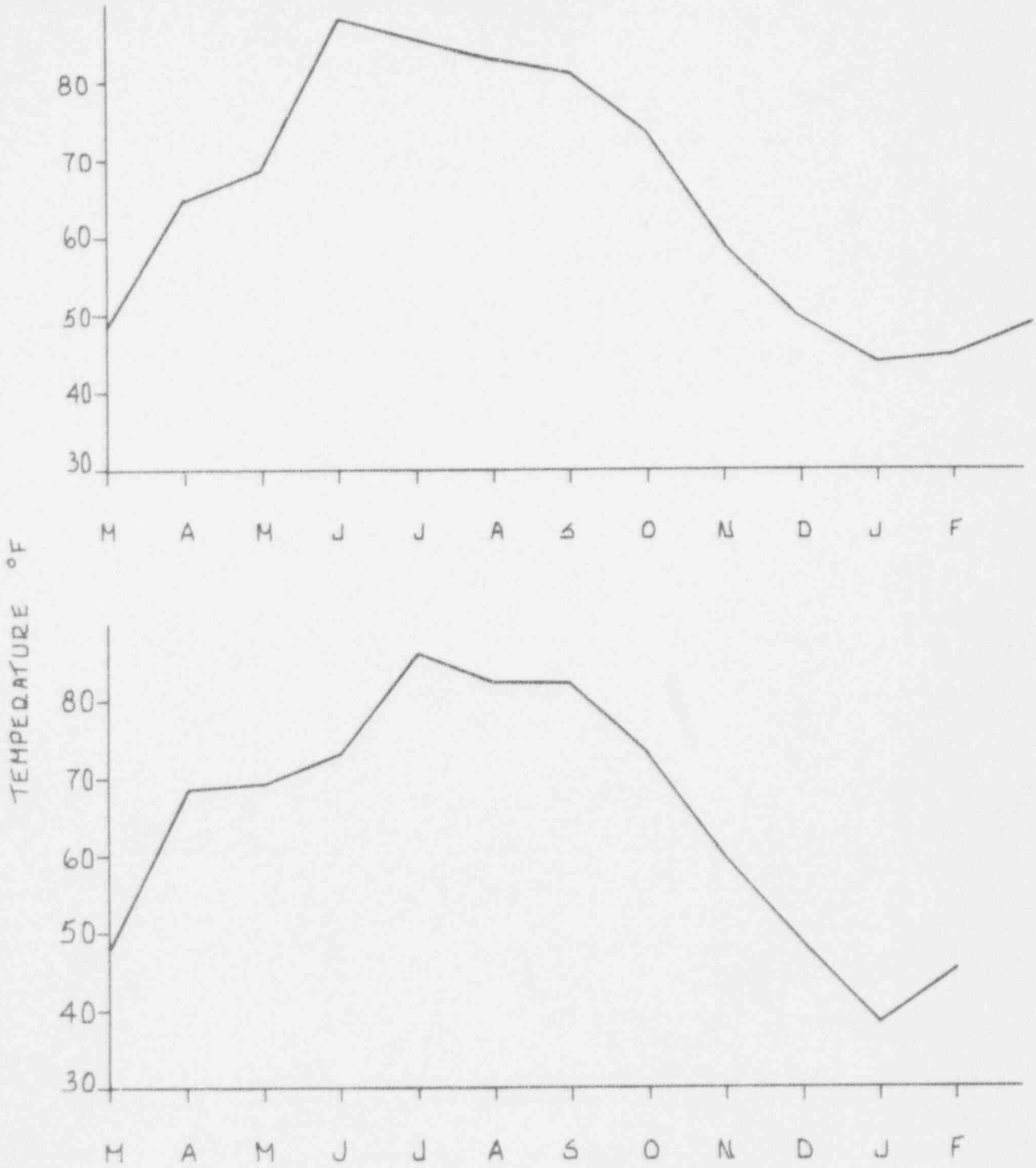
TYPICAL HIGH–TIDE AND LOW–TIDE ISOHALINES
FIG. NO. 3.3–2



NOTE:

Temperatures measured at monthly intervals from March 1969 through February 1970.

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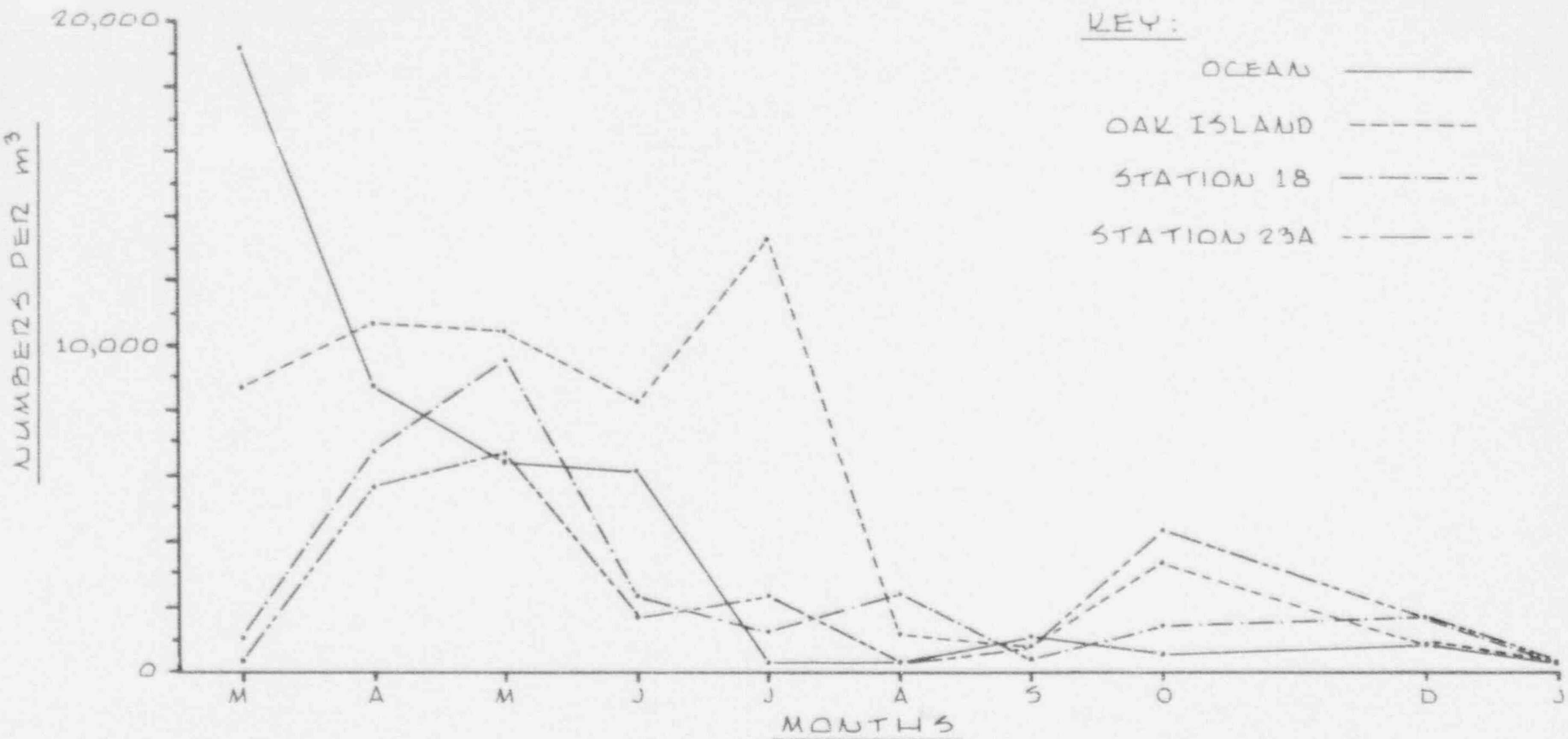
SURFACE WATER TEMPERATURES
STATION 23A AND OCEAN

FIG. NO. 3.3-3



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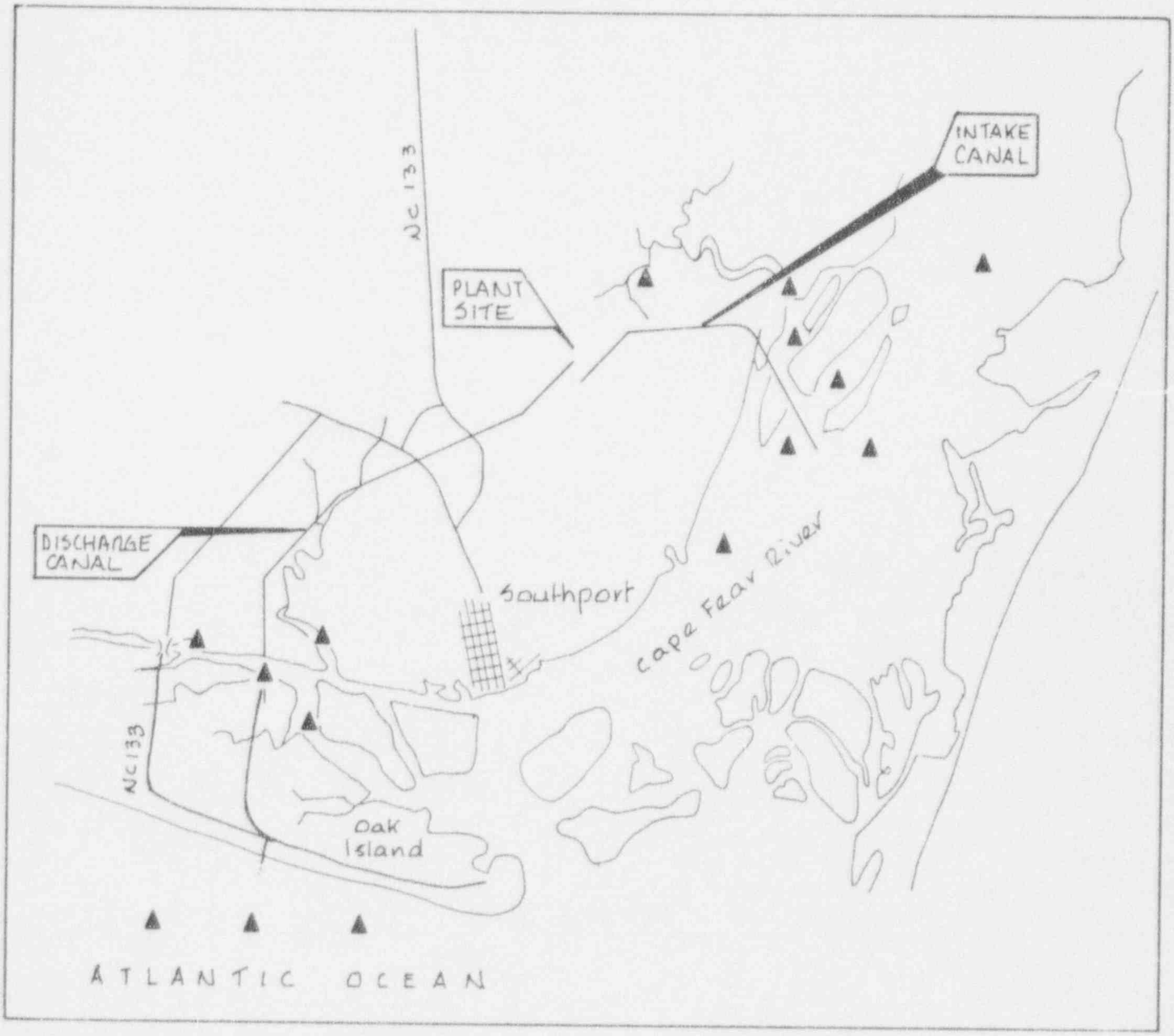
MONTHLY DISTRIBUTION OF ZOOPLANKTON
IN THE CAPE FEAR RIVER
AND NEARBY OCEAN

FIG. NO. 3.3-4



Stations to be sampled during the additional five (5) years of ecological study, that began in 1970, are denoted by "▲" symbol.

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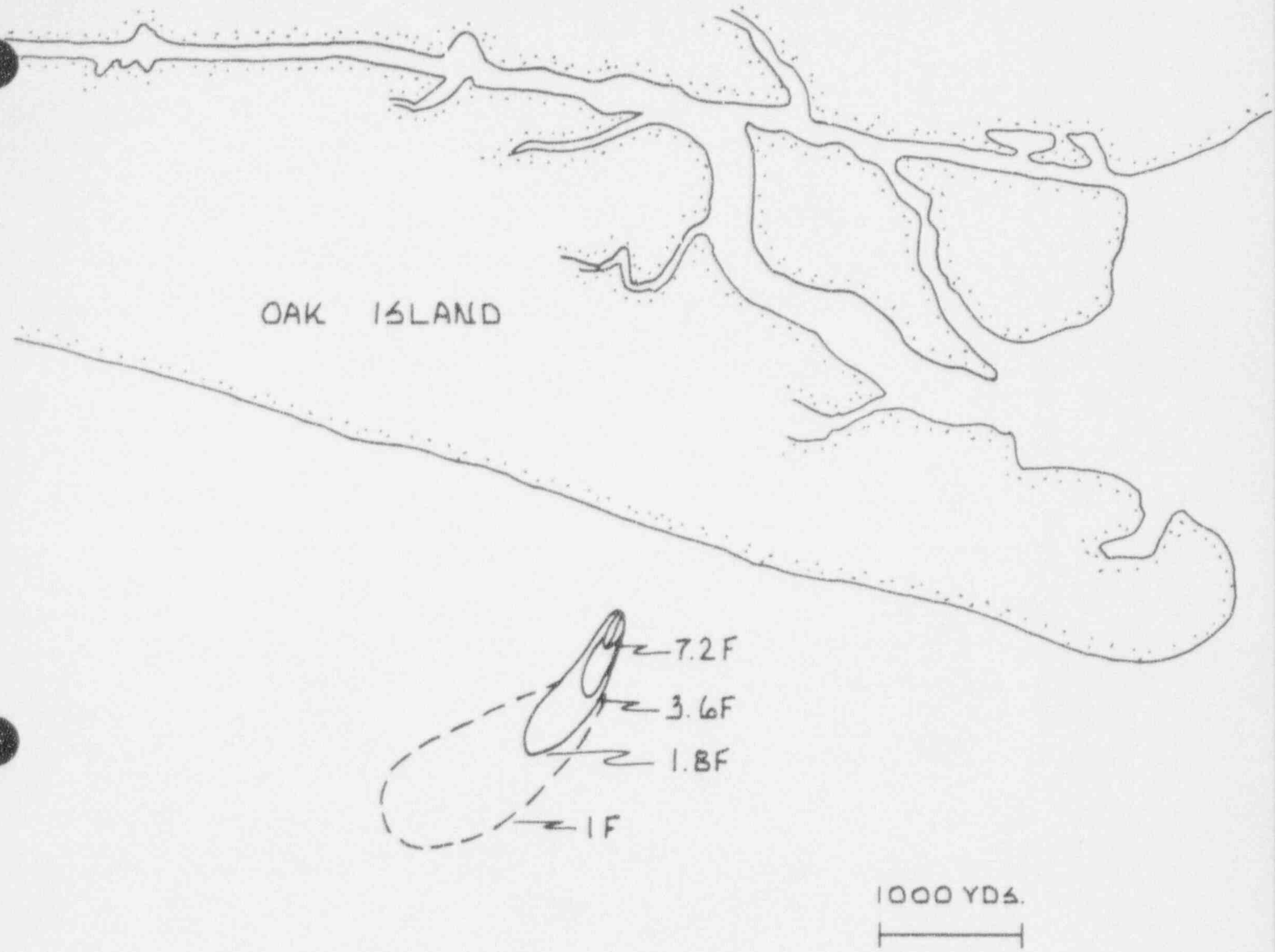
LOCATIONS OF PLANT SITE AND CIRCULATING WATER CANAL ROUTES	
FIG. NO.	3.3–5



NOTES:

1. Surface temperature increases are with respect to ambient.

2. Isotherms (of temperature increase) are identified by their temperature increases (degrees F).

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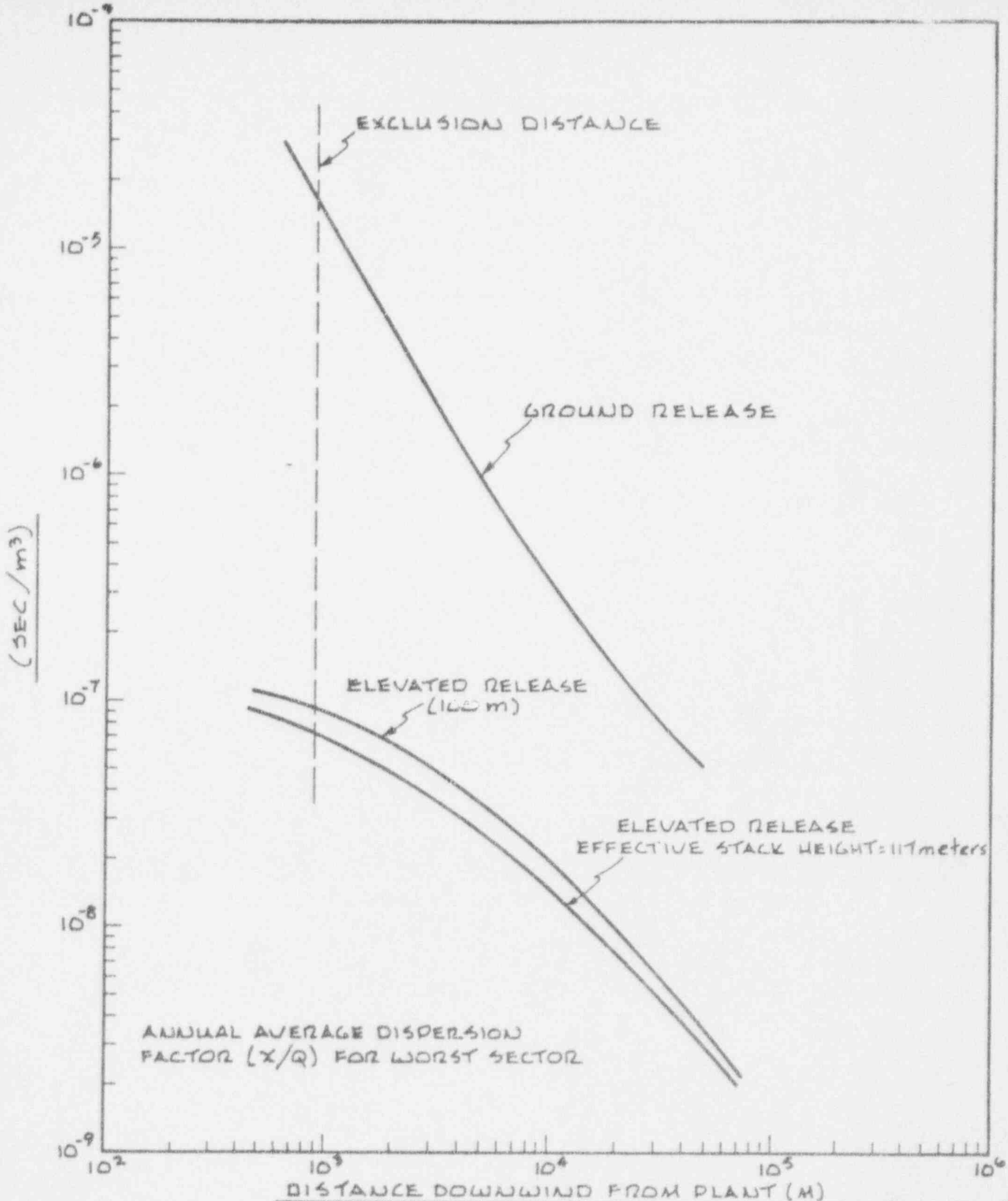
ESTIMATED SURFACE TEMPERATURE INCREASE DUE TO BSEP OCEAN OUTFALL

FIG. NO. 3.4–1



Amendment No. 5

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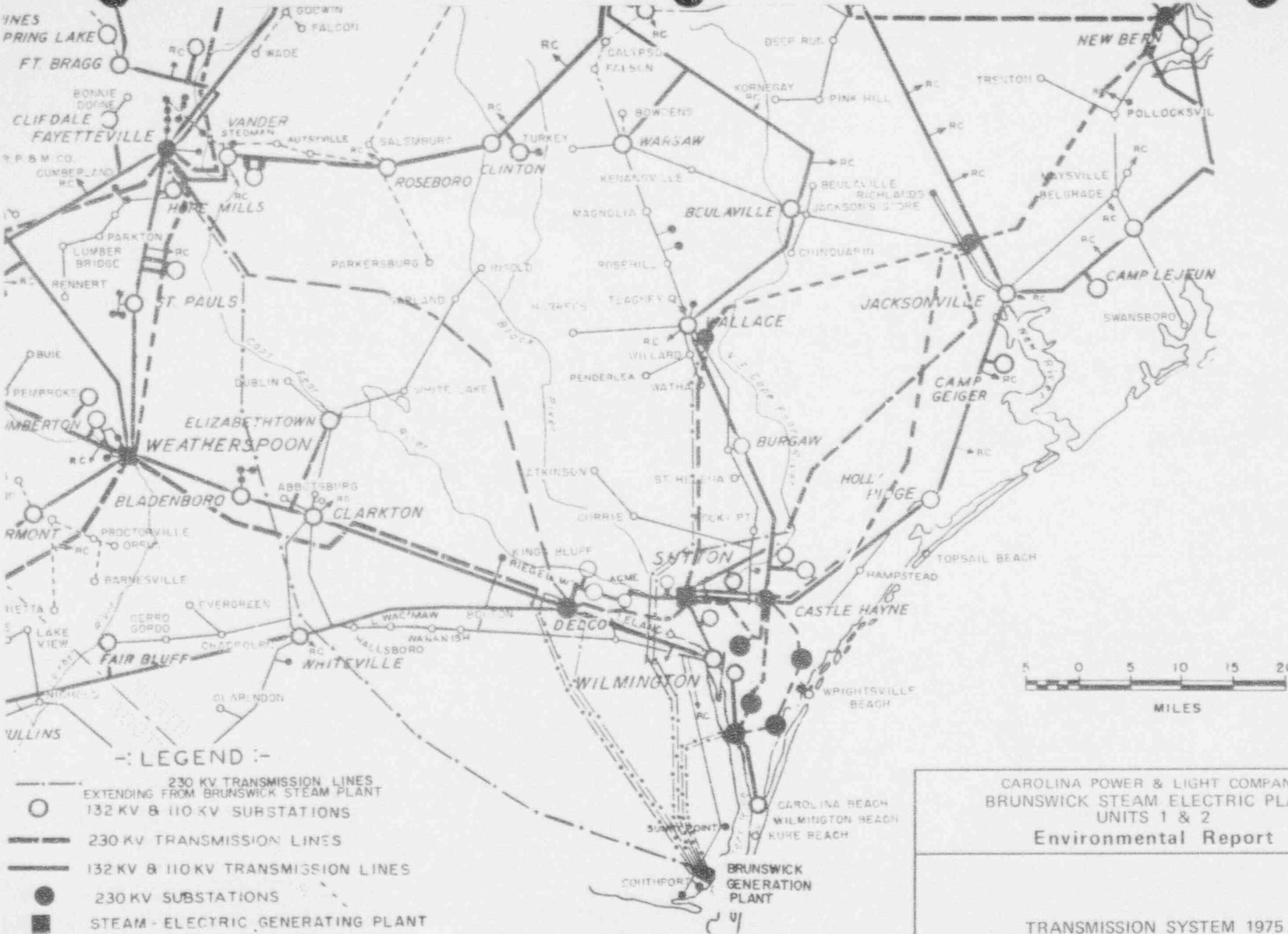
ANNUAL AVERAGE DISPERSION FACTOR (X/Q)

FIG. NO. 3.6 – 1



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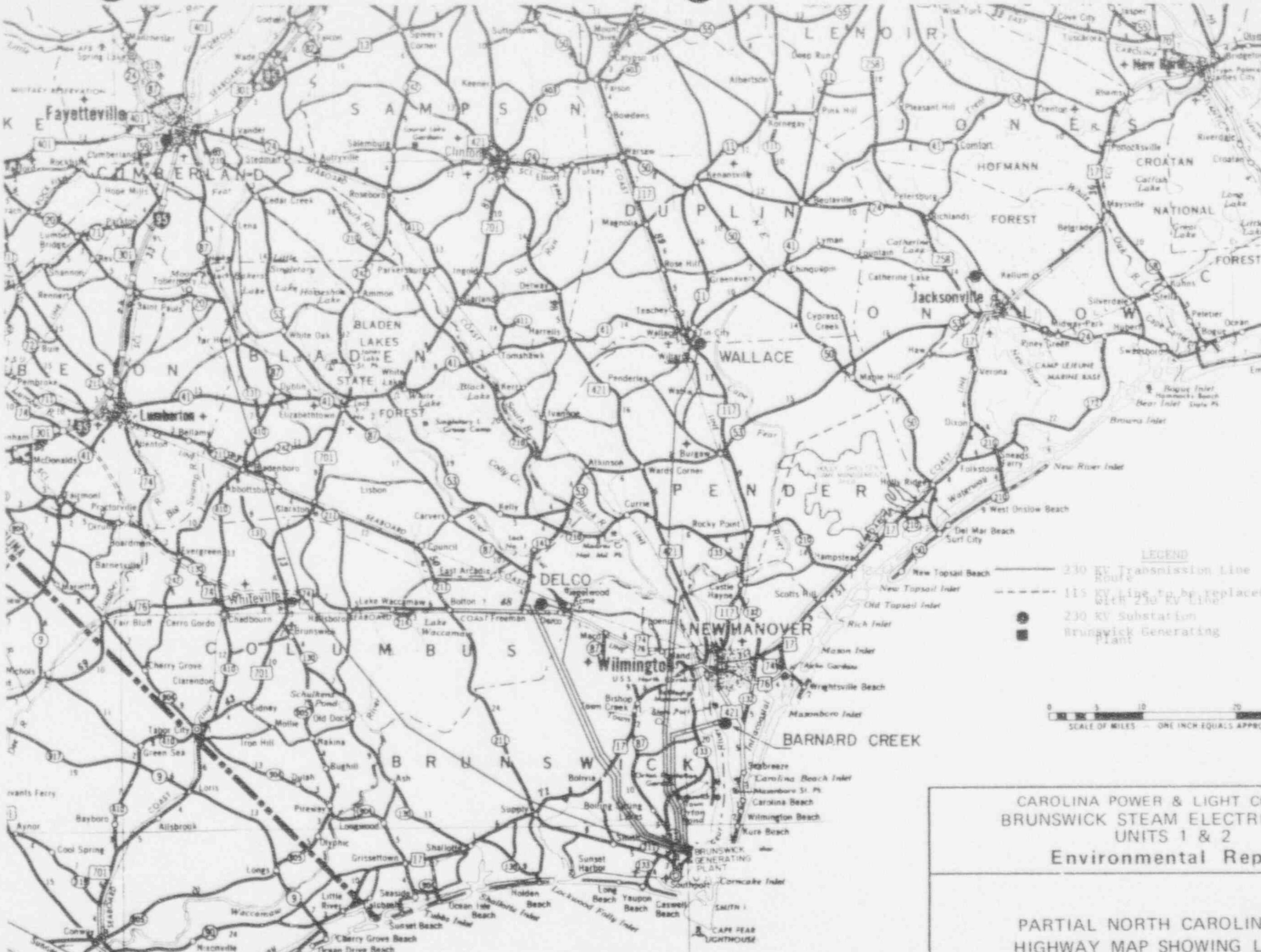
TRANSMISSION SYSTEM 1975

FIG. NO. 3.8–1



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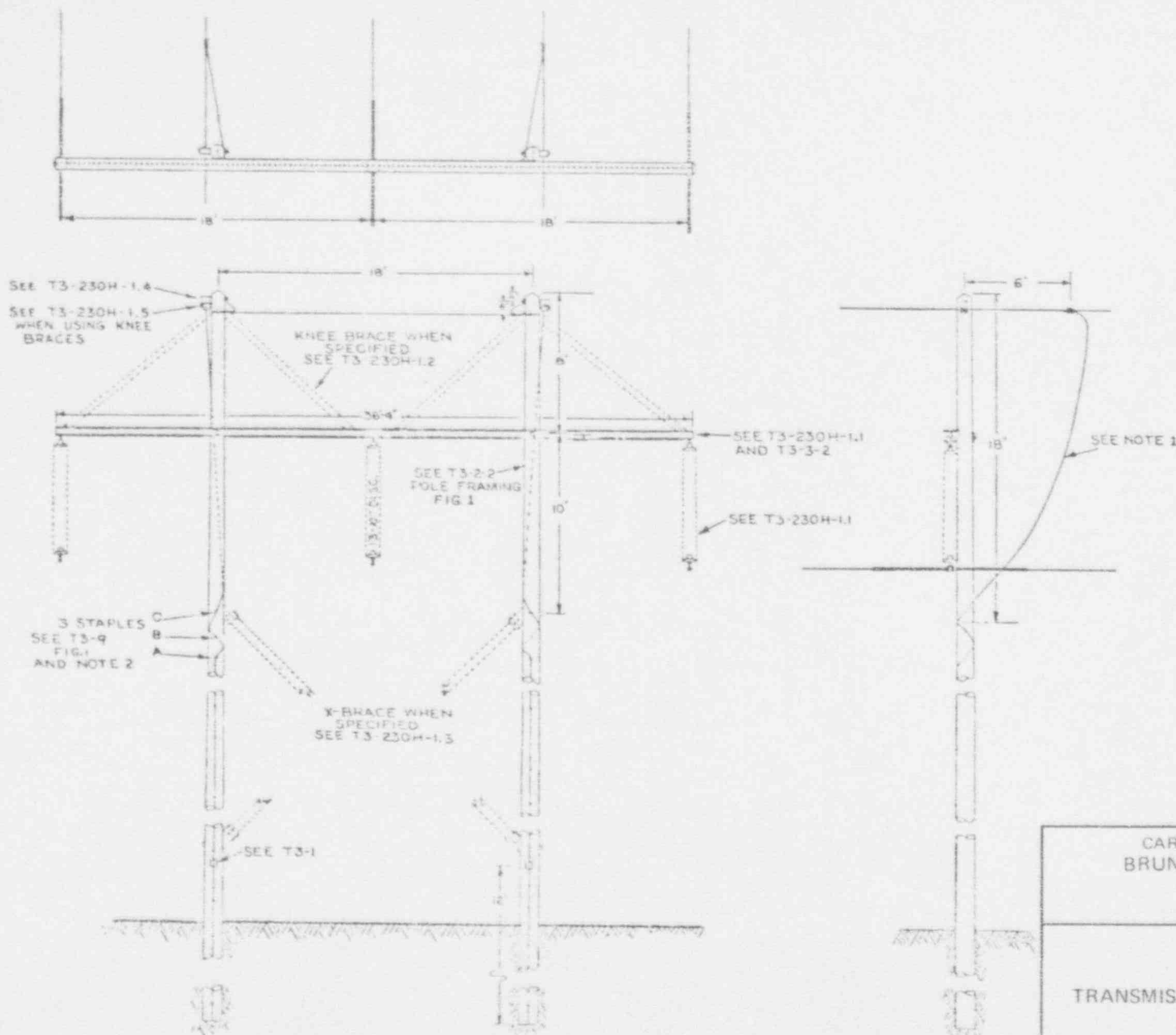
PARTIAL NORTH CAROLINA STATE HIGHWAY MAP SHOWING LOCATION OF BSEP TRANSMISSION LINES

FIG. NO. 3.8–2



NOTES

1. FLYING TAP SHALL BE PULLED HAND TIGHT, DO NOT PULL STATIC DOWN.
2. EACH FLYING TAP GROUND WIRE SHALL FIT CLOSE AND SNUG TO EACH POLE AND STAPLED SO THERE IS NO ABRUPT BEND, AND LEAVE EACH POLE ON THE INSIDE OF STRUCTURE.
3. ALL COTTER KEYS USED IN CONNECTION WITH INSULATORS AND FITTINGS SHALL BE SPREAD AT LEAST 1/4 INCH, UNLESS THEY ARE OF THE NON-SPREADING TYPE. ALL COTTER KEYS SHALL BE ON THE POLE SIDE OF ALL INSULATORS, HARDWARE OR FITTINGS. IN ANY CASE WHERE PINS ARE INSTALLED VERTICALLY, PLACE THE PIN SO THAT THE COTTER KEY IS ON THE UNDER SIDE.

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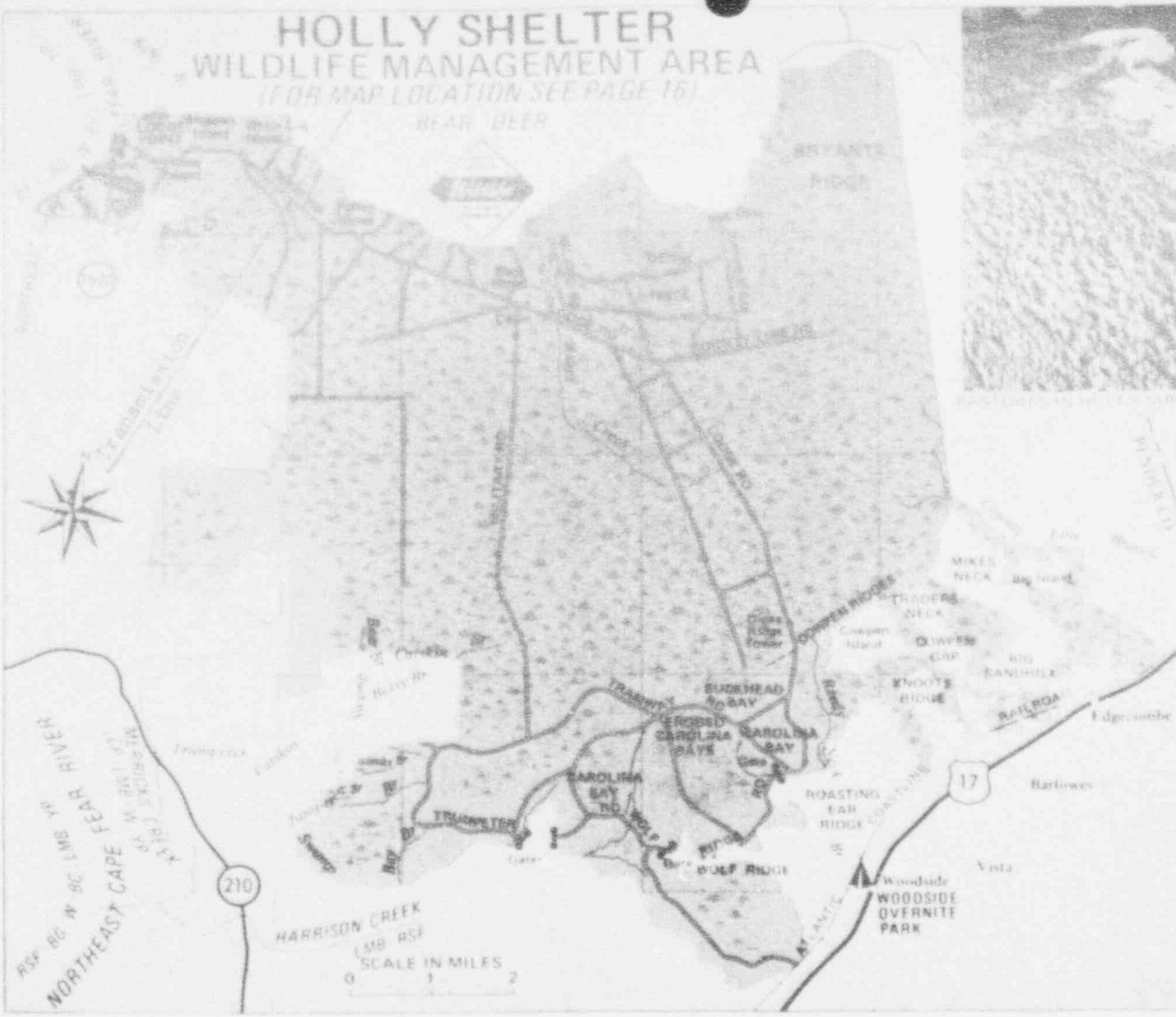
TRANSMISSION LINES SUSPENSION STRUCTURE (230KV)

FIG. NO. 3.8–3



HOLLY SHELTER WILDLIFE MANAGEMENT AREA

The 48,500-acre Holly Shelter area in Pender County is owned by the North Carolina Wildlife Resources Commission. It is mostly swampland with only a small acreage which can be considered dry land throughout the year. These sand ridges rise but a few feet above the level of the adjoining peat swamps. This, however, appears to be enough to provide good sites for pasture plantings which are heavily used by deer.

It is felt that these plantings have helped increase the deer population not only on the management area but also on surrounding private lands. It also has been noted that with the development of these pastures there has been a considerable increase and improvement in the size and condition of antlers.

Hunting with dogs is allowed since the area is largely swampland. Because the area is inaccessible, it is necessary to distribute hunters at designated stands along roads, boundary lines and fire lanes. Still hunting for deer has increased greatly in popularity in recent years. This is probably due to the high success rate of hunters and the fact that most hunters do not have dogs.

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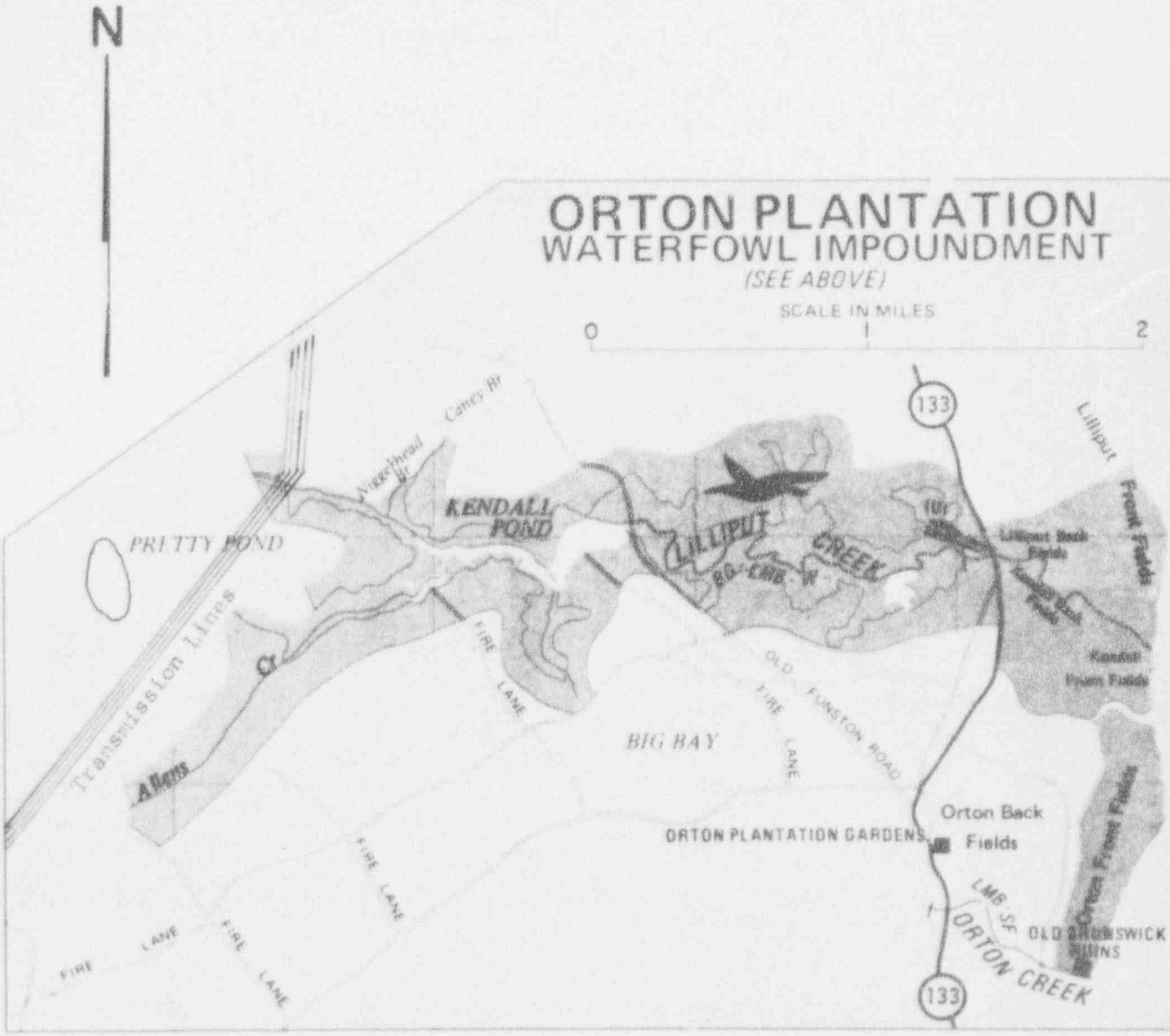
TRANSMISSION LINE ROUTING IN
VICINITY OF HOLLY SHELTER

FIG. NO. 3.8–4



CAROLINA POWER & LIGHT COMPANY BRUNSWICK STEAM ELECTRIC PLANT UNITS 1 & 2 Environmental Report
TRANSMISSION LINE ROUTING IN VICINITY OF ORTON PLANTATION
FIG. NO. 3.8–5

4. Alternatives to the Proposed Facility

There are no practical alternatives to the Brunswick Steam Electric Plant Units 1 and 2 for supplying the rapidly growing regional needs for electric power. By the mid-1970's, these units will be critical to meeting the electrical power requirements of the people who live and work in the service area of the Carolina Power & Light Company.

In arriving at the decision to construct the proposed facility at the chosen site, the alternatives discussed in Sections 4.2 through 4.5 were studied in light of the present and projected power requirements described in Section 4.1. These alternatives deal with means of generation, sites, cooling techniques and the possibility of purchasing outside power.

4.1 Specific Power Needs

Carolina Power & Light Company provides electrical service to consumers in North and South Carolina. The electrical energy requirements of these consumers are doubling every six years compared to the national average of doubling about every ten years. CP&L's commitment to provide electrical energy to its service area has required an accelerated pace of providing new electrical generation resources.

The construction and operation of Brunswick Plant Units 1 and 2 are essential to the ability of Carolina Power & Light Company to meet its load requirements during the period 1974 and beyond. As of November 1, 1971, CP&L owned and operated seven steam electric generating plants with a net winter capability of

3,622,000 kW, four hydroelectric plants with a net winter capability of 211,500 kW, and internal combustion generating units with a net winter capability of 560,000 kW. The Robinson Unit No. 2 is a nuclear unit which became operational in 1971 and provides 700,000 kW of the total steam electric generating plant capability.

Table 4.1-1 shows CP&L's summer and winter resources, loads, and reserves for Summer 1974, Winter 1974-75, and Summer 1975, assuming that the Brunswick units were not available for operation. This information indicates that CP&L would have 404,300 kW less capacity than would be necessary to meet its load requirements in the Summer 1975. CP&L's reserves at the other times would be critically low with reserves of 4.5% in Summer 1974, and 6.4% in Winter 1974-1975.

CP&L considers a minimum reserve of 18% is desirable in order to provide reliable service to its wholesale and retail consumers. This reserve margin is necessary to accommodate the unscheduled outage of its largest generating unit, reduced capability of its other units due to equipment failures, variations in actual load from the forecast, and extreme weather conditions which, experience has indicated, could result in load increases of as much as 4% above that forecast for normal conditions. If Brunswick No. 2 were not available as scheduled in 1974, CP&L's reserve margins would be so critically low that the unscheduled outage of any one of six generating units would leave the Company with insufficient capacity to meet its load requirements. An even more critical power supply would exist in 1975 if both Units 1 and 2 were not available. The unscheduled outage of any one of the Company's generating units in the Summer 1975 would further aggravate an already serious power deficiency of over 400,000 kW that would exist if both Brunswick units were delayed.

The timely construction and operation of Brunswick Units 1 and 2 will enable CP&L to meet its projected load demands for 1974 and 1975 with a margin of reserve sufficient to assure reliable electric service to its consumers.

TABLE 4.1-1

PROJECTION OF CP&L LOAD AND RESOURCES

Without Brunswick No. 1 & 2 Available

	1974 Summer	1974-75 Winter	1975 Summer
Installed Capacity, Mwe			
Hydro	213.5	211.5	213.5
Fossil	4034.0	4062.0	4034.0
Nuclear	730.5	730.5	730.5
IC's	487.0	560.0	487.0
Total Owned Capacity	5465.0	5564.0	5465.0
Long Term Purchases	212.7	213.2	212.7
Other Purchases & Sales	(122)	(122)	(140)
Pool Purchase (or Sale)	---	---	---
Total Power Resources	5555.7	5655.2	5537.7
Forecast Peak Load	5315	5315	5942
Reserve (deficit)	240.7	340.2	(404.3)
Percent Reserve (percent deficit)	4.5	6.4	(6.8)

4.2 Importing Power

Carolina Power & Light Company, and neighboring utilities with which CP&L is interconnected, are in similar situations with respect to the prospects of importing large quantities of power. Each utility is confronted with long lead times for construction of generating facilities, high rates of load growth, and a need to increase reserve capacity margins. None of these companies are installing any extra generating capacity in quantities required to allow selling to CP&L on a firm basis in the amounts required if the Brunswick units were not brought into operation in 1974 and 1975 as scheduled.

An analysis of 1969 summer peak loads for CP&L, Duke Power Company, South Carolina Electric & Gas Company, and Virginia Electric and Power Company reveals that the diversity between individual company peak loads and the simultaneous peak loads for the four companies was less than 1%. Therefore, diversity interchanges of large blocks of power is not available among CP&L and neighboring utilities. The primary function of the interconnections established with neighboring utilities, aside from the purchase and sale of small blocks of power, is to provide emergency assistance in the event of equipment failure.

4.3 Alternate Means of Power Generation

Carolina Power & Light Company is continuously conducting planning studies to determine the quantity of additional generation required to meet projected load demands. Planning studies have shown that base load type generation is required in 1974 and 1975. These studies also show that units of approximately 800,000 kW must be added to the system generating capability in each of these years.

Having identified the power need confronting it, CP&L evaluated various generating schemes for meeting this demand. Four means of generation were considered: hydroelectric, internal combustion, fossil/steam, and nuclear/steam.

The first means, hydroelectric, was ruled out as there are no sites having sufficient flow for plants of the size required.

The second generation scheme, internal combustion turbine, was ruled out due to the practical size limit of this means of generation, the high cost per kw of power generation, and are not suitabl: for base load operation.

The types of fuel available to the CP&L system for steam electric units are: coal, oil and nuclear. Production costs and capital investment cost studies were performed to aid in the determination of the type of steam electric plant to be constructed at the site. The results of studies, which projected the operation of the CP&L system for a number of years into the future, indicated an economical advantage in favor of building nuclear units as compared to fossil-fired units.

Factors which strongly influenced these studies were the high cost of fossil fuels and the uncertainty of availability of low sulfur oil or coal to meet increasing environmental requirements. For these environmental and economical reasons, CP&L elected to construct a two unit nuclear plant.

4.4 Alternate Sites

Selection of a site for a steam electric plant begins with load projections which show the amount of additional power required during the next decade and indicate where and when the additional power will be needed.

Once the need for additional generating capacity has been established, selection of a site for the generating facility proceeds. Site selection is a complex process involving analysis and optimization of many factors such as availability of adequate condenser cooling water, population density, location of schools and churches, proximity of parks and recreation areas, wildlife refuges, impact on historical monuments and areas of historical interest, interactions with airports and other industries, availability of adequate transportation facilities, cost of developing the site, local geology, effect of potential sources of pollution in the watershed, transmission requirements, and other environmental impacts.

Four sites were evaluated as possible locations for the Brunswick units. Two were estuarine sites, one a river site and the fourth was on a large man-made lake. All four sites had advantages and disadvantages for a large steam electric plant. The Brunswick site, however, was judged to have the best combination of advantages.

Site A, the alternate estuarine location, was located on the lower Neuse River east of New Bern, North Carolina. Its principal disadvantages, however, were the problems associated with condenser cooling and dissipation of waste heat. The estuary is enclosed by offshore islands and is connected to the ocean only through the small inlets separating the islands. These small inlets limit the interchange of water between the ocean and the estuary. Recirculation of condenser cooling water would have occurred during certain times of the year resulting in warmer water temperatures over a large area of the estuary. A much larger percentage of the available water was, furthermore, required for condenser cooling at this site than is required at Brunswick.

Alternate Site B, a river site, was located on the Cape Fear River northwest of Wilmington, North Carolina. This site is dedicated to power generation, with two small fossil units in operation at the time of the site investigation. Investigations of the availability of water for condenser cooling indicated that sufficient water was not available during certain months of the year for once-through cooling. Recirculation of cooling water during periods of low inflow would have exceeded the allowed temperature rise in a substantial area of the river. Therefore it was concluded that this site would not support units of the size required.

Alternate Site C is located on a hydroelectric impoundment in central North Carolina. Site C meets most of the siting requirements and may be utilized in future expansion of the Carolina Power & Light Company generating capacity. The lake provides over 5,000 acres of lake surface for recreation, and both summer cottages and permanent homes have been constructed around the lake. The number of people affected by developing a steam electric power plant site on the shore of the lake would have been considerably greater than the number of people affected by developing the Brunswick site.

4.5 Selection of Method for Dissipation of Waste Heat

Early in the project, CP&L conducted an extensive investigation into the best way to dissipate the waste heat from the Brunswick Plant, i.e., the method which would have the least environmental impact, consistent with reasonable cost, and reliability of proven technology to construct and operate. The following methods were investigated:

1. Wet cooling towers (natural and forced draft)
2. Closed cooling systems
3. Cooling lakes
4. Dilution of cooling water and return to river
5. Channeling the cooling water to the ocean for off-shore discharge

The wet cooling towers, both natural and forced draft, were eliminated because there was then, and still is, a lack of operating experience in the United States with salt water cooling towers. Of particular concern is the carryover of salt and deposition in the vicinity of the tower.

Closed cooling systems use an indirect cycle, and are therefore not susceptible to salt carryover. They are, however, substantially more expensive to construct and operate. As noted in "Considerations Affecting Steam Power Plant Site Selection" issued by The Energy Policy Staff of the Office of Science and Technology (December, 1968), "No dry towers have yet been installed at major thermal electric power plants in the United States. The largest hyperbolic dry tower in operation today is at a 120 mw plant in England. This tower was constructed in 1962 by the Central

Electricity Generating Board, primarily to obtain comparative investment and performance data. It is reported that the performance of the tower has been satisfactory. It should be remembered that summer air temperatures tend to be lower in England than in most areas of the United States." Furthermore as noted in the Federal Power Commission Staff Study Supporting the Commissions 1970 National Power Survey entitled "Problems in Disposal of Waste Heat From Steam-Electric Plants (1969)," "the cooling temperatures achievable in dry-type towers are limited by the dry bulb rather than the wet bulb air temperature with the result that higher turbine exhaust temperatures must be accepted. In the warmer parts of the country this would place a severe penalty upon the efficiency and capability of the power plant."

A cooling lake for the two units of BSEP would have required a minimum of 3000 acres. By comparison with the area needed for the ocean discharge canals, this would have entailed a ten-fold increase in land requirements, and would have resulted in the utilization of additional marshland. Furthermore, in the area of BSEP, the potential impact of a cooling lake on the groundwater was an additional deterent to this system.

The choice became, by a process of elimination, the channeling of river water via a circulating water system from the Cape Fear River and return to the river or to the ocean. A considerable amount of study preceded the final design of these canals in order to minimize their environmental impact. The cost-benefit evaluation of the canal system, as compared to the other cooling methods described above, is discussed in Section 9.5.

The first design for the circulating water system called for an intake from the Cape Fear River and discharge to the Cape Fear River near the N.C. State Highway ferry slip. This decision was predicated on the data available at that time. These data did not suggest there would be a problem of thermal accumulation or recirculation of warm water. However, during the summer of 1968 CP&L performed dye studies which suggested that possible thermal accumulation in the estuary in excess of the amount indicated by previously available data might occur. This method of returning heated water to the river was eventually ruled out for that reason.

In the design of the circulating water system, i.e., the system which cools the main condensers, the following items were considered in addition to operational hydraulic design and plant safety considerations:

1. Use of marshlands
2. Salt water intrusion into the aquifers which supply the potable water for the area
3. Upwelling of fresh water from the aquifers which supply the potable water
4. Heat dispersion in the ocean
5. Effects of canals on developed and high-ground property
6. Interception of existing drainage patterns with canals
7. Construction feasibility and economics

As mentioned in Section 3.4, the discharge of cooling water to the ocean was selected to minimize the impact on the environment at significant additional cost to CP&L. The final discharge canal routing was selected after consultation with State agencies in an effort to protect the more productive creeks and marshlands and to minimize conflicts with established land uses. The final design of the canal bypasses the town of Southport as shown in Figure 2.2-2, skirts Dutchman Creek, and crosses Oak Island by traversing the island on the east side of the golf course. Flow in the discharge canal is provided by gravity, and a pumping station is located at Caswell Beach to provide the necessary discharge velocity at the ocean discharge jets.

5. Environmental Effects Which Cannot Be Avoided

Although the Brunswick Steam Electric Plant is being constructed and will be operated to comply with all federal and State of North Carolina regulations designed to protect the environment, some environmental effects will occur. These effects on the environment will be kept to the minimum amount practicable consistent with state-of-the-technology and reasonable cost as part of CP&L's continuing efforts to conform to the spirit, as well as the letter, of the environmental protection laws.

Any effort on the part of man to provide a service or product necessary to maintaining or improving human life standards involves some possibility of impact on the environment. CP&L has attempted to balance the benefits of providing electric power against the risks to the environment in such a way that the risks are minimized using technically and economically feasible systems. In order to implement this policy, CP&L evaluated the different methods available for producing electricity and selected a nuclear plant because of its low impact on the environment.

Some broad categories of identifiable environmental effects are the diversion of land use and influences on the water resources of the area. More specifically, the evolution of the plant and its auxiliary structures results in the use of some land and marsh.

In keeping with its policy of responsible environmental practices, CP&L has kept land use to the minimum amount practicable. It was necessary to divert the use of some marshland in constructing the cooling water canals and approximately 25 acres were necessary for the intake canal, and 120 acres for the discharge canal. Spoil material from the construction of the canals is being deposited behind dikes in the highland areas, so as to minimize marshland use. The only marshland used is the cut of the canal itself. The route of the canal was chosen after consulations with state agencies, and was selected to help minimize any effects on the environment, including land diversion and release of warm water. The plant will discharge warm water which, although in compliance with appropriate regulations, may have an impact within a limited area near the point of discharge into the ocean. When discharged into the ocean at a point 2000 feet offshore, the warm water will be diluted ten fold to achieve a temperature difference not to exceed 1.5 F above ambient in June, July, and August and 4 F in other months, at the boundary of the mixing zone.

There will be some lowering of the ground water level in an area up to 1000 feet from the canal, but this loss will be small, and will be of limited influence. The few nearby private wells that will be affected will be redrilled deeper or moved to provide necessary water. Upwelling of fresh water from the Castle Hayne aquifer could potentially amount to about six percent of the flow available from the aquifer. Since the only public requirement on the aquifer uses only a small portion of the available flow, this potential loss would not adversely affect the area.

As a result of the operation of any nuclear power plant, there are certain radioactive products which must be disposed of. To minimize any effects these materials might have on the environment, the plant will be equipped with Waste Control Systems. These systems will collect radioactive fluids and these fluids will be sampled, analyzed, and processed as required and then released only under controlled conditions in accordance with all appropriate current regulations of 10 CFR 20 and 10 CFR 50, so that effluents will be held as low as practicable.

Solid wastes, which will consist of waste liquid concentrates, spent resins, and miscellaneous materials such as paper and glassware, will be packaged and shipped offsite for disposal at approved sites in accordance with AEC and U. S. Department of Transportation regulations.

The spent fuel from each fuel cycle will be stored for a time necessary to reduce its radioactivity, and then it will be shipped offsite for reprocessing and disposal in specially designed casks meeting all the necessary AEC and U. S. Department of Transportation regulations. By strictly adhering to these regulations, the environmental impact of any waste material will be minimized.

There will be some small unavoidable biological effects in the area as the result of the construction and operation of the BSEP. Clearing of the site area destroyed some cover used by wildlife, but reseeding of spoil areas is expected to create additional habitats in the future. Some aquatic mortalities will result from the passage of plankton through the plant condensers. The impact, however, is expected to be small.

In order to assure that environmental effects are minimized, monitoring programs have been established to detect any environmental change which might be attributed to the operation of the units, thereby assuring safe and healthful surroundings for the area.

Some temporary construction effects are unavoidable during construction of the plant. Dewatering has caused drawdown of the water table in the immediate vicinity of the plant site, and some private wells were affected. In these cases, CP&L has replaced the affected wells, and the dewatering process will terminate with construction. Canal excavation and dredging produces some spoil material, and this is being deposited on high land adjacent to the canal or on company-owned land in such a manner that will preserve the more productive natural creeks and marshes.

While under construction the aesthetic appearance of the site is unavoidably disturbed; however, after completion of construction this effect will be eliminated and the overall design will be architecturally pleasant.

The transmission of the electricity produced will also result in an effect on the environment which is unavoidable considering presentday technology. CP&L has taken measures to help minimize the effect of the transmission lines from the BSEP. These measures are discussed in Section 3.8.

The lines will cause no change in population patterns. The only lands committed to the lines are the areas they will traverse, and this land can be used for pasture or agricultural uses, access roads, recreation areas, or other uses. In addition, the right-of-way will provide an adequate fire break in the event of a forest fire.

By practicing environmental responsibility such as those measures described above, it is the desire of CP&L to attain the widest range of benefits for its consumers through harmonious use of the environment without degradation, risk to health or safety, or other undesirable consequences. If detrimental environment effects resulting from the operation of the plant are detected by the environmental monitoring program or other surveillance method, CP&L will take appropriate action to reduce the environmental impact.

6. SHORT-TERM USES VERSUS LONG-TERM PRODUCTIVITY

The ability of man to harness the energy resources of the earth has been an essential component of man's ability to survive and develop socially. Electrical energy is a key factor in providing food products, sewage treatment, the manufacture of goods and numerous physical comforts and necessities; and it is vital to the health and welfare of the nation. With the development of our modern society, electricity has advanced from a novel luxury to an essential requirement for the innumerable necessary services and products demanded by our present civilization. Electricity has become essential to the health, welfare, safety and economy of the residents of the area served and the organization entrusted to provide the residents with electrical energy must assure an adequate supply of electricity.

Electric power requirements in this country have been doubling every ten years. CP&L customer requirements for power have doubled in the past six years, and further expansion is expected to continue in much the same pattern. In order to provide the residents of its service area with the electricity necessary to meet this growth, it is necessary to build a power plant the size of the Brunswick Plant, Units 1 and 2. CP&L is aware of its responsibility to provide electricity to its consumers in a manner consistent with responsible environmental practices. As described in various parts of this report, detailed consideration has been given to the different environmental aspects of the plant in making decisions concerning design, construction and operation of the plant.

The short-term use of the environment to produce electricity for our immediate requirements must be evaluated with respect to the enhancement of long-term productivity and any adverse environmental effects which might be realized by future generations. Considered in this respect, the nuclear units being constructed at the Brunswick Plant will be compatible with the environment. The resources which must be diverted from the earth's environment to operate the nuclear power plant will be small. This consumption of natural resources is an important consideration when attempting to evaluate the quality of environment we are creating or leaving for future generations. In evaluating the short-term use of the environment, it is also important to consider the fact that the electricity which will be produced will be used to some extent to facilitate social progress and technological developments that will aid in protecting our environment.

At this stage in our technology, even with nuclear power and its very low radioactive release concepts, there does appear to be some possible slight but inevitable, short-term impacts on the environment. These impacts are associated with the basic principle of steam electric plants, the need to provide cooling water and the resultant heating of the air and water. They include such items as chemical, sanitary and radioactive discharges, temporary construction effects, land use, and discharging of heated water. These effects are of a short-term nature, and design of the plant has incorporated methods to minimize their impact. The cooling water discharged into the ocean will have essentially the same chemical analysis as the river, although slightly warmer. Radioactivity release is tightly controlled by federal regulations. The construction effects include such measures as road construction and dewatering, and these effects will exist during the construction phase only. The heating of the cooling system water is expected to be the major effect resulting from this short-term use of the environment, however, efforts have been made to minimize the heating of the ocean water, as explained previously in this report. Final temperature difference after discharge and diluting will not exceed 1.5 F above ambient in June, July, and August, or 4 F for the other months, at the boundary of the mixing zone. Any environmental impact associated with the short-term use of resources is expected to be limited by state of the technology and reasonable cost and then must be evaluated relative to the benefits derived from use of the electricity produced.

The short-term effects resulting from construction and operation of the plant will result in no cumulative adverse effects, and there is no reason why after the plant is decommissioned, the environment in due time could not be returned to its original state of existence prior to the nuclear unit, with no remaining adverse effects on the area's long-term productivity.

In keeping with responsible environmental practices, the land being used for the plant site and cooling water canals was held to the minimum amount practicable. Prior to the start of construction, the land being used for the site area consisted primarily of old-field vegetation and second-growth pine, which was used mainly as a source for low-medium grade pulpwood. Less than 20% of the land was devoted to agricultural activity or pasture land. Although prior to the start of construction the land being used for the site and canal right-of-way possessed limited recreational value, there are recreational areas nearby and use of these areas will not be infringed upon in any manner, except for a short temporary construction time where the discharge pipe will be installed beneath a beach area.

Approximately 25 acres of marshland were required for the intake canal, and 120 acres for the discharge canal. Since no spoil will be deposited on marshland, these areas will be preserved as marsh areas except for the cut of the canal itself. If the community so desires, at the end of the plant life, the marshland could be returned to its original state over a period of time, but this would possibly require a large effort.

The operation of the Brunswick Steam Electric Plant will not curtail the range of beneficial short-term uses of the environment. The units will result in increased productivity which will actually enhance long-term productivity in future generations. If future generations elect to convert the cooling water canals back to terrestrial uses, this can be done over a period of time and the area restored to essentially its pristine state.

7. Irretrievable and Irreversible Commitments of Resources

The construction and operation of the Brunswick Steam Electric Plant Units 1 and 2 will require no unusual commitments of resources. Any irretrievable and irreversible commitment of resources required by the plant will be small in comparison to the benefits gained from the electricity produced by it.

Each unit of the plant will convert raw energy to electricity, as is the case with all electric generating units. The consumption of fuel by nuclear units, such as the Brunswick Steam Electric Plant Units 1 and 2, is unlike fossil-fueled generating units, however, since the process is accompanied by the production of a new type of fuel (plutonium) and many other, potentially valuable, materials.

The resources committed at Brunswick that will be irretrievable in their present form are the materials used in the construction and operation of the plant, e.g., the nuclear fuel, steel and concrete, and the manpower commitment for the design, construction, manufacturing of components, and operation of the plant. These irretrievable resources must, of course, be measured against the benefits accrued to the residents of the CP&L service area provided by the availability of clean electric power.

At the end of the useful life of the plant, some of the land committed to the plant can be applied to a new useful purpose, and there will have been no significant change in the environment.

It is the opinion of Carolina Power & Light Company that the construction and operation of Brunswick Steam Electric Plant - Units 1 and 2 will not adversely affect the environment in terms of irretrievable and/or irreversible commitments of resources.

8 Radiological Accident Considerations

8.1 Introduction

In keeping with the practices and standards of the industry and of AEC requirements, the Brunswick Plant is designed to most exacting criteria. It is, nevertheless, prudent to postulate the occurrence of certain equipment failures and to calculate the resulting radiological consequences and associated probabilistic considerations.

An investigation of the radiological consequences of various severe equipment failures has always been an integral part of nuclear plant safety analysis reports, including the Brunswick Preliminary Safety Analysis Report. In order to assure acceptable conservatism in the plant design, failures were there postulated in coincidence with such plant conditions which would tend to make more severe the accident consequences albeit with little regard for the likelihood for these conditions to coincide. In the evaluation of the probable impact of the plant on the environment, reasonable assumptions, justifiable calculational models and techniques, and realistic assessments of environmental effects were used as indicated in the AEC guide (Ref. 2). The integrated dose consequences of certain system failures will be compared in this section with the dose from natural background radiation, integrated over the population within a 50-mile distance from the BSEP. The man-rem dose concept was discussed in Section 3.2.2.

8.2 Radiological Events Classification

The radiological events will be associated with the following general plant conditions:

1) normal steady state conditions
2) abnormal transient occurrences
3) postulated accident situations

Transport of reactor material will consider

1) normal shipments
2) incident conditions

The event classifications with AEC examples (Ref. 1, 2, 3) are listed along with the associated BSEP plant conditions in Table 8.2-1, -2, and -3 for normal operation, for postulated accidents and occurrences, and for reactor material transport conditions.

The following descriptions will identify the specific category/system/event associations within the reactor facility operation for the BSEP with respect to the AEC classification.

8.2.1 Normal Operation

Class A--Normal Operation Effluents

Effluent releases and direct radiation expected from the reactor facility during normal operation fall into this category. These would include:

(a) gaseous radwaste system releases (air ejector offgas)

(b) liquid radwaste system releases (discharge canal releases)

(c) direct radiation

- turbine generator system shine radiation
- solid radwaste system shine radiation

8.2.2 Transient and Accident Occurrences

Class 1--Trivial Incidents -- Small Leaks Inside Containment

Primary Coolant System leaks within the primary containment or the secondary containment (Reactor Building). Leaks or breaks greater than those cited would be identified and treated under Class 8--LOCA Inside or Outside Primary Containment. Small leaks or breaks (below tech spec limits) inside the Reactor Building are considered inside containment since in the BSEP safety actions take place automatically inside the Reactor Building as well as in the primary containment.

Class 1 events are not considered herein, in keeping with the guide of Ref. 2.

Class 2--Miscellaneous Small Leaks Outside the Containment

This class is defined as outside the primary or secondary containments. Effluents or sources of activities in this category include:

Turbine Building effluents

- gaseous, anywhere in Turbine Building
- liquid, anywhere in Turbine Building

Leaks or breaks greater than the allowable tech spec limits are identified and treated under Class 8--Loss of Coolant Accidents Outside Primary Containment.

Class 3--Radwaste System Failures

The events in this category would be confined to high probability single functional system or equipment failures or single operator error occurrences. Low probability radwaste system failures would be considered Class 8 events. Effluents or sources in this category include:

(a) Single functional equipment failures
   - gaseous release from offgas system
   - liquid leakage through valves

(b) Single operator error
   - liquid discharge with batch testing
   - gaseous release of holdup system via purge valve operation

Class 4--Events that Release Radioactivity into Primary System

The design basis for the BSEP precludes fuel defects from operational transients. Fuel defects which occur during normal operation are covered in Section 8.4. Therefore, there are no events identified in this class for this plant.

Class 5--Events that Release Radioactivity into Secondary System

In the BSEP, "secondary system" is interpreted to mean the secondary side of heat exchangers whose primary side contains reactor water. The Brunswick Plant has several heat exchangers within this category, including:

(a) Main Condenser...liquid leak path

(b) RHRS Heat Exchanger...liquid leak path

(c) Drywell Cooler Heat Exchanger...liquid leak path

(d) Spent Fuel Storage Heat Exchanger...liquid leak path

Items (a) and (b) during operation exhibit in-leakage due to ΔP inward: Items (c) and (d) are cooled by closed cooling loops. Therefore, there are no events identified in this class for this plant.

Class 6--Refueling Accidents Inside Containment

This category includes refueling accidents involving a fuel assembly dropping onto the reactor core, onto spent fuel racks, into the fuel pool, or against the pool. The event is the Design Basis Accident (DBA) refueling accident.

Class 7--Accidents to Spent Fuel Outside Containment

This event occurs only when the spent fuel cask is on its transportation vehicle and between the Reactor Building and plant gate. No lifting of the cask occurs outside the containment.

A fire while on site is a possible occurrence as defined by 10CFR71.

Class 8--Accident Initiation Events Considered in the Design Basis

These events are considered in the Final Safety Analysis Report and include the following:

(a) DBA-LOCA Inside Primary Containment-Recirculation Loop Pipe Break Accident

(b) DBA-LOCA Outside Primary Containment-Main Steam Line Break Accident

(c) DBA-CRDA Control Rod Drop Accident

(d) Offgas Holdup System Failure, or Catastrophic Failure of a Liquid Radwaste Tank

8.2.3 Reactor Material Transportation Operations

The following will help identify the specific category/system/events associated with reactor material transportation operations for the plant with respect to the AEC Classifications.

a) New and Spent Fuel Shipments

Normal shipments are governed by and include the allowances in the 10CFR71 regulation for normal shipments.

Incident occurrences for new and spent fuel are governed by the 10CFR71 accident source allowances.

b) High/Low Level Radioactive Waste Shipments

Normal shipments are governed by and include the allowance in 10CFR71 regulations for normal shipments.

Incident occurrences for contained solid radwaste would be governed by 10CFR71 source allowances.

TABLE 8.2-1

REACTOR FACILITY

CLASSIFICATION OF NORMAL OPERATION

No. of Class	Description	AEC	BSEP Design-Analyses
A	Reactor Facility Effluent Releases	Normal Operation Expected Effluents	Effluents releases or direct radiation expected during normal operation

TABLE 8.2-2

REACTOR FACILITY

CLASSIFICATION OF POSTULATED ACCIDENTS AND OCCURRENCES

No. of Class	Description	AEC Example(s)	Plant Design-Analyses
1	Trivial Incidents	Small spills Small leaks inside containment	None
2	Misc. small releases outside Containment	Spills Leaks and pipe breaks	Reactor Coolant leaks outside PC or RB
3	Radwaste System Failures	Equipment Failure Serious malfunction or human error	Any Single Equipment Failure or Any single Operator Error
4	Events that Release Radioactivity into the Primary System	Fuel deflects during normal operation Transients outside expected range of variables	Fuel Failures during transients outside the normal range of plant variables but within expected range of protective equipment and other parameter operation
5	Events that Release Radioactivity into Secondary System	Class 4 and Heat Exchanger Leak	Primary Coolant Loop to auxiliary cooling system Secondary side of heat exchanger leak
6	Refueling Accidents Inside Containment	Drop fuel element Drop heavy object onto fuel Mechanical malfunction or loss of cooling in transfer tube	Dropping of fuel assembly on reactor core, spent fuel rack or against pool boundary
7	Accidents to Spent Fuel Outside Containment	Drop fuel element Drop heavy object onto fuel Drop shielding cask - loss of cooling to cask Transportation incident on site	Transportation incident involving spent and new fuel Shipment on site but outside PC or RB

TABLE 8.2-2 (CONT'D.)

No. of Class	Description	AEC Example(s)	Plant Design-Analyses
8	Accident Initiation Events considered in Design-Basis evaluation in the Safety Analysis Report	Reactivity Transient Rupture of Primary Piping Flow Decrease - Steamline Break	a. Reactivity Transient b. Loss of Reactor Coolant inside or outside primary containment
9	Hypothetical Sequences of Failures More Severe than Class 8	Successive Failures of Multiple Barriers normally provided and maintained	None

TABLE 8.2-3

REACTOR MATERIAL TRANSPORTATION

CLASSIFICATION OF SHIPMENT ACTIVITIES

No. of Class	Description	AEC & BSEP Design Analyses & Others
I	New & Spent Fuel Off-site Shipment Activities	Normal Shipment Activities-New & spent Fuel Shipment Incidents-New & Spent Fuel
I	High & Low Level Radioactive Off-Site Shipment Activities	Normal Shipment Activities-High & Low Level Wastes Shipment Incidents-High & Low Level Wastes

8.3 Radiological Effects

The analysis of radiation effects is a systematic examination of the normal steady state, abnormal transient, or postulated accident occurrences of all modes of the BSEP operation. This includes both reactor facility operation and reactor material transportation considerations. Each operational mode is placed into an AEC-classification category as described in Section 8.2. Radiological effects are determined for the appropriate events in each classification. The analysis is conducted as directed by the AEC guide[(2)], utilizing reasonable assumptions, justifiable calculational models and techniques, and realistic assessments of environmental effects. For a discussion of radiological effects see Section 3.2.2.

8.4 Normal Reactor Facility Operation

8.4.1 Event Identification

Normal operation of a power reactor results in a small release of gases into the atmosphere, liquids into the plant's discharge canal, and direct(shine) radiation from plant equipment containing radioactive materials.

8.4.2 Initial Reactor Facility Conditions

For calculational purposes the reactor is assumed to be at steady-state full power operation with expected fuel performance and normal operation of liquid and gaseous cleanup systems. Based on these considerations, an off-gas rate of 25,000 μCi/sec/unit as measured after 30 minute decay has been used in the calculations as a representative value. The installation of the augmented off-gas system reduces the activity by a factor of 1000, resulting in an activity of 25 μCi/sec/unit.

Past BWR experience for about 10 plants with holdup systems providing less than 1 hour delay has shown average annual off-gas rates between 1000 and 30,000 μCi/sec. These include plants with thermal power output between 200 and 2400 MWt.[28] Therefore, based on BWR experience to date, an average off-gas over the years of the order of 25,000 μCi/second/unit is more representative for estimating long term dose than the traditional 100,000 μCi/sec/unit upper limit design basis for BWR's. Due to other design features and site and environs characteristics, the resulting dose estimate to any off-site member of the public will be low compared to the dose from natural background radiation. Therefore, variations in operating experience from the representative value of 25,000 μCi/second/unit will produce variations in dose of only minor significance.

8.4.3 Off-gas Effluents

The gaseous effluent of primary importance for BSEP is from the main turbine condenser exhaust system. The design of the off-gas treatment system, coupled with expected fuel performance, provides for a decay period sufficient to reduce the expected annual average noble gas emission rate to less than 25 μCI/sec/unit. Normal effluent releases are discussed in detail in Section 3.6.

8.4.3.1 Calculation of Sources and Doses

In addition to the above release rate of 25 μCi/sec for each of 2 units the following assumptions and associated values were used in defining the environmental effects from this event.

1. Meterological data has been collected at the BSEP site for a period of about 1 year; however, this data has not been analyzed and is not available for this report. Typical meteorological data from a coastal site, expected to be representative of the BSEP site atmospheric diffusion, has been used in the calculation of population doses for this report. Any difference in the data used and that from the BSEP site would not change the resulting doses significantly.

2. Population Density - Population to 50 miles as extracted from the 1960 census and extrapolated to the year 1996. The data were in good agreement with the 1970 census.

3. A 100-meter release height above grade was used.

The basic mathematical model used to calculate the whole body exposures is defined in Reference 4 and modified as follows:

$$D_g = \sum_{\substack{\text{Stability} \\ J=1}}^{4} \sum_{\substack{\text{Isotope} \\ I=1}}^{3} \iiint_{Y Z \tau} C_1 C_i f_i X_j G_i \, dY \, dz \, d\tau \quad (1)$$

Where

D_g = Cloud gamma dose (rem)

C_1 = Conversion factor (3.7×10^4 Dis/sec-μCi)

C_i = Flux to dose conversion factor for the i^{th} isotope (rem/sec-γ/cc)

f_i = Number of photons of the i^{th} isotope emitted per disintegration (γ's/dis)

G_i = Dose attenuation kernel for the i^{th} isotope (dimensionless)

$$X_j = \left[\int_Y \frac{f_j Q_i}{2\pi u \sigma_y \sigma_z} \exp\left(-\frac{z^2}{2\sigma_z^2} - \frac{y^2}{2\sigma_y^2} \right) dY \right] \Big/ \phi R \quad (2)$$

Where

X_j = Average annual isotopic airborne concentration of the i^{th} isotope (μCi/cc)

f_j = Accumulative frequency for wind speed, stability and sector (dimensionless)

Q_i = Plant release rate of the i^{th} isotope ($\mu Ci/sec$)

σ_y, σ_z = Horizontal and vertical diffusion coefficients (cm)

u = Wind speed (cm/sec)

Y,Z = Horizontal & vertical distances from plume centerline (cm)

ϕ = Sector angle over which plume is averaged (radians)

R = Distance from release point to detector position (cm)

Equation 1 provides the yearly offsite dose to a detector located a distance of R-cm from the release point and within a sector angle of $\emptyset$ radians. The man-rem/yr is determined by multiplying the result of equation 1 by the population density located within the sector of concern. Values of sector dose at a distance of R (cm) are assumed to be applicable to all individuals located in that sector from a distance of $R-\Delta R$ to $R+\Delta R$. The cumulative man-rem presented in Table 8.14-1 is determined by summing the dose contributions from all sectors and adding this to the previous radial man-rem exposure.

8.4.3.2 Radiological Results

The cumulative man-rem effect for both units for this event is presented in Table 8.14-1 as a function of distance to 50 miles. It should be noted that the cumulative effects are a factor of 57,000 below those effects received from normal background.

8.4.4 Direct (Shine) Radiation

8.4.4.1 Sources and Doses

Under normal operation a minor contribution to dose at the plant boundary is from direct radiation from the turbine and associated equipment. Other potential contributors are the Reactor Building, Radwaste Building, radwaste storage tanks, and the off-gas stack.

8.4.4.2 Radiological Results

Dose rate computations show the direct and scattered shine are insignificant over an area large enough to be of concern to the general population. Therefore, for this plant the direct shine contribution may be neglected.

8.4.5 Liquid Effluents

8.4.5.1 Calculation of Sources and Doses

The primary area of importance where liquid effluents are considered is the ingestion mode via drinking water. Since the waters to which the plant releases its liquid effluents are not used for public consumption, and there is no significant path from the discharge canal via the Castle Hayne aquifer to the nearest (Southport) municipal water system, it can be concluded that this mode of exposure is of no significant importance. The only mode of exposure to the population from liquid releases is the water-fish-man pathway. This pathway is discussed in detail in Section 3.6 and determined to be of only very minor significance.

8.5 Transient and Accident Occurrences in Reactor Facility

The treatment of transients and accidents in this section follows the AEC guide which points out that it is not practical to consider all possible accidents, so a spectrum of accidents is suggested which are divided into classes. Each class is characterized by an occurrence rate and a set of consequences. As suggested by the guide, typical or average characteristics for each classes 2 through 8 are used, and Class 1 and Class 9 events are omitted.

The first parts of the accident discussion which follows will describe for each class the nature of the occurrence, the operating conditions at the time of the occurrence, and a justification of its use as typical of its class. A few classes encompass events of such widely different consequences and frequencies of occurrence that two or more events are studied, no single one being qualified to be called truly typical of the entire class. In particular, each of the design basis accidents described in the Final Safety Analysis Report are treated in Class 6 and 8 but are treated individually.

Subsequent parts of this section will describe the source and dose calculational techniques, the resulting exposures expressed in man-rem and a statement of probability. Probability considerations are discussed in Section 8.15.

8.6 Class 2-Miscellaneous Small Releases Outside Containment

8.6.1 Event Identification

A variety of leakage paths, and hence type of leaks, could exist in an operating power plant. Since this class of events must occur within the turbine building they must manifest themselves either in the building drains, in which case no release to the environment occurs, or the building ventilation. This characterization of the class of events is simply stated in terms of building ventilation content. The theoretical release is a continuous steam leak equivalent to 7 gpm of saturated liquid, located on the upper turbine building floor. This has been selected based on experience in operating plants. A reactor coolant inventory consistent with a 30-minute delay 25,000 μCiNG/sec off-gas activity (prior to treatment) is considered applicable for this 7 gpm leak. The release to the environment occurs from the turbine building roof vent.

8.6.2 Calculation of Sources and Doses

Assuming a leak rate of 7 gpm, a coolant concentration consistent with a noble gas offgas activity of 25,000 μCi/sec as measured after 30-minute decay and a condensation - plateout factor of 2 results in a release rate to the environment of 0.013 μCi/sec of I-131 with corresponding releases of I-132 to I-135. This value for I-131 can be compared to measurements which have been made on operating BWR's which have shown release rates from the building ventilation systems of $2X10^{-3}$ μCi/sec to $4X10^{-2}$ μCi/sec.

Due to their limited mobility, particulate fission products exist in lesser quantities in effluents and so their contribution to the overall environmental effects is negligible compared to the isotopes considered and they are therefore neglected in this analysis. Depending on the type of leak (i.e., steam or liquid) the potential for noble gas release may or may not exist. If the leak were between the main steam line isolation valve and main steam turbine, one could expect a release of noble gas activity; whereas if the leak were liquid, one would expect no gaseous contribution from this source due to the relative insolubility of noble gases in water. For the iodine activity the environmental effects were determined by comparing the average annual concentrations at various radial distances in 16 sectors (22.5/sector) to the Maximum Permissible Concentration in Air (MPC_A) as set forth in 10CFR20 Appendix B, Table 2, Column 2.

Mathematically the environmental effects can be described as follows:

$$D_{Thyroid} = \left[\sum_{I-131}^{I-135} \sum_{\substack{Stability \\ J-1}}^{4} \int_Y \frac{Q_i}{(2\pi u \sigma_y \sigma_z)} \exp\left(-\frac{z^2}{2\sigma_z^2} - \frac{y^2}{2\sigma_y}\right) dY \right] \frac{Df}{\phi R(MPC_i)} \qquad (3)$$

Where

$D_{Thyroid}$ = Thyroid dose (rem/yr)

D_f = Dose conversion factor (i.e., $\frac{\chi_i}{MPC_i} = 1 = 1.5$r/yr.), other parameters as previously defined.

Equation 3 applies to the dose in a given sector at a radial distance R. Therefore, to determine the integrated population exposure, it is necessary to multiply equation 3 by the population distribution in a given sector and at the given distance R, and to sum this product for all sectors and distances to 50 miles. Concerning the whole body dose effects from the release of noble gas activity the steam, and hence activity release rate, is based on an equivalent 7 gpm water leak. The cloud gamma exposures are based on those mathematical models presented in section 8.4 and are presented in Table 8.14-2.

8.6.3 Radiological Results

As shown in Table 8.14-2, the cumulative thyroid exposure to the general population is 1.5 rem. As noted in Section 8.3.1, the allowable thyroid exposure is orders of magnitude above typical whole body dose effects because of the limited biological effects on the thyroid gland. However, for the purpose of this evaluation the thyroid exposure is compared on the same level as whole body exposures. As noted in Table 8.14-2, using even this conservative approach the cumulative thyroid man-rem exposures are orders of magnitude below the whole body exposures received from normal background. This comparison will also be made in relation to the whole body dose effects in subsequent sections, where applicable.

The whole body exposure for this event, as noted in Table 8.14-2, results in radiological doses which are 4 to 5 orders of magnitude below normal background. It can, therefore, be concluded that the environmental effects from a small leak external to the primary containment will be of no importance with respect to the general population exposure.

8.6.4 Event Probability Considerations

Experience with mechanical equipment shows that small, sometimes even undetectable, steam leaks do occur from time to time. Thus, this class is judged to fall into the "upset" category but with an annual probability close to one.

8.7 Class 3-Radwaste System Failures

Since the mechanisms leading to significant accidental discharges of gaseous and liquid radwaste are so different, two events were selected to represent this class.

8.7.1 Liquid Radwaste

The discharge of liquid radwaste to the discharge canal is controlled by redundant valves. Even if, through operator error, an excessively high activity batch were released, the radiation monitor on the discharge line would detect this and would (1) indicate an alarm in the central control room, and (2) automatically close the second discharge valve. If the automatic feature should fail, the control room operator has 42 seconds from alarm till the liquid reaches the second valve, to close that valve manually from the central control room. Therefore this failure is considered extremely remote and its consequences are not considered here.

8.7.2 Gaseous Radwaste

Examination of the equipment contained in the off-gas system reveals that the only source of potential release, other than the normal effluent path, is via the drain lines. Drain lines for the removal of condensed steam are located in close proximity to the inlet and outlet of the holdup pipe and normally have a water seal to prevent gaseous leakage. For this event it is assumed that the water seal to the inlet drain line is lost and a 2-minute-old gaseous diffusion mixture is available for release. Considering the diameters of the drain line and the holdup pipe, and assuming that the flow in the drain line is proportional to the area ratios, approximately 0.2% of the 2-minute-old mix will be released via the drain line. Since gaseous effluents from the drain line are not positively contained in any storage tanks, the assumption is made that the gaseous effluent will be released at a height equal to the ventilation discharge of the building. It is assumed that the off-gas activity of 25,000 μCi/sec diffusion mix, as measured after 30 minutes, is approximately equal to 143,000 μCi/sec at 2 minutes. Considering that 0.2% of this value (i.e. 286 μCi/sec) is released to the environment under the same environmental conditions as the stack effluent but at a lower release height, the resultant off site exposure is a very insignificant increase in the exposures received from the main stack effluent. In addition to the 286 μCi/sec of fission product gases, approximately 18 μCi/sec of N-13, 15,000 μCi/sec of N-16, and 1,300 μCi/sec of O-19 will be released to the environment. Consideration of the energy spectrum, abundance, and transport time to any receptor off site, results in the conclusion that these sources are also negligible in comparison to the exposure received from normal stack effluents. In addition, considering the relatively small amount of time (~ 2 hours) that this condition would exist before being detected, further justifies the insignificance of the dose results.

It can therefore be concluded that the radiological exposures for this event are completely insignificant when compared to normal background exposures.

8.8 Class 4-Events that Release Activity Into Primary System

Events which lead to release of radioactive material (activity) into the primary system must be associated with fuel cladding defects or perforations which in turn permit escape of the activity. Cladding defects or perforations can occur as a random defect in manufacture or as a result of transitory stress which exceeds the cladding material mechanical properties. Random cladding defects as a category of events leading to activity release are considered in Section 8.4 under Normal Reactor Faulty Operation.

Plant design bases, as described in the Final Safety Analysis Report, includes the requirement that any anticipated transient event, concomitant with a single equipment malfunction or single operator error, must not result in a Minimum Critical Heat Flux Ratio (MCHFR) less than 1.9 for any normal plant operating mode. Since the design bases correlation[24] used in determination of the CHF is conservatively selected with a large margin between predicted and observed CHF, fuel which experiences a MCHFR of 1.0 is not likely to have cladding failure. Plant design assumes that such events do not release activity into the primary system. Thus there are no events identified in the Safety Analysis Report which fit into Class 4.

8.9 Class 5-Events That Release Activity Into Secondary System

In BSEP, "Secondary System" is interpreted to mean the secondary sides of heat exchangers whose primary sides contain primary system coolant: in particular, the main condenser sheil and the service water side of the RHR heat exchangers.

The main condenser is protected against outleakage during plant operation by normal vacuum.

Outleakage from the primary coolant loop to the service water may occur during the shutdown mode, when the RHR heat exchangers are cooling the reactor. At this time, should there be a leak in the heat exchanger, some fission products in the primary coolant could slowly leak into the service water and hence into the discharge canal.

Because of the relatively short duration of this mode, the low fission product concentration, and the large dilution into the discharge canal, such an outleakage is not a major concern. Should the leakage be larger than acceptable, the faulty RHR heat exchanger will be valved off, and the second heat exchanger will be used alone.

8.10 Class 6-Refueling Accidents Inside Containment

There is only one refueling accident considered to have any reasonable probability of occurrence, namely dropping a heavy object onto the core. This event will be treated in this section.

8.10.1 Heavy Object Dropped onto Core

The accident chosen as typical of this category is the design-basis refueling accident, wherein an equipment failure allows a fuel bundle to drop onto the core from the maximum permissible height, resulting in the perforation of a maximum of 49 rods. This event is chosen because the fuel assembly is the only heavy object which is routinely suspended over the core and, if dropped, could cause damage to the core.

8.10.1.1 Calculation of Sources and Doses

The environmental consequences of this accident are dependent upon many interrelated parameters, such as: decay time between shutdown and fuel transfer, number of rods experiencing damage sufficient to release stored activity, type and quantity of activity released, safety systems (passive and active) in operation, meteorological conditions existing during the subsequent release period, etc.

The associated values assumed applicable for the above parameters are defined as follows:

1. Decay time - 4 days between shutdown and commencement of fuel transfer
2. Rods experiencing fuel damage - 49
3. Safety systems

   a. Passive - Water in the refueling cavity, plateout in the secondary containment, and the secondary containment serving as an effective holdup barrier.

   b. Active - Standby Gas Treatment System (SGTS) (initiated on high radiation)

4. Parametric values applicable to above safety systems:

   a. Water - Partition Factor of 10^4 (Ref. 7)

   b. Plateout - 4 (Ref. 7)

   c. SGTS Filter Efficiency - 99.9% For Iodine, 0% for Noble gas (Ref. 7)

5. Type and fractional activity released - as specified in Ref. 7
6. Meteorology - as specified in Section 8.4.3.1
7. Breathing Rates - 232 cc/sec
8. Volumetric leak rate from Reactor Building to environment - 100%/day
9. Release Height - 100 meters

The calculational models used to define the environmental dose effects for this event are the same as those presented in Section 8.4.3.1.

8.10.1.2 Radiological Results

As noted in table 8.14-2 the integrated man-rem exposure for this accident is between 10^{-5} and 10^{-6} of those exposures received from normal radiation background. It can, therefore, be concluded that this event is of no significance with regard to the environmental effects.

8.10.1.3 Event Probability Considerations

Spent fuel is transferred from the reactor to the fuel pool by means of the refueling hoist. Each fuel bundle to be removed is grappled in the reactor, lifted vertically until the bottom of the fuel transfer channel is cleared and then transported across the fuel pool but always under water. A brake is provided to prevent excessive drop velocity. A limit switch is provided to prevent excessive lifting velocity.

The accident postulated assumes that a spent fuel bundle drops from the maximum height above the core, falls through the water and damages not only some of its own rods upon impact, but also some rods of those bundles still in the core. If the accident were to occur, either the hoist must go out of control or one of the supporting equipment components must fail. For the hoist to go out of control the limit switch must fail to decelerate the motion of the fuel bundle. The probability of either of these events occurring would constitute a fault condition (see Section 8.15). A random failure of the cable, grapple, handle, or tie rod would be no more likely than an emergency condition and probably closer to a fault condition. Since there is less than one chance in four that such a failure could occur while the fuel is at the maximum height above the core, the combined event would be no more likely than a fault condition for each bundle transferred. Assuming that one-fourth of the core is transferred each year, the likelihood of the event becomes that of an emergency condition. (See Section 8.15.)

8.11 Class 7-Spent Fuel Accident Outside Containment, On-Site

This class applies to the movement of a spent fuel cask on a railroad flatcar from the time it leaves the reactor building until it reaches the site boundary. Spent fuel movement outside containment is always done with the fuel inside the cask. The engineering and procedural cautions pertaining to the movement of spent fuel on site essentially preclude the possibility of the cask dropping due to instability, improper attachment to the bed of the flatcar, or derailment; further, even if such a drop were to occur, it would be from a height such that the shipping cask would sustain the impact without leakage. The cask could conceivably be damaged by fire. Though fires aboard railroad cars due to bearing overheating have occurred, it is extremely unlikely in this case, considering the low velocity of the car. Fires aboard the switching engine or other forms of locomotion, themselves highly unlikely, pose no hazard to the cask.

Thus exposure to the public due to on-site movement of spent fuel outside the containment is not expected.

8.12 Class 8-Accident Initiation Events Considered In Design-Basis Evaluation In The Safety Analysis Report

These events are as described in Section 14 of the PSAR, and are briefly detailed in the following paragraphs. These include the inside-containment loss-of-coolant accident (recirculation pipe break), the outside-containment loss-of-coolant accident (steam line break), and the reactivity excursion accident (control rod drop).

The design-basis refueling accident falls in Class 6 and has been treated in Section 8.10.1.

Two non-design-basis accidents (catastrophic failures of a liquid radwaste tank and of the offgas holdup system) are also treated here, in order that Class 8 contain one event of each type which could result in significant releases to the environment.

8.12.1 Loss of Coolant Accident (LOCA)

A sudden circumferential break is assumed to occur in a recirculation line, permitting the discharge of coolant into the primary containment from both sides of the break. Concurrent with this failure, the worst single active component failure is assumed to occur; that which would produce the maximum damage to the core. This is the failure of the LPCI injection valve (in the unaffected recirculation loop) to open.

8.12.1.1 Calculation of Sources and Doses

The calculation of core heatup following a double-ended recirculation line break was predicted on a realistic basis, as suggested by the guide, by applying the results of parametric studies to the standard core heatup models currently in use (Reference 6).

The approach in the thermal-hydraulic analysis was to select realistic values for those key assumptions normally used in the Safety Analysis Report, for which very conservative estimates are made. Other assumptions, which are of lesser significance, use values as described in the PSAR or in AEC safety guides. Where parameters are not specifically mentioned, AEC assumptions, whose inherent conservatism has been well documented, have been employed.

Peak clad temperatures were calculated for a spectrum of break sizes utilizing the assumptions listed in Table 8.12-1. The percentage of perforations was conservatively calculated from the resulting temperatures.

The realistic analysis shows no heatup of fuel into the perforation range except for the double-ended recirculation pipe break, for which perforations will be 2.5% or less. The resultant radiological effects are a function of the quantity and type of activity released, natural fission product removal effects, containment leak rate, etc.

Those values assumed applicable for the above parameters of concern are identified as follows:

1. Fuel Rods damaged - 2.5% of core inventory
2. Fission products available for release - as specified in Ref. 7
3. Primary containment leak rate - 0.635%/day initial, with average 30 day release rate of 0.2%/day
4. Plateout - condensation effects - 10 (Ref. 7)
5. Partition factor suppression pool - 10^4 (Ref. 7)
6. Mixing secondary containment - 100%
7. Standby gas treatment system efficiency - 99.9% for I_2 and CH_3I and 0% for noble gases (Ref. 7)
8. Metecrology - As specified in Section 8.4.3.1
9. Breathing rate - 232 cc/sec
10. Release Height - 100 meters

The atmospheric diffusion and external gamma dose models for the time period 8 hours-30 days are the same as those presented in Section 8.4.3.1.

The thyroid inhalation dose model and 0-8 hour cloud gamma and atmospheric diffusion models are as follows:

A. <u>0-8 hr. Atmospheric Diffusion Model</u>

$$\left(\frac{\chi}{Q}\right)_{0\text{-}8hr} = \frac{1}{2\pi u \sigma_y \sigma_z} \exp\left(-\frac{z^2}{2\sigma_z^2} - \frac{y^2}{2\sigma_y^2}\right) \quad (4)$$

B. <u>0-8 hr. Cloud Gamma Dose Model</u>

$$\left(D_{c\gamma}\right)_{0\text{-}8hr} = \sum_{\substack{\text{Isotopes} \\ i=1}}^{13} \iiint_{XYZ} \left(\frac{\chi}{Q}\right)_{0\text{-}8hr} Q_i C_i f_i G_i C_1 \, dx\, dY\, dZ \quad (5)$$

where

Q_i = Activity of the i^{th} isotope released in 0-8 hrs.

$D_{c\gamma}$ = Cloud gamma dose received in 8 hours. (rem)

C. <u>Thyroid Inhalation Dose (0-8 hrs.)</u>

$$\left(D_{inh}\right)_{0\text{-}8hr} = \sum_{I\text{-}131}^{I\text{-}135} \left(\frac{\chi}{Q}\right)_{0\text{-}8hr} B_r C_I Q_i \quad (6)$$

D_{inh} = Thyroid Inhalation dose received in 8 hrs. (rem)

B_r = Breathing rate (cc/sec)

C_I = Dose Conversion factor (rem/ci)

D. Thyroid Inhalation Dose (8 hrs. - 30 days)

$$(D_{inh})_{8h\text{-}30d} = \sum_{\substack{\text{Stability} \\ J=1}}^{4} \sum_{I=131}^{I=135} X_j Q_i B_r C_I \qquad (7)$$

where

D_{inh} = Inhalation dose received between 8 hrs. and 30 days (rem)

8.12.1.2 Radiological Results

The man-rem/event is calculated in the manner previously described in Section 8.4.3.1. The resulting environmental effects for this accident are presented in Table 8.14-2. As noted the effects are orders of magnitude below these resulting from normal radiation background. It can therefore be concluded that the environmental effects as a consequence of this accident are insignificant.

8.12.1.3 Event Probability Considerations

The probability of a large break falls within the range of an Emergency Condition (See Section 8.15) based on estimates of pipe failure rates contained in the literature, and on the number of pipes that satisfy the conditions for a large break design basis accident.

The probability that an LPCI system injection valve will be unable to open when desired should also fall within the range of an Emergency Condition, based on an analysis using failure rates from references 24, 25, and 26, and considering anticipated downtimes and the interval between injection valve tests.

Since each probability is low and the outcomes are not critically interdependent, the joint probability of pipe break and injection valve failure is expected to be very low placing this event in the fault condition. (See Section 8.15.)

8.12.2 Steam Line Break Accident

The postulated accident is a sudden, complete severance of one main steam line outside the drywell with subsequent release of steam and water containing fission products to the pipe tunnel and the turbine building. Since this accident does not result in any fuel damage, the environmental effects are limited to those radiological doses which may be received as a consequence of exposure to the activity associated with the primary coolant.

8.12.2.1 Calculation of Sources and Doses

The mass of coolant released during the 4 second isolation valve closure time is 60,000 pounds. As a consequence of depressurization, approximately 30% of the released liquid will be flashed to steam. Due to the affinity of iodine for water, it is not expected that any additional iodine will be released from the remaining coolant. Therefore, the iodine released to the turbine building, as a consequence of the accident, will be proportional to that quantity of water flashed to steam. Due to the condensation, plateout will occur on surfaces with which the steam will come in contact prior to release to the general environment. It is assumed that an iodine removal factor of two is applicable to these effects. The iodine activity associated with the coolant flashed to steam is based on a noble gas activity of 25,000 μCi/sec of a diffusion mix as measured after a 30-minute holdup.

8.12.2.2 Radiological Results

The environmental effects for this accident are presented in Table 8.14-2. Due to the type of activity released, the primary dose effect from this accident is inhalation thyroid exposure. As noted in Table 8.14-2, the cumulative thyroid exposure is approximately 6 orders of magnitude below the normal whole body background. It can therefore be concluded that the environmental effects as a consequence of this accident are insignificant.

8.12.2.3 Event Probability Considerations

The Design Basis Main Steam Line Rupture Accident postulates complete severance of one of the main steam lines while the reactor is at full power followed by total isolation of the break from the reactor within four seconds. The probability of this event is essentially the probability of the severance. Based upon estimates of pipe failure rates contained in the literature (Ref. 8) and considering the number of locations where the rupture could occur in the Main Steam System, the probability of pipe severence should be well within the "emergency category" (See Section 8.15.)

8.12.3 Control Rod Drop Accident (CRDA)

The postulated accident is a reactivity excursion caused by accidental removal of a control rod from the core at a rate more rapid than can be achieved by the use of the control rod drive mechanism. In the CRDA, a fully inserted control rod is assumed to fall out of the core after becoming disconnected from its drive and after the drive has been removed to the fully withdrawn position. The design of the control rod velocity limiter limits the free fall velocity to 3 ft/sec. Based on this velocity and assuming the reactor is at full power, the maximum rod worth is approximately 1%, resulting in the perforation of less than 10 rods; a high probability exists that none will actually fail.

8.12.3.1 Calculation of Sources and Doses

In addition to the assumed failure of 10 rods, the radiological effects are also based on rated steam and recirculation flow, an iodine carry-over fraction of 1%, and a main steam line isolation valve closure time of 4 seconds.

In addition to isolating the main steam line (MSL), the MSL radiation monitors also isolate the normal offgas system thereby isolating the activity between the MSL isolation valves and the offgas isolation valves. The primary source of leakage from the system will therefore be via the turbine gland seals and will be due to changes in environmental pressure with respect to the turbine condenser.

The activity airborne in the condenser is a function of the partition factor, volume of air and water, and chemical species of the fission product activity. The values associated with these parameters are: a partition factor of 10^4 for iodine, a condenser plus turbine free volume of 103,000 ft^3 and a condensate volume of 7,680 ft^3.

8.12.3.2 Radiological Results

As noted in Table 8.14-2, the radiological exposures for this accident are orders of magnitude below those effects received from normal background.

It can therefore be concluded that environmental effects as a consequence of this accident are insignificant.

8.12.3.3 Event Probability Considerations

In order for a rod to drop from the core, it must first become detached from the drive, remain lodged in position while the drive is withdrawn from the core, and then, while the drive is still withdrawn, become dislodged and fall. This is a complex series of events, since there are many possible actions (or inactions) that are interrelated, but this is offset by the many annunciators and procedures that are provided to avoid such an event. The rods are tested daily providing many opportunities for the rod to become uncoupled, but many opportunities for detection as well.

Actual experience has been good. However, conservative judgement indicates that this event should be assigned as an emergency condition. (See Section 8.15.)

8.12.4 Liquid Radwaste Tank Accident (LRTA)

The low level liquid radwaste tanks are unpressurized accumulators. Although the tanks are not pressure vessels, those containing high activity inventories are designed in accordance with appropriate ASME codes to AEC seismic Class I criteria. These tanks are surrounded by a containment basin sized to contain more than twice the total capacity of all tanks in the Radwaste Building. Should a tank fail and thereby release its contents, the release would be contained within the basin. The probability of an uncontrolled catastrophic release to the environs from a radwaste tank failure is so low as to classify it in the fault category (See Section 8.15). It is not considered an event for consideration here.

8.12.5 Offgas System Accident (OGSA)

The postulated accident for this category is an ignition of radiolytic hydrogen and oxygen in the offgas holdup volume, followed by a detonation of sufficient impulse to rupture the holdup pipe. The activity released to the environment would therefore be that activity contained within the holdup volume.

8.12.5.1 Calculation of Sources and Doses

The source terms applicable to the base input to the system as well as the parameters appropriate to release and dispersion are as follows:

1. Base Input - 143,000 μCi/sec of a 2 minute old diffusion mix which after 30 minutes holdup is equivalent to 25,000 μCi/sec.
2. Release of 100% noble gas activity contained in the pipe and 10% of the Iodine, with subsequent removal of 50% of the released iodine by plateout and other natural removal mechanisms.
3. Height of release - 30 meters.
4. Meteorology - as specified in Section 8.4.3.1.

The mathematical models used to evaluate the whole body dose effects are the same as those presented in Section 8.12.1.1.

8.12.5.2 Radiological Results

The radiological exposures received as a consequence of this hypothetical accident are presented in Table 8.14-2. As noted, the environmental exposures are orders of magnitude below those exposures received from normal background.

It can therefore be concluded that the environmental exposures which could theoretically be received as a consequence of this accident are of negligible importance in comparison to the actual exposures received from normal background.

8.12.5.3 Event Probability Considerations

The noble gases generated in the nuclear process are allowed to decay for approximately 30 minutes before discharging up the stack. The small amount of noble gases are accompanied by a mixture of hydrogen and oxygen, also generated in the nuclear process. This hydrogen-oxygen mixture is subject to ignition and theoretically could detonate under proper conditions.

If the mixture ignites, it burns rapidly and forces a substantial portion of the noble gas inventory out the stack with less than normal decay time. Ignition has occurred in operating reactors without H_2-O_2 recombiners at a rate that should be classified as an upset condition.

Detonation is far less likely because it can occur only under rather ideal conditions of pressure, mixture, and piping geometry. A rupture disc is installed in the holdup pipe to protect the pipe from rupture. Ignitions and most detonations would not create a high enough pressure to rupture the disc. A detonation of such force as to rupture the disc or the pipe is expected to have a low probability, of the order of the low end of the emergency category in plants without H_2-O_2 recombiners.

TABLE 8.12-1

ASSUMPTIONS USED IN THERMAL-HYDRAULIC CALCULATIONS FOR LOCA

	Best Estimate	AEC Assumptions
Metal-Water Reaction	≈Baker x 0.5	Baker
Steam Cooling	Included	No Credit
Blowdown Flow Rate	≈Moody x 0.7	Moody
Core Spray Wetting Time	$\bar{t}$	$\bar{t}$ + 60 sec
Duration of Nucleate Boiling	Transient Data	Steady-State Data
Lower Plenum Flashing Heat Transfer	Rewetting Data	Groeneveld Correlation

8.13 Reactor Material Transportation

The generation of electrical energy in a nuclear power plant requires the periodic shipment of new fuel assemblies to the plant and spent fuel assemblies and low level radioactive wastes from the plant. These shipments are made in compliance with the USAEC and U. S. Department of Transportation (DOT) regulations pertaining to the proper packaging and transportation of radioactive materials. Transportation and the environmental effects resulting from this transportation are discussed in detail in Section 3.10.

8.14 Radiological Impact Summary

The total man-rem exposures for the population out to 50 miles from the plant, for the various conditions evaluated in the nuclear environmental effects determination, are summarized in Table 8.14-1. This tabulation includes the man-rem results for normal plant operation considerations, transportation considerations, various abnormal conditions, and for postulated design basis accident conditions. The radiological impact of the BSEP is discussed in detail in Section 3.2.2.

TABLE 8.14-1

SUMMARY OF POPULATION EXPOSURE FROM NATURAL AND MAN-MADE BACKGROUND COMPARED WITH NUCLEAR RADIOLOGICAL EFFECTS

	Cumulative Man-Rem[a] Versus Distance					Integrated Thyroid-Rem
Annular Distance (miles)	10	20	30	40	50	50
Population (thousands)	33.4	147.8	218.8	250.3	303.1	303.1
Radiation Background						
Natural	4630	20500	30600	35000	42400	(42400)
Man-Made	1990	8802	13110	15000	18168	(18168)
Normal Reactor Operation						
Gaseous	0.337	0.818	0.976	1.01	1.06	NA
Liquid	NA	NA	NA	NA	10	NA
Solid	Negl	Negl	Negl	Negl	Negl	NA
Direct Shine	Negl	Negl	Negl	Negl	Negl	NA
Transportation (b)						
Normal						
New Fuel	Negl	Negl	Negl	Negl	Negl	NA
Spent Fuel	Negl	Negl	Negl	Negl	Negl	NA
Solid Waste	Negl	Negl	Negl	Negl	Negl	NA
Accident						
Spent Fuel	Negl	Negl	Negl	Negl	Negl	NA

(a) Man-Rem/year for normal reactor operation; Man-Rem/event for transportation.

(b) Population affected is that population average along transportation route.

NOTE: "NA" means not applicable; "Negl." means negligible, i.e., less than 0.01 man-rem.

TABLE 8.14-2

SUMMARY OF POPULATION EXPOSURE FROM NATURAL AND MAN-MADE BACKGROUND COMPARED WITH NUCLEAR RADIOLOGICAL EFFECTS

		Cumulative Man-Rem[a] Versus Distance					Integrated Thyroid-Rem
Annular Distance (miles)		10	20	30	40	50	50
Radiation Background							
Natural		4630	20500	30600	35000	42400	(42400)
Man-Made		1990	8802	13110	15000	18168	(18168)
Postulated Accidents and Occurrences							
Class 2		0.12	0.17	0.18	0.18	0.18	1.5
Class 3	Liquid	NA	NA	NA	NA	NA	NA
	Gaseous	0.029	0.041	0.043	0.043	0.043	Negl
Class 4		NA	NA	NA	NA	NA	NA
Class 5		NA	NA	NA	NA	NA	NA
Class 6	Refueling	0.11	0.26	0.32	0.33	0.35	Negl
Class 7		Negl	Negl	Negl	Negl	Negl	Negl
Class 8	LOCA	Negl	0.01	0.013	0.013	0.014	0.01
	SLBA	Negl	Negl	Negl	Negl	Negl	0.04
	CRDA	Negl	Negl	Negl	Negl	Negl	Negl
	OGSA	0.019	0.043	0.046	0.047	0.048	Negl

(a) Man-rem/year for radiation background; man-rem/event for postulated accidents and occurrences.

NOTE: "NA" means not applicable; "Negl." means negligible, i.e., less than 0.01 man-rem.

8.15 Probability In Perspective

8.15.1 Probabilistic Considerations

In Reference 2, the Commission requires that "in the consideration of the environmental risks due to postulated accidents, the probabilities of their occurrence must.... be taken into account."

Consideration of the yearly probabilities of abnormal conditions is, of course, entirely necessary to an assessment of environmental risk for the obvious reason that such conditions are not expected to occur as often as once a year or even once in a plant lifetime. Comparison of accident exposures with the man-rems per year fully expected from natural sources and normal operation of the plant requires that the former be weighted by their annual frequencies in order to predict an average annual effect.

It will be noted, however, that the foregoing analyses have concentrated principally on prediction of exposures given the occurrence of the accident; probabilities of occurrence of each incident have been calculated and grouped into broad categories explained below, but no attempt has been made to calculate man-rems per year for each class nor to sum these figures to a plant total. The reason for this treatment is two-fold:

(1) It emphasizes the fact that radiological exposures due to the accidents are in fact acceptably low in themselves, without additionally complicating the issue with probabilities;

(2) The "classes" of accidents tend to be less homogeneous in their probabilities than in their releases; thus, to propose a two-significant figure probability as "typical" of a class would be not only inaccurate but misleading as well.

8.15.2 Probability Categories

To alleviate the problem of inhomogeneity mentioned above, the probability of occurrence of each "class" of accidents and incidents has been placed in a broad probability category about two decades wide. The system chosen for this categorization is derived from Section III of the ASME Boiler and Pressure Vessel Code (15). These classes have been used in the design safety analyses included in the safety anaysis reports for other plants. A brief semi-quantitative description of each class is given below.

8.15.2.1 Normal Condition ($p \simeq 1$)

A normal condition is any planned and scheduled event that is the result of deliberate plant operation according to prescribed procedures.

8.15.2.2 Upset Condition ($1 > P > 2.5 \times 10^{-3}$)

An upset condition is a deviation from normal conditions that has a moderate probability of occuring during a 40 - year plant lifetime. These conditions typically do not preclude subsequent plant operation.

8.15.2.3 Emergency Condition ($2.5 \times 10^{-3} > P > 2.5 \times 10^{-5}$)

An emergency condition is a deviation from normal plant operation that has a low probability of occurring during a 40-year plant lifetime. Emergency condition events are typified by transients caused by a multiple-valve blowdown of the reactor vessel or a pipe rupture of an auxiliary system.

8.15.2.4 Fault Condition ($2.5 \times 10^{-5} > P > 2.5 \times 10^{-8}$)

A fault condition is a deviation from normal conditions that has an extremely low probability of occurring during a 40-year plant lifetime. These postulated events include, but are not limited to, the most drastic that must be designed against (the limiting design bases).

8.15.3 Basis for Probability Estimation

The occurrences described in this analysis are of such a nature that their frequencies cannot be derived from historical data. The nuclear industry is too young to have accumulated much information even on the most frequent events. The events with the more serious consequences are not likely to occur and historical data is not possible.

As a result, probabilities on most events must be inferred from our knowledge of other events. Table 8.15-1 lists event descriptions and their associated probabilities, as reported in the literature. These findings, reinforced by individual modeling studies of the postulated events specified in these analyses, lead to the assignment of each occurrence to one of the four probability categories described in Section 8.15.2. As a point of reference, Table 8.15-2 is included to give some mortality statistics for the U.S.A.

It must be emphasized that the probability assignment is one of judgement and can never be proven. However, the broad classification of probability ranges and the assignment of each event to a category does quantify the best that is known about the relative frequency of occurrence of many events, and is thus informative and useful on a comparative basis.

TABLE 8.15-1

TABLE OF EVENT PROBABILITIES

Event	Probability	Reference
Reactivity Fault at Power	10^{-2}/year	16
Emergency Injection System Failure	10^{-2}/demand	17
Reactor Bldg. Atmosphere Washing and Cooling System Failure	10^{-2}/demand	17
Core Spray System Failure	2.1×10^{-3} to 5.2×10^{-2}/demand	16
Operator Error	10^{-2} to 10^{-3}/operation	18
Diesel Generator Unavailability	0.004/years/year	19
Loss of Load	$>10^{-3}$/year	20
Excessive Load Increase	$>10^{-3}$/year	20
Loss of One Feedwater Pump	$>10^{-3}$/year	20
Loss of Flow (one pump)	$>10^{-3}$/year	20
Primary System Pipe Rupture	10^{-3}/year	17
Failure to Isolate Containment	10^{-3}/year	19
Core-Flooding System Failure	10^{-3}/demand	17
Operator Error	10^{-2} to 10^{-4}/trial	5
Reactivity Fault at Startup	10^{-4}/year	16
Instrument Part Rupture	5×10^{-4}/year	16
Pipe Severance Rate	6.3×10^{-4}/year/plant	21
Reactor Shutdown System Failures	10^{-5}/demand	17
Failure to Trip Reactor	7×10^{-5}/demand	19
Emergency Power Unavailability	2×10^{-5}/years/year	19
Large Aircraft Crashing into Reactor 5 mi. from Airport	2.4×10^{-6}/year	21
Failure to Trip Reactor	2×10^{-7}/demand	20
Truck Accident Rate (severe)	5×10^{-7}/mile	derived from 18,22

TABLE 8.15-2

SOME U.S. ACCIDENTAL DEATH STATISTICS FOR 1966 (Ref. 23)

Accident	Total Deaths	Probability Death/Person/Yr
Motor Vehicle	53,041	2.7×10^{-4}
Falls	20,066	1.0×10^{-4}
Fire and explosion	8,084	4.0×10^{-5}
Drowning	5,687	2.8×10^{-5}
Firearms	2,558	1.3×10^{-5}
Poisoning (solids and liquids)	2,283	1.1×10^{-5}
Cataclysm	155	8.0×10^{-7}
Lighting	110	5.5×10^{-7}

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9.0 Benefit-Cost Analysis

Carolina Power & Light Company has played an important part in the social and economic development of North Carolina and South Carolina for more than 63 years. The Company's commitment to environmental concerns has been reflected in the design and construction of the Brunswick Steam Electric Plant. The Company recognizes its obligations not only to supply the electrical power required for public health, safety, and comfort, but to provide the opportunity for enhancing the quality of life for its customers through responsible environmental management. CP&L has adopted methods to ensure that major decisions on generation capacity will provide additional benefits other than economic.

9.1 Introduction

In the decision making process required for selection and design of a nuclear power plant, numerous parameters must be evaluated and compared with feasible alternatives in order to arrive at a completed system design. The term generally applied to this type of evaluation is a Benefit-Cost Analysis. In the past, these types of analyses have been performed during the decision making process and the final design was submitted as a part of the licensing request. These analyses were generally not included, however, as a separate documentation in the license and permit applications for nuclear units. Revised Appendix D of 10 CFR 50 now requires that these analyses be included as a part of all Environmental Reports. In response to this requirement, Carolina Power & Light Company has prepared this Benefit-Cost Analysis, which describes the major system decisions which were made in arriving at the plant design. The analysis includes a description of the alternatives that were evaluated in weighing various environmental costs compared to the benefits accrued from the Brunswick Steam Electric Plant.

Benefit-cost analyses, in the past, have been conducted by economists as a tool for governmental decision making, whereby proposed projects could be compared on the basis of the dollar benefit per dollar cost. Various philosophies and approaches have been applied to benefit-cost problems encountered to date and no real uniformity exists in the techniques applied by various individuals in specific cases. With the increasing commitment of CP&L and other utilities to preservation and enhancement of environmental values, the need has come for a formalized benefit-cost technique. In the past, a formalized technique has not been applied extensively to the decisions relative to power plants and their environmental impact, although most of the more important factors were weighed in the decision making process. When Federal and/or State permits were required, the Company obtained these approvals.

In view of the above mentioned need for a formalized benefit-cost accounting technique, CP&L has prepared this analysis which addresses those major considerations which were evaluated. In preparing the Benefit-Cost Analysis, an effort was made to present the results of the analyses which were deemed to be of the greatest general interest. Thus, the emphasis of the analyses here is upon the benefits and effects of the proposed units on various environmental values.

In May, 1972, the Atomic Energy Commission issued a "Guide for Submission of Information on Costs and Benefits of Environmentally Related Alternative Designs for Defined Classes of Completed and Partially Completed Nuclear Facilities." Where possible, the information provided in the BSEP benefit-cost analysis has been incorporated in the format suggested by this guide. In evaluating the benefit-cost analysis, it is necessary to establish a proper time perspective and consider this when evaluating alternatives. During construction of the Brunswick Plant, systems have come into existence which were not available at the time when decisions were required for timely construction.

For example, in considering alternative cooling systems at the time of the plant design, saltwater cooling towers did not have guaranteed drift losses low enough to assure that no serious damage would result to surrounding vegetation. At the present time, however, drift losses are projected at lower amounts, and for a new plant, such a cooling system could be considered more favorably for a plant using cooling water of high salinity if actual experience verifies the warranted lower drift factors. In the interest of providing a complete benefit-cost analysis, such systems--although not feasible at the time of initial design--have been evaluated.

Because of the diverse approaches of Benefit-Cost Analyses, no uniform technique has evolved. In view of this lack of consensus, some general comments are appropriate to further develop an understanding of the philosophy of the benefit-cost analysis for this report. The basic approach to most benefit-cost analyses is to evaluate the benefits and costs of the project in quantitative monetary terms wherever possible so that a ratio of dollar benefit to dollar cost can be made. Alternatives can then be compared and selected on the basis of maximum benefit to cost ratio. While this type of approach is amenable to certain decision making fields, it is not responsive to some social and environmental concerns which are important to the Company and the residents of its service area.

In order to include an evaluation of important and relevant factors which are not amenable to quantification in monetary terms, this report approaches the benefit-cost analysis using an integrated format whereby benefits and costs are quantified wherever possible using a multidimensional format. When a specified benefit or cost can be feasibly measured in dollars, such as electrical output or capital and operating costs, then these specified benefits or costs are given dollar dimensions. Many of the parameters of interest, however, are of a subjective nature and attempts to quantify these factors in monetary terms would reflect misleading values. Thus in the case of some environmental effects and social concerns, the analyses have been based on developing ranges of values for the parameters in the dimensions that best describe the particular effect. This type of multi-dimensional approach affords a realistic comparison of benefits and costs in that it does not force subjective comparison of parameters incapable of correlation in the present state of the art, but rather allows these factors to be considered in their most meaningful dimension.

Some perspective is now possible on the problems of benefit-cost analyses. The actual environmental cost of a project will be its net environmental impact, since an environmental impact may be beneficial as well as adverse. Yet, as explained previously, certain beneficial and adverse impacts are simply not amenable to quantification. Thus, as a simplified example, determining the net environmental impact of a benefit such as reduced thermal loading and a concomitant adverse impact such as decrease of wildlife habitat would require an intermediate conversion requiring subjective correlation of the two impacts. It is the opinion of the Company that such subjective evaluation for the sole purpose of arriving at a numerical correlation would quite possibly result in misleading values and would defeat the true intent of the National Environmental Policy Act (NEPA). For this reason, the multidimensional approach has been retained and, in selecting various systems for the plant, the environmental impact of the systems has been compared with the impact of alternative systems. So that the net impact of the plant can be readily viewed, Subsection 9.8 summarizes the benefits and costs which the selected design will achieve.

9.2 Alternatives to the Plant

Because of its legal, social, and moral responsibility to provide the electrical power demanded by its consumers, Carolina Power & Light Company must continually forecast the energy needs of its consumers. Long-range planning studies indicated that during the years 1974-1975 additional capacity would be required in order to meet the electrical demands of CP&L's customers. A decision was required as to which of several alternatives should be adopted to provide this additional power. The alternatives considered were:

1. To import or purchase the power from producers in or near the area where the need will exist.

2. To expand presently available operating units within the Company.

3. To construct new generating units.

The first alternative, purchase of power, is a method often employed by utilities on a temporary basis to fill power demands until additional generating units are placed in service. However, the opportunity for long-term purchases of over 1600 megawatts is not available to CP&L, since no neighboring utilities of CP&L are building or planning to build generation capacity of sufficient amounts to provide this power to CP&L on a firm basis. Neighboring utilities face a similar situation in that they, too, are confronted with long lead times for construction of facilities, high rates of load growth and a need to increase reserve capacity margins.

Carolina Power & Light Company serves consumers in North and South Carolina and shares with Virginia Electric and Power Company (VEPCO), South Carolina Electric & Gas and Duke Power Company the responsibility for providing the bulk power supply for this area. Subsections 4.1 and 4.2 show in detail the power supply situation of the VACAR subregion during the period 1974-1976. Further discussion of the purchase power alternative is contained in Amendment No. 1, Question I.1.

A second alternative, expansion of presently operating units, was considered but dismissed as impractical because of technical, economic, and certain social consequences. Plants are designed as generating units with all the interrelated equipment such as steam generators and turbines of a compatible size. It is not technically feasible to increase the capacity of existing units by the addition of equipment.

The third alternative, construction of new units, was the only practical means of providing the additional generation. It has the highest benefit-cost ratio since it will incorporate the latest technological advances and will include current methods for minimizing environmental impacts in all areas. This alternative will allow the Company to maintain or improve reliability of its generation system.

In order to build new generating capacity, a decision was required as to what method of generation should be used. Four types of generation were considered:

1. Hydroelectric Generation
2. Gas Turbine Generation
3. Fossil Generation
4. Nuclear Generation

Load studies showed that firm base load power was required for the period 1974-1975. A careful examination of the water resources of the area disclosed that no suitable hydroelectric resources existed for the continuous base load operation required; therefore, the hydroelectric generation alternative was abandoned. Gas turbines are useful in providing peak load service, but are not suitable for continuous base load operation. Because of the quantity of base load generation required, gas turbines were eliminated as a feasible alternative. Both the fossil steam and the nuclear steam generating alternatives were given careful scrutiny.

An economic analysis was conducted to compare the capital and operating costs of nuclear and fossil units. The results of the studies, which projected the operation of the CP&L system for a number of years in the future, indicated an economical advantage in favor of nuclear units.

From an environmental standpoint, the nuclear units were favored because of cleaner operation, more pleasing aesthetical appearance, and lack of environmental costs associated with air pollution. Therefore, for economical and environmental reasons, CP&L elected to construct a nuclear plant to serve consumer requirements.

9.3 Site Selection

9.3.1 General

Selection of a site is based on the size and location of the generating facility required to meet load projections. Site selection is a complex process involving analysis and optimization of many environmental and economic factors. The environmental factors include evaluation of the impact of the proposed generating plant on the site area, land use, wildlife habitat, and aquatic ecology. Involved in the consideration of existing land use are the present and projected area population density, agricultural activities, educational, social, and medical institutions, parks and recreational areas, churches, cemeteries, forest, wetlands, historical monuments and areas of historical interest, and other lands dedicated to public use. Consideration of the wildlife habitat includes identification of animal species, feeding areas, and determination of any areas essential to the survival of a species in the general area. Evaluation of the aquatic ecology involves identification of fish species, spawing areas, impact on other organisms, and thermal effects of the condenser cooling system. In addition, requirements of governmental agencies involved in environmental protection are evaluated in consideration of potential sites.

Economic considerations include evaluation of the site meteorology, geology, seismology, hydrology, soils, and site development costs. The quantity and quality of water available for condenser cooling are determined. The adequacy of transportation facilities is evaluated, and interaction with airports and other industries is examined. The types and costs of fuels available to the site are determined, and an assessment is made of the transmission requirements. Before a site is finally selected, all factors are carefully weighed to yield an overall measure of each site.

The initial investigations and evaluations that were conducted to determine potentially available sites of the size needed to support the additional generation required, narrowed the selection to four potentially available sites. These four sites were a man-made lake site, a river site, and two estuarine sites.

9.3.2 Location and Access

The Brunswick Site is located in the southeastern portion of North Carolina in Brunswick County, approximately 135 miles SSE of Raleigh, North Carolina, 175 miles due east of Columbia, South Carolina, and 150 miles northeast of Charleston, South Carolina. This site 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. The general area of the Brunswick Site is served by N. C. Highway No. 133; rail access is by the Leland Spur off the Seaboard Coast Line Railroad.

Site A, the alternate estuarine site, is located on the lower Neuse River east of New Bern, North Carolina. Access for this site would have been by

N. C. Highway 55 and railroad access would have been by a spur off Norfolk-Southern Railway.

Alternate Site B, a river site, is located on the Cape Fear River northwest of Wilmington, North Carolina. U. S. Highway 421 provides access to this site with rail access off the Seaboard Coast Line Railroad.

Alternate Site C is located on a hydroelectric impoundment in central North Carolina. Road access for this site would have been by N. C. Highway 731. Rail access would have been off the Norfolk-Southern Railway.

9.3.3 Geology

The Brunswick Plant is located in the North Carolina Coastal Plain, and the site involves several local geological formations. These are the surficial deposits of the Pamlico Terrace formation, the Yorktown formation, the Oligocene sediments, the Castle Hayne, and Peedee formations. The Pamlico Terrace formation consists chiefly of fine-grained argillaceous sands and sandy clays. The thickness of the deposit varies from 5 to 20 feet. The Yorktown formation is approximately 65 feet thick and consists of an upper sandy clay and a lower well compacted sand. The Oligocene is approximately 35 feet thick and consists of sand, clay, and lenses of limestone. It begins at a depth of approximately 80 feet below the surface of the ground and continues to a depth of approximately 115 feet.

The Castle Hayne limestone, which is approximately 115 feet thick, begins at a depth of approximately 114 feet below the surface and continues to a depth of approximately 230 feet. The upper half of the Castle Hayne is composed of well consolidated shell limestone that varies from blue gray to tan or brown in color. The lower half consists of light to dark gray sandstone that contains varying amounts of clay. It is well compacted to semi-consolidated.

The Peedee formation begins at a depth of approximately 230 feet below the surface and continues to a depth of approximately 600 feet. Older Cretaceous rocks rest on the crystalline basement at a depth of approximately 1500 feet.

9.3.3.1 Site A

The geological formations in the area of Alternate Site A consist of surficial deposits that may belong to the Pamlico Terrace formation of Pleistocene Age, the Yorktown formation of late Miocene Age, the Pungo River formation of middle Miocene Age, and the Castle Hayne limestone of Eocene Age.

Beneath these are sediments of upper Cretaceous Age and lower Cretaceous Age, the latter resting on a crystalline basal complex, none of which would have had a direct bearing on this site.

The Yorktown formation of upper Miocene Age, which lies immediately beneath the Pamlico Terrace or surficial deposits, is the most important rock unit in the region of this site with reference to foundations. In the area explored by drilling, the Yorktown formation apparently varies from about 100 to 120 feet in thickness. Immediately beneath the Yorktown formation is the Pungo River formation of middle Miocene Age. Although the Pungo River formation would not have been used directly as a foundation unit, it would have made an excellent support for the overlying Yorktown formation and any load it may have been required to support.

9.3.3.2 Site B

There are several formations in the Alternate Site B area, ranging in age from late Cretaceous to recent. Overlying the Tuscaloosa formation is the Black Creek formation, which crops out in western Lenoir and Duplin Counties but which is buried coastward beneath the Peedee formation. The Black Creek and Peedee are also of late Cretaceous Age and together with the Tuscaloosa formation, represent a unit of sand and clay, varying greatly in thickness and in degree of assortment of mineral constituents. Overlying the Peedee formation is the Castle Hayne limestone of Eocene Age. In the eastern part of the area, the Yorktown formation of late Miocene Age overlies the Castle Hayne limestone. At the surface throughout the area is a layer of sand and sandy clay of Pleistocene Age.

9.3.3.3 Site C

Alternate Site C is located in the geological division of North Carolina known as the Carolina Slate Belt and in the subdivision of the Carolina Slate Belt containing rocks classed as bedded argillites (volcanic slate). The rocks of the site area are primarily bedded volcanic slate, containing lenses of acid and basic fragmental and flow material. The largest masses of intrusive rocks in the Carolina Slate Belt are granite plutons; however, none have been mapped in the vicinity of the site. Much of the slate is massive and jointed, showing little effects of metamorphism, while in other places it has been strongly metamorphosed and shows a well defined slaty cleavage. They are only gently folded and contain very few faults, all of which were formed approximately 180 million years ago at the end of the Paleozoic era and appear to have been inactive during that time. The Gold Hill fault is the only major fault along the western border of the Carolina Slate Belt. This fault is a thrust-fault that was formed no more recently than the Appalachian Mountain building at the end of the Paleozoic era, and has been inactive for 180 million years. These rocks make excellent foundations for the lake and any other structures that may be needed in the area.

Geologically, all four sites appear to be satisfactory for safe construction and operation of a nuclear plant.

9.3.4 Seismology

North Carolina is not considered to be seismically active.

The significant earthquake activity in North Carolina and the surrounding areas usually can be related to known faulting or other documented geologic features. Most of the reported earthquakes have been concentrated in four rather distinct areas. These are:

1. Charleston, South Carolina, area
2. Union County, South Carolina, area
3. Giles County, Virginia, area
4. Richmond-Charlottesville, Virginia, area

There have been 69 shocks with maximum intensities of V or greater reported within about 250 miles of the four sites since the first historical account at the end of the 18th Century. Within approximately 100 miles of the four sites, there have been only three shocks reported. Two of these were shocks near the Virginia-North Carolina border; neither exceeded Intensity V. The third, with an Intensity of VI, occurred in South Carolina.

The Coastal Plain area of North Carolina, containing the Brunswick site and Alternate Sites A and B is relatively free of earthquake activity. Although on the order of 100 earthquakes were recorded within the borders of North Carolina, only approximately one-half of these earthquakes had their epicenters in the state, and only eight of these epicenters were recorded in the Coastal Plain. Six of these were reported as occurring in the Cape Lookout-Wilmington-Southport area, of which five were near Wilmington and Southport. On the Modified Mercalli Scale, only one had an estimated or established intensity as great as V.

Alternate Site C lies in the Piedmont Province of North Carolina. Regionally, the Piedmont is characterized by a gently rolling topography resulting from extensive erosion of the underlying bedrock. There is no geologic evidence of surface faulting within the Piedmont region or adjacent geologic regions that is even remotely related to the earthquakes that have occurred in historic times. It is concluded that there are no identifiable active faults that could be expected to produce surface displacement anywhere within the Piedmont geologic region of the site.

It does not appear likely that any of the four sites would be subjected to significant earthquake ground motion during the life of the proposed facility.

9.3.5 Land Use

Determination of acceptability of a site for future electric generating stations must consider the land use requirements of the region or community in which it is located and area which it serves in addition to the energy, technological, economic and other environmental needs. The principal interest that must be served is supplying energy needs of a region in a manner that creates the greatest overall benefit and minimum overall detrimental impact for that entire region. The anticipated as well as the current demographic composition of the area must also be considered. The site should also be assessed for its impact upon natural resources, such as historical, archaeological, and recreational characteristics.

The region within a 50-mile radius of the Brunswick site is predominantly rural, with less than half the land devoted to farming. The remainder of the region consists of undeveloped, non-utilized marshes and woodlands. The only large population center within 50 miles of the site is Wilmington, 20 miles north-by-northeast of the site, with a 1970 population of 46,169. The Wilmington population is estimated to be 90,000 in 1996, based upon Southern Bell Telephone and Telegraph Company data for exchanges in the area, as well as from county projections of the North Carolina Department of Natural and Economic Resources (formerly the Department of Conservation and Development). Within a five-mile radius of the site, the only population concentration is in Southport, North Carolina, for which the 1970 population was 2,220 and the 1996 estimate is 4,430.

A new home building development, 7 miles north-by-northwest of the site, which has a 1970 population of 92, is projected to reach its capacity by 1996. 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 percent of the land area is under cultivation, most farming is in the southwestern section. The nearest dairy farm is approximately 11 miles NNE from the site.

Industry in the Cape Fear region is centered on the fertilizer, chemical and synthetic fiber industries. Representative companies include Armour, Mobil, Royster, Borden, Hercules, DuPont and W. R. Grace. Their plants are located in the vicinity of Navassa, which is 22 miles north of the site, and upstream of Wilmington on the Cape Fear and the northeast Cape Fear Rivers. Sunny Point Terminal and the Wilmington industries rely heavily upon sea transport. The presence of the plant will have no effect on sea transportation. Two bridges have been constructed where the discharge canal intersects state highway 87 and 211 in order to maintain existing surface transportation.

The lower Cape Fear area in Brunswick and New Hanover Counties is a popular recreational area. The waterways are used by fishing, motor, and sailing boats. Both freshwater and ocean fishing are popular; however, sewage pollution in the Cape Fear River from upstream municipalities prevents the harvesting of oysters and clams. The ocean beaches are well developed and camping facilities and several modern hotels provide good accommodations. During the summer months the population of the beaches within 20 miles of the site increases by about 10,000 people. During the season, duck hunting takes place in the salt marshes.

Sunny Point Army Terminal, which is located some 4-1/2 miles north of the site, tran-ships munitions by transferring them from trucks and railroad cars to ocean-going vessels. Ships are loaded at three separate piers, which are located approximately 3400 feet apart to prevent an explosion at one pier from inducing explosions at adjacent piers.

Exclusion boundaries have been established by the Corps of Engineers for the Sunny Point operation. The furthest exclusion distance in the direction of the Brunswick Plant is the K-70 line. The K-70 boundary is based upon damage estimates of less than 0.1 percent of the replacement cost of frame dwellings, and upon the effects of an explosion of the largest concentration of explosives allowed at this site (7 million pounds of high explosives).

The interaction between Brunswick Steam Electric Plant and Sunny Point Terminal has been thoroughly investigated by CP&L, the AEC, and their consultants and was found to be inconsequential.

The plant vicinity has been investigated in relation to the National Historical Preservation Act of 1966. There are several historical markers located in Southport, North Carolina, along the local beaches and approximately 4.5 miles north of the plant in the vicinity of the ruins of Old

Brunswick Town, an early settlement (founded in 1725) on the Cape Fear River. There are two historical sites on this area that are in the Federal Register of Historic Places: The ruins of St. Phillips Church which is located at Old Brunswick Town approximately 4.5 miles north of the plant, and the remnants of Fort Fisher located on the beach approximately 5 miles east of the plant. Construction and operation of the plant will have no effect on these areas of historical interest.

Archaeological investigations have been made in the vicinity of Old Brunswick Town and in the vicinity of Fort Fisher. The plant will have no effect on these archaeological activities.

Land use characteristics of Alternate Sites A, B, and C were not evaluated beyond preliminary investigations since other adverse impacts precluded further evaluation of these sites as feasible alternatives for the size units needed to meet projected load demands. During the preliminary investigation, however, it was determined that the number of people which would be affected by developing a steam electric power plant at Alternate Site C was substantially greater than the Brunswick Site, or the other alternatives.

9.3.6 Hydrological Considerations

Two aspects of the surface water hydrology were considered in the area of the Brunswick Site: the normal hydrology of the Cape Fear River and estuary tides and the hydrology associated with severe weather conditions. The lower section of the Cape Fear River near the site is characterized by strong semidiurnal tides with a range of about four feet. Salinity data available from the North Carolina Department of Water and Air Resources and the United States Geological Survey were supplemented by salinity data collected at monthly intervals over a period of one year from March of 1969 through February of 1970. Considering the stratification of salinity, only on infrequent occasions does the salinity at the bottom in the vicinity of the plant intake canal fall below about half-strength seawater. The net flow of water past the plant intake toward the ocean, which is maintained by fresh water input and vertical mixing of the ocean water, is considerably greater than the flow that would exist if only fresh water were moving toward the ocean in the upper layer. Net flow toward the ocean in the upper layer is approximately fifteen times the fresh water input during dry periods. Under a low flow condition of 1400 cfs fresh water input, there would be a net flow toward the ocean in the upper layer of approximately 21,000 cfs. The average tidal flows in the Cape Fear Estuary are estimated to be from 200,000 cfs to 280,000 cfs.

The Brunswick Plant, employs a once-through method of cooling by withdrawing water from the lower Cape Fear River, and discharging to the Atlantic Ocean, some 2000 feet off-shore from Oak Island. The circulating water flow is approximately 2,800 cfs, and 10 fps along the discharge canal during maximum load conditions.

The cooling water releases some heat to the atmosphere along the discharge canal and enters the Atlantic Ocean approximately perpendicular to the natural drift, which averages about 0.7 feet per second. This discharge arrangement provides for rapid dilution and cooling and confinement of effects on the marine biota to a small area. A further explanation of the effects of the condenser intake and discharge systems on the aquatic biota is given in subsection 9.8.2.1.

Site A, the alternate estuarine location, presented problems associated with condenser cooling and dissipation of waste heat. The estuary is enclosed by off-shore islands and is connected to the ocean through the small inlets separating the islands. These small inlets limit the interchange of water between the ocean and the estuary. Recirculation of condenser cooling water would have occurred during certain times of the year resulting in warmer temperatures over a large area of the estuary. Furthermore, a larger percentage of the available water was required for condenser cooling at this site than is required at Brunswick.

Investigations of the availability of water for condenser cooling at Alternate Site B indicated that sufficient water was not available during certain months of the year for once-through cooling. Recirculation of cooling water during periods of low inflow would have exceeded the allowed temperature rise in a substantial area of the river. It was concluded that this site would not support units of the size required.

Alternate Site C is located on a hydroelectric impoundment in central North Carolina. This lake provides over 5,000 acres of lake surface with the capability of providing the amount of cooling water supply for units of the size required. However, as pointed out in the discussion of land use in subsection 9.3.5, the number of people affected by developing a steam electric power plant site on the shore of the lake would have been considerably greater than the number affected at the Brunswick Site.

9.3.7 Economic Considerations

Economic factors which were considered as significant parameters include transmission costs, land costs and cooling system costs. Land acquisition and site development costs would have been very similar, except for the lake site, and thus were not determinative. The lake site involved a more densely populated area than the other three sites which are all low population density areas. The decisive cost item which had to be evaluated was the heat sink for unrecovered heat energy. The flow of water passing the river site could not support "once-through" cooling. After excluding the closed cooling system as prohibitively expensive, and deciding that wet towers would have required too large a fraction of the available coolant flow during a dry season, it was concluded that provision of an environmentally acceptable cooling system represented a decisive cost item against the river site. Of the two estuarine sites, Brunswick was chosen because the more favorable cooling conditions assure a more rapid dissipation of waste heat.

9.3.8 Summary

The investigations and analyses which were performed to select a site large enough to support the required units evaluated the need for selection of a site which offered minimal environmental impact. Various considerations narrowed the choice to four sites in CP&L's service area. Land acquisition and site development costs would have been very similar, except for the lake site, which involved a more densely populated area than the other three sites which are all low population density areas.

The decisive cost item in selection was the heat sink for unrecovered heat energy. The flow of water passing the river site could not support "once through" cooling. After excluding the closed system as prohibitively expensive, and deciding that wet cooling towers would have required too large a fraction of the available coolant flow during a dry season, it was concluded that provision of an environmentally acceptable cooling system represented a decisive cost item against the river site. Brunswick was chosen over the other estuarine site because the more favorable cooling conditions assure a more rapid dissipation of waste heat.

Although the other sites investigated have factors which are amendable to the production of electricity, the benefit-cost considerations in the final site selection decision were thus simplified by the overwhelming heat sink considerations.

9.4 Alternative Cooling Systems

The selection of a cooling system for the plant was a decision integrated with the selection of the site, since the site selection is predicated on the ability of a site to accommodate cooling with minimum impact. Once the site has been selected, further studies to determine the expected effects of various alternatives and their net impact can be performed. Early in the project, Carolina Power & Light Company conducted an extensive investigation into the best way to dissipate the excess heat from the Brunswick Plant, i.e., the method which would have the least environmental impact, consistent with reasonable cost, and reliability of proven technology to construct and operate. The following methods were investigated:

1. Dilution of cooling water and return to river
2. Closed cooling systems
3. Wet cooling towers (natural and forced draft)
4. Cooling lakes
5. Channeling the cooling water to the ocean for off-shore discharge

The approach taken in evaluation of the alternate cooling methods was a multidiscipline one to allow comparison of numerous parameters that might have an impact on the environment.

9.4.1 Discussion of Alternate Cooling Systems

Alternative cooling systems were evaluated by considering the environmental impact, technical feasibility, and cost. As explained previously, it is the policy of CP&L to minimize environmental effects which might have an adverse impact.

Some guidelines are necessary in evaluating potential environmental effects so that design objectives can be established. One of the major effects studied is possible thermal impact from the system. It is, of course, desirable to minimize such effects, and it is for this purpose that water quality standards have been established by Federal and State agencies. Thus, a major design objective of the cooling system is to assure that releases of warm water to the natural body of water will meet all applicable temperature standards. In the case of the Brunswick Steam Electric Plant, the applicable standards are the North Carolina State Water Quality Standards which have been approved by the Environmental Protection Agency.

In addition to evaluation of thermal effects, the design of the cooling water system considered the following impacts:

1. Effects on marshlands
2. Salt water intrusion into the aquifers which supply the potable water for the area
3. Upwelling of fresh water from the aquifers which supply the potable water
4. Heat dispersion

5. Effects of any canals on developed and high-ground property
6. Interception of existing drainage patterns with any canals
7. Construction feasibility and economics
8. Hydraulic design
9. Plant safety

9.4.1.1 Wet Cooling Towers

Wet cooling towers, both natural and forced draft, were evaluated as alternative cooling methods available for the plant. This evaluation revealed potential environmental problems due to the lack of adequate fresh water supply to makeup evaporative losses from the towers. On the other hand, while adequate salt water makeup supply is available, there is a lack of operating experience in the United States with salt water cooling towers. The following paragraphs discuss the various parameters evaluated for salt water cooling towers, since fresh water supply was not available.

9.4.1.1.1 Environmental Impact

Salt Deposition

Operation of natural or mechanical draft towers at the Brunswick Plant would have resulted in damage to vegetation in the vicinity due to salt deposition resulting from drift losses in the towers. Salt deposition in the vicinity of the Brunswick Plant on an annual basis for both mechanical draft and natural draft towers is included as Tables 9.4-1 and 9.4-2. Assumptions for the mechanical draft towers included a release height of

20 meters, a drift rate of 0.05 percent, and no plume rise. Assumptions for the natural draft tower included a drift rate of 0.005 percent, a release height of 100 meters, and no plume rise. It is important to note that these drift losses are those for present-day systems. When the Brunswick cooling systems were being evaluated during design, studies showed salt water cooling towers could possibly cause adverse salt deposition and damage to vegetation. At the time that initial cooling studies were made, drift losses as low as those used in this analysis were not guaranteed. Particle size distribution and settling velocities were assumed to be identical to the particle size distribution and settling velocities included in the Forked River Nuclear Station Environmental Report. Deposition was calculated using the standard Gaussian diffusion equation and meteorology data collected at the plant site.

Using the above assumptions with Pasquill diffusion category F and invariant wind, the maximum eight-hour salt concentration was calculated to be 210,000 micrograms per cubic meter for a mechanical draft tower and 235 micrograms per cubic meter for a natural draft tower. It was reported in the Forked River Nuclear Station Environmental Report that vegetation damage has been observed at airborne salt concentrations of about 100 micrograms per cubic meter for a period of several hours. It was also reported that airborne salt concentrations above 10 micrograms per cubic meter may have long term effects on the vigor and distribution of plant types.

Some damage to vegetation from salt deposition in the area would be expected due to the operation of either type of cooling tower; however, damage from mechanical draft towers is expected to be considerably more extensive than damage from natural draft towers because of the higher drift losses and the lower emission height of mechanical draft towers. Because of the potential for damage to vegetation and lack of operating experience in the United States with salt water towers, the towers were eliminated and quantitative estimates of potential damage were not performed.

Fogging

Since salt water towers were ruled out based on other environmental considerations, no specific studies of fogging were conducted for the Brunswick site. Some general discussion is possible, however. The fogging potential for mechanical draft towers is higher than for other alternatives. The vapor resulting from the evaporation would rise, and the mixing with cooler ambient air above the tower and cooling by condensation causes the water to condense into a visible plume. The vertical plumes from mechanical draft towers do not rise very high, probably less than 600 feet above the emission point under stable atmospheric conditions due to the lack of buoyancy of the plume. The plume tends to move near the ground with the wind. Natural draft towers have an elevated emission point and on most days of light wind, the moist plume would continue to rise so that little or no ground fogging should occur.

Studies projecting the increase in fogging from cooling towers at other locations have been reported by Phillip Altomare, in a paper presented at the 1971 annual meeting of the Air Pollution Control Association. Altomare stated that "the induced fog (from evaporative cooling systems) is not likely to occur as a discrete occurrence, but is more likely to be observed as a fog forming somewhat earlier than natural and lasting somewhat longer. The increased occurrence of fog is more aptly measured as an increase in minutes in the duration of natural fog." Although Altomare's paper was not specific for the Brunswick Plant Site, it was an analysis of several locations from the east coast to the west coast of the United States and the results should be generally applicable.

9.4.1.1.2 Other Impacts

During the operation of cooling towers, it would be necessary to occasionally blowdown the towers to reduce accumulation of materials in the towers. Blowdown from the towers would contain solids from the cooling water, corrosion products from the circulating water system, corrosion inhibitors, and, possibly, traces of biocides used to retard the growth of aquatic organisms in the circulating water system. Although these discharges could be handled in a manner to meet water quality standards, there would be some environmental impact associated with the discharge of the blowdown.

There would be some noise associated with the operation of mechanical draft towers. While not believed to be objectionable, the noise would increase the noise level in and around the plant, but not off-site levels.

Although aesthetic considerations are primarily subjective, it is believed that natural draft towers (which exceed 400 feet in height and have highly visible plumes) would present some aesthetic impact on the local area including the beaches. Mechanical draft towers are not as tall and should not be directly visible from the beaches; however, the plume would have some aesthetic impact.

9.4.1.1.3 Economics

The estimated capital and capitalized operating costs of mechanical cooling towers for the Brunswick Plant are between $21 million and $25 million. For wet, natural draft towers, the same costs are between $31 million and $35 million. The costs are those associated with the towers only, and do not include costs for land and makeup water supply and disposal.

A realistic evaluation of cooling towers at the present time requires that the impact of scheduling for engineering and construction be considered. Assuming that the existing condenser could be used, it is estimated that six to nine months would be required for engineering before an order for the equipment could be placed. An additional 18 to 24 months would be required after receipt of an order to completion of the tower. Approximately 2 to 3 months would be required to obtain bids, evaluate proposals and select a vendor. Thus, a total of 32 to 36 months would be required to engineer, procure, and construct cooling towers at the Brunswick Site. This delay, plus the fact that abandoning the selected system would create an adverse environmental impact during new construction, makes the adoption of cooling towers at this late date impractical. These reasons, plus the environmental reasons for not adopting towers initially (salt deposition and vegetation damage, aesthetic intrusion and impact, lack of experience with salt-water towers, etc.) make cooling towers an undesirable selection from environmental and social (unavailability of power to consumers) standpoints.

9.4.1.2 Closed Cooling Systems

An additional cooling method which was given consideration was dry cooling towers. However, a multidiscipline analysis of this type of tower revealed factors inconsistent with proper environmental protection and enhancement. Dry towers avoid the potential problems of fogging, mist, and high water consumption associated with wet towers, but the concomitant technological and operating problems associated with a dry tower prevent consideration of dry towers at the present time. The technology for constructing dry towers for a large generating station is not presently available. The largest operating dry tower is at a 120 MW plant in England. Towers for a twin unit plant like Brunswick would have a severe impact on the aesthetics of the area. Dry towers are one-third to one-half larger than comparable capacity wet towers, which themselves are quite large (approximately 400 feet in diameter at the base and over 400 feet high for an 800 MW unit). A dry tower will only cool the water to dry bulb temperature, since only sensible heat is removed from the water. This operation is efficient in dry, cool climates. However, in the CP&L service area, this type of cooling system would impose severe limitations on the capacity of the Brunswick units during hot, humid periods when electrical demands are at a peak. The sensitivity of such a cooling system to meteorological conditions would create a situation in which the reliability of the CP&L system was dependent on uncontrollable factors and would require the addition of reserve generation capacity to protect against the unavailability of necessary power.

Estimates of the cost of a dry tower for a single nuclear unit in the 800 - 900 MW range generally exceed $50,000,000. Because of the adverse impact on regional aesthetics, the lack of available technology, the effect on system reliability, and the high economic costs, dry cooling towers were dismissed as a feasible alternative in the initial investigations of alternate cooling systems.

9.4.1.3 Cooling Lakes, Spray Ponds

In the original evaluations of cooling methods for the Brunswick Plant, spray cooling ponds were eliminated, along with cooling lakes due to technical and land use considerations.

A cooling lake for the two units of BSEP would have required a minimum of 3000 acres. Compared with the area needed for the ocean discharge canals, this would have entailed a major increase in land requirements. Furthermore, in the area of BSEP, the potential impact of a cooling lake on the groundwater was an additional deterent to this system.

The following discussion presents information relating to the environmental and economic considerations which were evaluated in the benefit-cost analysis of spray ponds.

9.4.1.3.1 Environmental Impact

Acreage Requirements and Land Use Distribution

A conceptual design of a spray pond cooling water system is shown in Figure III.1-1, Amendment No. 1. In essence, this pond would consist of a canal, 12,000 feet long, which loops the plant from the discharge weir around to the intake structure. The land requirements for the canal only (area at surface elevation) would be approximately 77 acres. Assuming that a 1500 foot right-of-way would be required for such a canal, the total acreage would be approximately 413 acres. Should salt water be used in this canal, there would be no acreage requirement for a storage pond to cover periods of low river flow conditions. If a freshwater spray cooling pond were used, a storage pond would be required so that adequate makeup water would be available for use during periods of low freshwater flow. Assuming an average depth of water of approximately 15 feet for dike stability, the lake surface would be about 2,100 acres. Additional area would be required for the dikes and for construction. The total area required for the freshwater storage pond would be approximately 2,500 acres.

Fog and Drift

Fog resulting from a spray cooling pond probably would not be an extensive problem. Studies of cooling towers and experience with heated water canals indicate that fog from an evaporative cooling system is not likely to occur as a discrete occurrence, but is likely to be observed as a fog forming somewhat earlier than natural fog and lasting somewhat longer.

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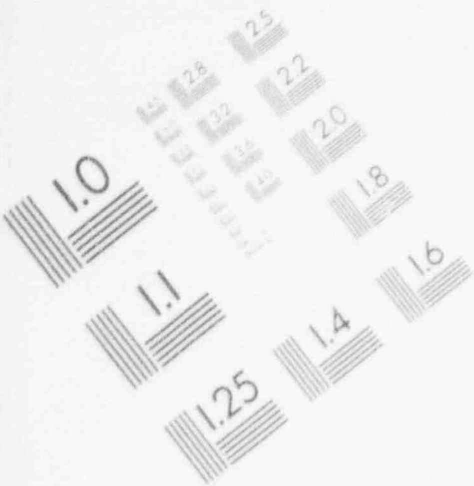
IMAGE EVALUATION TEST TARGET (MT-3)

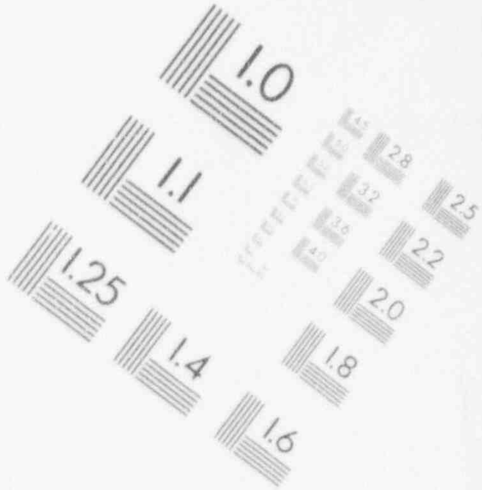
150mm

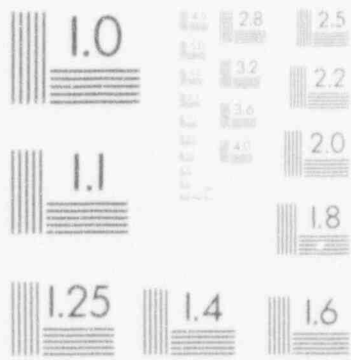
6"

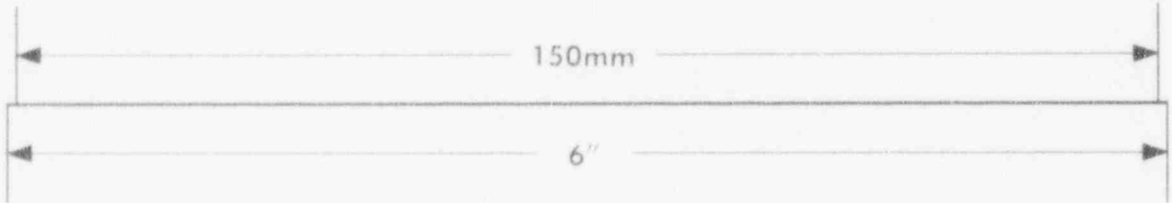
1

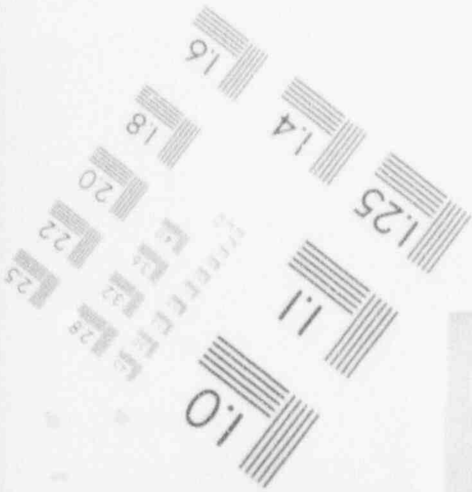
IMAGE EVALUATION TEST TARGET (MT-3)

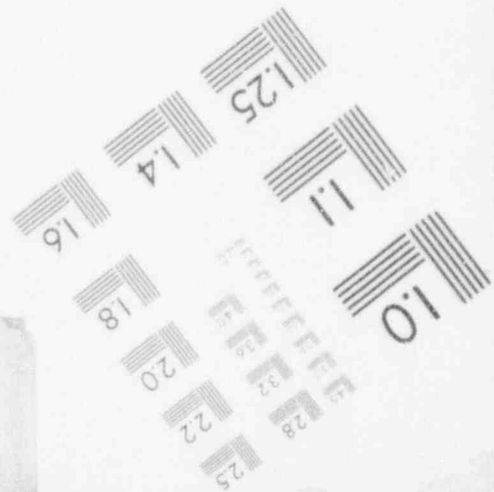












1

IMAGE EVALUATION TEST TARGET (MT-3)

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IMAGE EVALUATION TEST TARGET (MT-3)

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Drift resulting from spray modules has not been studied and there is limited operating experience with these systems. Water droplets are expected to be larger than cooling tower drift; however, the extent of the area affected by drift should be less due to the low profile of the spray. A smaller area probably would be affected by drift, but deposition in this area probably would be greater.

Makeup Requirements Including Water Storage for Low River Flow Conditions

Makeup water would be required for the system to replace losses from evaporation, drift, and blowdown.

Use of a saltwater spray pond would involve makeup water requirements of approximately 65 to 80 cfs. Considering the average and minimum tidal flows in the Cape Fear Estuary, an additional water storage facility would not be required for a saltwater spray pond.

A freshwater spray pond would require approximately the same makeup water as the saltwater pond for efficient and economical plant operation. If a freshwater intake, pipeline, and storage pond were constructed, the incremental cost of facilities sized for efficient plant operation would be more than offset by the economies of the better water; that is, to allow a greater blowdown rate to reduce the concentration of dissolved salts. The nearest adequate freshwater supply, however, is the Cape Fear River at Lock & Dam No. 1, approximately 37 miles upstream. Consideration of other uses of the

Cape Fear River and estimates of low flows indicate the need for storage of approximately 21,000 acre-feet of fresh water for makeup during drought years.

Pond Blowdown Requirements

Evaluation of a saltwater spray cooling pond includes consideration of the concentration of dissolved salts as a result of evaporation losses. The salts reduce the efficiency of heat transfer and also cause scale formation. Salt water as a makeup source results in a greater blowdown rate than would a freshwater source in order to maintain the concentration of salts at a reasonably efficient level. The cooling water should be limited to no more than two concentrations of the saltwater makeup sources; therefore, the required blowdown for a saltwater spray pond would be about 35 or 40 cfs.

Blowdown of a freshwater spray pond would be minimal compared with a salt water pond; blowdown of approximately 5 cfs would hold dissolved salts to lower concentrations than that of the saltwater pond. However, efficient cooling by the pond requires the lowest practicable concentration of dissolved solids; therefore, blowdown of 30 to 40 cfs would result in more efficient and economical operation of the plant.

Disposal of blowdown would be a problem, as the cooled water of the pond would exceed stream standards of the estuary unless a sufficiently large mixing zone in the estuary were allowed by the N. C. Board of Water and Air Resources. Discharge of the blowdown would also require a permit from the Board.

9.4.1.3.2 Economics

The postulated spray pond design would require 300 spray modules. As indicated on Figure III.1-1, Amendment No. 1, these modules would be operated on 40 foot centers, parallel to the canal flow and 160 foot centers along the canal. Each module would require a 75 hp propell pump to discharge the water through four spray heads. The modules would float in the canal on polyurethane floats and would cost approximately $15,000 each.

The canal design would require the removal of approximately two million cubic yards of earth. Based on an estimated excavation cost of $1.25 per cubic yard, it is estimated that the cost of constructing the canal would be $2,500,000.

The operating costs associated with such a cooling system would include both the auxiliary power requirements and a turbine penalty due to increased condenser pressure above design conditons. The estimated capitalized power cost of 300 seventy-five hp motors is estimated to be $3,120,000. A turbine penalty, based on deviation from design conditions, of $5,620,000, would result. Capitalized maintenance cost for the pond is estimated at $219,000.

In addition to the costs specified above, it is estimated that auxiliary electrical equipment (transformers, wiring, controls, etc.) would have a capital cost of approximately $500,000.

The pond power consumption for 300 seventy-five hp motors results in a capitalized power penalty of $3,120,000 per year. The total capitalized pond cost is estimated as about $16,460,000. In these discussions, no assessment of costs for providing a freshwater storage pond has been made, nor have the costs been included for obtaining water from Lock & Dam No. 1, if this were possible.

9.4.1.3.3 Summary

Based upon additional land and marsh requirements, and the makeup water supply necessary, it was felt that the spray pond and cooling lake imposed adverse environmental impacts which could best be avoided by adoption of a different system.

9.4.1.4 River Intake with River Return

The original design of the plant cooling system called for return of condenser cooling water to the Cape Fear River. However, further studies conducted by the Company showed that possible adverse environmental impacts might result from such a system. During the summer of 1968 dye studies were conducted in the lower Cape Fear River to determine probable temperature distributions that would result from plant cooling water being discharged to the Cape Fear River. These studies indicated a possible thermal accumulation in the estuary in excess of the amount indicated by previously available data. Because of the uncertainty of potential effects, CP&L felt that more positive methods should be investigated to assure minimization of potential adverse environmental effects. This concept, then, was eliminated and other possibilities studied.

9.4.1.5 River Intake with Ocean Discharge

This type of system, with ocean discharge, was selected as the most desirable alternative from an environmental standpoint. The river return system had originally been selected in an impact minimization evaluation; however, as a consequence of the previously mentioned dye studies, CP&L committed substantial additional investment to the condenser cooling system and changed the cooling water discharge from the Cape Fear River to the Atlantic Ocean. The final discharge canal routing was selected after consultation with State agencies in an effort to protect the more productive creeks and marshlands and to minimize conflicts with established land uses. The final design of the canal bypasses the town of Southport as shown in Figure 2.2-2, skirts Dutchman Creek, and crosses Oak Island by traversing the island on the east side of the golf course. Flow in the discharge canal is provided by gravity, and a pumping station is located at Caswell Beach to provide the necessary discharge velocity at the ocean discharge jets. A more complete description of the cooling system and its potential impact are given in Sections 2 and 3. The following discussion, therefore, provides a summary of the system.

9.4.1.5.1 Environmental Impact

The final system design was chosen to minimize potential environmental effects. As explained in preceeding sections of this Environmental Report, certain effects are anticipated and the system is designed to minimize these effects. A particular area of investigation was the effect upon water resources. The entire canal system was routed and designed to minimize upwelling and downwelling, and the impact on fisheries and wildlife and to maximize heat dissipation. No saltwater intrusion to drinking water supplies is expected to occur with the system design adopted. The heated water will be released 2000 feet offshore to minimize potential thermal effects.

Fogging from the canal system is not expected to create any adverse effects, since discrete fogging caused by the system is expected to be minimal.

From an aesthetic viewpoint, the canal system affords more aesthetical appeal than other systems evaluated, since the unnatural imposition upon the environment is less.

Since extensive discussion of the system is contained in previous sections, it is not deemed necessary to repeat those discussions at this point.

9.4.1.5.2 <u>Economics</u>

The cost of the river intake-ocean discharge cooling system is considerably higher than other alternatives such as river intake-river discharge. However, the system was selected because of its ability to help minimize potential environmental effects. The total cost of the system, including land and equipment, is estimated to be approximately $53 million.

9.4.2 Feasibility of Late Adoption of Alternatives

The Brunswick Steam Electric Plant Units 1 and 2 are presently (as of June 30, 1972) 35 percent and 64 percent complete. The cooling system was selected because it offered maximum opportunity to minimize potential environmental effects. Because of construction progress at the plant, large capital expenditures have been committed to the condenser cooling system and a major portion of the environmental impact from construction has already occurred. Abandonment of the system and construction of a new one would incrementally increase environmental impact. Adoption of a different cooling system at this late date could cause considerable delay in the plant and result in the necessary power for consumers not being available. A more complete discussion of economic investments on the canals and equipment is contained in Amendment No. 1, Question III.2. Accordingly, CP&L feels that adoption of a different cooling system at this late date would place an unnecessary burden on consumers.

9.4.3 Summary

The river intake and ocean discharge system was selected as the system for cooling the plant condensers with minimum net environmental impact. Land use requirements for this canal system were based on minimizing marsh usage and thorough discussions with State officials regarding routing of the canal. Measures taken by the Company in environmentally planning the cooling system should assure that water resources in the area are not adversely affected by the cooling system. Aesthetically, the overall appearance should be plea ing. The quiet nature of the system while in operation should not affect wildlife. Because of the Company's continuing concern for environmental protection and enhancement, CP&L will continue to formulate studies and programs designed to evaluate potential environmental effects which have been discussed in this report.

TABLE 9.4-1

SALT DEPOSITION (μg/m²sec) assuming an emission height of 20 m, drift rate of 0.05%, and no plume rise

Wind Direction	DISTANCE FROM SOURCE (MILES)							
	0.25	0.50	0.75	1.0	2.0	5.0	10.0	15.0
N	100.47	64.55	42.77	29.88	11.59	3.24	1.25	0.72
NNE	144.51	91.37	59.46	41.22	15.82	4.37	1.68	0.97
NE	215.47	138.40	90.44	62.80	24.16	6.69	2.58	1.48
ENE	139.21	100.77	67.28	47.06	18.31	5.12	1.98	1.14
E	94.34	71.00	49.09	34.89	13.87	3.94	1.54	0.90
ESE	74.71	55.79	38.05	26.86	10.[illegible]8	2.99	1.16	0.67
SE	66.81	51.84	35.89	25.51	10.14	2.88	1.13	0.65
SSE	71.54	48.92	33.63	23.89	9.49	2.70	1.05	0.61
S	92.32	66.98	46.74	33.38	13.35	3.82	1.50	0.87
SSW	84.05	52.69	34.75	24.25	9.39	2.62	1.01	0.59
SW	111.86	75.17	50.36	35.35	13.81	3.87	1.50	0.87
WSW	116.01	68.74	44.46	30.78	11.78	3.25	1.25	0.72
W	95.95	61.62	40.77	28.47	11.04	3.08	1.19	0.69
WNW	114.15	64.88	41.48	28.54	10.83	2.97	1.14	0.66
NW	98.94	64.74	44.16	31.29	12.38	3.51	1.37	0.80
NNW	66.93	54.89	39.54	28.60	11.64	3.36	1.33	0.78

TABLE 9.4-2

SALT DEPOSITION ($\mu g/m^2 sec$) assuming an emission height of 100 m, drift rate of 0.005%, and no plume rise

Wind Direction Sector	DISTANCE FROM SOURCE (MILES)							
	0.25	0.50	0.75	1.0	2.0	5.0	10.0	15.0
N	0.104	0.303	0.220	0.169	0.101	0.048	0.026	0.017
NNE	0.114	0.334	0.257	0.218	0.154	0.074	0.038	0.025
NE	0.163	0.478	0.371	0.317	0.228	0.112	0.058	0.038
ENE	0.059	0.175	0.150	0.149	0.141	0.081	0.043	0.029
E	0.065	0.191	0.146	0.123	0.092	0.052	0.029	0.020
ESE	0.048	0.142	0.108	0.091	0.071	0.041	0.023	0.016
SE	0.036	0.105	0.084	0.076	0.065	0.038	0.022	0.015
SSE	0.077	0.223	0.162	0.124	0.072	0.035	0.019	0.013
S	0.102	0.297	0.210	0.155	0.087	0.045	0.026	0.018
SSW	0.087	0.254	0.186	0.145	0.087	0.040	0.021	0.014
SW	0.095	0.278	0.209	0.170	0.114	0.057	0.031	0.020
WSW	0.126	0.367	0.269	0.210	0.123	0.054	0.027	0.018
W	0.096	0.280	0.204	0.159	0.097	0.047	0.025	0.016
WNW	0.153	0.445	0.313	0.228	0.116	0.049	0.025	0.016
NW	0.124	0.361	0.256	0.188	0.098	0.045	0.025	0.017
NNW	0.054	0.157	0.115	0.092	0.063	0.036	0.022	0.015

9.5 Consideration of Alternative Radwaste System Design

The radioactive waste processing system for the plant is described in subsection 3.6. The system is designed to meet the design objectives of the AEC's proposed Appendix I to 10 CFR 50, dated June 9, 1971 (36 F.R. 11113), which provides numerical guidance for meeting the "as low as practicable" criteria for effluent releases. A complete discussion of releases and effects is contained in subsection 3.6.

Accidental release of radioactivity is prevented by system design and operating procedures; however, in the unlikely event that such releases could occur, the radiological consequences would be within applicable AEC guidelines. Accidents and the environmental consequences of accidents were discussed in Section 8.

The AEC in May, 1972, distributed the "Guide for Submission of Information on Costs and Benefits of Environmentally Related Alternative Designs for Defined Classes of Completed and Partially Completed Nuclear Facilities," which indicated that if the design of the radioactive waste system was able to meet the design objectives of the proposed Appendix I, 10 CFR 50, consideration need not be given to the reduction of radiological impacts in formulating other alternative plant designs. These objectives have been met; therefore, no consideration is given to alternative designs in this part of the benefit-cost analysis.

9.6 Consideration of Alternative Chemical Effluent Systems

All steam electric plants require the use of various chemicals during plant operations. In order to minimize the effect these chemicals might have on the environment, various treatment systems are included in the plant design. The purpose of these systems is to treat chemical effluents in a manner that will reduce their impact on the environment to a level consistent with the state-of-the-art technology. In the operation of the Brunswick Plant, some non-radioactive chemical wastes will be produced in the processing of the high quality reactor makeup water, in the treatment of sanitary wastes, in the operation of some auxiliary systems, and by the two oil fired systems; the auxiliary boilers and the emergency diesel generators. Those chemical wastes subject to possible radioactive contamination will be processed through the radioactive waste treatment system where they will be collected, monitored, neutralized, filtered, demineralized, evaporated or otherwise treated prior to release into the environment. Chemical wastes not subject to radioactive contamination are discussed in the following paragraphs.

The domestic wastewater treatment system for the plant will be designed to achieve a secondary level of treatment. The system will consist of an extended aeration aerobic digestion facility and a chlorine contact tank which will be designed to treat a minimum of 7500 gallons per day of domestic sewage having a 5-day BOD of 20 pounds per day.

The raw domestic sewage entering the aeration tank is mixed with activated sludge and continuously aerated by supplying air to the aeration tank at a minimum rate of 2100 cubic feet of air per pound of 5-day BOD in the domestic sewage. Following this period of aeration, the mixed liquor passes to the final settling tank where settled activated sludge particles are continuously returned to the aeration compartment by air lifts. Provisions are made to manually transfer waste sludge to the integral sludge holding tank where the wasted sludge is continually aerated until it is disposed. The clarified liquid leaves the final settling tank and enters the chlorine contact tank where it is mixed with a chlorine solution, and leaves as treated effluent with a BOD less than 30 mg/l.

The makeup water treatment system will provide a supply of high purity water ($\sim$0.2 micro mhos/cm^2 conductivity) free of materials which could become radioactive. It provides a low hardness, low sulfate and low turbidity potable water. The system will purify raw well water and will supply all normal requirements for demineralized water and potable water throughout the plant.

Demineralized water will be used for make-up to the reactor building auxiliary systems and for the reactor building closed cooling water system, the turbine building closed cooling water system and for plant usage where high quality water is necessary. It will be piped to the radiochemical and health physics laboratories, sampling sinks and various places in the plant where radioactive decontamination work will be performed.

Raw water from the wells will be pumped through the demineralizer system. Potable water will be taken off after flow passes through the weak cation exchangers and degasifier. It will undergo pH adjustment and chlorination as it enters a potable water storage tank. The remaining water will flow through strong cation, strong anion and mixed bed exchangers to the demineralized storage tank from which redundant pumps will distribute it through the plant demineralized water lines. The non-radioactive regenerant chemicals associated with the regeneration of the non-radioactive demineralizers will be neutralized before release to the discharge canal; the resulting salts from this discharge will be a negligible increase to the saline estuarine cooling water.

Chlorinating systems will be utilized for the control of algae and slime growth in the service water system, main condensers and circulating water tunnels; they will normally operate for only two 30-minute cycles per day. Chlorine residuals in the water leaving the condenser and service water system will be no more than 0.5 ppm and should be no more than a trace at the discharge into the ocean.

In areas where oil or grease can enter floor drains, the pipe lines from these drains will be equipped with traps which will collect the oil or grease and the material will be periodically removed for disposal. The turbine lube oil tanks, located just outside the Turbine Building, will be placed in concrete moats which will be equipped with a sump to permit collection for disposal as necessary. The shop drains and the Turbine Building oily drains will be taken to a centrifuge where the water and oil will be separated. The waste water will be routed to the detergent drain tank where all the detergent wastes (low specific activity less than 1.0×10^{-5} μCi/ml) will be sampled and released to the discharge canal, if they meet effluent limits established in 10 CFR 20 and the proposed Appendix I of 10 CFR 50, dated June 9, 1971. The above ground storage tank for fuel oil for the diesel generators and the auxiliary boilers will be protected by surrounding dikes that are capable of containing the full contents of the tanks.

The only releases of chemical combustion products to the atmosphere will be those associated with the occasional operation of two auxiliary boilers and four diesel generators provided for emergency power. Both the auxiliary boilers and the emergency diesels will be fired with No. 2 fuel oil, but will have a capability of operating with No. 6 oil as well when No. 2 oil is not available. Each boiler will be capable of generating 55,000 pounds of steam per hour. The combustion gases will be vented from stub stacks some 35-40 feet above plant grade which will adequately diffuse any possible concentrations. Because of the high quality fuel, the diesel generators and the auxiliary boilers are not considered to contribute significant chemical gaseous wastes. Both systems will operate within the limits of the standards for emission of stationary sources for the State of North Carolina.

The chemical discharges for the plant are listed on Table 9.6-1 as well as a description, source, and discharge point for each of the releases.

TABLE 9.6-1

BRUNSWICK UNITS 1 AND 2
CHEMICAL DISCHARGES

Descriptions	Source	Discharge Point	Discharge
Treated Sanitary Waste-Liquid	Sewage Treatment Plant	Discharge Canal	2,000,000 Gal./Yr. Treated Waste with 30 mg/L 5-day BOD, 1 ppm chlorine, 20 ppm suspended solids, 6.0 to 8.0 pH.
Make-up Water Demineralizer Regeneration Waste-Liquid	Make-up 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
Auxiliary Boiler Exhaust	Auxiliary Boiler Burning No. 2 Fuel Oil	Atmosphere	934 (lbs./Million BTU) stack gas at 350°F CO_2 - 160 O_2 - 26.8 H_2O - 69.5 SO_2 - 0.5 N_2 - 677 Particulates - 0.05
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

9.7 Transmission Systems

9.7.1 Selection of Transmission Voltages

The development of a transmission system for a generating plant involves a complex analysis of technical requirements and environmental effects. The transmission system must be reliable and have a minimum impact on the environment. Decisions must be made as to the terminals of the transmission lines so that the electric power generated at the plant will be delivered to the most appropriate load centers. The voltage and number of the transmission lines must be selected so that the lines not only will have the capability to deliver the total plant output but will have an adequate reserve margin for contingencies. Studies of contingencies must be made on the proposed transmission system to assure that it will provide a firm tie between the plant and the transmission network and will meet the stability requirements of the system.

The location for the Brunswick Plant is at the southeastern edge of the CP&L system. The nearest elements of the CP&L transmission network are approximately 25 miles from the plant. Because the Brunswick Plant will be a base load plant and will be located in an area remote from CP&L's major transmission elements, reliability of service was considered by CP&L to be of paramount importance in the design of the transmission system.

The generation at the Brunswick Plant will be from two 821 megawatt units, for a total generation of 1642 megawatts. The transmission lines must be capable of reliably delivering this 1642 MW to the CP&L system on a firm basis.

The alternate transmission plans that were developed involved several voltage systems: an all 500 KV, combination 500 and 230 KV, and all 230 KV. The transmission alternatives studies for the Brunswick Plant may be grouped into three basic plans.

Plan I consists of six 500 KV lines connecting the plant to load centers, as shown in Figure 9.7-1. Five new 500/230 KV substations and a total of 6350 acres of transmission rights-of-way would be required. Plan I would have an estimated total investment of $69,733,500. Table 9.7-1 shows the details of this plan.

Plan II consists of two 500 KV and six 230 KV lines connecting the plant to load centers as shown in Figure 9.7-2. Two new 500/230 KV substations would be required. This plan would require a total of 4940 acres of transmission rights-of-way of which 3085 acres would be for the 500 KV lines and 1865 acres for the 230 KV lines. Plan II requires 1410 acres less rights-of-way than Plan I. The estimated total investment of Plan II would be $47,391,500 which would be $22,342,000 less than Plan I. Table 9.7-2 lists details of this plan.

Plan III consists of eight 230 KV lines connecting the plant to load centers as shown in Figure 9.7-3. This alternative would require a total of 3600 acres of transmission rights-of-way or 2750 acres less than Plan I and 1340 acres less than Plan II. Plan III would have an estimated total investment of $23,809,000 which is $23,582,500 less than Plan II and $45,924,500 less than Plan I. Table 9.7-3 lists details of this plan.

Studies indicate that each of the transmission alternatives developed have adequate capability to reliably deliver the power to the load centers and provide a strong tie between the plant and the transmission network. When these alternatives were compared for minimum environmental impact and maximum economy, Plan III was selected for development as the transmission system for the Brunswick Plant. Table 9.7-4 gives a comparison of the alternatives.

9.7.2 Selection of Transmission Line Construction

Once the system voltages have been determined, the type of construction to be used on the 230 KV lines as selected under Plan III must be determined. The parameters considered in this selection were:

1. Reliability of service.
2. Environmental impact.
3. Maintenance.
4. Economics.

The construction alternatives are overhead and underground construction.

9.7.2.1 Overhead Construction

The structure design and color is selected to minimize the impact on an area. The standard 230 KV Carolina Power & Light Company's wood H-frame structure, which embodies simple minimum silhoutte design, low profile, and good reliability will be used. A schematic outline of the structure is shown in Figure 3.8-3. These wood H-frame structures will be pentachlorophenol treated, producing a soft brown color which will blend into the vegetative background, and have an average height of 65.5 feet.

Wood construction has proven very reliable on the CP&L system. If a permanent fault should occur, replacement parts are readily available and the outage time would generally be between one and twenty-four hours depending upon location.

The visual impact of this type construction is minimized by the use of low-profile structures and the right-of-way clearing practices of Carolina Power & Light Company.

H-frames offer other advantages. The wood pole structures are transported to each site and constructed with a minimum disturbance to the environment. Due to the simplicity of the H-frame, fewer and lighter material hauls are required to any given structure location. Their foundations, two per structure, require an absolute minimum of excavation, since the pole butt will be buried directly in the ground. Holes are augered 36 inches in diameter and about 9-1/2 feet deep, the pole is set in the hole and backfilled with soil removed from the augered hole. Excess soil removed from the pole hole is evenly distributed over the surrounding area. Each tangent structure occupies an area of only approximately 4-1/2 square feet after erection; therefore, structures set in open fields impose minimum conflicts for planting and harvesting cycles and maximize crop production acreage.

9.7.2.2 Underground Construction

The only proven method of placing 230 KV underground is by use of high pressure oil pipe type cable. The cable consists of three conductors insulated from one another and ground by oil-impregnated paper wrapped around each conductor. The cables are then placed in a pipe which is filled with oil under pressure, the oil serving as insulation and a heat dissipating medium. This type of installation requires reactance facilities and oil pumping stations at regular intervals along the transmission route. Each station would require between one and two acres of land. Distribution lines must be constructed to each station to provide power for the oil pumps. The number of these stations would depend on the line length and the terrain. At each terminal of the line, approximately one-half acre would be required for monitoring equipment, circuit protection devices, and for towers needed to terminate the underground cable at the surface. This space requirement is in addition to the land needed for the substation.

The underground installation would provide a high degree of reliability against interruptions caused by lightning, insulation contamination, tornado winds, etc. However, every fault that occurs on an underground system is a permanent fault. When a fault occurs, it must be located, the extent of the fault must be determined, repair parts must be obtained, the pipe must be excavated, the oil must be frozen and then the cable can be repaired. The time required to repair a faulted underground cable can range from 4 to 21 days.

The environmental impact of an underground transmission line can be greater than a properly designed and constructed overhead line. For example, the banks of streams crossed by an underground line are difficult to restore. No root growth can be allowed over the cable thereby making it difficult to screen the right-of-way from roads and major stream crossings. The possibility exists of a pipe rupture allowing the pressurized oil to escape with a damaging effect upon the environment.

The estimated cost of the eight 230 KV lines emanating from the Brunswick Plant using overhead construction is $17,118,600. These same lines placed underground would cost from ten to forty times as much as overhead construction. The underground cost ratio is obtained from a report to the Federal Power Commission entitled "Underground Power Transmission" published in April, 1966.

The transmission lines to Barnard Creek Substation will cross the Cape Fear south of Wilmington. Both overhead and underwater construction were evaluated. A detailed evaluation of the routing and of underwater construction are contained in the responses to Questions IV.3 of Amendments 1 and 3 to this report, dated June 5, 1972 and September 1, 1972.

Because of the environmental impact, the permanence of faults, the state of the art of technology, and economic considerations, overhead construction for the 230 KV lines has been selected for the Brunswick Plant transmission development.

9.7.2.3 Tower Selection for River Crossing

Original Engineering Evaluation - 1971

Carolina Power & Light Company was cognizant of the fact that the transmission structures to be installed for the Cape Fear River crossing should be aesthetically designed, and because of this concern, the Company conducted an evaluation of possible alternatives for the Cape Fear River crossing.

Ebasco Services was commissioned to prepare an engineering and economic evaluation of alternative aesthetic designs for the 230 KV Cape Fear River crossing structures. The evaluation, completed in December 1971, is included as Appendix 9A and summarized as follows:

Alternate I was underwater cable circuits, and is discussed in detail in the response to Question IV.3 of Amendment No. 1 to this Report, dated June 5, 1972.

Alternative II was a conventional double circuit steel lattice type tower with the conductors arranged in vertical configuration. Alternate III was a Vierendel tubular frame type four-legged structure with the two circuits arranged in vertical configuration. The same design was considered with the circuits arranged in a horizontal configuration as Alternate IV. Alternate V consisted of a Vierendel tubular frame type two-legged structure. An additional alternate consisted of a single steel pole design with both single and double circuits considered.

The analysis resulted in only two practical alternatives. These were Alternatives II and III. The single steel pole was ruled out because the load on the pole would be in excess of the maximum moment capacity now available. It was determined that the two-legged Vierendel structure would deflect excessively under longitudinal high wind loadings thus making it unsatisfactory from a technical point of view. The four-legged Vierendel structure with double circuit horizontal configuration was considered unsatisfactory as far as reliability is concerned. Should a shield wire or conductor break or a galloping condition exist, a double circuit outage could occur. Therefore, it was determined that the double circuit vertical configuration is the preferred construction. The conventional structure (Alternative II) and the four-legged Vierendel structure (Alternative III) with vertical configuration were the only two practical alternatives. Further evaluation revealed an additional cost of $784,000 for the Vierendel structure.

In order to justify the additional cost, CP&L conducted a visual sensitivity analysis of the portion of the Cape Fear River between Wilmington and Southport. A map of the area is shown on Figure 9.7-8. Carolina Power & Light Company rated the area between metropolitan Wilmington and the southern tip of Eagle Island to be of relatively high visual significance because it is a heavily populated area. In the metropolitan Wilmington area, visitors to the Battleship North Carolina Memorial and major highway bridge crossings provide high visual exposure to the area. Similarly, the land around the Cape Fear River from Orton Plantation and Snow's Cut south beyond Southport was rated relatively high in visual sensitivity. It was so rated because of the high degree of visual exposure in this area that will occur from Inland Water Way traffic, beach vacationers, and visitors to the Orton Plantation and Brunswick Historical Museum. The area of the river between Snow's Cut and north to Eagle Island was rated relatively low in visual significance. The development in this area is primarily industrial in nature, with fuel storage facilities and the Wilmington sewage treatment plant. The only vehicular access to this area is along River Road which is a lightly traveled secondary road. Marine traffic along this portion of the Cape Fear is primarily commercial shipping.

The distance from vantage points along River Road to the structures in the river, and the short viewing time from vehicular traffic will not allow an appreciable difference in appearance between the two alternative structures. This is particularly true since either structure will be painted International orange and white to comply with F.A.A. regulations.

After considering the fact that the area is relatively isolated and not in a heavily populated area, and that the structures would tend to have the same outline from a distance, the Company concluded that the expenditure of an additional $784,000 to provide the alternative shaped structure could not be justified at this location. Alternative II was therefore selected as the proper structure to be installed.

Effect of Structure Design Modification at Present Stage - 1973

It is not practical to change the design of the Cape Fear River crossing structures at this time. All materials have been purchased, shipments of materials have started, and construction contracts for foundation construction have been awarded. Any changes in design will require the cancellation of these contracts and a complete redesign of structures. The estimated additional cost involved in changing the design to the type of structure as outlined in Alternative III would total $909,000, including cancellation charges.

In addition to the above cost, it is conservatively estimated such a change would require an additional twenty months of engineering, material purchasing, and construction to complete the crossing after another type of structure is selected.

Conclusion

Carolina Power & Light Company is convinced that the original decision to use the conventional river crossing structure is based on sound engineering judgement with proper consideration of environmental effects and aesthetic considerations. To reconsider an alternative design at this point would add an additional cost differential and unnecessarily delay the completion of the required line.

9.7.2.4 Construction Techniques

Selective clearing will be performed at road or major stream crossings and in other areas of high visibility. In the event woods are some distance from the road, selective clearing will be practiced at the edge of the wooded area. At major stream crossings no clearing will be allowed on the sloping banks and tree trimming only as required. Selective clearing will be undertaken beyond the banks a minimum of 100 feet back from the normal shoreline. Selective clearing techniques are illustrated in Figures 9.7-4 through 9.7-7.

In selective clearing as much natural vegetation cover as practical will be retained within the right-of-way. Only trees which will affect the integrity of the energized line will be trimmed or removed. The trees to be removed or pruned will be marked in the field by competent personnel. Areas to be selectively cleared will be carefully marked and adequately protected to prevent damage during the surveying, clearing, construction and future maintenance of the line.

The location of vehicle access through selectively cleared areas will be at an angle, thereby preventing views down the right-of-way. All movement of equipment for surveying, construction and maintenance will be confined to these access routes. Clearing operations in these areas will be carefully regulated to prevent scouring or excessive disturbance to the land and to prevent damage to the uncut vegetation.

To insure permanency of the selectively cleared or planted areas, future maintenance will be carefully controlled to retain the original concept of screening the line. Trimming will be accomplished to prevent undue damage and leave the remaining natural undergrowth and woody material untouched. Removal of danger trees will be restricted to those which will strike the line when falling, with a ten-foot allowance for tree growth.

Material cut in a selectively cleared area will be carefully disposed of.

When the construction is complete, cleanup and restoration will be performed. In addition to removal of excess construction material, cleanup will include the restoration of the grounds to approach their original condition. Where necessary, culverts or other drainage devices will be repaired, replaced or installed to maintain adequate drainage, to prevent or control erosion and so as not to impede the natural drainage pattern.

Right-of-way maintenance will be required in the future to control resurgence of growth. The long range objective will be two-fold: to retard growth that may prove a hazard to the line and to encourage new growth of types that will provide a desirable ground cover for erosion control and improved appearance.

Normal operation and maintenance of the lines will require infrequent traversing of the right-of-way. Air patrol of the lines is conducted on a regular basis. Maintenance personnel can be directed to the precise area requiring attention as a result of the spotting by this patrol. Once a year either two or three men in a suitable vehicle will travel the entire line length closely inspecting the condition of structures and right-of-way. This infrequent traveling of the right-of-way will have a minimum of effect on the land and growth. Right-of-way maintenance will be scheduled on a 4 to 5 year cycle to control vegetation growth. Areas such as major road and major stream crossings will be maintained and improved so as to preserve the effects obtained by special clearing. The screening at these crossings will improve each year as selective pruning will enhance the growth and thickness of the vegetation. Right-of-way maintenance will also take into account any uses of the land for recreational and wildlife purposes.

9.7.3 Selection of Routes

The selection of transmission line routes is a progressive type of analysis. The most economical route would normally be a straight line between a plant and a load center. This approach is not often practical due to topography, land use, and environmental factors.

Wide corridors were investigated between the plant and various load centers on the CP&L system. A detailed study was made of the corridors to determine areas of high environmental sensitivity and land use patterns. Alternate transmission line routings were selected in the corridors and upon completion of intensive field investigation, final locations for the lines were selected. The final routings are shown in Figure 3.8-2.

In making the study of the transmission line routes, the guidelines set forth in Federal Power Commission Order #414, "Protection and Enhancement of Natural, Historic, and Scenic Values in the Design, Location, Construction and Operation of Project Works," Order #415, "Implementation of the National Environmental Policy Act," and The United States Department of Interior and The Department of Agriculture publication, "Environmental Criteria for Electric Transmission Systems," were followed where applicable.

Charles T. Main, Inc., a consulting firm with extensive experience in the field of transmission line routing, was employed to select the route for the Brunswick-Fayetteville 230 KV line and to review the route selection work done by CP&L for the other seven lines.

This firm was retained to independently review the work done by CP&L and to assure CP&L management that the transmission routes for the Brunswick Plant conformed to the federal guidelines noted above and fully reflected a recognition of all applicable environmental considerations.

9.7.4 Conclusion

Carolina Power & Light is faced with an increase in electric power demand which is doubling about every six to seven years. To meet this requirement, new generation and transmission facilities are being constructed, with ever increasing concern for the environment.

Carolina Power & Light Company recognizes that the transmission lines needed to transmit power from the Brunswick Plant to certain load centers, should be located and engineered with a serious concern for their impact on the area.

The guidelines established by the Federal Power Commission, the United States Departments of Interior and Agriculture, and the recommendations of Charles T. Main, Inc., were considered in the selection of routes and will be followed where applicable in connection with right-of-way clearing and construction.

The selection of voltage, the selection of construction, and the selection of routes for the transmission lines out of the Brunswick Plant, all reflect Carolina Power & Light Company's concern for facilities which will serve the public with a minimum environmental impact and with maximum economy.

TABLE 9.7-1

TRANSMISSION LINE SYSTEM
PLAN I - ALL 500 KV LINES

	Line	Mileage	Acres Of Right-of-Way
1.	Brunswick-Fayetteville 500 KV	97	2090
2.	Brunswick-Delco West 500 KV	31	615
3.	Brunswick-Delco East 500 KV	31	615
4.	Brunswick-Wallace 500 KV	54	995
5.	Brunswick-Jacksonville 500 KV	76	1270
6.	Brunswick-Castle Hayne 500 KV	39	765
	Total Miles 500 KV	328	
	Total Acres Right-of-Way		6350

TABLE 9.7-2

TRANSMISSION LINE SYSTEM
PLAN II - COMBINATION 500 KV & 230 KV

	Line	Mileage	Acres of Right-of-Way
1.	Brunswick-Fayetteville 500 KV	97	2090
2.	Brunswick-Weatherspoon 230 KV (Brunswick-Delco Section)	31	305
3.	Brunswick-Delco West 230 KV	31	305
4.	Brunswick-Delco East 230 KV	31	310
5.	Brunswick-Wallace 500 KV	54	995
6.	Brunswick-Jacksonville 230 KV	76	615
7.	Brunswick-Barnard Creek West 230 KV	16	160
8.	Brunswick-Barnard Creek East 230 KV	16	160
	Total Miles 500 KV & 230 KV	352	
	Total Acres of Right-of-Way		4940

TABLE 9.7-3

TRANSMISSION LINE SYSTEM
PLAN III - ALL 230 KV LINES

	Line	Mileage	Acres of Right-of-Way
1.	Brunswick-Fayetteville 230 KV	103	1240
2.	Brunswick-Weatherspoon 230 KV (Brunswick-Delco Section)	31	305
3.	Brunswick-Delco West 230 KV	31	305
4.	Brunswick-Delco East 230 KV	31	310
5.	Brunswick-Wallace 230 KV	54	505
6.	Brunswick-Jacksonville 230 KV	76	615
7.	Brunswick-Barnard Creek West 230 KV	16	160
8.	Brunswick-Barnard Creek East 230 KV	16	160
	Total Miles 230 KV	358	
	Total Acres of Right-of-Way		3600

TABLE 9.7-4

ALTERNATIVE TRANSMISSION LINE SYSTEMS

Effect Considered	Plan I	Plan II	Plan III
Number of Lines and Voltages	6 - 500 KV	2 - 500 KV 6 - 230 KV	8 - 230 KV
Total Acres of New Right-of-Way Required	6,350	4,940	3,600
Number of New 500 KV Substations	5	2	0
Estimated Total Investment	$69,733,500	$47,391,500	$23,809,000

REFERENCES

1. Federal Power Commission Order No. 414, "Protection and Enhancement of Natural, Historic, and Scenic Values in the Design, Location, Construction, and Operation of Project Works."

2. Federal Power Commission Order No. 415, "Implementation of the National Environmental Policy Act."

3. The United States Department of the Interior and The Department of Agriculture publication, "Environmental Criteria for Electric Transmission Systems."

4. Charles T. Main, Inc., Report to CP&L, "Environmental Review of the Selection of all Transmission Line Routes and Design for Lines Emanating from Brunswick Plant," December, 1971.

5. Charles T. Main, Inc., Report to CP&L, "Environmental Report on a Location for the Proposed Brunswick Plant-Whiteville-Fayetteville 230 KV Transmission Line," October, 1971.

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SEE APERTURE CARDS

NUMBER OF OVERSIZE PAGES FILMED ON APERTURE CARDS 1

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APPENDIX 9A

CAROLINA POWER & LIGHT COMPANY
230 KV CAPE FEAR RIVER CROSSING
COST COMPARISON
ALTERNATIVE DESIGNS

DECEMBER 1971

CAROLINA POWER & LIGHT COMPANY
230 KV CAPE FEAR RIVER CROSSING
COST COMPARISON
ALTERNATIVE DESIGNS

1 - Scope

At the request of CP&L, Ebasco has prepared additional cost estimates for the crossing towers encompassing alternate designs which utilize steel pole sections. These estimates were prepared on the same basis as the estimate Ebasco prepared in October of this year comparing the cost of an underwater crossing with an overhead crossing utilizing conventional lattice type structures. These previous estimates are included in this report and are referred to as Alternatives I and II in the following description and in the tabulated costs on page 9A-3.

2 - Alternative Designs

Alt. I - Two 230 kV underwater cable circuits consisting of four pipe-type cables as depicted on sketch SK-9224-E-1.

Alt. II - Two overhead circuits using two tangent, double-circuit, galvanized steel lattice-type towers, Fig. 1 and four single-circuit galvanized steel, guyed dead-end lattice-type towers, Fig. 2, one at each end of each circuit.

Alt. III - Two overhead circuits using two tangent, double-circuit, galvanized, Vierendel Frame type four-legged structures with the circuits in parallel vertical configuration, Fig. 3, and four single-circuit, galvanized guyed steel pole section dead-end structures with the conductors in horizontal configuration, Fig. 4.

Alt. IV - Two overhead circuits using two tangent, double-circuit, galvanized, Vierendel Frame type four-legged structures, with circuits in parallel horizontal configuration, Fig. 5, and dead-end structures as described in Alternative III.

Alt. V - Two overhead circuits using two tangent, double-circuit, galvanized, Vierendel Frame type two-legged structures with the circuits in parallel horizontal configuration, Fig. 6 and dead-end structures as described in Alternative III.

3 - Other Alternatives

An additional alternative was a single steel pole design for both single and double circuit use. Base reactions for either the single or double circuit single steel pole designs with the loading criteria used for the Cape Fear River Crossing would be in excess of the maximum moment capability of 40 000 000 foot pounds now available, according to one of the leading suppliers of steel poles. Their letter confirming this information is attached to this study. This rules out the single steel pole.

Another alternative was a single circuit, galvanized, Vierendel Frame type two-legged structures similar to Alternative V. This alternative required two single circuit crossings of the river, which are substantially more expensive than Alternative V since the longitudinal wind load is the governing condition and no appreciable reduction in weight is possible for each of the single circuit tangent structures as compared to the double circuit design.

Although Alternative V is possible, Ebasco considers that the excessive deflection of this type of structure under longitudinal high wind loadings makes it unsatisfactory from a technical viewpoint.

Alternative IV is less costly than Alternative III, however, the double circuit horizontal configuration is exposed to a two circuit outage in the case of a broken shieldwire or conductor, or a galloping condition. Therefore, the double circuit vertical configuration is the preferred construction.

4 - Cost Estimates

All cost estimates shown on the following page are based upon the crossing being located at the Bernard Creek site, with each circuit having a maximum capability of 2000 amperes.

The estimates include escalation of costs for construction during the period of January 1973 to December 1973, premium time (48 hour week), sales tax, contingencies, indirect and overhead costs and Interest at 7 percent per annum.

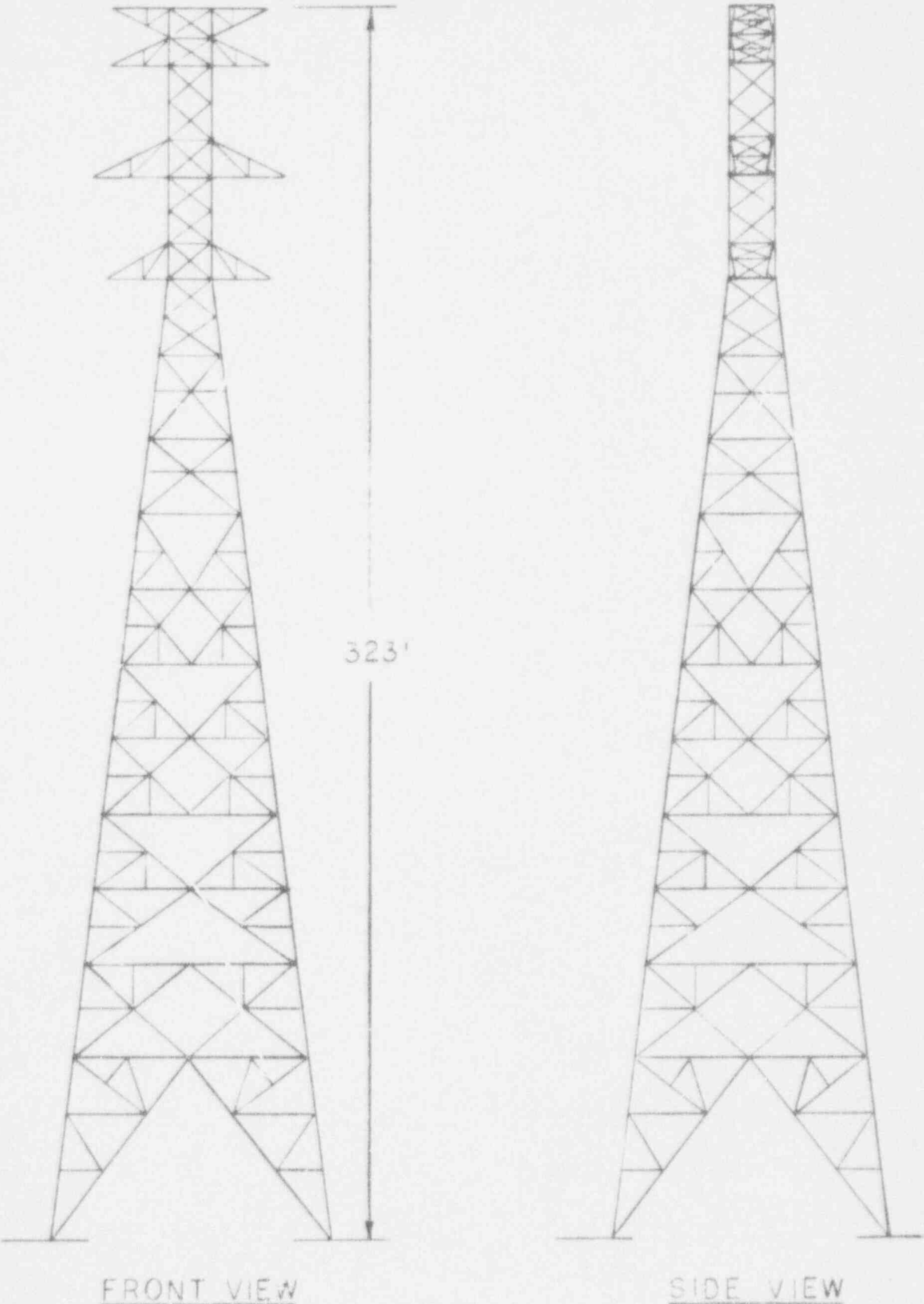
The costs of line survey, right-of-way, clearing, permits and client charges for off-site electrical facilities were not included in these estimates.

5 - Design Data

The same loading conditions were used for each of the alternative overhead designs. They are listed in Table I (Tangent Structures) and Table II (Dead-End Structures). These loads are for the wind and ice loading conditions which will be used for the final design. The general plan of the underwater and overhead crossings is shown on sketches SK-9224-E-1 and SK-9224 E-2, respectively.

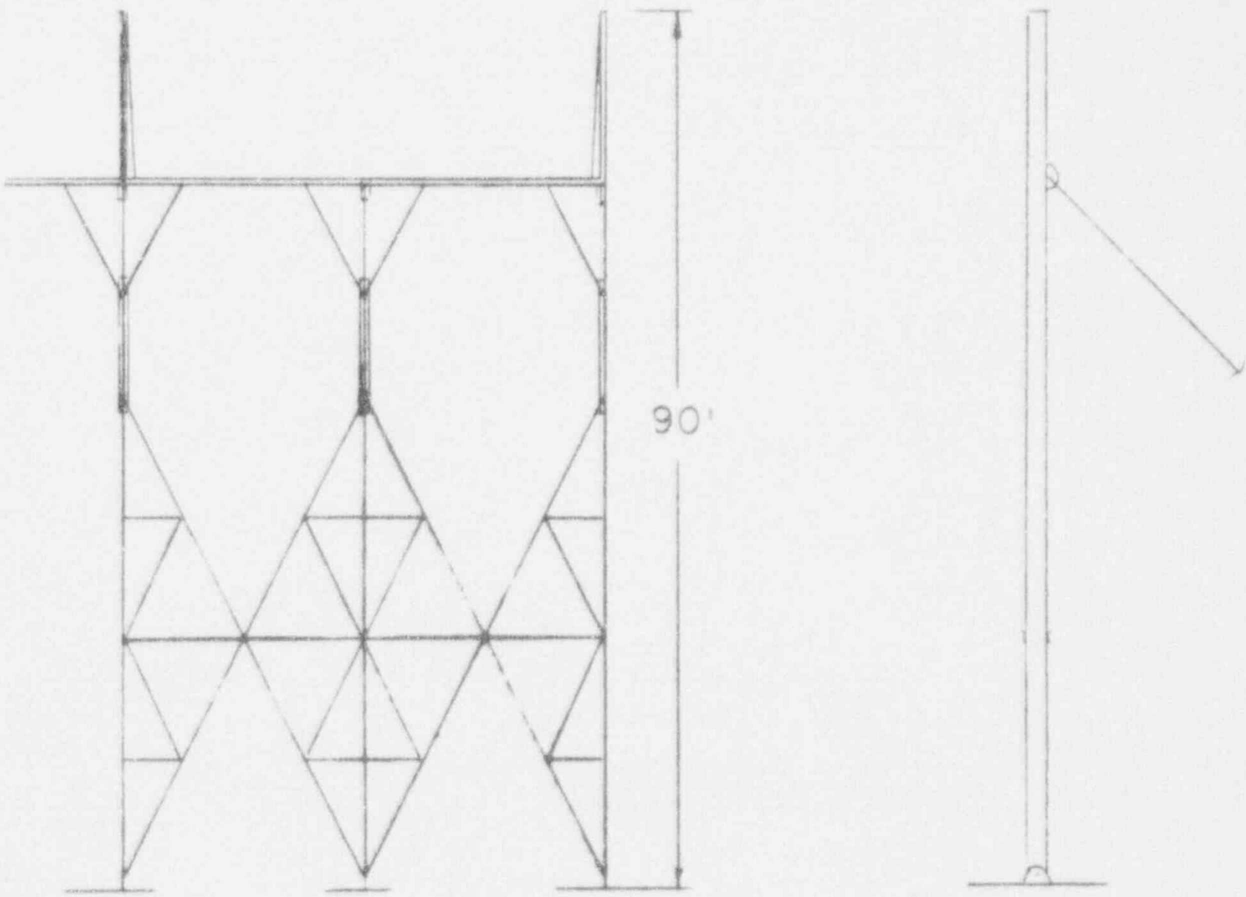
230KV CAPE FEAR RIVER CROSSING
ESTIMATED COSTS IN $1000

FPC Acct.	Item 6	ALTERNATIVE DESIGNS I	II	III	IV	V
354.	TOWERS, FIXTURES & SITE FAC	-	1471	2098	1967	1980
.1	Site Facilities	-	3	3	3	3
.2	Foundations	-	521	813	729	763
.3	Towers	-	947	1282	1235	1214
356.	OVERHEAD CONDUCTOR & DEVICES		257	257	257	257
357.	UNDERGROUND CONDUIT & SITE FAC	1626	-	-	-	-
.1	Site Facilities	27	-	-	-	-
.2	Foundations	106	-	-	-	-
.3	UG Conduit & Terminal Tower	1493	-	-	-	-
358.	UNDERGROUND CONDUCTOR & DEVICES	1978	-	-	-	-
	PREMIUM TIME	157	102	115	109	107
	SALES/USE TAX	56	18	33	31	32
	CONTINGENCIES	267	142	181	171	170
	TOTAL CONSTRUCTION COST	4084	1990	2684	2535	2546
	INDIRECT CONSTRUCTION COST, OVERHEAD CONSTRUCTION COST, AND INTEREST	527	349	439	423	424
	TOTAL PROJECT COST	4611	2339	3123	2958	2970
	APPROXIMATE COST RATIO	2.00	1.00	1.33	1.25	1.25



ALTERNATIVE II

EBASCO SERVICES INCORPORATED NEW YORK DIV. ELEC DR. AS SCALE - CH. AJT DATE 12-6-71 APPROVED	CAROLINA POWER & LIGHT COMPANY 230 KV CAPE FEAR RIVER CROSSING D/C TANGENT STRUCTURE CONVENTIONAL STEEL LATTICE TYPE VERTICAL CIRCUIT CONFIGURATION	FIGURE 1



FRONT VIEW SIDE VIEW

ALTERNATIVE II

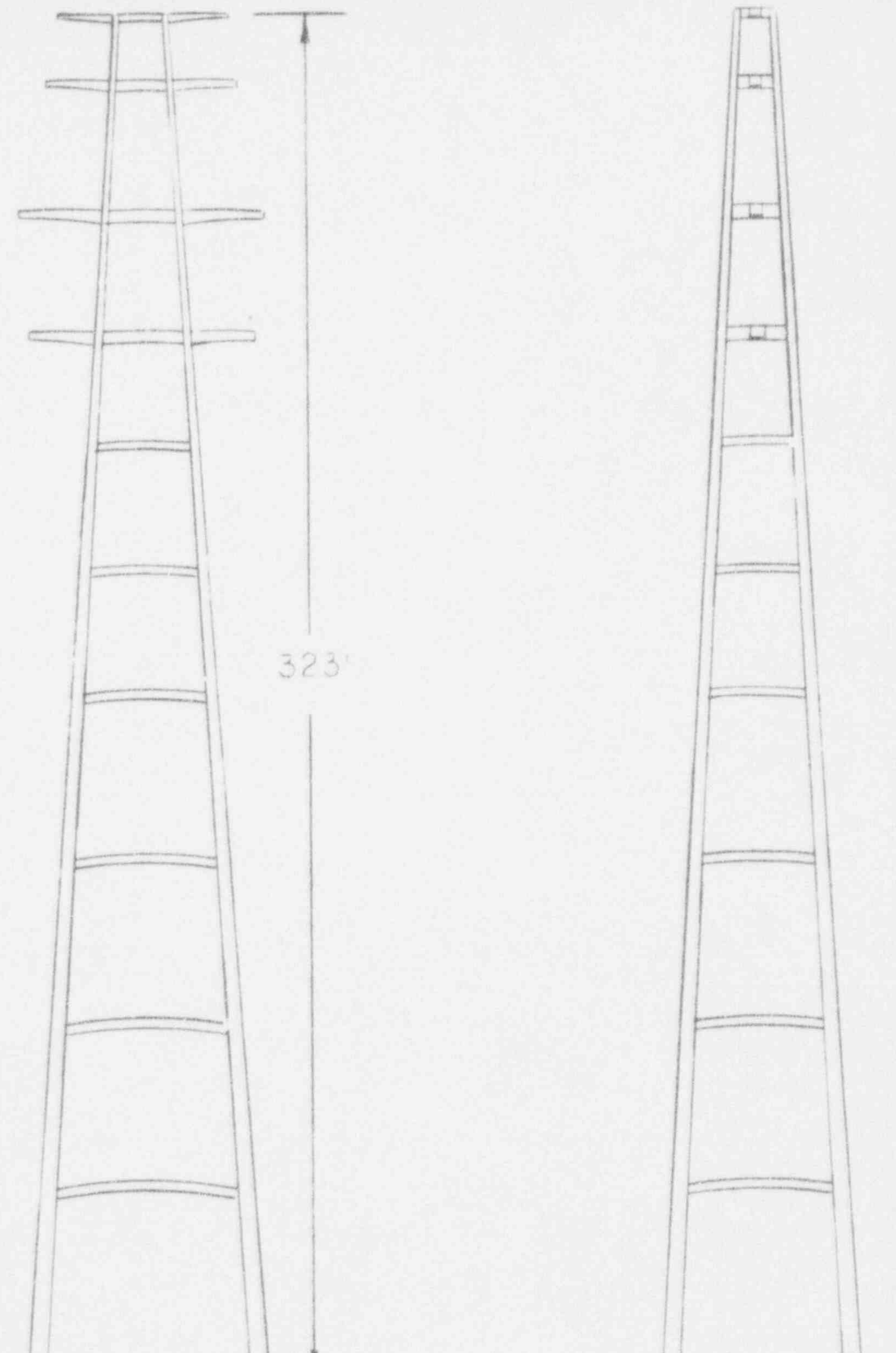
EBASCO SERVICES INCORPORATED
NEW YORK

DIV. ELEC DR. AS
SCALE - CH. AJT
DATE 12-6-71

APPROVED

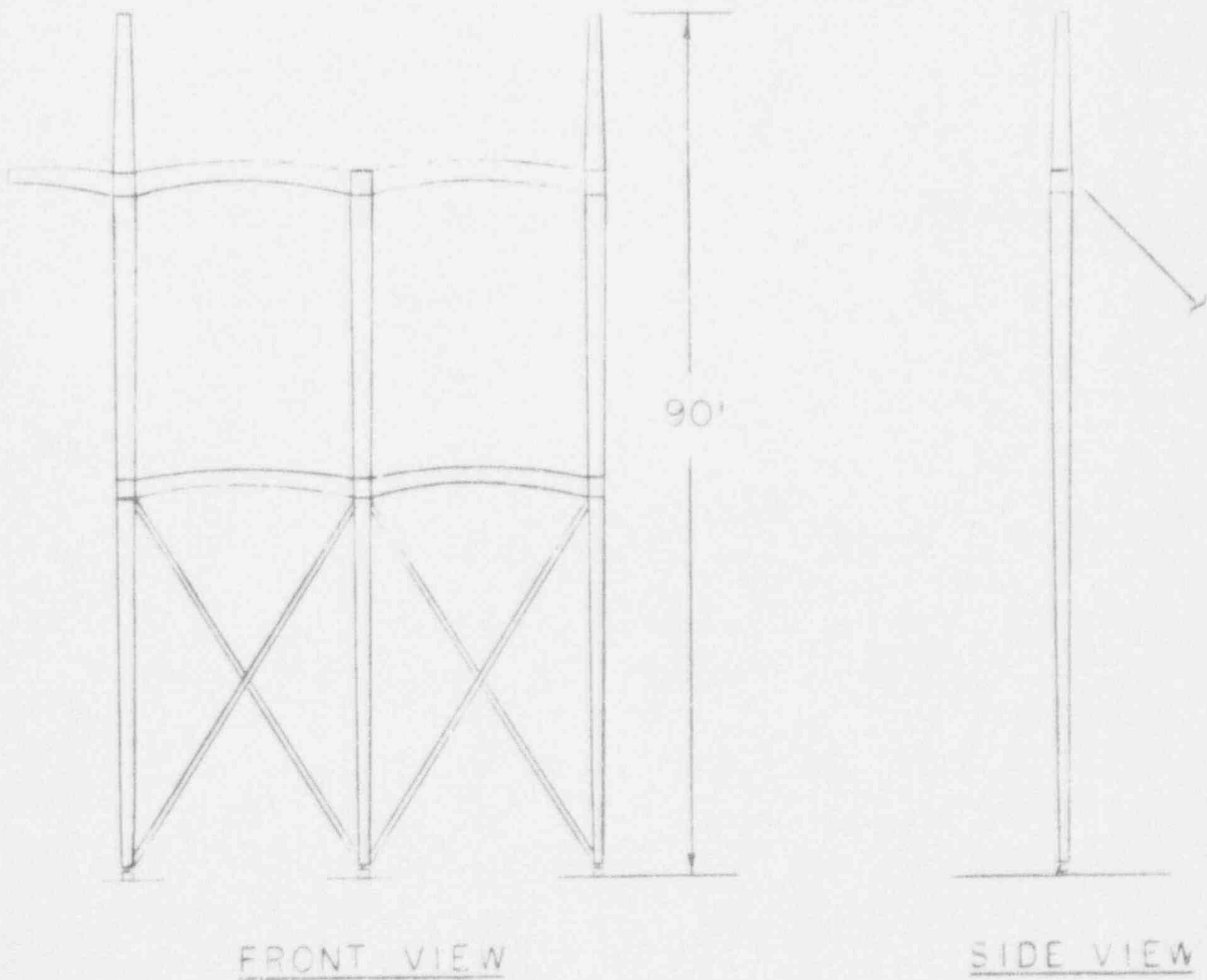
CAROLINA POWER & LIGHT COMPANY
230 KV CAPE FEAR RIVER CROSSING
S/C GUYED DEAD-END STRUCTURE
CONVENTIONAL LATTICE TYPE
HORIZONTAL CIRCUIT CONFIGURATION

FIGURE 2



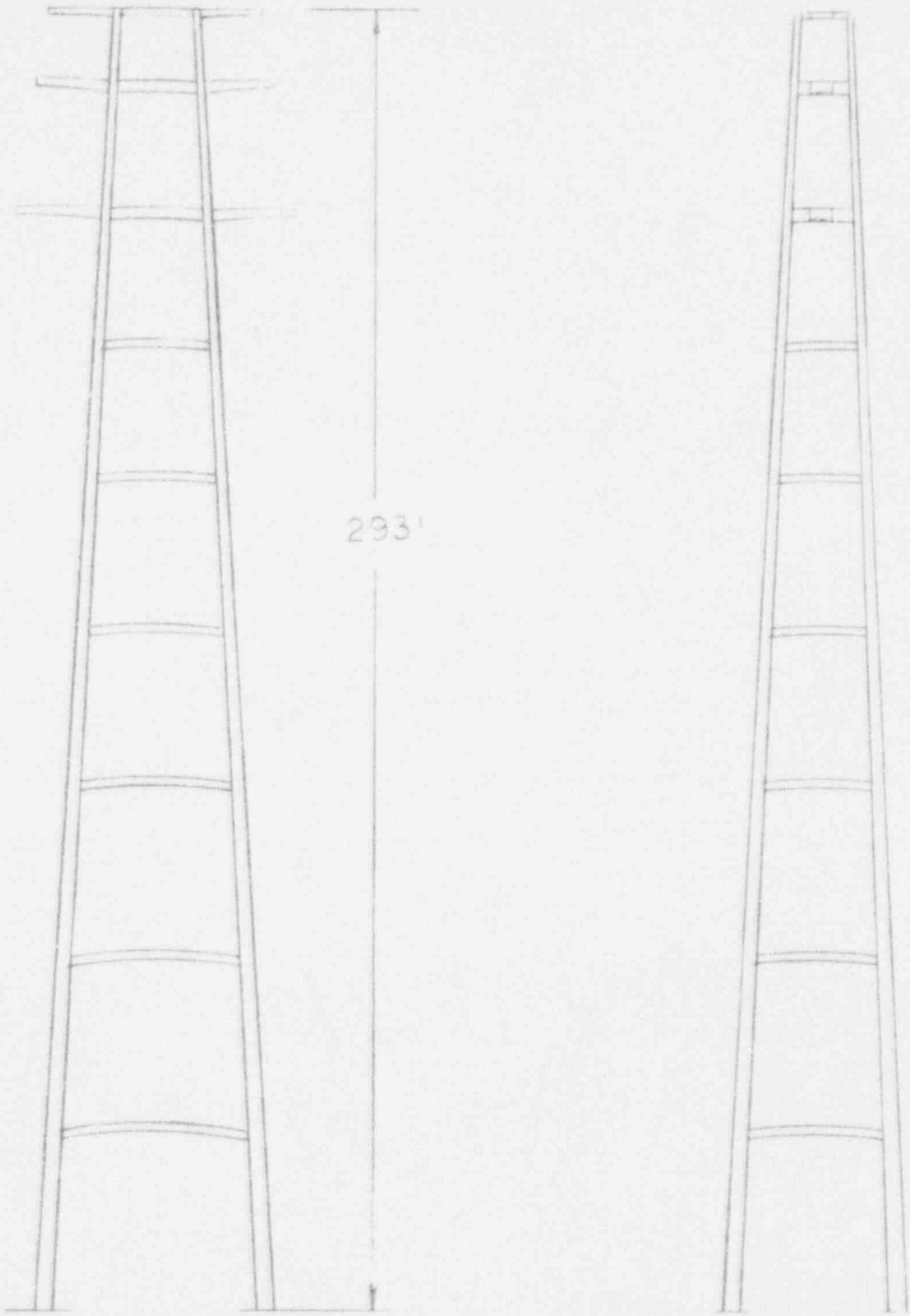
ALTERNATIVE III

EBASCO SERVICES INCORPORATED NEW YORK DIV. ELEC DR. AS SCALE - CH. AJT DATE 12-6-71 APPROVED	CAROLINA POWER & LIGHT COMPANY 230 KV CAPE FEAR RIVER CROSSING D'C TANGENT STRUCTURE VIERENDEL FRAME TYPE - FOUR LEGGED VERTICAL CIRCUIT CONFIGURATION	FIGURE 3



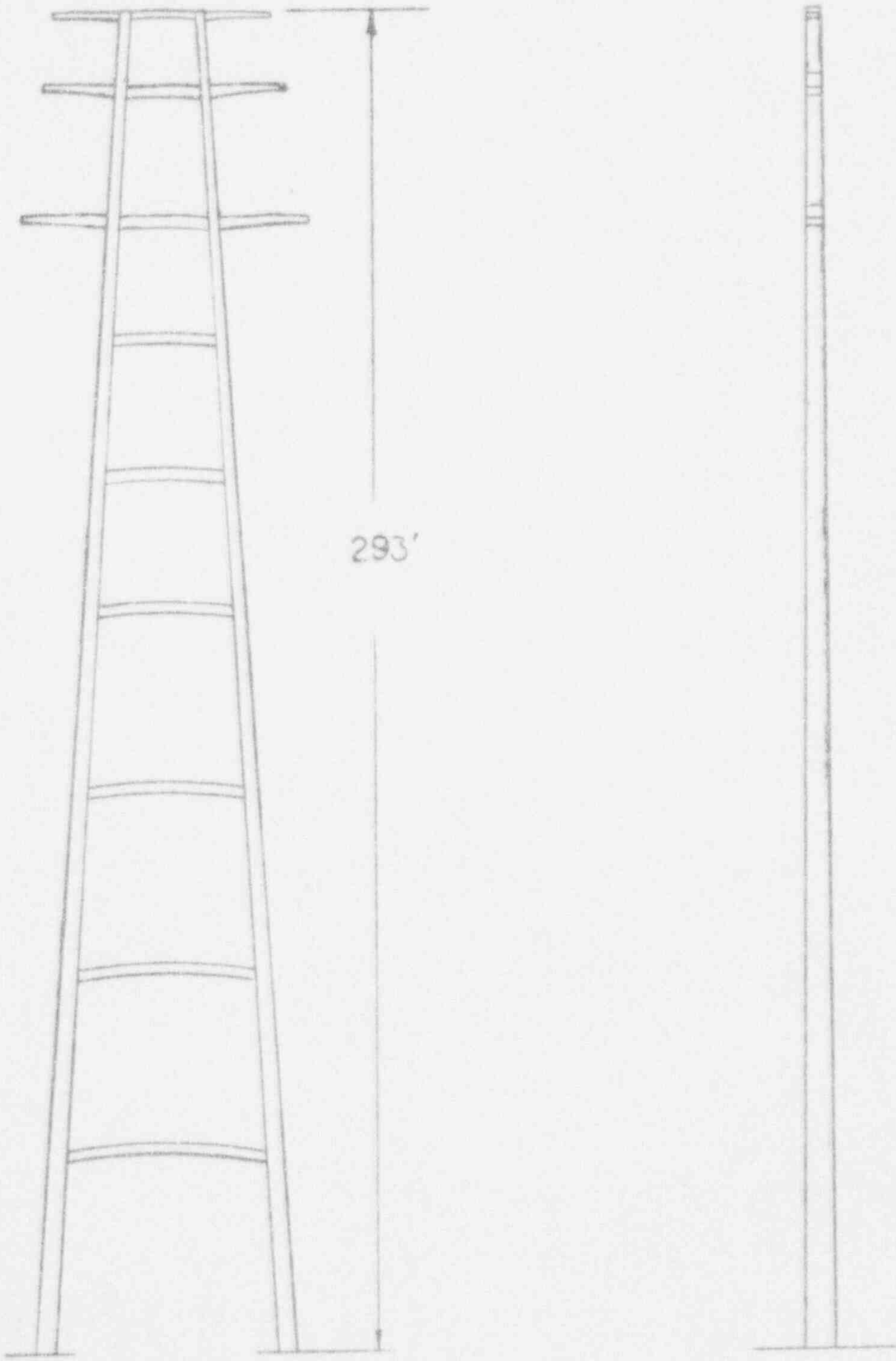
ALTERNATIVES III THROUGH V

EBASCO SERVICES INCORPORATED NEW YORK	CAROLINA POWER & LIGHT COMPANY 230 KV CAPE FEAR RIVER CROSSING S/C GUYED DEAD-END STRUCTURE STEEL POLE SECTION TYPE HORIZONTAL CIRCUIT CONFIGURATION	FIGURE 4
DIV. ELEC DR. AS SCALE - CH. AJT DATE 12-6-71 APPROVED		



ALTERNATIVE IV

EBASCO SERVICES INCORPORATED NEW YORK	CAROLINA POWER & LIGHT COMPANY 230 KV CAPE FEAR RIVER CROSSING D/C TANGENT STRUCTURE VIERENDEL FRAME TYPE - FOUR LEGGED HORIZONTAL CIRCUIT CONFIGURATION	FIGURE 5
DIV. ELEC DR. AS SCALE - CH. AJT DATE 12-6-71 APPROVED		



ALTERNATIVE V

EBASCO SERVICES INCORPORATED NEW YORK	CAROLINA POWER & LIGHT COMPANY 230 KV CAPE FEAR RIVER CROSSING D/C TANGENT STRUCTURE VIERENDEL FRAME TYPE - TWO LEGGED HORIZONTAL CIRCUIT CONFIGURATION	FIGURE 6
DIV. ELEC DR. AS SCALE - CH. AJT DATE 12-6-71 APPROVED		

TANGENT STRUCTURE LOADS

LINE ANGLE 0.0 DEG, WEIGHT SPAN 2800.0 FT, WIND SPAN 2300.0 FT

CONDUCTOR 2500 KCMIL 96/19 AACSR, 1 CONDUCTOR PER PHASE, DIAMETER 1.937 IN., WEIGHT 3.214 LB/FT, ULTIMATE TENSILE STRENGTH 136,800 LB

SHIELD WIRE 19 NO. 6 AWG ALUMOWELD, 1 SHIELD WIRE PER SUPPORT, DIAMETER 0.810 IN., WEIGHT 1.134 LB/FT, ULTIMATE TENSILE STRENGTH 61,700 LB

LOADING CONDITION	TEMP DEG.F	ICE IN	WIND PSF	VERTICAL COND LB	VERTICAL SH.W. LB	TRANSVERSE COND. LB	TRANSVERSE SH.W. LB	LONGITUDINAL COND. LB	LONGITUDINAL SH.W. LB	WIND ON STRUCT. PSF	NO. OF FACES	OCF
NESC MED.	15	0.25	4.0	15,800	5,500	5,000	2,600	0	0	16.3	1.5	CODE
HIGH WIND	60	0.00	46.0	13,200	4,300	22,800	9,000	0	0	87.5	2.0	1.25
HEAVY ICE	30	1.00	0.0	26,600	15,600	0	0	0	0	0.0	2.0	1.25
STRINGING	60	0.00	0.0	15,000	5,500	0	0	27,500	17,500	0.0	2.0	1.25

NOTES:

1 - LOADS TABULATED ABOVE INCLUDE OVERLOAD CAPACITY FACTORS (OCF).

2 - CODE OCF ARE - VERT. 1.27, TRANSV WIND 2.54, TRANSV TENSION 1.65, LONGITUD. 1.65

3 - CABLE LOADS ARE PER CONDUCTOR SUPPORT AND PER SHIELD WIRE SUPPORT.

4 - ALL HORIZONTAL MEMBERS ARE TO BE DESIGNED FOR A VERTICAL LOAD OF 500 LBS.

5 - CONDUCTOR AND SHIELD WIRE LOADS, AS WELL AS STRUCTURE WIND AND WEIGHT LOADS, ARE APPLIED SIMULTANEOUSLY FOR THE CORRESPONDING LOADING CONDITION, EXCEPT FOR THE STRINGING CONDITION, WHERE CABLE LOADS ARE APPLIED AT ANY ONE CONDUCTOR OR SHIELD WIRE SUPPORT.

6 - THE FOLLOWING VERTICAL LOADS (FOR INSULATORS, HARDWARE, ETC.,) AND HORIZONTAL LOADS (FOR WIND ON INSULATORS) WERE MULTIPLIED BY THE APPROPRIATE OCF AND INCLUDED IN ABOVE LOADS.

LOADING CONDITION	VERTICAL LOAD/SUPPORT CONDUCTOR(LB)	VERTICAL LOAD/SUPPORT SHIELD WIRE(LB)	WIND LOAD/SUPPORT CONDUCTOR(LB)
NESC MED.	1500.0	200.0	100.0
HIGH WIND	1500.0	200.0	1150.0
HEAVY ICE	2000.0	3000.0	0.0
STRINGING	3000.0	1200.0	0.0

7 - TO SATISFY RULE 261.A.1.(C) OF THE NATIONAL ELECTRICAL SAFETY CODE, THE METAL STRUCTURE MUST ALSO BE CAPABLE OF WITHSTANDING, WITHOUT ANY CABLES, A TRANSVERSE WIND LOAD OF 42.2 LB/SQ FT ON 1.5 FACES.

EBASCO SERVICES INCORPORATED NEW YORK	CAROLINA POWER & LIGHT COMPANY 230 KV CAPE FEAR RIVER CROSSING TANGENT STRUCTURE LOADS	TABLE 1
DIV. ELEC DR. AS SCALE - CH. AJT DATE 12-6-71 APPROVED [signature]		

GUYED DEAD-END STRUCTURE LOADS

LINE ANGLE 0.0 DEG. WEIGHT SPAN 2200.0 FT. WIND SPAN 2100.0 FT

CONDUCTOR 2500 KCMIL 96/19 AACSR. 1 CONDUCTOR PER PHASE. 3 PHASES/STRUCTURE. DIAMETER 1.937 IN., WEIGHT 3.214 LB/FT. ULTIMATE TENSILE STRENGTH 136,800 LB

SHIELD WIRE 19 NO 6 AWG ALUMOWELD. 1 SHIELD WIRE PER SUPPORT. 2 SUPPORT(S)/STRUCTURE. DIAMETER 0.810 IN. WEIGHT 1.134 LB/FT. ULTIMATE TENSILE STRENGTH 61,700 LB

LOADING CONDITION	TEMP DEG F	ICE IN	WIND PSF	VERTICAL COND LB	VERTICAL SH.W. LB	TRANSVERSE COND LB	TRANSVERSE SH W LB	LONGITUDINAL COND. LB	LONGITUDINAL SH.W. LB	WIND ON STRUCT. PSF	NO OF FACES	OCF
ALL CABLES INTACT WITH 0.0 DEG LINE ANGLE												
NESC MED.	15	0.25	4.0	12,800	4,400	4,600	2,400	0	0	16.3	1.5	CODE
HIGH WIND	60	0.00	46.0	10,800	3,400	21,000	8,200	0	0	87.5	2.0	1.25
HEAVY ICE	30	1.00	0.0	21,400	13,100	0	0	0	0	0.0	2.0	1.25
ANY ONE OR ALL CABLES DEAD-ENDED ON ONE FACE WITH 0.0 DEG LINE ANGLE												
NESC MED.	15	0.25	4.0	12,800	4,400	4,600	2,400	60,400	31,400	16.3	1.5	CODE
HIGH WIND	60	0.00	46.0	10,800	3,400	21,000	8,200	71,800	34,400	87.5	2.0	1.25
HEAVY ICE	30	1.00	0.0	21,400	13,100	0	0	65,500	36,300	0.0	2.0	1.25

NOTES:

1 - LOADS TABULATED ABOVE INCLUDE OVERLOAD CAPACITY FACTORS (OCF).

2 - CODE OCF ARE - VERT 1.27. TRANSV. WIND 2.54. TRANSV. TENSION 1.65. LONGITUD. 1.65.

3 - CABLE LOADS ARE PER CONDUCTOR SUPPORT AND PER SHIELD WIRE SUPPORT.

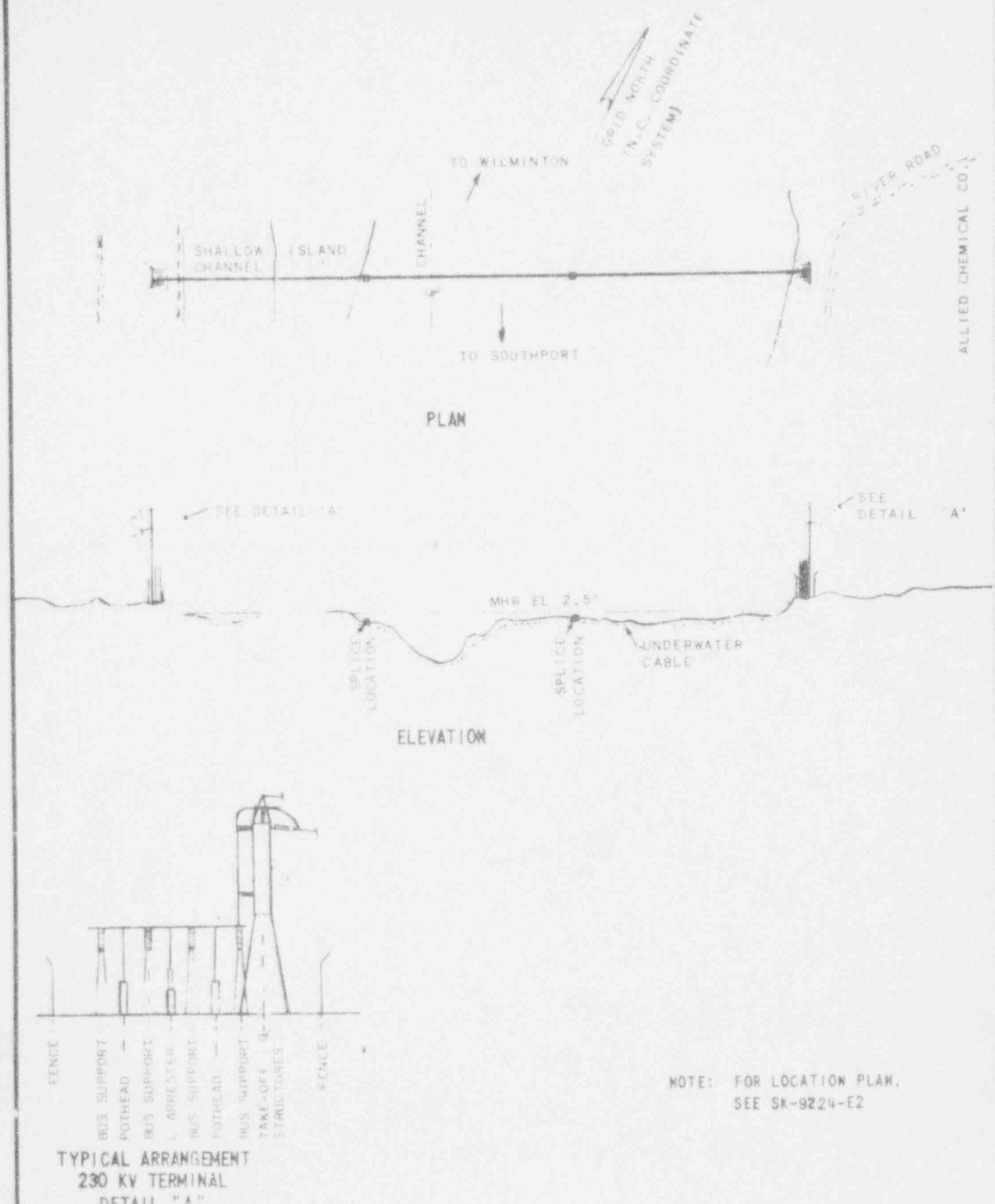
4 - ALL HORIZONTAL MEMBERS ARE TO BE DESIGNED FOR A VERTICAL LOAD OF 500 LBS.

5 - CONDUCTOR AND SHIELD WIRE LOADS, AS WELL AS STRUCTURE WIND AND WEIGHT LOADS, ARE APPLIED SIMULTANEOUSLY FOR THE CORRESPONDING LOADING CONDITION.

6 - THE FOLLOWING VERTICAL LOADS (FOR INSULATORS, HARDWARE, ETC.) AND HORIZONTAL LOADS (FOR WIND ON INSULATORS) WERE MULTIPLIED BY THE APPROPRIATE OCF AND INCLUDED IN ABOVE LOADS

LOADING CONDITION	VERTICAL LOAD/SUPPORT CONDUCTOR(LB)	VERTICAL LOAD/SUPPORT SHIELD WIRE(LB)	WIND LOAD/SUPPORT CONDUCTOR(LB)
NESC MED.	1500.0	200.0	100.0
HIGH WIND	1500.0	200.0	1150.0
HEAVY ICE	2000.0	3000.0	0.0

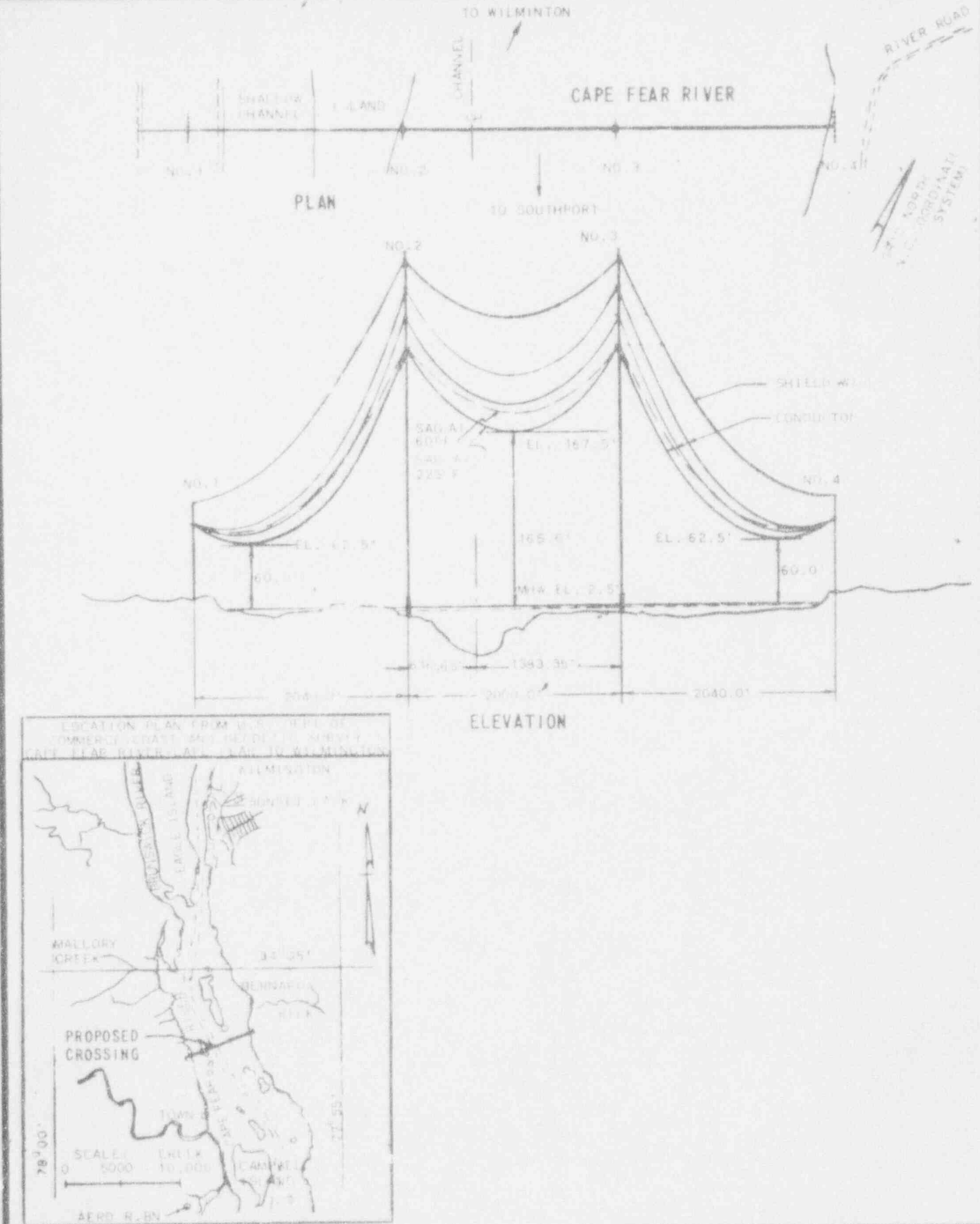
EBASCO SERVICES INCORPORATED NEW YORK	CAROLINA POWER & LIGHT COMPANY 230 KV CAPE FEAR RIVER CROSSING GUYED DEAD-END STRUCTURE LOADS	TABLE 2
DIV. ELEC DR. AS SCALE - CH. AJT DATE 12-6-71 APPROVED		



NOTE: FOR LOCATION PLAN, SEE SK-9224-E2

REV. 1 12-6-71

EBASCO SERVICES INCORPORATED NEW YORK	CAROLINA POWER & LIGHT COMPANY 230 KV CAPE FEAR RIVER CROSSING UNDERWATER CABLE ALTERNATIVE	SK-9224-E1
DIV. ELEC DR. AI SCALE – CH. LDC DATE 10-14-71 APPROVED		



EBASCO SERVICES INCORPORATED NEW YORK	CAROLINA POWER & LIGHT COMPANY 230 KV CAPE FEAR RIVER CROSSING GENERAL OVERHEAD PLAN	SK-9224-E2
DIV. ELEC DR. PB SCALE - CH. AJT DATE 12-6-71 APPROVED		

MEYER INDUSTRIES, INC
P.O. BOX L, HAZLETON, PENNA. 18201 TELEPHONE (717) 455-8551

December 2, 1971

EBASCO Services, Inc.
2 Rector Street
New York City, N. Y.

Attn: Mr. Norbert Mueller

Dear Norbert,

With reference to our phone conversation this afternoon, we believe tubular sections greater than 100" in dia. and with moment capacity greater than 40,000,000 ft. lbs. are not feasable at this time.

Very truly yours,

Jim Rarig

Jim Rarig
Chief Engineer - Hazleton

9.8 Discussion of Benefits and Costs of the Facility

9.8.1 Benefits of the Facility

The addition of the Brunswick facility to the resources of the area will have numerous benefits, some of which can be assigned values in monetary terms. Other benefits which will have resultant monetary benefits to the area can only be evaluated in qualitative dimensions at the present time. In determining the overall balance of the facility, it is more relevant to present benefits and impacts or costs in meaningful parameters, rather than assess a numerical benefit-cost ratio.

9.8.1.1 Needed Power

When the plant is completed and in full operation, the units will constitute about 23 percent of CP&L's generating capability. The annual sales from the units are expected to amount to about 11,507,000,000 kilowatt hours. This power will be necessary to support the residents of the Company's service area in a number of ways. The electrical energy requirements of industry in the area are increasing at a rapid rate due to new and expanding industries. In 1970, 78 new plants and 143 expansions were announced for the CP&L service area, with an expected increase of 13,000 jobs. Further industrial growth has been announced and is expected in succeeding years. In addition to this large industrial growth, the energy required to support each industrial job has been increasing and is expected to continue in a similar fashion. Between 1960 and 1970, employment in the CP&L eastern North Carolina service area rose from 221,887 to 373,076. The growth to 1980 is expected to raise the total to about 501,300. Energy requirements are also increasing in residential use due to population growth and increasing per capita usage. Various pollution control processes being implemented, such as wastewater treatment, will require increased energy usage. All these considerations and others have been taken into account in determining what size generation capacity to add to the Company's system. This increased growth could not be supported without the necessary electricity which the Brunswick Plant will generate, since as discussed in Section 4, outside purchases of power are not available.

The capacity of the Brunswick Plant was selected based on providing a reliable electrical energy supply for Company customers. Carolina Power & Light Company needs reserve capability of its largest generating unit plus 100 MW, or 18 percent, whichever is larger. As shown in subsection 4.1, the on-schedule completion of the Brunswick Plant will enable CP&L to provide this reliability.

9.8.1.2 Taxes

The plant is located within Brunswick County, North Carolina. The Brunswick Plant will have a substantial and positive effect upon property taxes in Brunswick County. If the Brunswick Plant had been completed by January 1, 1971, it would have represented about 67.5 percent of the real taxable property value in Brunswick County in that year. Stated in another form, when the plant was announced to represent a minimum investment of $200 million, it was noted that such an investment would triple the then existing tax base of Brunswick County. In 1969, the County voted a $2,585,000 bond issue for the construction of three new consolidated high schools. This bond issue was voted, at least in part, in anticipation of the additional tax revenues which would be afforded by the Brunswick Plant. The revenues from taxes will in turn benefit the community in numerous areas, such as better educational facilities, transportation, and others.

Additional revenues to the community will accrue since new jobs in the area due to economic growth and also due to employment at the plant will create new retail sales and property sales in the area, which in turn will generate increased sales and property tax revenues.

9.8.1.3 Economic Benefits

The Brunswick Plant will afford significant positive economic benefits to the community. The preceding section briefly discussed the tax benefits which the plant will create for the area. In addition to these benefits, the plant will employ a large number of permanent employees. Although not yet finalized, this number is estimated to be about 138 permanent employees. Based on a U. S. Chamber of Commerce economic research study, the economic benefits which could materialize from employment of 138 persons, if one assumes they reside in the same town, are listed below:

$ 916,500 more retail sales per year

$ 624,000 more bank deposits

$1,950,000 more personal income per year

4 more retail establishments

900 more employed in non-manufacturing or non-industrial

138 more households

An additional benefit, which is presently being effected, is the employment of construction personnel. The peak number of construction personnel at the Brunswick Plant will be in excess of 3,000 persons, with an estimated total construction payroll for the facility of $64,000,000. This $64 million will result in approximately $384 million of turnover in the area surrounding the project. Indirect employment will also result from the monetary turnover.

9.8.1.4 Summary

The benefits of the Brunswick Steam Electric Plant will be numerous and diverse, as shown in the preceding subsections. The economic benefits to the immediate community and the Company service area will be great, although complete quantification of all the benefits is not possible. The plant is an integrated, well-planned part of the long-range growth planning of the area. It will play an important role in supplying energy needs for research, industry, recreation, pollution control and residential uses. It is, of course, not possible to quantify the benefits that might result from research or the personal value of recreation but this does not in any way diminish the value to society or the individual.

In planning and in the building of the plant, CP&L feels that the benefits, both quantitative and qualitative, achieve a desirable balance with the costs and impacts discussed in the following subsections.

9.8.2 Environmental Benefits and Costs

9.8.2.1 Aquatic Biota

9.8.2.1.1 Discharges to Natural Water Body

Cooling water discharged into the oceanic environment is expected to have only a localized effect on the marine biota. The cooling water will be discharged in a horizontal direction at 10 feet per second, approximately perpendicular to the natural drift (0.7 feet per second) in the discharge area. This arrangement provides for rapid dilution, cooling, and confinement of effects on the marine biota to a small area.

Although significant detrimental effects are not anticipated, it is recognized that: (1) benthic organisms will be affected in a small area near the outfall structure; (2) there is a possibility migrating animals may tend to orient on the discharge water;

(3) fish may be attracted to the discharge during winter months, and (4) species composition of plankton may change in the area immediately in front of the discharge. The nature of these effects is known but definitive data for quantitative evaluations are presently nonexistent. However, studies in progress will provide the necessary data for later quantification.

The effect of the discharge on the benthic community will be confined to approximately two acres adjacent to the end of the discharge pipe. A scouring action resulting from friction as the water flows over the bottom will probably eliminate benthic organisms in this area. The warm water will then rise to the surface and is not expected to affect the benthic community outside the two-acre area.

The possibility that migrating postlarvae of various marine animals will orient on the discharge is slight. Recent research indicates that these animals utilize organic material (such as amino acids that are discharged to the ocean from an estuary) to locate the mouth of estuaries; however, this research is not conclusive. However, assuming orientation of these amino acids is the mechanism employed by these organisms, little or no disorientation of the migrants is expected since the discharge will not be an isolated concentration of these amino acids. Aerial photographs of the area clearly show that the natural discharge from the estuary moves southwestward, carrying organic materials through the cooling water discharge area.

There is nothing in the design of the discharge facility that will trap fish. Because of the high velocities at which the cooling water will enter the ocean, fish will be kept from the warmest area of the plume thereby minimizing the potential thermal shock resulting from a shutdown of the plant.

Plankton populations inhabiting the waters adjacent to the discharge may undergo a slight shift in species composition as a result of the elevated water temperature. However, this effect will be limited to a small area because the cooling water will rapidly mix with the cooler ocean water.

Any changes in plankton populations, the benthic community and the abundance of migrating postlarvae will be documented by the present ecological studies of the outfall area.

9.8.2.1.2 Impact on Migratory Fish by Heat Discharge

Since the heated discharge from the Brunswick Plant will not enter the Cape Fear River, migratory fish within the river should not be affected by cooling water. The possibility of migrating organisms orienting to the cooling water discharged into the ocean is discussed in the subsection 9.8.2.1.1.

9.8.2.1.3 Condenser Cooling System Effects on Micro-organisms

The effect on organisms passing through the plant condensers has received increasing attention from biologists during recent years. Factors which influence the effect on entrained organisms upon passage through the condenser include temperature rise through the condenser, maximum temperature attained, length of time the organisms are held at the elevated temperature, mechanical mortalities, and effects of biocides such as chlorine.

Studies in the vicinity of the Dickerson Power Plant on the Potomac River[1] did not find a significant difference in the number of diatom species or the total number of individuals between upstream and downstream stations. These results are supported by other studies at the sample plant which indicate that there were no significant effects on algae by passage through the condensers in August. Additional work[2] indicates that there will be little effect on algae being passed through the condensers if temperatures do not exceed 100°F-101°F.

In England, nannoplankton populations were not significantly affected by passage through the condensers of the Bradwell Nuclear Power Plant[3]. However, at the Chalk Point Power Plant located on the Patuxent River in Maryland, significant effects on plankton being passed through the plant condensers were found[4]. Samples taken at the intake and discharge locations showed reduction in photosynthetic capacity of up to 94 percent during the warmest part of the summer. However, it was noted that factors such as chlorine could have been partially responsible for the effect. Chlorine at this power station has been reported to be as high as 5 ppm in the discharge canal[5]. At the same power plant, Morgan and Stross[6] found that there was a decrease in primary production over the period of a year. Loss of production during the summer months was calculated to be as high as 424 tons. Increased production during the winter months did not equal this loss and there was a net loss in production over a year. However, the effects of heat and chlorination were not separated and much of the loss may be attributable to abnormally high levels of chlorine. As indicated in subsection 9.6, the residual levels of chlorine used in the Brunswick Plant will be limited to 0.5 ppm.

A report completed for the Edison Electric Institute by researchers at Johns Hopkins University(7) found that photosynthesis was increased by increased temperatures from a power plant on the James River. Photosynthesis was reduced during the summer months; however, the reduction in photosynthesis was not nearly as great as reported by Morgan and Stross. In addition, increased photosynthesis during the cooler months was greater than the loss during warmer months and there was a net gain in photosynthesis over the year.

Trembley(8) found fewer species in the warm water discharge of Martin's Creek Plant on the Delaware River but each species was represented by a greater number of individuals than were present in unaffected waters. Conversely, the addition of chlorine reduced the total numbers of individuals but did not appear to reduce the number of species in the warm water discharge.

Heinle(9) reported that estuarine copepods were killed during passage through the condensers of the Chalk Point Plant even though temperatures encountered were generally below the upper limits of thermal tolerance of the copepods. Chlorine was suspected as being the major factor in the kill. Population densities of copepods in the Patuxent River were found to be relatively constant in spite of significant mortalities in the plant condensers. This indicates that copepod populations have considerable resilience to changes in increased predation and environmental temperatures.

Studies in England of the effect of the Bradwell Nuclear Power Plant on zooplankton populations in the Blackwater River were conducted both before and after the plant started operation(10). No changes were detected that could be attributed to the effects of the power plant.

Other work has demonstrated rapid recovery of freshwater protozoans after extreme temperature shocks(11). When the temperature was increased from 74°F to 122°F, the number of species dropped from 26 to 7. Within 24 hours, the number of species had increased to 18 and complete recovery was demonstrated within 144 hours. A 48°F shock is much more severe than that produced in a power plant condenser. In the case of the Brunswick Plant, the temperature increase of the cooling water as it is passed through the condensers will be about 18°F.

From data cited above, one can predict that there will be some loss of phytoplankton and zooplankton during the summer months in the water being passed through the condensers of the plant. It is not possible to predict the extent of these losses or what effect the losses will have on populations in the estuary. However, the amount of water to be pumped through the condensers will be only a fraction of the net drift of water past the plant intake toward the ocean. The length of the discharge canal is of significant concern in terms of survival of entrained organisms in that organisms will be held at elevated temperatures for five-six hours before entering the ocean. However, even assuming significant mortality due to this length of time, this is not considered to represent a significant loss from the estuary due to the small percentage of water from the estuary to be diverted through the plant.

9.8.2.1.4 <u>Effects on Fishes by Intake Structure and Condenser Cooling Systems</u>

Although the design of the Brunswick circulating water system has no inherent factor which may attract fish to the intake structure, awareness of problems at other locations resulted in early consideration for fish diversion devises. The impact of the intake structure without effective fish diversion is presently unknown in the absence of definitive data concerning the distribution of various fish within the estuary. However, experience at other power plants within the CP&L system has been that significant mortalities at the intake structure have not occurred in freshwater habitats.

Assuming uniform distribution of fish throughout the waters which will flow past the intake, the impact is expected to be directly proportional to the ratio of tidal flow to circulating water system flow. Under the most adverse circumstances of minimum freshwater input to the estuary, circulating water flow will be between 2.3 and 3.5 percent of the tidal flow. Thus, assuming 100 percent mortality at the intake and condensers, the maximum impact on total fish population would be 3.5 percent or less during the most adverse conditions.

Preoperational experiments are planned in order to realistically evaluate the effect of the intake and condensers on fish in the intake canal. These studies will determine the number of fish and the nature of physical damage other than heat (if any) on fish in passing through the intake and condensers by coordinated sampling in the intake and discharge canals. This work will be initiated in September 1973 under the direction of Dr. B. J. Copeland, Director of the N. C. State University's Pamlico Marine Laboratory. Data from this study should prove to be valuable in determining the most appropriate type of fish diversion facility.

9.8.2.2 Terrestrial Biota

In order to minimize usage of the marshland in the project area, the cooling water canal system was routed through upland areas wherever feasible. Also, in the interest of marsh protection, spoiling ponds were built in upland locations. Thus, the terrestrial habitats were utilized in many instances in order to effect minimum damage to the more productive marshes.

A right-of-way along the entire canal system was cleared; thus, this habitat was temporarily disturbed. A total of approximately 1882 acres of woodland were cleared for the right-of-way of the intake canal (354 acres), discharge canal (785 acres), and plant site area (743 acres). An additional 503 acres were committed to spoil deposition, bringing the total acreage of upland area utilized to 2385 acres, whereas only 427 acres of marshland were included in the entire canal system right-of-way. Most of these upland acreages can be restored to wildlife habitat once construction is completed, with the exception of 369 acres which lie within the canal system proper.

9.8.2.3 Chemical Effluents and Water Quality

In the operation of the Brunswick Plant some non-radioactive chemical wastes will be produced in the processing of the high quality reactor makeup water, in the treatment of sanitary wastes and in the operation of some auxiliary systems.

The liquid chemical discharges will be those associated with chlorination of the main condenser cooling water and service water as well as those associated with the regeneration of the non-radioactive demineralizers. Non-radioactive regenerant chemicals will be neutralized before release to the discharge canal, and will be negligible added inventory to the saline estuarine cooling water.

The discharge into the ocean will have essentially the same chemical analysis as the river. Chlorine residuals in the water leaving the condenser will be no more than 0.5 ppm and should be no more than a trace at the discharge into the ocean. The closed cooling water systems may contain chemical additives for corrosion protection. Provisions have been made to collect water containing chemical additives for processing prior to discharge or off-site disposal. A wastewater treatment plant will be installed to process all domestic wastes from the plant. The liquid effluent from this process will be chlorinated and discharged in accordance with applicable standards and regulations.

9.8.2.4 Consumption of Water

There will be no loss of domestic or municipal water supplies resulting from the construction and operation of the Brunswick Plant. Water for consumptive use in the lower Cape Fear region is obtained from wells, with the exception of the city of Wilmington, which obtains its water from the Cape Fear River. This water is withdrawn upstream of Lock and Dam No. 1, approximately 23.5 miles north of the city of Wilmington and upstream from the Brunswick Site. Tidal salinity influences preclude potable use of the Cape Fear River below Lock and Dam No. 1.

Regarding agricultural activity, there are no known withdrawals for irrigation from the Cape Fear River below Lock No. 1. Municipal water supplies in Brunswick County are furnished to Long Beach and Southport, whose wells terminate in the Castle Hayne aquifer. Sunny Point Army Terminal also draws its water from this aquifer. Industrial wells in the Navassa area, 20 miles north, are in the surficial deposits.

The plant freshwater requirements will be supplied from two 300 gpm deep wells set in the Castle Hayne aquifer. A detailed investigation has been conducted to determine the effects of the plant on public and private wells within a ten-mile radius of the plant. This investigation has shown that only a few shallow wells will be affected by the plant, none of which are public water supplies. Where necessary and appropriate, alternate forms of water supply have been provided by CP&L as replacement for those shallow wells reduced in flow.

Therefore, based on the aforementioned water supplies and uses, it has been determined that the Brunswick Plant will not significantly affect agricultural, municipal, or industrial water utilization in areas of the lower Cape Fear River.

9.8.2.5 Chemical Discharge to Ambient Air

Because nuclear powered units do not burn fossil fuels for heat production, there will be essentially no chemical discharge to the ambient air as a result of the operation of the Brunswick Plant. The only releases of chemical combustion products will be those associated with the occasional operation of two auxiliary boilers and four diesel generators provided for emergency power. The combustion gases will be vented from stub stacks some 35 - 40 feet above plant grade which will adequately diffuse any possible concentrations. Both systems will operate within the limits of the Air Quality Standards for the State of North Carolina.

9.8.2.6 Chemical Contamination of Groundwater

The Castle Hayne aquifer is the only source of public water supplies in the vicinity of the Brunswick Plant. Small amounts of chemical effluents will be released to the discharge canal under controlled conditions. Because of the upwelling conditions that exist along most of the canal, the possibility for intrusion into the aquifer is very limited. In the area of Oak Island where the net hydrological head is negative, the downwelling of chemical effluents will have a negligible effect since the material will be very diluted in the canal water.

9.8.2.7 Radiological Impacts

The Brunswick Steam Electric Plant will be equipped with a comprehensive waste processing system as described in subsection 3.6. The design objective of the system is to minimize the release of radioactivity to the environment. The release estimates have been made in subsection 3.6 of this report and they are within the numerical guidelines of the proposed Appendix I to 10 CFR 50 dated June 9, 1971 and are believed to be as low as practicable. A complete discussion of the radiological effects and estimated doses is contained in subsections 3.6.2 through 3.6.4.

9.8.2.8 Fogging and Icing

A quantitative estimate of the probability and extent of fogging resulting from the operation of the canal and ocean discharge system is not available. However, based on CP&L's experience with cooling lakes and discharge canals, it is believed that the discharge canal will cause no problems due to fogging and will have no effect on navigation in the Intracoastal Waterway.

The potential for damage due to rime icing caused by fogs from the canal is also believed negligible based on CP&L's experience at other plants. Fog due to the discharge canal is not believed to be a problem and rime icing due to the discharge canal at CP&L's other plants has not been a problem. Icing is more probable further inland than in the Southport area. Therefore, experience gained at plants located further inland provides a reasonable assurance that rime icing due to the discharge canal will not be a problem.

9.8.2.9 Raising/Lowering of Groundwater Levels

The Castle Hayne aquifer is the only source of public water in the vicinity of the Brunswick Plant. Plant freshwater requirements will be supplied from two 300 gpm deep wells at a typical depth of 150 feet. The calculated daily requirement is not a significant load on the aquifer which can supply better than 1000 - 3000 gpm at the site, seasonally averaged. A study has been conducted to determine the radius of influence of these wells, and to establish operating limits so as to have a negligible effect on the groundwater level.

A detailed investigation has been conducted by CP&L to determine the effects of the plant on public and private wells within a ten-mile radius of the plant. This investigation has shown that only a few shallow wells will be affected by the plant, none of which are public water supplies. Where necessary and appropriate, some alternative form of water supply has been provided by CP&L as replacement for those shallow wells affected by the canal excavation. The intake and discharge canals may lower the water table in the immediate vicinity of the canals; however, at a distance of about 1000 feet from the canal, the piezometric surface should only be lowered five to six feet. A discussion of the probable environmental impact of the plant is provided in Section 3.

9.8.2.10 Ambient Noise

The Brunswick Plant will be quiet, both because of the intrinsic nature of a nuclear plant, and because the design for this plant includes provisions which minimize plant noise. The turbine generators are surrounded by heavy concrete shielding walls and the entire complex is further housed in a fully enclosed building.

Since most of the Brunswick Steam Electric Plant facilities are housed within the plant structures, the plant communications systems will be primarily within the structures and therefore the usual communications system sounds will be reduced substantially.

9.8.2.11 Aesthetics

Although aesthetic considerations are primarily subjective, it is considered that the Brunswick Plant will have a pleasing landscaped appearance that will enhance all aesthetic attributes of the site. The overall aspect of the plant will present an impressive grouping of structures that blend with rather than stand out on the site.

9.8.2.12 Effects of Construction Activity

The effect of the construction of the plant upon the surrounding area was discussed in subsection 3.7. The change in some wildlife habitat, as a result of clearing operations was an unavoidable impact, although the impact is felt to have been minimized by careful land use planning, and through consultation with State agencies about routing of the canals.

A limited number of shallow domestic wells have been influenced by dewatering operations. However, CP&L has provided those homeowners with a dependable and acceptable water supply through a combination of pump replacements and redrilling or deepening of the wells. The dewatering is only a temporary operation, and will be discontinued.

Spoil material from excavation and dredging are being deposited on high land adjacent to the canal or on other Company-owned land. These materials are being placed in a way that will preserve natural creeks and marshes.

The Company feels that efforts made during construction operations to minimize impacts to the amount practicable will result in the plant having a minimum adverse environmental impact. A thorough discussion of the preventive measures being undertaken during construction is contained in subsection 3.7.

9.8.2.13 Summary

This Benefit-Cost Analysis has presented in summary form a discussion of various environmental and social considerations which may potentially be affected by the plant in a beneficial or adverse manner. The purpose of this discussion has been to present these potential effects in a straightforward manner so that the net environmental and social considerations of interest may be evaluated in a comparative method. In designing the plant and its various systems, Carolina Power & Light Company feels that it has achieved a plant which fulfills the Company's desire of minimizing to the maximum amount practical those effects whose impact on the environment may be potentially adverse. When the potential effects on the environment are compared with the benefits which the plant will furnish, the net total environmental effect is a favorable one. Further detail of potential environmental effects is contained throughout the preceding sections of the report. Recognizing its commitment to environmental protection and enhancement, Carolina Power & Light Company will continue to conduct studies designed to study the impact of the Brunswick Plant on the environment, and to examine methods of minimizing potential effects which may create an adverse impact.

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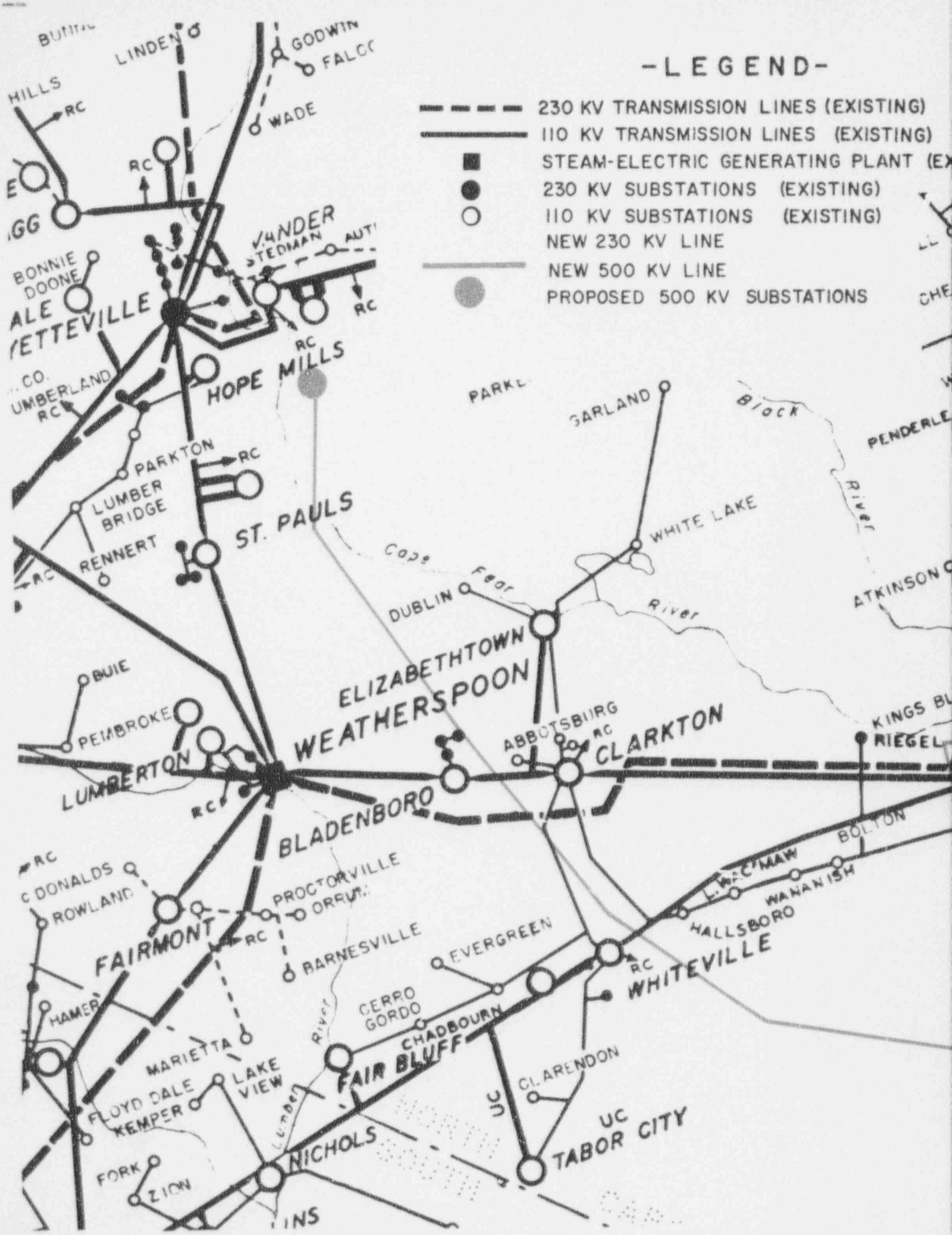
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110 KV TRANSMISSION LINES (EXISTING)
STEAM-ELECTRIC GENERATING PLANT
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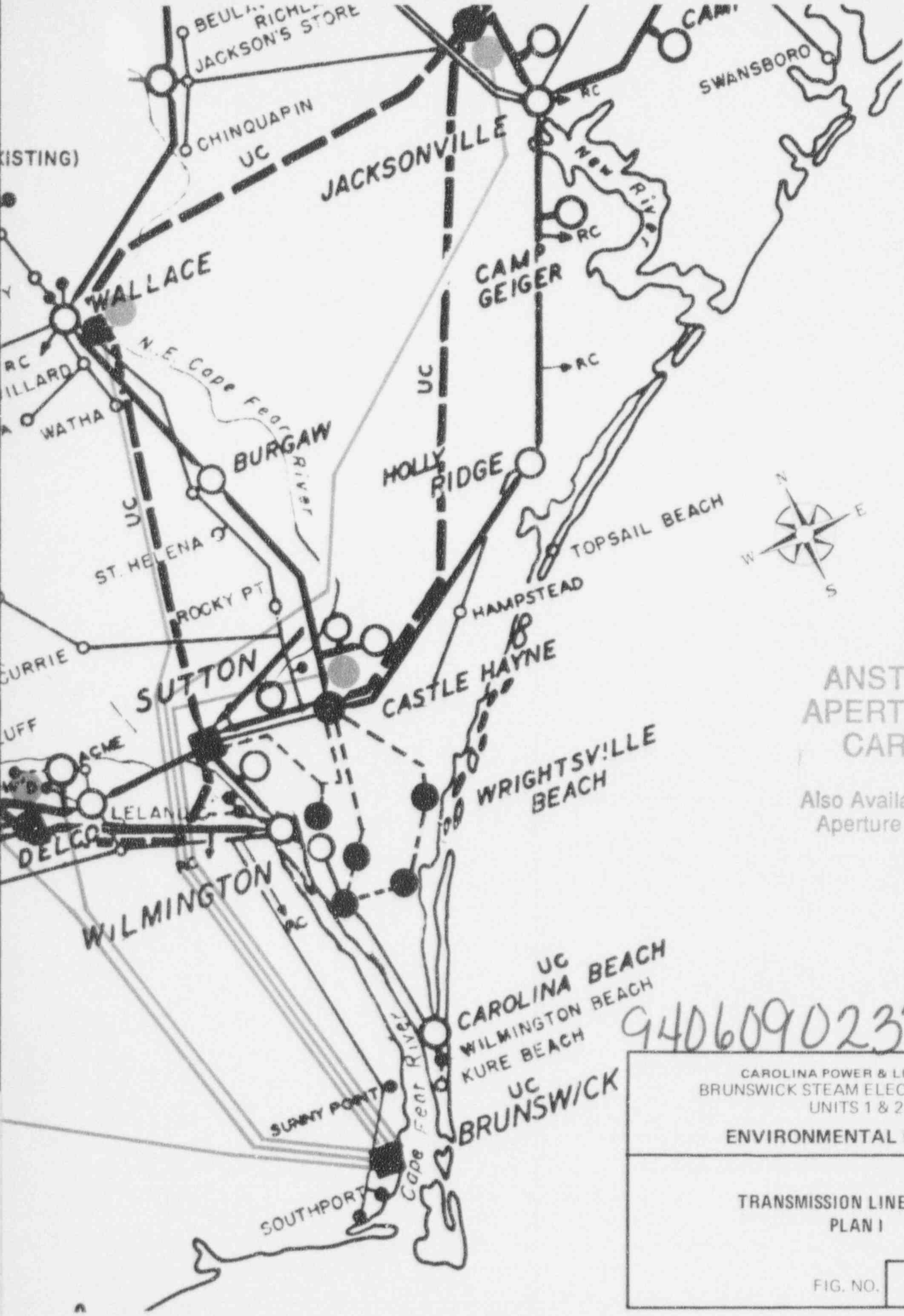
110 KV SUBSTATIONS (EXISTING)
NEW 230 KV LINE
NEW 500 KV LINE
PROPOSED 500 KV SUBSTATIONS
LINDEN
GODWIN
WADE
HILLS
RC
VANDER
STEDMAN
BONNIE DOONE
HOPE MILLS
PARKTON
LUMBER BRIDGE
RENNERT
ST. PAULS
GARLAND
WHITE LAKE
DUBLIN
ELIZABETHTOWN
WEATHERSPOON
Cape Fear River
Black River
ATKINSON
ABBOTSBURG
CLARKTON
KINGS BL
RIEGEL
BUIE
PEMBROKE
LUMBERTON
BLADENBORO
BOLTON
L. WAC'MAW
WANANISH
HALLSBORO
C DONALDS
ROWLAND
PROCTORVILLE
FAIRMONT
BARNESVILLE
EVERGREEN
WHITEVILLE
HAMER
CERRO GORDO
CHADBOURN
FAIR BLUFF
MARIETTA
LAKE VIEW
CLARENDON
FLOYD DALE
KEMPER
UC
TABOR CITY
NICHOLS
FORK
ZION
Lumber River



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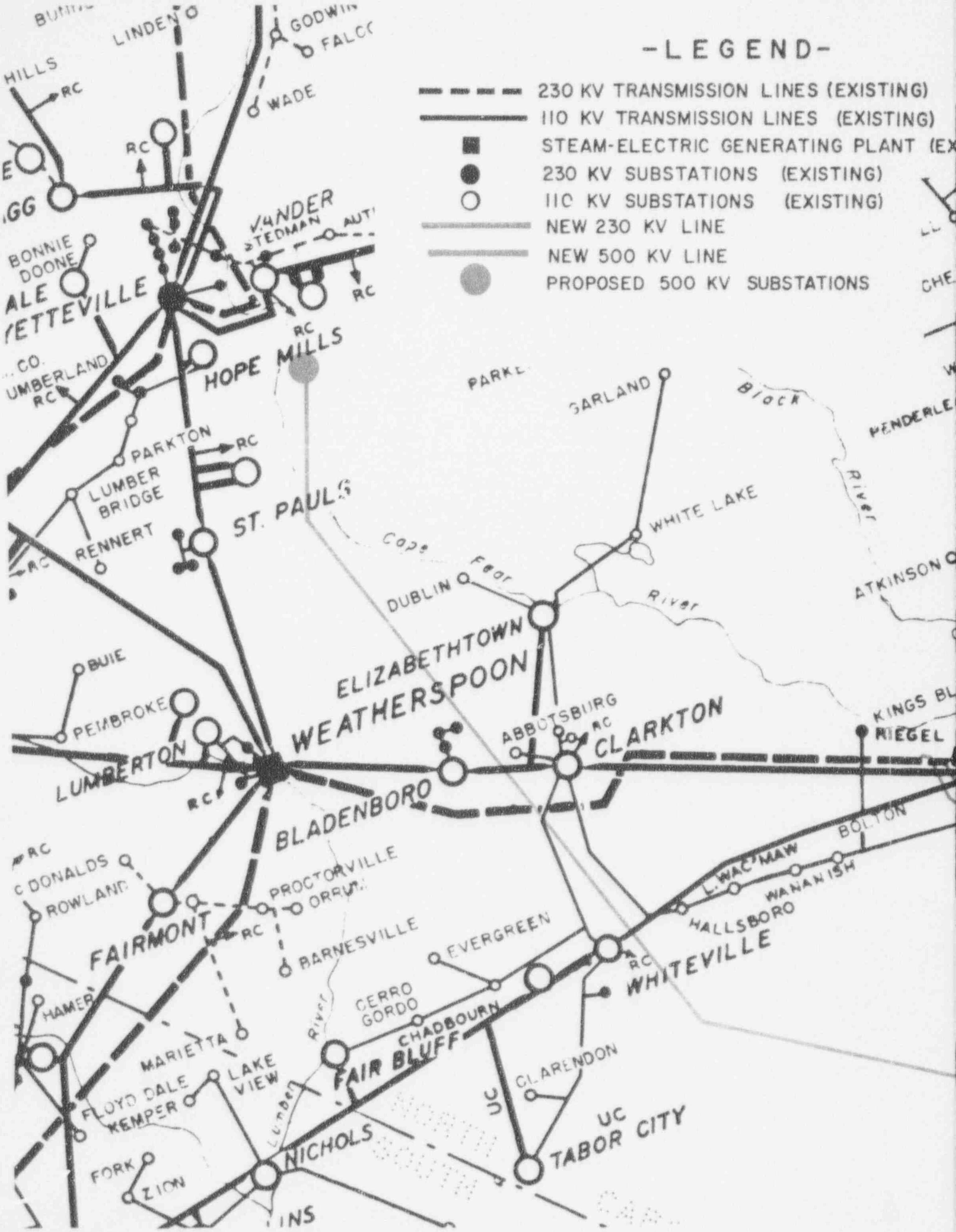
CAROLINA POWER & LIGHT CO.
BRUNSWICK STEAM ELECTRIC PLANT
UNITS 1 & 2

ENVIRONMENTAL REPORT

TRANSMISSION LINE SYSTEM PLAN I

FIG. NO.	9.7–1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STEAM-ELECTRIC GENERATING PLANT
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110 KV SUBSTATIONS (EXISTING)
NEW 230 KV LINE
NEW 500 KV LINE
PROPOSED 500 KV SUBSTATIONS
LINDEN
GODWIN
WADE
HILLS
RC
VANDER
STEDMAN
BONNIE DOONE
HOPE MILLS
PARKTON
LUMBER BRIDGE
RENNERT
ST. PAULS
GARLAND
WHITE LAKE
DUBLIN
ELIZABETHTOWN
WEATHERSPOON
BUIE
PEMBROKE
LUMBERTON
ABBOTSBURG
CLARKTON
BLADENBORO
KINGS BL
RIEGEL
ATKINSON
PENDERLEA
PROCTORVILLE
ROWLAND
FAIRMONT
BARNESVILLE
EVERGREEN
HALLSBORO
WANANISH
BOLTON
WHITEVILLE
CERRO GORDO
CHADBOURN
FAIR BLUFF
MARIETTA
LAKE VIEW
CLARENDON
HAMER
FLOYD DALE
KEMPER
NICHOLS
TABOR CITY
FORK
ZION
UC

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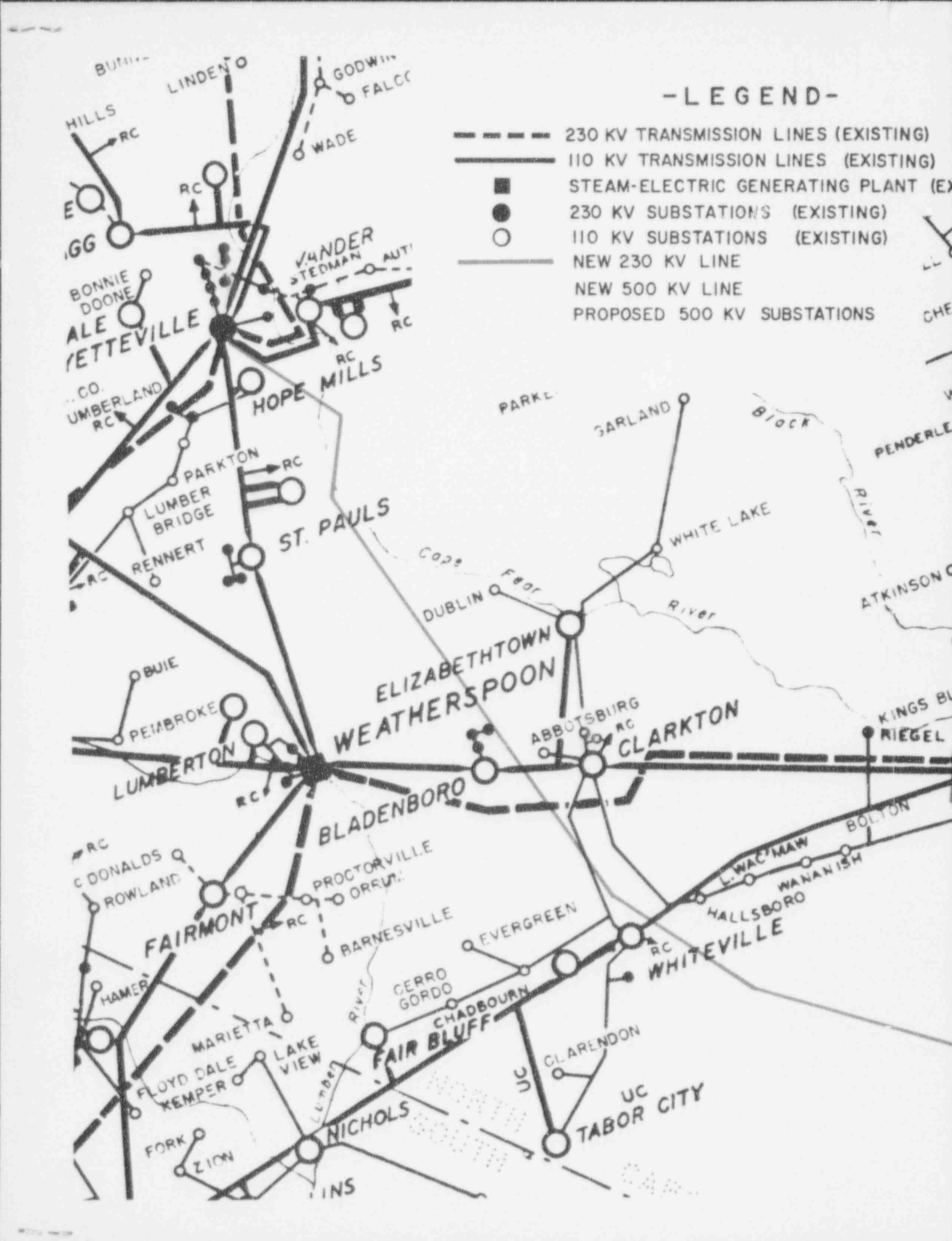
CAROLINA POWER & LIGHT CO.
BRUNSWICK STEAM ELECTRIC PLANT
UNITS 1 & 2

ENVIRONMENTAL REPORT

TRANSMISSION LINE SYSTEM
PLAN II

FIG. NO. 9.7–2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230 KV SUBSTATIONS (EXISTING)
110 KV SUBSTATIONS (EXISTING)
NEW 230 KV LINE
NEW 500 KV LINE
PROPOSED 500 KV SUBSTATIONS
LINDEN
HILLS
WADE
VANDER
STEDMAN
BONNIE DOONE
HOPE MILLS
PARKTON
LUMBER BRIDGE
RENNERT
ST. PAULS
DUBLIN
GARLAND
WHITE LAKE
Cape Fear River
Black River
PENDERLE
ATKINSON
ELIZABETHTOWN
WEATHERSPOON
BUIE
PEMBROKE
LUMBERTON
ABBOTSBURG
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CHADBOURN
FAIR BLUFF
CLARENDON
LAKE VIEW
FLOYD DALE
KEMPER
NICHOLS
TABOR CITY
FORK
ZION
RC
UC

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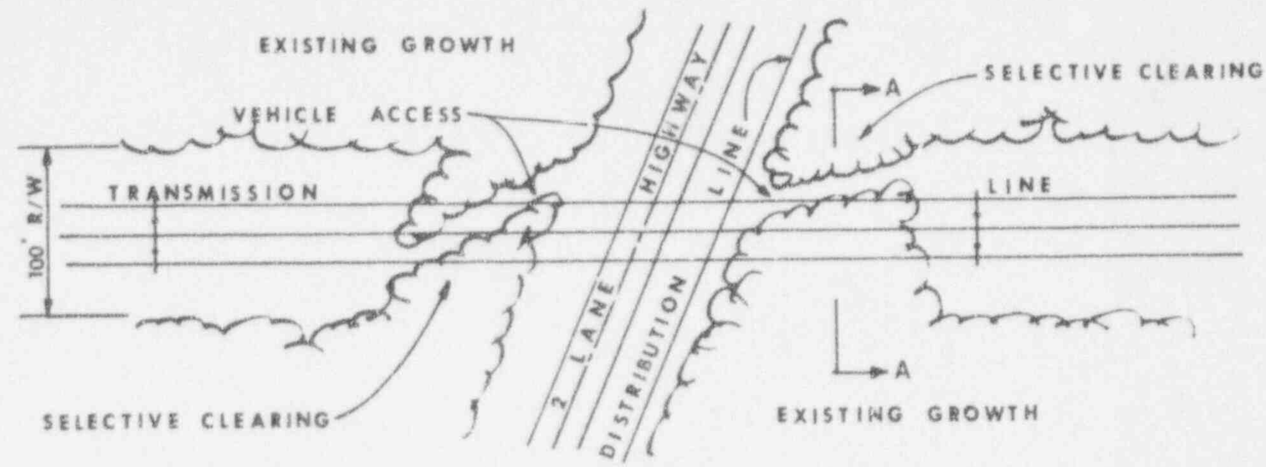
CAROLINA POWER & LIGHT CO.
BRUNSWICK STEAM ELECTRIC PLANT
UNITS 1 & 2

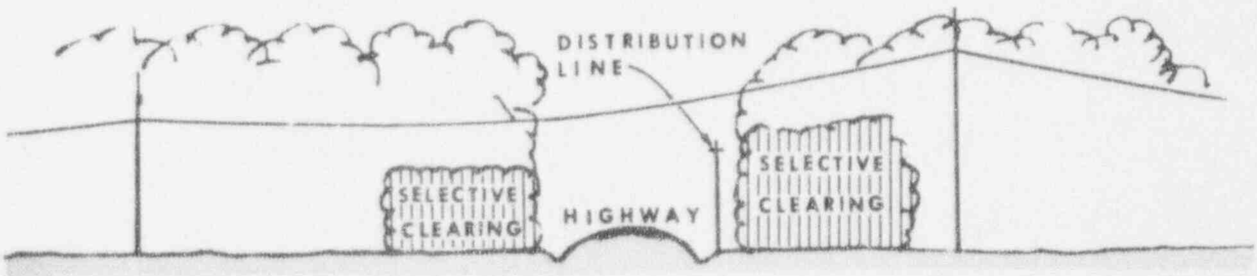
ENVIRONMENTAL REPORT

TRANSMISSION LINE SYSTEM
PLAN III

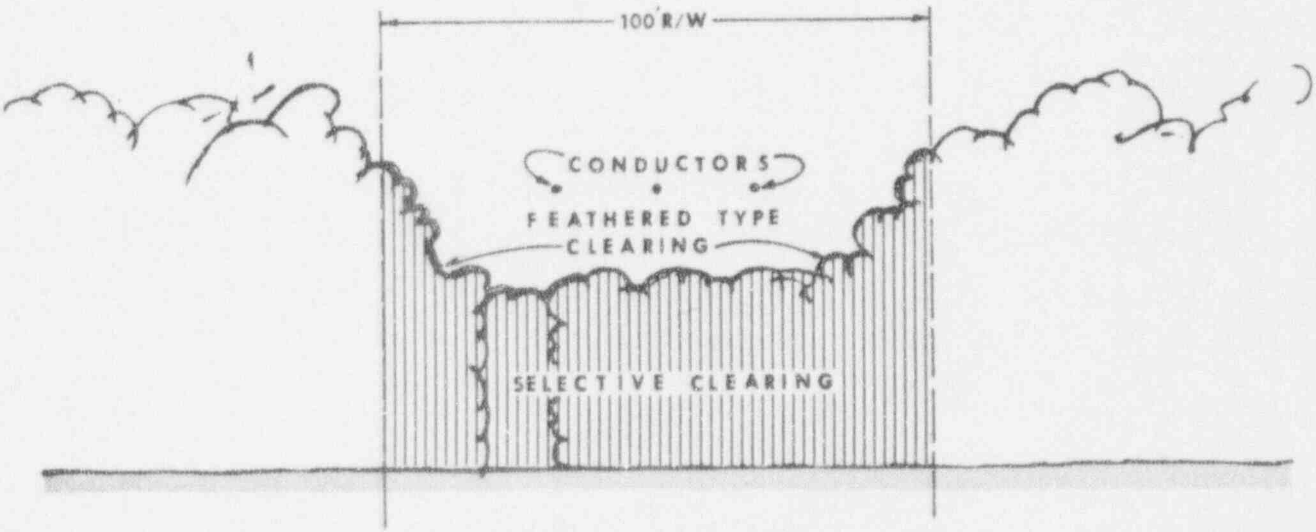
FIG. NO. **9.7–3**



PLAN



PROFILE



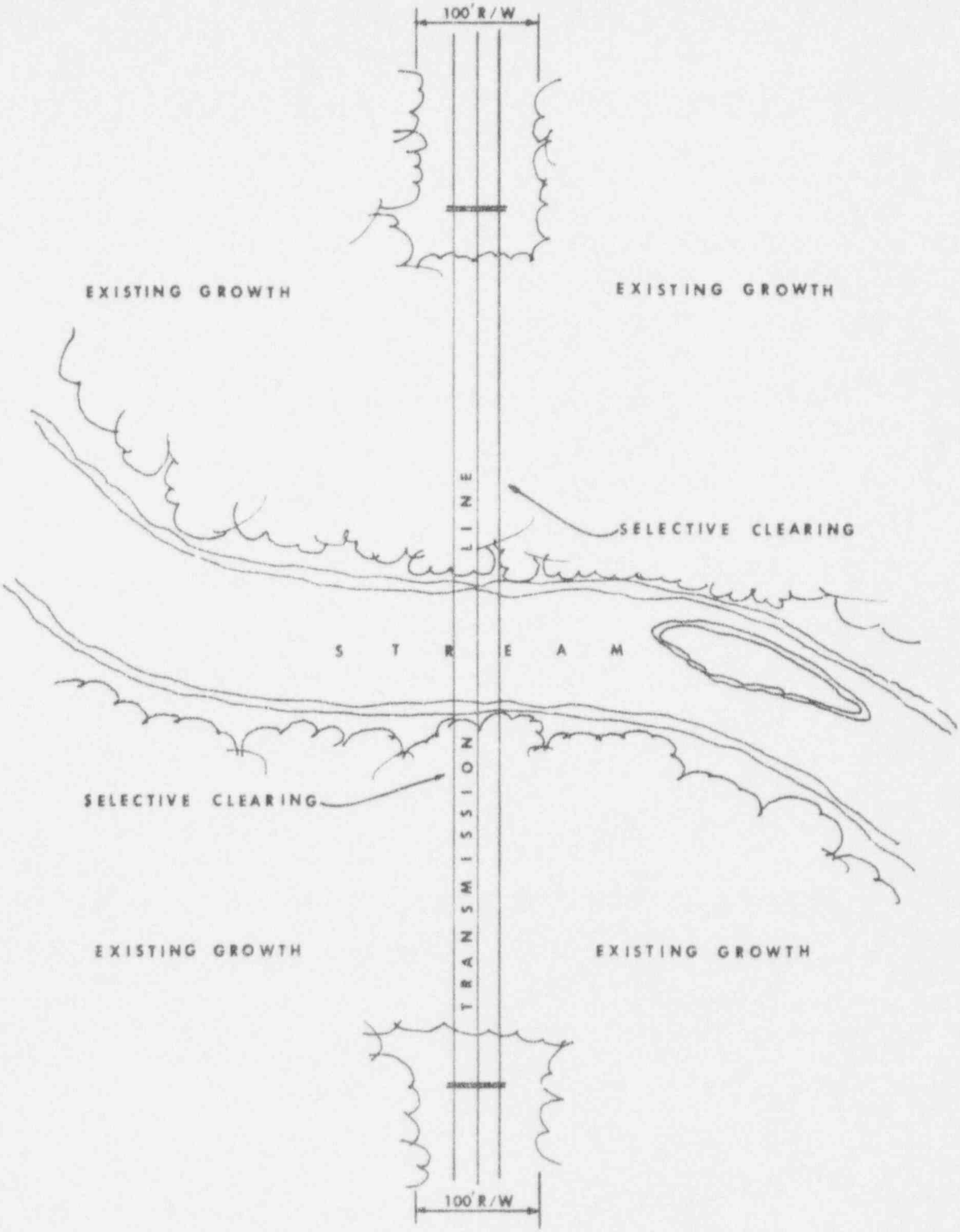
SECTION A–A

CAROLINA POWER & LIGHT CO.
BRUNSWICK STEAM ELECTRIC PLANT
UNITS 1 & 2

ENVIRONMENTAL REPORT

SELECTIVE CLEARING AT
HIGHWAY CROSSING

FIG. NO. 9.7–4

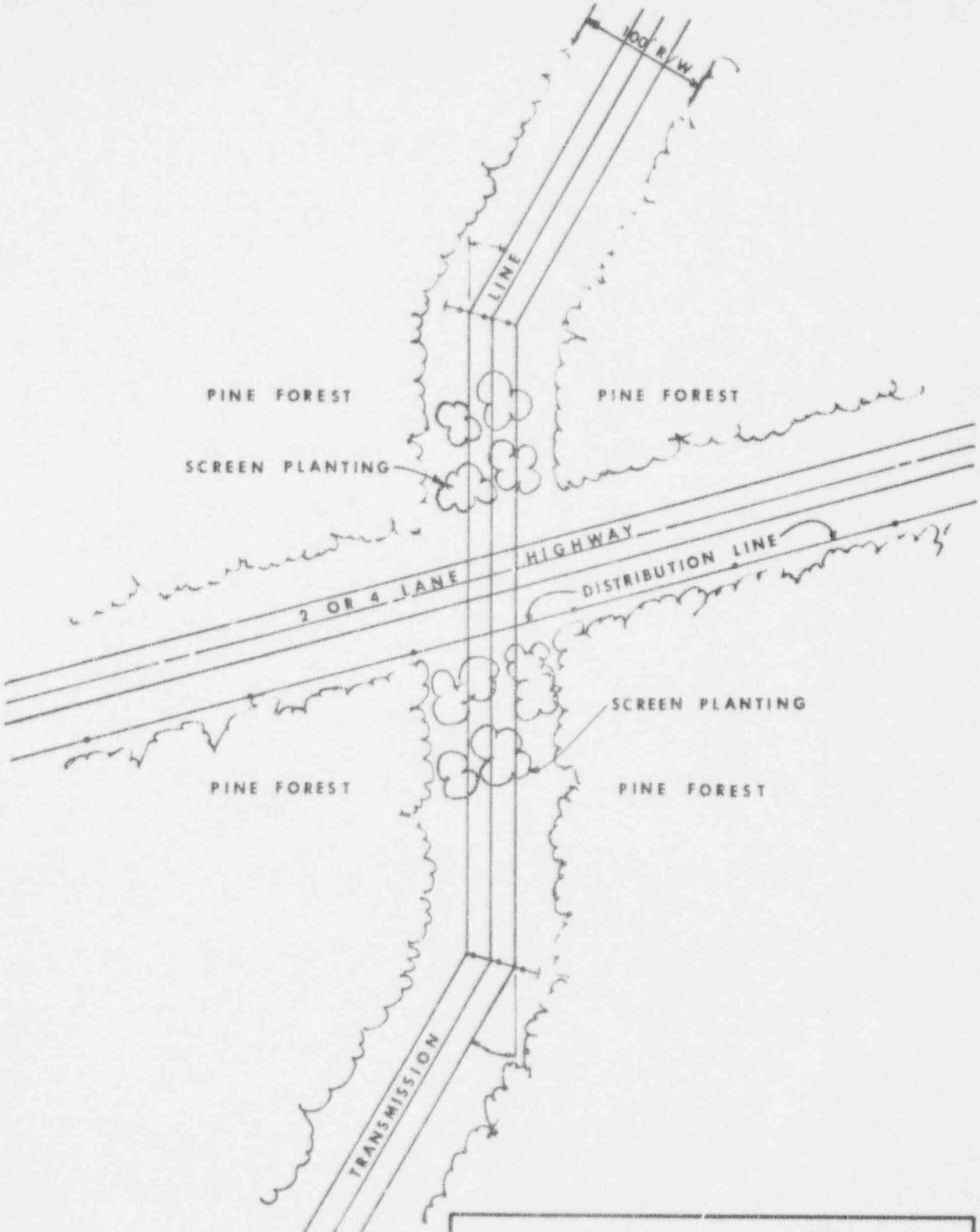


CAROLINA POWER & LIGHT CO.
BRUNSWICK STEAM ELECTRIC PLANT
UNITS 1 & 2

ENVIRONMENTAL REPORT

STREAM CROSSING WITH SELECTIVE CLEARING

FIG. NO. 9.7–5



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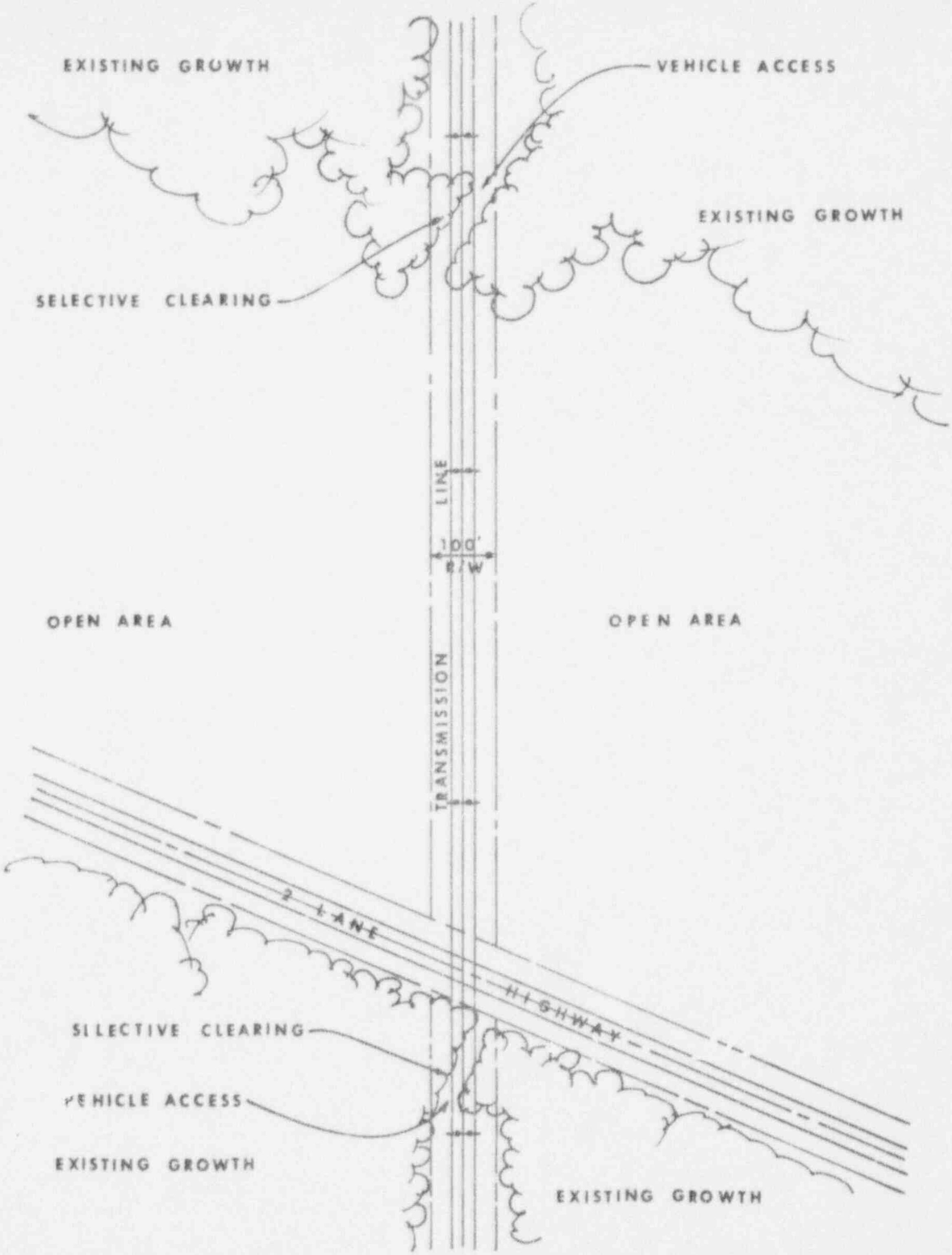
BRUNSWICK STEAM ELECTRIC PLANT
UNITS 1 & 2

ENVIRONMENTAL REPORT

HIGHWAY CROSSING IN PINE FOREST

FIG. NO. 9.7–6



CAROLINA POWER & LIGHT CO.
BRUNSWICK STEAM ELECTRIC PLANT
UNITS 1 & 2

ENVIRONMENTAL REPORT

SELECTIVE CLEARING PROCEDURE AT CLEARED AREAS

FIG. NO. 9.7–7

10. Conclusion

The Brunswick Steam Electric Plant has been designed in accordance with all applicable federal, state, and local criteria and industrial standards. The environmental impact of the plant is not negligible; it has, however, been minimized with meticulous care to where this impact is acceptable. The Brunswick Plant is being constructed in order to satisfy a demand by society. The benefits derived by society from its generated power far outweigh the costs of its construction and operation in terms of societal investment and environmental impact. The plant has been provided with safeguards so that it does not constitute a significant radiation hazard even during any credible accidental event. The construction and operation of the Brunswick Steam Electric Plant is a sound societal endeavor.