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November 10, 1981

Mr. Harold R. Denton, Director
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Attention: Ms. E. G. Adensam, Chief
Licensing Branch No. 4

Re: Catawba Nuclear Station
Docket Nos. 50-413 and 50-414

Dear Mr. Denton:

Duke Power Company is filing herewith Amendment 22 to its Application for Licenses for the Catawba Nuclear Station, which is under construction pursuant to Construction Permits CPPR-116 and 117. This filing includes three signed original copies of the amendment with the following attachment:

Revision 3 to the Environmental Report - Operating License Stage for the Catawba Nuclear Station.

This filing also includes 41 copies of Revision 3 to the Environmental Report - Operating License Stage.

The purpose of Amendment 22 is to respond to Mr. Darrell G. Eisenhut's letter of June 2, 1981 and to submit other miscellaneous revisions to the above document.

Copies of this Amendment 22 have been distributed in accordance with the requirements of 10CFR 2.101 and the instructions contained in Mr. Darrell G. Eisenhut's letter of June 2, 1981.

Respectively submitted,

William O. Parker, Jr.

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November 10, 1981

DUKE POWER COMPANY
APPLICATION FOR LICENSES
DOCKET NOS. 50-413 & 414

CATAWBA NUCLEAR STATION
ENVIRONMENTAL REPORT

Revision 3

CHANGES AND CORRECTIONS:

Remove and insert pages in accordance with the following tabulations:

Remove these pages:	Insert these pages:
Volume 1	
Introduction (pg 2)	Introduction (pg 2)
ER ix thru ER xx	ER ix thru ER xxi
ER 1.3-1, 1.3-2	ER 1.3-1, 1.3-2
ER Figure(s) 1.1.1-1, 1.1.1-2	ER Figure(s) 1.1.1-1, 1.1.1-2
ER 2v thru ER 2ix	ER 2v thru ER 2ix
ER 2.1-1 thru 2.1-6	ER 2.1-1 thru 2.1-6
ER 2.2-15 thru 2.2-20	ER 2.2-15 thru 2.2-20
ER 2.3-1 thru 2.3-3	ER 2.3-1 thru 2.3-3
ER 2.4-1 thru 2.4-7	ER 2.4-1 thru 2.4-8
	ER Table(s) 2.2.2-12 thru 2.2.2-18
ER Table(s) 2.3.0-1 (pg 1) & (pg 2)	ER Table(s) 2.3.0-1 (pg 1) & (pg 2)
	ER Figure(s) 2.2.2-2, 2.2.2-3
Volume 2	
ER ix thru ER xx	ER ix thru ER xxi
ER 3.4-1 thru 3.4-3	ER 3.4-1 thru 3.4-4
ER 3.6-1 thru 3.6-3	ER 3.6-1 thru 3.6-3
ER 3.9-3, ER 3.9-4	ER 3.9-3, ER 3.9-4
ER Table 3.3.1-1 (1 of 2) & (2 of 2)	ER Table 3.3.1-1 (1 of 2) & (2 of 2)
ER 5.1-1 thru 5.1-9	ER 5.1-1 thru 5.1-10
ER 6.1-1 thru 6.1-20	ER 6.1-1 thru 6.1-22
ER 6.2-1 thru 6.2-3	ER 6.2-1 thru 6.2-3
	ER 8.0-1
ER 8.1-1 thru 8.1-5	ER 8.1-1 thru 8.1-5
ER 8.2-1, 8.2-2	ER 8.2-1, 8.2-2
ER Table(s) 8.2.1-1, 8.2.1-2	ER Table(s) 8.2.1-1, 8.2.1-2
ER Table(s) 9.3.2-1 thru 9.4.0-1 (2 of 2)	ER Table(s) 9.3.2-1 thru 9.4.0-1 (2 of 2)
All Appendix 2	Cover Letter/May 28 thru pg 69
RAI-1 thru RAI-4	RAI-1 thru RAI-4
RAI-7 thru RAI-11	RAI-7 thru RAI-11
11 x 17 Figures	
Figure 2.1.1-5	Figure 2.1.1-5

Construction activities under a Limited Work Authorization (LWA) date back to June 1974 at the Catawba site. A Construction Permit was issued in July 1975. Since the review of the Environmental Report - Construction Permit stage and the issuance of the Construction Permit changes have occurred in the design of the station. These changes are covered in detail in the body of the Environmental Report and are summarized in Table I-1. Also included in the document is a requirement at the Operating License Stage and is included simply for the sake of completeness. 290.

Fuel load dates for Catawba Units 1 and 2 are August 1983 and February 1985 respectively. Project status (percent complete) as of June 1, 1981 for Unit 1 was 83 percent and 31 percent for Unit 2. Total overall project completion was 57 percent.

A reduction in financial pressures on Duke was effected in the sale of 75% of both Units 1 and 2, and their support facilities. The sale of the remaining 25% of Unit 2 is currently being negotiated. The station is operated as part of the combined Duke System.

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1.3 CONSEQUENCES OF DELAY

It is not possible to predict at this time the long-range effect of energy conservation on load growth, nor the duration of financial constraints on construction. The proposed schedule of capacity additions, therefore, is based on the best information available at present and, because of the tight money market, represents a minimum capital investment. To delay any unit beyond the proposed schedule can seriously jeopardize service to the system as a whole.

For the year 1984, minimum reserve requirements are calculated to be:

Forecast 1984 Summer Peak Load	11,986 MW
Add For Extreme Temperature	960
Add For Loss of Largest Unit on System	1,180
Add For Miscellaneous Capacity Reduction	642
Total Capacity Required	14,768 MW
Reserve Over Forecast Peak	2,782 MW
Reserve expressed as percent	23.2

In 1984 summer with Catawba 1 delayed one year, the following is calculated:

Total Capacity	Load	Reserve MW	Reserve %
14,501 MW	11,986 MW	2,515	21.0

The above comparison indicates that total reserves with Catawba delayed one year would be below the minimum requirements. The following is a calculation of reserves on the Duke system if Catawba is delayed for 2 years and 3 years:

Two-Year Delay

Year	Capacity	Load	Reserve	%
1985	14,501 MW	12,413 MW	2,088 MW	16.8

Three-Year Delay

Year	Capacity	Load	Reserve	%
1986	14,366 MW	12,934 MW	1,432 MW	11.1

It is apparent that the reliable operation of the Duke system would not be seriously endangered with a one year delay in the installation of Catawba. However, if Catawba is delayed more than one year, reserve requirements are not adequate to insure reliable operation of the Duke system.

First year of proposed operation replacement energy costs for Unit 1 and first year operation production costs are given in Tables 1.3.1-1 and 1.3.1-2, respectively.

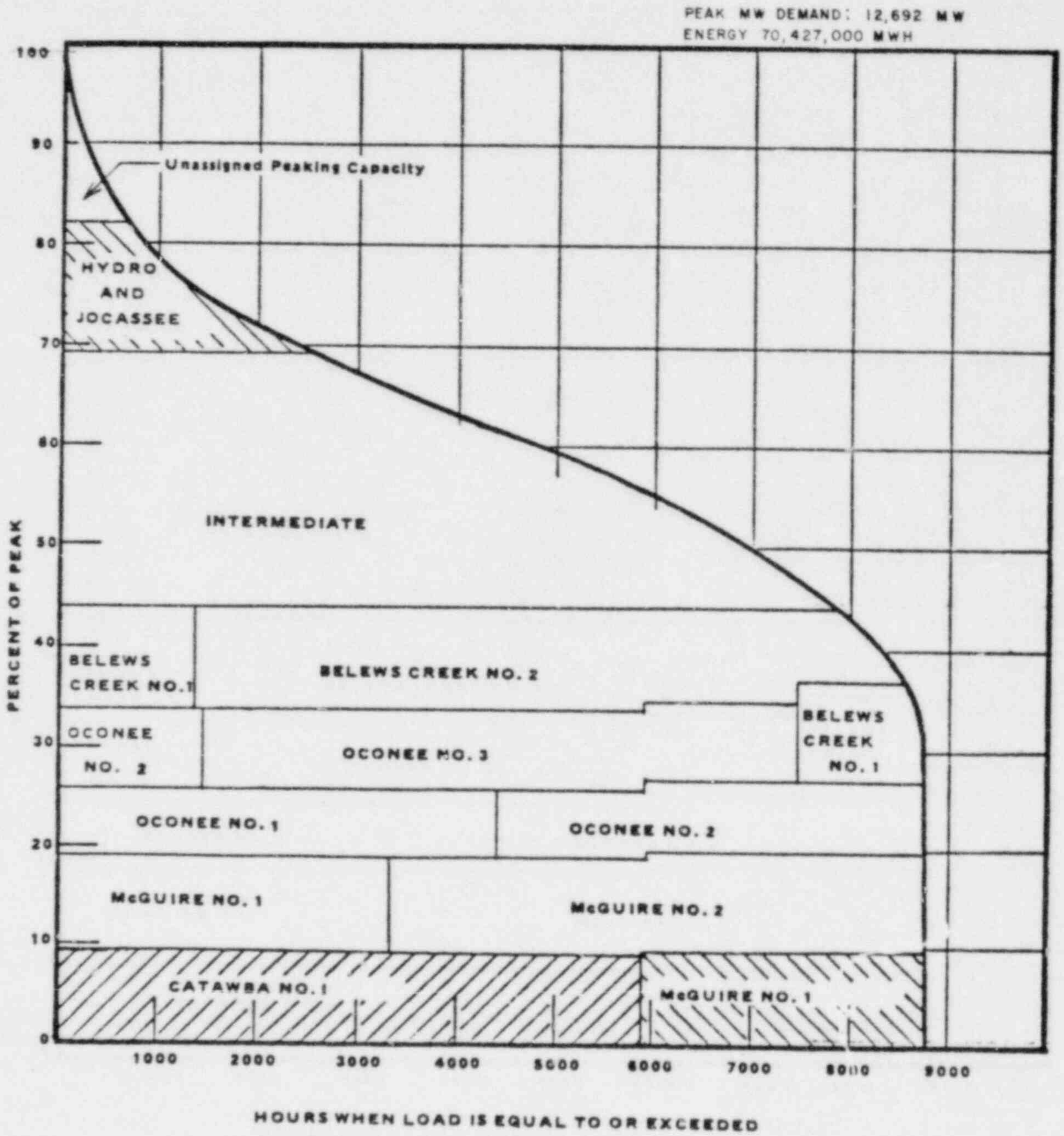
Simulations of the Duke system were performed on a probabilistic production costing model for the years 1984 through 1990. Economic scheduling considerations, refuel outages, maintenance schedules, and forced outage rates were utilized in the calculations.

ER Table 1.3.1-3 is a tabulation of total system production costs along with Catawba Nuclear Station's capacity factor for each unit, fuel cost, and variable O & M costs. In this scenariok Duke's load is assumed to be as the latest forecast indicates. ER Table 1.3.1-3a is a similar tabulation with the exception that Duke's load is held constant during the study years. The value used was the load experienced during 1980. 320.1

ER Table 1.3.1-4 is a tabulation of total system production costs if Catawba should not be in operation during the study period of 1984 through 1990, and loads are as in the latest forecast. Sources of replacement energy, cost of replacement energy, and variable O & M are also tabulated in this table. ER Table 1.3.1-4 Sheet 2 is an identical type tabulation for the study period with the assumption that Duke's load is held constant at the value experienced during 1980.

This condition is evident with normal growth expected and also should no growth above the 1980 level occur.

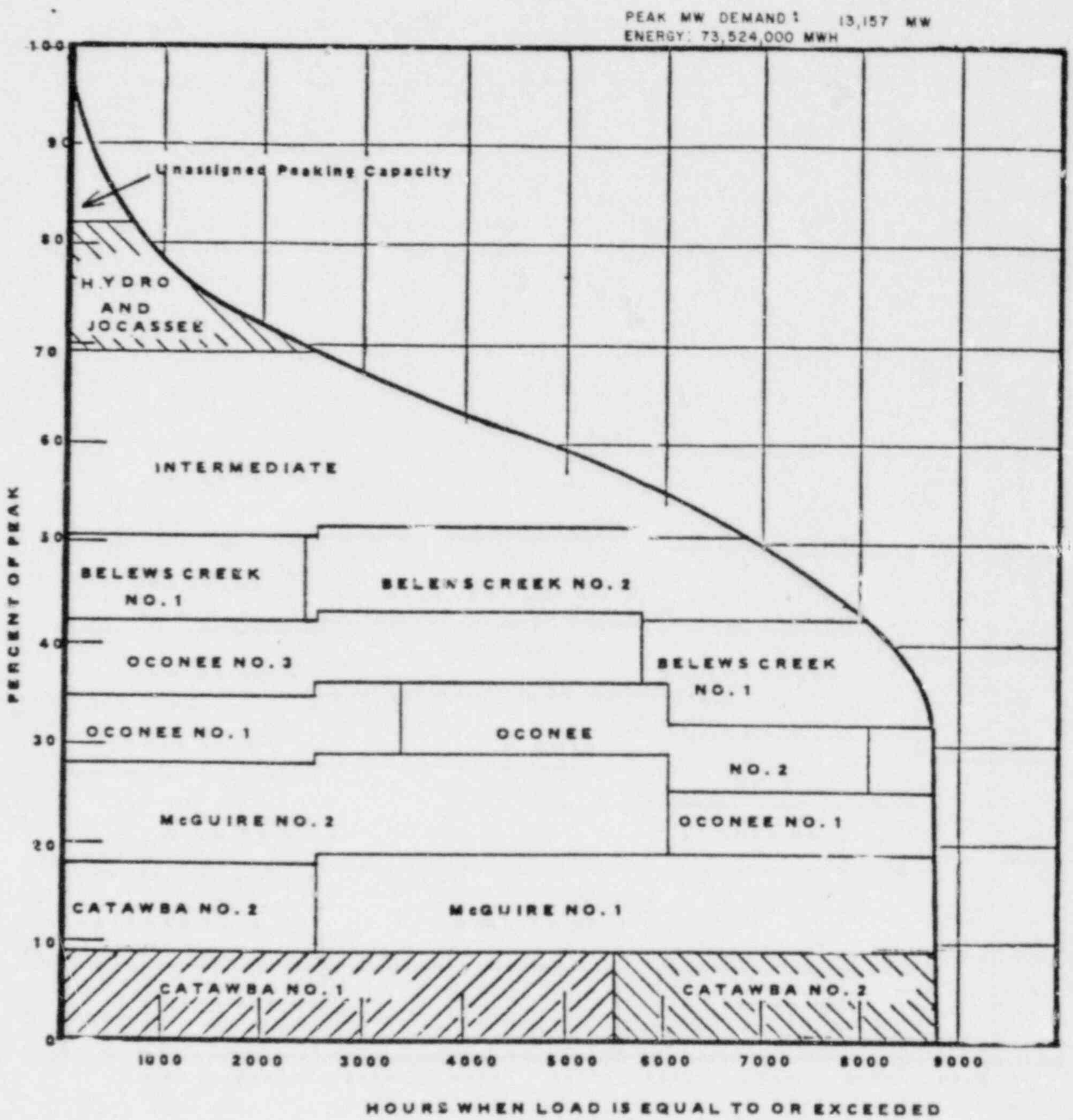
Catawba Nuclear Station is owned by more than one entity, but the production simulations described previously integrate the plant into the Duke system. The results then are the aggregate of all participants.



LOAD DURATION CURVE FOR THE YEAR 1985

CATAWBA NUCLEAR STATION

ER Figure 1.1.1-1
Revision 1



LOAD DURATION CURVE
FOR THE YEAR 1986

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2.1 GEOGRAPHY AND DEMOGRAPHY

This section presents information on the Catawba Nuclear Station site location and description, boundaries for establishing effluent release limits, exclusion area control, and population and population distribution within 50 miles (80.4 km) of the site.

2.1.1 SITE LOCATION AND DESCRIPTION

2.1.1.1 Specification of Location

Catawba is located in the north central portion of South Carolina approximately 6 mi (9.6 km) north of Rock Hill and adjacent to Lake Wylie, as shown on Figure 2.1.1-1. The station center is located at latitude 35 degrees-3 minutes-5 seconds north and longitude 81 degrees-4 minutes-10 seconds west. The corresponding Universal Transverse Mercator Coordinates are E 493, 660 and N 3, 878, 558, zone 17.

Figure 2.1.1-2, the site location map, shows the station location with respect to local features.

The site is located in the northeastern portion of York County on a peninsula bounded by Beaver Dam Creek to the north, Big Allison Creek to the south, the main body of Lake Wylie to the east, and private property to the west. The Duke Power Company Wylie Dam and Hydroelectric Station are located approximately 4.5 mi (7.2 km) southeast of the site. Rock Hill, South Carolina and Charlotte, North Carolina are the nearest large cities. The city limit of Rock Hill is located approximately 5.8 mi (9.2 km) south-southeast of the site and the Charlotte city limit is located approximately 10.5 mi (16.9 km) east-northeast of the site.

2.1.1.2 Site Area

Figure 2.1.1-3, the site area map, shows the 1036 ac (419 ha) Duke owned property at Catawba, the Duke property line, the 391 ac (158 ha) site, the site boundary, location and orientation of principal station structures, roads adjacent to the site, the 2500 ft (762 m) exclusion radius and locations within the exclusion area boundary of the visitors' overlook provided by Duke, and the Concord Cemetery property.

The site boundary lines are the same as the station perimeter fence. The perimeter fence erected around the immediate station area is shown in Figure 2.1.1-3. The station property line, shown on Figure 2.1.1-3, is the same as the Duke property line. There are no industrial, commercial, institutional, or residential structures within the site boundary or the exclusion boundary.

The exclusion area boundary is a circle formed by a 2500 ft (762 m) radius centered on the Reactor Building's centerlines as shown on Figure 2.1.1-3. Access to the area is controlled for security and radiation protection purposes by regular and routine patrols by security guards. The security patrol maintains records of all individuals entering the area. All authorized visitors are under the control of station personnel and trespassers are removed.

2.1.1.3 Boundaries for Establishing Effluent Release Limits

The exclusion area boundary is set as the boundary for gaseous effluent release limits. Liquid effluents are discharged into Lake Wylie at the station service water discharge structure. Distances of the release points from the boundary are shown on Figure 2.1.1-4. There are no permanent residences within the exclusion boundary.

2.1.2 POPULATION DISTRIBUTION

Population within 50 mi (80.4 km) of Catawba is based on the 1970 census. Population distributions for 1980, 1981 (year of plant startup), and by decade to 2020 are based on projections made by the United States Department of Commerce, Bureau of Economic Analysis (Reference 1 and 2). Though 2021 is the year of expected end of plant life, the year 2020 is used for end of plant life population distribution.

The disaggregation of the 1970 census county subdivisions into each radial sector is based on road densities, population accumulations, land usage, and general area information. The population distribution within 5 mi (8 km) of the site is based on an actual house count performed in 1971. The distribution of the projected populations is based on the ratio of the distributed 1970 populations within each radial sector to the total county population. An additional house count within 5 mi (8 km) of the site, made in December 1977, is used to establish an adjusted distribution within Mecklenburg County, North Carolina and York County, South Carolina. The December 1977 population within 5 mi (8 km) is shown on Table 2.1.2-1.

The age distributions within 50 mi (80.4 km) of the site for the year 2000 based on the 1970 combined populations of York and Mecklenburg Counties as required by Appendix D of Regulatory Guide 4.2, Rev. 2 are estimated to be: 281,536 (11 years and younger), 182,170 (ages 12 through 18), and 1,192,387 (greater than 18 years of age).

2.1.2.1 Population Within 10 Miles

Figure 2.1.2-1 identifies places of significant population groupings within 10 mi (16.1 km) of the station. Table 2.1.2-2 gives 1970 population distribution within 10 mi (16.1 km). Projected population distributions by census decade (1980 through 2020) and for 1981 are shown on Tables 2.1.2-3 through 2.1.2-8.

The developers of Tega Cay and River Hills, the two major housing developments within 5 miles (8 km) of the site, Figure 2.1.3-2, were consulted. Their projected growth as well as growth in significant population groupings, towns and communities, within 10 miles (16.1 km) was considered in the population projections. 310.3

Age distributions within 10 mi (16.1 km) of the station for the year 2000 for age groups of 0 to 12 years, 12 to 18 years, and greater than 18 years are approximately: 14,729, 9,530, and 62,379, respectively.

2.1.2.2 Population Between 10 and 50 Miles

Places of significant population groupings in the area from 10 mi (16.1 km) to 50 mi (80.4 km) of the station are shown on Figure 2.1.2-2. Tables 2.1.2-9 through 2.1.2-15 detail the 1970 and projected population distributions.

The 10 mi (16.1 km) to 50 mi (80.4 km) age distribution for the year 2000 are approximately 266,807, 172,640, and 1,130,008 for ages to 12 years, 12 to 18 years, and greater than 18 years, respectively.

2.1.2.3 Transient Population

Transient population within 5 mi (8 km) of Catawba is primarily recreational on
and along the shores of Lake Wylie. Industrial facilities in the northeastern
quadrant and in the southeastern quadrant are the major sources of transient
population between 5 and 10 mi (8 to 16.1 km). Carowinds Theme Park, located
approximately 8 mi (12.8 km) to the east-northeast, is the largest recreational
area within 50 mi (80.4 km) of the site. Carowinds attendance in 1978 was
1,041,000 with a daily average attendance of 10,014. Projected 1979 attendance
is 1,150,000 (Reference 3). Carowinds operates approximately 110 days each
year normally beginning the last weekend in March through mid-October. The 310.5
theme park is open on weekends only until the first of June and after mid-
August. From early June to mid-August, the park is open 6 days per week and
closed on Fridays.

Tables 2.1.2-16 and 2.1.2-17 show 1977 seasonal and average daily recreational transient population distribution within 10 mi (16.1 km) of the station. Table 2.1.2-18 shows the daily industrial transient population distribution within 10 mi (16.1 km) of the site.

No large industries or businesses providing job opportunities are located within 5 mi (8 km) of the site. A reduction of daily population in the vicinity of the station due to workers commuting to population centers where job opportunities exist is expected.

2.1.3 USES OF ADJACENT LANDS AND WATERS

Topographic features within a 5 mi (8 km) radius of Catawba are shown on Figure 2.1.3-1. The site area map, Figure 2.1.1-3, shows the locations of station facilities, exclusion boundary, adjacent and utility properties, and the station perimeter. Figure 2.1.3-2 shows the location of residences, water bodies, settlements, industries, public facilities, recreational areas, and transportation routes within 5 mi (8 km) of the station. The total acreage owned by Duke and that part occupied or modified by the station and station facilities is:

Duke Owned Land = 1036 ac (415 ha)

Area Within Site Boundary = 391 ac (158 ha)

Permanent Station Facilities = 129 ac (52 ha)

Two areas within the exclusion boundary are devoted to uses other than station operation. These are the 1 ac (0.4 ha) Concord Cemetery and the approximately 2 ac (0.8 ha) visitors' overlook area, shown on Figure 2.1.1-3.

By agreement with the Concord Cemetery Association, the cemetery property may be used solely as a shrine and for the purpose of conducting memorial and burial services. Visitors may gain access to the cemetery by contacting station security personnel. Visits to the cemetery property consist of relatively small numbers of people. 310.4

The visitors' overlook is a limited-use picnic area. Attendance at the overlook averages 27 visits per day excluding security patrols.

Table 2.1.3-1 gives the distance and direction from the centerline of the station to the nearest milk cow, milk goat, residence, site boundary, and vegetable garden greater than 500 ft^2 (46.5 m^2) within a 5 mi (8 km) radius. Dairy operations are noted.

Existing land use within 5 mi (8 km) of the site is predominately rural nonfarm with residential and recreational development bordering Lake Wylie. Small amounts of land are used to support beef cattle and farming. Few industrial or business facilities are located within 5 mi (8 km) as shown on Figure 2.1.1-2. Land use in the area remains relatively constant with no abnormal trends or changes in either population or industrial patterns (References 4 and 5). Current land use within 5 mi (8 km) is approximately 6% Urban, 12% Water, 21% Agricultural, and 61% Forest. 310.6

Zoning within 5 mi (8 km) is shown on Figure 2.1.3-3. Zoning in Mecklenburg County, North Carolina is predominately residential within 5 mi (8 km) of the station. There is no zoning outside of the city limits in York County, South Carolina (References 4 and 5).

Tables 2.1.3-2 through 2.1.3-4 provide data on annual truck farming, milk, and meat production within a 50 mi (80.4 km) radius of the station. The type, quantity, and yield of crops grown within 50 mi (80.4 km) are given in Catawba ER Table 4.4-2.

The grazing season for beef and dairy animals within a 50 mi (80.4 km) radius of the station is 12 months per year with supplements to the diet during the mid-winter months (December-February). Feeding regimes for cattle consist of pasture grass, small grains, hay and corn silage, and grain sorghum. Pasture grass density is approximately 59.9 lbs/ac. (1.05 kg/m^2), and approximate yield statistics for harvested forage crops are: hay - 15.6 lbs/ac. (.28 kg/m^2), corn - 123 lbs/ac. (2.21 kg/m^2), and small grains - 75.3 lbs/ac. (1.35 kg/m^2) (Reference 6).

Commercial and recreational fishing on Lake Wylie is addressed in Catawba ER Subsection 2.2.2, and pages 610 thru 612 of Baseline Predictive Environmental Investigation of Lake Wylie (Reference 7). Additional information on these 290.6
fisheries in Lake Wylie and downstream waters to the Atlantic Ocean is presented in Tables 2.2.2-12 through 2.2.2-18, and in Figures 2.2.2-2 and 290.7
2.2.2-3. Estimation techniques are located in References 65-69.

The closest publicly accessible location to the point of discharge and influenced by the discharge flow is 1435 feet (436 m.) south of the station at the discharge structure.

Two game management areas are located within 5 mi (8 km) of Catawba, one approximately 3.9 mi (6.3 km) west and one approximately 3 miles (4.8 km) west-northwest, as shown on Figure 2.1.3-3. Information concerning annual average harvest by species for the two areas is not available. (Reference 8)

Surface water users, groundwater users, and riverbank wells within a 20 mi (32 km) radius and 53 mi (85.3 km) downstream of the site to Wateree Dam are detailed on Tables 2.1.3-5, 2.1.3-6, and 2.1.3-7, and located on Figures 2.1.3-4, 2.1.3-5, and 2.1.3-6, respectively. Table 2.1.3-8 provides data on major dischargers within a 20 mi (32.2 km) radius and 50 mi (80.4 km) downstream of the station. Locations of the major dischargers are shown on Figure 2.1.3-7.

An 11.8 percent consumption factor, as recorded by the Water Resources Council for the South-Atlantic-Gulf Region of the United States in 1970, is used to estimate present industrial and municipal consumptive water use within a 20 mile (32.2 km) radius and 50 miles (80.4 km) downstream of Catawba. Average daily industrial and municipal withdrawal is 125.7 mgd (476 X 10^6 l/day) or approximately 4.3 percent of the flow at the Rock Hill gage. Consumptive withdrawal, based on the 11.8 percent is approximately 14.8 mgd (56 X 10^6 l/day), less than one percent of the Rock Hill gage flow. Approximately 111 mgd (420 X 10^6 l/day) of the total 125.7 mgd (476 X 10^6 l/day) withdrawn is returned to the river.

Water use projections for the year 2020 use a 12.1 percent consumption factor for municipal and industrial withdrawals as recorded by the Water Resources Council and an estimated increase in water usage of 50 percent based on population projections by the U.S. Environmental Protection Agency. Average daily industrial and municipal withdrawal for the year 2020 is projected to be 188.5 mgd (713 X 10^6 l/day) or 6.5 percent of the flow at the Rock Hill gage, for the area within a 20 mile (32.2 km) radius and 50 miles (80.4 km) downstream of the Catawba site. Industrial and municipal consumptive withdrawal is approximately 22.8 mgd (86 X 10^6 l/day) or 1 percent of the flow at the Rock Hill gage. Therefore approximately 165.7 mgd (627 X 10^6 l/day) is returned to the river for use by others.

Effects of present and projected regional consumptive water use by the station is minimal due to Catawba's location on Lake Wylie. The storage volume of Lake Wylie is adequate to supply water for station operation during periods of low flow. Station water use is discussed in Section 3.3.

REFERENCES FOR SECTION 2.1

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2. U.S. Department of Commerce, Bureau of Economic Analysis, Projection, Economic Activity in South Carolina, Series E Projection, April 1976.

3. Telephone Conversation, January 17, 1979, Carowinds Theme Park.

4. Telephone conversation, October 27, 1977. Catawba Regional Planning Council, Rock Hill, South Carolina.

5. Telephone conversation, July 18, 1978. Charlotte-Mecklenburg Planning Commission, Charlotte, North Carolina.

6. Letters, November 1977 from County Agriculatural Extension Offices.

7. A Baseline/Predictive Envrionmental Investigation of Lake Wylie, Catawba Nuclear Station and Plant Allen, Volume II, (Industrial Bio-Test Laboratories, Inc., September 1973 - August 1974).

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Ecological Succession

According to Odum (Reference 64) the fish community of an impoundment undergoes three stages of ecological succession. Initially, the entire biotic community is highly productive due to nutrients released from newly submerged soils and decaying vegetation. During the second stage, fish production decreases somewhat as these nutrients become depleted. Finally, fish production, standing crop and species composition become stable.

Lake Wylie was originally impounded in 1904; however, the dam was raised 50 feet (15 m) in 1925 so the impoundment in its present form is in effect 53 years old. According to cove-rotenone samples, Lake Wylie fish populations remained similar in species composition and standing crop between 1957 and 1970 (Reference 5). Lake Wylie has become increasingly eutrophic (Reference 7), which could eventually cause shifts in fish species composition and changes in production.

REFERENCES FOR SECTION 2.2

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2.3 METEOROLOGY

Meteorology is evaluated for use ⁱ structural design and in consideration of environmental safeguards for gas ᵢₜₛ releases. The following paragraphs summarize the atmospheric charac..ristics pertinent to these design bases.

Synoptic features during winter effect rather frequent alternation between mild and cool periods with . .sional outbreaks of cold air. Such intrusions of cold air, however, are modified in the crossing and descent of the Appalachian Mountains. Summers, noted for their greater persistence in flow pattern, experience fairly constant trajectories from the the south and southwest with advection of maritime tropical air. Wintertime precipitation occurs primarily in connection with migratory low pressure systems. Recurrence and areal distribution, therefore, are reasonably uniform. Summer rains, on the contrary, are associated more with showers and thundershowers of the air mass variety, occasioned by intense and uneven heating of the earth's surface. Local meteorologica. (site) conditions are in general dominated by synoptic scale processes.

Winter conditions, as a rule, are not conducive to the development of major snow storms. Long-term records for the area show highest 24 hour snowfall near 18 in. (Winston Salem, N.C., December, 1930) (Reference 1). The ice storm, a much more frequent occurrence, does effect considerable damage over limited areas and is expected several times a year. Typical accumulations range between one-quarter to one-half inch.

Spring, summer and autumn storms, phenomena of widespread consequence, are the major bearers of severe weather. For the area of North Carolina, South Carolina and their coastal waters, an average of one tropical storm per year and one hurricane every other year is computed based on a period of record of 63 years (1901-1963) (Reference 2). Within this period, seven years are void of any activity while nine years produce a combined total of three storms per year. Highest winds over the area are 110 miles per hour (fastest mile, Cape Hatteras, N.C., September, 1944) along the coast and near 80 miles per hour (fastest mile, Wilmington, N.C., October, 1954) for inland maxima (Reference 1). Maximum 24 hour rainfalls, again higher for coastal stations, are recorded near 15 in. along the ocast (Cape Hatteras, N.C., June, 1949) to near 9 in. inland (Wilmington, N.C., September, 1938) (Reference 1). Figure 2.3.0-1 relates tornado frequency to two degree squares for the period 1916-1955 (Reference 3). For the site area a total of 50 tornados are shown per two degree square (square area about 125 miles by 125 miles). Put in terms of probability for a point (nuclear station), such a translation predicts a recurrence interval of 4405 years (Reference 4). Thunderstorms, with greater frequencies during the summer, occur about 46 days per year (from Charlotte, N.C., period of record 73 years) (Reference 1). Thunderstorm occurrence by season averages: 11 for spring (March-May), 29 for summer (June-August), 5 for fall (September-November) and 1 for winter (December-February) (Reference 5). Associated hail is expected about one day per year over inland areas as indicated in Reference 6.

Air pollution over the Carolinas is of greatest potential during the fall. An average of ten episode - days per year is computed for a period of five years (from upper air observations at area Weather Service Stations, i.e., Athens, Georgia; Greensboro, N.C.; Cape Hatteras, N.C.; and Charlestion, S.C.) (Reference 7).

Table 2.3.0-1 depicts normal and extreme values for the following parameters; 451.3
temperature, rain, sleet and snow, fog, relative humidity, dew point and wind 451.12
direction and speed.

To provide the necessary wind and stability information for some calculations, a joint stability-wind distribution is generated which displays the joint frequencies of wind direction and speed by atmospheric stability type as they were observed onsite at the 40 m level (see Table 2.3.0-2). A similar joint frequency distribution is generated for data at the 10 m level for other
considerations (see Table 2.3.0-3). Data recovery for both summaries is 92%. 415.5
Regarding definition of calm winds, hourly average winds speeds less than 1 mph 415.2
are categorized as calm. In the manual reduction of wind speed, periods with speeds below instrument threshold are taken to have wind speed of 0.3 mph. An average for the hour is then derived as discussed in Section 6.1.3.1. The distribution of speeds summarized in Tables 2.3.0-2 and 2.3.0-3 result from
these reduction procedures. The period of record for these tables is from 451.4
December 17, 1975 to December 16, 1977.

STAR processing of Charlotte Airport data has been accomplished for the period of onsite data (1976-1977) in addition to a five-year period (1969-1973); see Table 2.3.0-4. Comparison of wind direction and speed, and of stability type forms the basis of judging the representativeness of data for the period 1976-1977, with respect to long-term conditions, as for the period 1969-1973; see Table 2.3.0-5. The 1976-1977 period is taken on balance to be reasonably representative of long-term conditions at the site.

Figure 2.1.1-1 shows general topography in plan view to 50 mi; Figure 2.1.3-1 is a detailed plan view, as modified by the plant to 5 mi. Figure 2.3.0-2 depicts maximum elevation versus distance to 5 mi for each of the sixteen 22.5° sectors.

Table 2.3.0-6 is a summary of X/Q and D/Q values for critical receptors both onsite and offsite, appropriate for evaluation of controls on routine releases.
Distance and direction from release points to each onsite intake location are 451.6
included on ER Table 2.3.0-6. Values of σ_z for distances less than 100 m were interpolated assuming a linear from from the release point to 100 m (i.e., an extrapolation from the 100 m value with a power law exponent of 1.0). Changes in the numerical values of X/Q and D/Q estimates result from the correction of a coefficient in the calculations of stable plume rise pertaining to the respective codes used for these purposes. Specifically, these changes pertain to computer codes described in Section 2.3.5 of the Catawba FSAR. They affect
X/Q and D/Q estimates in: FSAR Tables 2.3.5-1, 2.3.5-2, 2.3.5-4, and 2.3.7-2; 451.2
and ER Table 2.3.0-6, p. 2 of 2. FSAR Tables 2.3.5-1, 2.3.5-2, and 2.3.5-4 are
arrays of annual average X/Q and D/Q values by distance and direction out to 50 451.7
miles from the plant for-use in determining population exposure from routine releases of radioactive material; FSAR Table 2.3.7-2 and ER Table 2.3.0-6 p. 2 of 2 are a summary of initial offsite receptors. The second part of these tables, listing a single population X/Q, is simply a population weighted annual average X/Q value for the purpose of determining average population doses from routine releases within 50 miles of the plant. Table 2.3.0-7 is a summary of X/Q values for critical receptors, appropriate for evaluation of accident releases.

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2.4 HYDROLOGY

2.4.1 SURFACE WATERS

2.4.1.1 Hydrological Properties

The main hydrologic features influencing the station are the Catawba River and Lake Wylie. The headwaters of the Catawba River are the Blue Ridge Divide (Eastern Continental Divide) near Old Fort, North Carolina. The river flows east and then south where it joins the Wateree River at Lake Wateree near Camden, South Carolina. The Catawba River is 240 mi (386 km) long and has a drainage area of 4750 mi^2 (12296 km^2). There are six hydroelectric dams on the Catawba River upstream from the site. Figure 2.4.1-1 shows the major hydrologic features of the Catawba River drainage basin.

Lake Wylie is the station water supply. To serve Catawba there are two intake structures in the lake, one for the nuclear service water system and one for makeup water, conventional service water and other water needs. The station discharges (which include nuclear service water and conventional service water blowdown) are returned to Lake Wylie.

The average flow recorded for the Catawba River at the United States Geological Survey (USGS) gage number 1460 near Rock Hill, South Carolina, 3.5 mi (5.6 km) downstream from Wylie Dam is 4547 cfs (128.7 m^3/s). The period of record for this gage is 1895 to 1903 and 1942 to 1977. The drainage area for this gage is 3050 mi^2 (7896 km^2). This corresponds to an average flow at Wylie Dam of approximately 4500 cfs (124.5 m^3/s, with a drainage area of 3020 mi^2 (7819 km^2). Due to upstream hydroelectric dams there is no consistent seasonal variation in river flow.

Wylie Hydro Station and Mountain Island Hydro Station (upstream from Lake Wylie) operate in the peak portion of Duke's load curve. Normally, these stations operate in the mornings and afternoons of the weekday which is typically the peak period. Weekend generation occurs to prevent spillage and wasted generation or replace generation due to mechanical problems of other system units. Each of the four units at Mountain Island can pass up to 2480 cfs (67.9 m^3/s) of water at maximum output. Water output of the four Wylie Hydro units can range from 0-2800 cfs (0-79.2 m^3/s) at maximum generation. The intake opening elevation range for Wylie Hydro is from 509.4 ft (155.3 m) to 548.4 ft (167.2 m) msl.

The maximum flow recorded at the USGS gage (number 1460) is 151,000 cfs (4273 m^3/s) on May 23, 1901. The period of record for the gage is 1895 to 1903 and 1942 to the present. Two major floods not recorded by the gage are the flood of 1916 with an estimated flow at Wylie Dam of 299,400 cfs (8473 m^3/s) and the flood of 1940 with a flow of 169,160 cfs (4748 m^3/s). Table 2.4.1-1 presents the flood return period.

The one-percent chance flood and floodplain evaluation defined by Executive Order 11988 are not practical for the Catawba site. All major structures necessarily requiring placement in the floodplain (i.e., intake structures and discharge structures) were completed prior to the Order's being issued in May, 1977. Furthermore, because of the large amount of storage and control that the six upstream dams provide, it is impractical to consider conditions other than 240.:

those discussed in the Catawba FSAR, Section 2.4. The structures placed in the floodplain will cause no adverse impacts due to their location. 240.3

The minimum instantaneous flow recorded at the USGS gage (number 1460) is 102 240.1
cfs (2.89 m^3/s), October 31, 1961. The minimum daily flow recorded at the gage is 490 cfs (13.9 m^3/s), October 21, 1954. Water inflow to Lake Wylie is from Mountain Island Lake (Catawba River), the South Fork Catawba River and tributary creeks which contribute approximately 50, 25 and 25 percent, respectively, of the total flow. The FERC license for the Catawba-Wateree Project, No. 2232, requires a minimum average daily release of 314 cfs (8.89 m^3/s) from Mountain Island Dam and 411 cfs (11.6 m^3/s) from Wylie Dam. To calculate the low flow entering Lake Wylie, it is assumed the Catawba River contributes the 314 cfs 240.1
(8.89 m^3/s) required release from Mountain Island Dam and the remainder of the basin contributes a flow equivalent to the 7Q10 yield per square mile for the South Fork Catawba River. The total flow entering the lake based on these assumptions is about 516 cfs (14.6 m^3/s).

Lake Wylie extends north from Wylie Dam up the Catawba River 28 mi (45 km) to Mountain Island Dam. The lake also extends 5 mi (8.0 km) up the South Fork Catawba River. At full pond elevation 569.4 ft (174 m) msl, Lake Wylie has a surface area of 12,455 ac (5000 ha), a shoreline of 325 mi (523 km), a volume of 281,900 ac-ft ($3.46 \times 10^8 m^3$) and a mean depth of 22.5 ft (6.9 m). Area-volume curves for Lake Wylie are presented in Figure 2.4.1-2 and a map showing lake bed bottom topography in Figure 2.4.1-3. The design basis flood elevation for Lake Wylie is 592.2 ft (180.5 m) msl. This is the maximum water level calculated for the station assuming the Standard Project Flood and the simultaneous failure of Cowans Ford Dam.

Table 2.4.1-3 presents a 22 year period of the lowest lake levels recorded for Lake Wylie. The lowest level ever recorded for the lake occurred on October 23, 1952 at elevation 559.9 (9.5 ft (2.9 m) drawdown). The lake was intentionally lowered to permit work on the connecting canal at the upstream Plant Allen.

Defining a "drought period" on the Catawba River is difficult because of the high degree of regulation from storage impoundments. For example, note that at the times of the lowest recorded flows at the USGS gage below Wylie dam described
above do not correspond with the occurrence of the lowest recorded lake level 240.1
for that year. These low flows occurred because of choice of operation as opposed to drought conditions.

From the records of the rainfall station at the Wylie Dam, two months out of 336 that have been recorded as having no rainfall (or roughly 1 month in fourteen years with no rainfall). These months are September, 1947 and October, 1963. The dryest year on record at this station is 1966 recording only 32.09 81.5 cm) inches. [The annual average for the period of record is 45.77 inches (116.3 cm).] The lowest lake elevation for 1966 was 564.4 [5.0 ft (1.52 m) drawdown].

Average natural evaporation for Lake Wylie is approximately 42 inches (107 cm) per year. Forced evaporation for Plant Allen is calculated to be 11 cfs (0.31 m^3/sec); and for Catawba, it is 59 cfs (1.67 m/sec). The maximum permissible drawdown permitted by the FERC is 10 ft (3 m). The nuclear service and conventional service water intake pumps are designed to operate in this 10 ft

drawdown range. Based on the FERC requirements, the large storage volume of water above Lake Wylie, and Duke's operational control of the lake and upstream impoundments, it is anticipated that the lake level would not be below the operational level of the intake pumps at any time over the life of the plant. 240.
However, should an extreme event cause a drawdown greater than 10 ft (3 m), proper instrumentation is in place to notify the operators to shut down and use the SNSW panel to maintain cold shutdown.

2:4.1.2 Physical and Chemical Properties

Physical, chemical and biological data indicate that Lake Wylie is comprised of three distinct water systems: The Catawba River, a well mixed river environment; the South Fork Catawba River, a permanently stratified system resulting from the flow of ambient South Fork water beneath the Allen Station thermal effluent; and the main body of Lake Wylie, a seasonally stratified lake system (Reference 3).

Levels of major chemical constituents in Lake Wylie reflect the geology and mineralogy of the drainage system. Highest values of most parameters including turbidity, fecal coliform bacteria, aquatic nutrients and trace metals occur in ambient South Fork waters (Reference 3).

Lake Wylie is a warm monomictic reservoir (References 3, 4, 5, 6 and 7) with thermal stratification typical of Carolina Piedmont reservoirs (Reference 8). Thermal stratification extends from May through September. Highest surface temperatures (usually near 30 C (86 F)) typically occur in August while minimum surface temperatures (usually near 6 C (43 F)) occur in January or February (References 3, 4, 5, 6 and 7). Surface dissolved oxygen concentrations range from 7 mg/l to 11 mg/l (Reference 3). During stratified periods, hypolimnetic dissolved oxygen approaches zero (Reference 4). Within the main body of Lake Wylie, very little spatial difference exists for temperature or dissolved oxygen other than natural stratification. Table 2.4.1-2 and Table 2.4.1-4 presents descriptive statistics for water quality constituents in Lake Wylie.

Lake Wylie is typically a bicarbonate system (Reference 4). Specific conductance and total dissolved solids (T.D.S.) values in the main body of the lake fluctuate slightly around baseline values of 75 ∂ohms/cm and 60 mg/l respectively (Reference 3). In general, specific conductance and T.D.S. values vary inversely with turbidity and flow, with values in the Lake Wylie sector being intermediate in both variability and magnitude between the Catawba River and the South Fork Catawba River. Alkalinity concentrations generally inversely reflect flow conditions of incoming streams, with minimum concentrations occuring during maximum flow. Total alkalinity values average about 15 mg $CaCO_3$/l. The pH for Lake Wylie has an average value of 6.9.

Turbidity and total iron values follow similar trends in each of the three sectors of the lake. These parameters are substantially affected by surface water runoff. The lowest values occur in the fall when incoming stream flow is generally the lowest. Large quantities of geologically derived iron give the water a reddish-brown color characteristic of piedmont waters (References 3, 4, 5, 6 and 7).

Based on both inorganic N/P ratios and bioassay results, Lake Wylie is phosphorus limited (References 2, 3, 4, 5, 6 and 7). Total phosphorus concentrations are highest in the South Fork sector of the lake and appear to vary with turbidity.

Heavy metals have not been extensively studied. The existing data indicate a great degree of heterogeneity in spatial and temporal variations. There have not been any recorded detrimental effects to aquatic life in Lake Wylie from heavy metal concentrations.

2.4.2 BACKGROUND POLLUTANTS

The location of major industrial waste discharges to the Catawba River drainage in the vicinity of the station are presented in Figure 2.1.3-7, and available information is presented in Table 2.1.3-8. The physical and chemical properties of Lake Wylie are addressed in Subsection 2.4.1.2.

A summary of dissolved oxygen (DO) and biological oxygen demand (BOD) data from four stations downstream of Wylie Dam is presented in Table 2.4.2-1. On the basis of DO and BOD the Catawba River immediately below Wylie Dam is relatively unpolluted.

2.4.3 SITE IMPOUNDMENTS

The only water impoundment to be constructed for Catawba Nuclear Station is the Standby Nuclear Service Water Pond (SNSWP). This pond is to serve as an ultimate heat sink during a Loss of Coolant Accident (LOCA) to dissipate waste heat from the Nuclear Service Water System. The pond is located north of the plant yard.

At full pond elevation of 571.0 ft (174.0 m) msl the pond has a surface area of 46 ac (0.19 km^2) and a volume of 560 ac-ft ($6.9 \times 10^5 m^3$). The area-volume curves for the pond are presented in Figure 2.4.3-1.

Runoff and groundwater flow are the main source of water for the SNSWP. The area of the drainage basin at the dam is approximately 450 ac (1.82 Km^2). A typical average drainage basin yield for this area is 1 cfs/mi^2 (0.007 $m^3/sec/km^2$), which provides the pond with an average inflow of 0.7 cfs (0.02 m^3/sec). The average evaporation is estimated to be 38 in (97 cm) per year which corresponds to roughly 0.2 cfs (6.3×10^{-3} m^3/sec). The maximum drawdown for the pond is elevation 570.0 ft (173.7 m) (Reference FSAR Section 9.2.5-4).

A ten year study completed in 1971 was made by the USGS[8] to adequately measure reservoir evaporation on a continual basis for a period of several years so that evaporative losses during critical periods could be understood and accounted for in water supply management in the southeast U.S. This study was performed on Lake Michie near Durham, N.C., and the findings are considered representative for the Duke Power Service area. Findings of this study state "... frequency studies indicate that over 16 inches of net evaporation may occur during a six 240.2
month period every 50 years, on the average".

From the above study and findings, it is anticipated that the SNSW pond would need to be replenished once over the life of the plant by a source of water other than natural inflow. The plant can supply this make-up by aligning two valves from the control room to shut off normal discharge to Lake Wylie and open the SNSW discharge pipe to allow this normal discharge to flow to the SNSW pond until it is full.

Filling in the above manner can be done only if Lake Wylie is maintained above elevation 559.4 ft (170.5 m) msl to allow proper operation of the NSW and conventional service water intake pumps. For a discussion of maintaining Lake Wylie above this elevation, reference ER Section 2.4.1.1. An intake to allow direct piping of water from the lake to the SNSWP is not available. 240.

Discharge from the SNSWP into Lake Wylie is through an overflow standpipe in the pond with the invert at elevation 571.0 ft (174.0 m) msl.

2.4.4 GROUNDWATER

2.4.4.1 Groundwater Aquifer

The Catawba site lies within the Piedmont Groundwater Province. Groundwater recharge in this area is derived entirely from infiltration of local precipitation. The surface materials in many locations are relatively impermeable with the result that only 10 in (25 cm) to 15 in (38 cm) of the average 45 in (114 cm) of annual precipitation percolate to the water table. Groundwater is contained in the pores that occur in the weathered material (residual soil-saprolite) above the relatively unweathered rock and in the fractures in the igneous and metamorphic rock. There are numerous localized perched water tables as well as very localized artesian aquifers.

Present groundwater use in the area is limited to domestic use. Flowrates generally range from 3 to 150 gallons per minute (11 to 568 l/min). Figure 2.4.4-1 shows the locations of wells and one spring in the vicinity [approximately 1 mi (1.6 km) radius] of the site and Table 2.4.4-1 is the available information. Regional groundwater users are listed in Tables 2.4.4-2 and 2.4.4-3.

2.4.4.2 Groundwater Levels

In the region of the site, groundwater rarely occurs at depths more than 300 ft (91 m) below ground surface, and usually occurs in significant quantities at depths less than 150 ft (45 m). Observations of groundwater elevations at about 60 locations in the immediate vicinity of the site are used to make a contour map of the preconstruction water table as shown in Figure 2.4.4-2. This map shows that the preconstruction elevation of the groundwater varies from about 10 to 40 ft (3 to 12 m) below the natural ground surface near the location of the reactors and that it approaches the surface elevation of Lake Wylie near the lake-shore. Thus, groundwater movement is from the plant area toward the lake coves which cut into the peninsula to the north and to the south of the site.

A permanent groundwater drainage system is installed to maintain a normal groundwater level near the base of the foundation mat and basement walls for the Auxiliary and Reactor Buildings. This decreases the groundwater gradient and groundwater movement away from the site is therefore decreased.

Experience in the region is that the groundwater level normally declines during the late spring, summer and early fall months as a result of evapotranspiration and when rainfall is low. The groundwater level then rises in late fall, winter and early spring.

The USGS monitors the groundwater level in a well across Lake Wylie from the station. This well is 700 ft (213 m) in depth with the upper 50 ft (15 m) cased. The surface elevation is about 600 ft (183 m) msl. Figure 2.4.4-3 shows the monthly groundwater hydrograph from October 1973 to September 1977 for the well. The maximum groundwater change since the well has been monitored is 6.64 ft (2.02 m).

2.4.4.3 Groundwater Hydraulics

Several types of tests are performed to evaluate the hydraulic characteristics of the subsurface materials at the site. Packer permeability tests are used in estimating rock permeability. Results from 62 tests performed in 13 borings show the permeability to range from 0.0 to less than 500 ft (152 m) per year, with an exception being observed in one boring where a permeability of 1761 ft (537 m) per year is measured. Test results are presented in Table 2.4.4-4.

To evaluate the horizontal permeability in soil-saprolite and weathered rocks the constant-head permeability test is used. Results, shown in Table 2.4.4-5, indicate a very low permeability, less than the packer tests in rock.

Vertical soil permeability is measured by laboratory variable-head tests on undisturbed samples. The laboratory tests can be divided into two categories: (1) tests made under conditions designed to simulate the overburden pressure present under field conditions, and (2) tests made without overburden pressure. Test results are presented in Table 2.4.4-5. The tests made under simulated field conditions yield permeabilities significantly lower than those tests for which overburden pressure is not applied. Also, the vertical permeabilities determined under simulated field conditions are significantly smaller than the horizontal permeabilities measured in the field. Values range from less than 1.0 ft (0.3 m) per year up to 378 ft (115 m) per year.

Constant-discharge pumping tests are conducted to determine average values of horizontal permeability, transmissivity and storage coefficient of the aquifer. The results of the constant discharge pumping tests are summarized in Tables 2.4.4-6 and 2.4.4-7. Values of the drainable porosity of the aquifer or storage coefficient computed from the two pumping tests range from 1.6×10^{-2} to 2.8×10^{-1}. The geometric means of the storage coefficients are 4.6×10^{-2} and 7.9×10^{-2}. Permeabilities calculated from the pumping tests range from 31 ft/yr (9 m/yr) to 1017 ft/yr (310 m/yr).

Groundwater flow, based on preconstruction data, is from the site to the lake coves north and south of the site. Using Darcy's Law with the permeability of 1761 ft/yr (537 m/yr), the porosity of 0.05 and the gradient of 0.03, the velocity is calculated to be about 1100 ft/yr (335 m/yr). The travel time is computed to be less than one year by dividing the length of the assumed critical path, 750 ft (229 m) by the groundwater velocity. There are no domestic wells along the groundwater path of travel. The gradient after plant construction is not conducive to any groundwater movement from the powerhouse towards the lake.

2.4.4.4 Groundwater Quality

The chem:-al and bacteriological groundwater quality in the vicinity of the site is high and satisfactory for domestic use without treatment. Results of chemical and physical tests are presented in Table 2.4.4-8.

REFERENCES FOR SECTION 2.4

1. NC Department of Natural and Economic Resources. Water Quality Management Plan. Catawba River Basin. Environmental Management Commission, Raleigh, NC. 1976.

2. U.S. Environmental Protection Agency. Report on Lake Wylie, York County, South Carolina, and Gaston and Mecklenburg Counties, North Carolina, EPA Region IV. Working Paper No. 441 USEPA, Corvallis, OR. 1975.

3. Industrial Bio Test Laboratories, Inc. A Baseline-Predictive Environmental Investigation of Lake Wylie. Report to Duke Power Company. Industrial Bio Test Laboratories Inc., Northbrook, IL. 1974.

4. Duke Power Company. Catawba Nuclear Station. Interim Monitoring Study. 1974-1977. Duke Power Company, Charlotte, NC. 1977.

5. Duke Power Company. Catawba Nuclear Station. Interim Monitoring Study. 1977-1978. Duke Power Company, Charlotte, NC. 1978.

6. Duke Power Company. Catawba Nuclear Station. Interim Monitoring Study. 1978-1979. Duke Power Company, Charlotte, NC. 1979.

7. Duke Power Company. Catawba Nuclear Station. Interim Monitoring Study. 1979-1980. Duke Power Company, Charlotte, NC. 1980.

8. Bowling, T. J. and Flowe, M. B. Chemical Characteristics of Piedmont Lakes. Workshop in Aquatic Ecology in the Southeast. Augusta, GA. October 14, 1977 sponsored by Southeastern Section of ESA.

9. U.S. Environmental Protection Agency. Quality Criteria for Water. EPA 440/9-76-023. U.S. EPA, Washington, DC. 1976.

Table 2.2.2-12
Catawba Nuclear Station
Recreational Harvest from Lake Wylie, by Zone, from Summer 1979 through Spring 1980 (Reference 65)

		Zone 1*	Zone 2*	Zone 3*	Totals
Largemouth Bass	No.	27,987	35,376	20,114	83,477
	kg.	20,043	24,808	14,052	58,903
Striped Bass	No.	-	-	288	288
	kg.	-	-	277	277
Crappie	No.	105,138	87,592	39,131	231,861
	kg.	18,833	15,772	5,673	40,278
Sunfish	No.	7,484	28,722	32,219	68,425
	kg.	503	2,105	2,356	4,964
Catfish	No.	12,535	34,899	79,130	126,564
	kg.	3,736	13,110	23,452	40,298
White Bass	No.	1,249	3,346	17,144	21,739
	kg.	561	709	5,902	7,172
Carp	No.	-	-	192	192
	kg.	-	-	250	250
Yellow Perch	No.	-	240	939	1,179
	kg.	-	36	302	338
Bowfin	No.	-	-	669	669
	kg.	-	-	41	41

* See Figure 2.2.2-3 for location of zones.

Table 2.2.2-13
Catawba Nuclear Station
Estimated Recreational Harvest Taken by All Fishermen on Lake Wateree (Reference 66)

January 1, 1971 - December 31, 1971

Species	Total Number	Total Weight (kg)	Average Weight (kg)
Largemouth Bass	62,228	44,602	.717
Bluegill	80,498	9,226	.115
Redbreast	1,474	357	.242
Crappie	218,742	77,576	.355
White Bass	60,763	24,284	.400
Catfish	34,566	12,782	.370
Other	3,301	2,475	.750

January 1, 1972 - June 30, 1972

Species	Total Number	Total Weight (kg)	Average Weight (kg)
Largemouth Bass	41,875	38,810	.927
Bluegill	49,813	5,837	.117
Crappie	181,276	70,299	.388
White Bass	7,762	5,548	.715
Striped Bass	7,752	9,997	1.290
Catfish	40,225	20,300	.505

Table 2.2.2-14
Catawba Nuclear Station
Recreational Harvest in kg Round Weight - Lakes Marion and Moultrie
(Reference 67)

Species	1971	1972
Largemouth Bass	65,450	133,374
Bluegill	48,800	37,532
Crappie	89,336	138,899
White Bass	2,407	6,010
Striped Bass	82,590	100,212
Catfish	19,262	13,584
Yellow Perch	1,733	2,587
Pickerel	1,314	3,231

Table 2.2.2-15
Catawba Nuclear Station
Commercial Harvest in kg from the Santee River Below Wilson Dam

Species	1975	1976	1977	1978*	1979*	1980
.	No Data					
River Herring				28,773	1,727	31,933
Shad (general)			16,239			
Shad Buck				5,000	773	320
Shad Roe				1,909	3,591	1,686
Shrimp		19,550				760
Blue Crab				63,227	52,727	79,393
Clam		68,040	66,861	52,818	47,455	70,486
Oyster					4,500	103,129

* 1978 and 1979 data from Reference 67; all other data from Reference 68.

Table 2.2.2-16
Catawba Nuclear Station
Commercial Harvest in kg from the Cooper and Ashley Rivers Below Penopolis Dam*

Species	1975	1976	1977	1978**	1979**	1980
Carp	318					
Catfish	203,394	121,792				184,140
Catfish and Bullhead		6,804	204,120			
Crocker	45					
Red Drum	3,538		45			
Eel	8,981	7,938	6,214	11,409	4,545	4,644
Flounder	499					
Mullet	1,361		544			
Gray Trout	454					
Spotted Trout	2,087		45			
Spot	136		136			
Shad	726			All Clupeids 60,591	All Clupeids 149,909	
River Herring		30,346	146,694			267,835
Bluefish			45			
Whiting			45			
Blue Crab	71,669	25,084	105,643	187,136	207,727	60,903
Clam	635		363	4,000	1,182	2,068
Oyster	635	45		3,364	3,455	1,539
Conk					29,955	

* Catfish data are from the River and from Lake Moultrie.

** 1978 and 1979 data are from Reference 67; all other data from Reference 68.

Table 2.2.2-17
Catawba Nuclear Station
Commercial Harvest in Kg from the Wando River*

Species	1975	1976	1977	1978	1979	1980
.	(No data)	(No data)	(No data)			
Blue Crabs				1,733	113,227	147,296
Clams				727	45	---
Oysters				2,045	136	---

* 1978 and 1979 data from Reference 67; other data from Reference 68.

Table 2.2.2-18
Catawba Nuclear Station
Number of Fish Sampled and Calculated Total Number
Of Dead Fish in a 1973 Fish Kill on the Catawba River
(Sample Area Includes From the Lower Portion of Fishing
Creek Reservoir to Approximately 30 km Upstream)(Reference 69)

Species	Number Sampled	Calculated Total Number
Gizzard Shad	436	45,247
Threadfin Shad	19	1,972
River Carpsucker	33	3,425
Creek Chubsucker	3	311
Silver Redhorse	1	104
Channel Catfish	14	1,453
Black Crappie	11	1,142
Bluegill	33	3,425
Carp	3	311
Longnose Gar	1	104
Redbreast	113	11,727
Warmouth	1	104
Flat Bullhead	960	99,624
White Catfish	217	22,519
Bait Fish	8	830
Striped Bass	2	208

	Temperature					Precipitation				Snow-Sleet		Fog	Humidity	Wind				
Month	Daily Maximum	Daily Minimum	Monthly	Record Highest	Record Lowest	Normal Monthly	Maximum Monthly	Minimum Monthly	Maximum 24 Hour	Maximum Monthly	Maximum 24 Hour	Mean Number of Days*	Mean Dew Point	Mean Speed	Prevailing Direction	Mean Resultant	Record Speed**	Record Direction
January	52.1	32.1	42.1	78	-3	3.51	7.44	1.24	3.57	11.7	10.2	4	32	8.0	SW	WNW/3	56	NE
February	54.9	33.1	44.0	81	-5	3.83	7.59	0.74	2.92	14.9	16.5	3	32	8.4	NE	---	54	SW
March	62.2	39.0	50.6	90	4	4.52	8.76	2.11	3.83	19.3	8.0	2	37	8.9	SW	---	49	SW
April	72.7	48.9	60.8	93	24	3.40	7.64	0.30	3.20	T	T	1	46	8.9	S	SW/3	53	NW
May	80.2	57.4	68.8	100	32	2.90	12.48	0.11	3.67	0.0	0.0	1	57	7.6	SW	---	48	NW
June	86.4	65.3	75.9	103	45	3.70	8.26	0.67	3.77	0.0	0.0	1	63	7.0	SW	---	57	NW
July	88.3	68.7	73.5	103	53	4.57	16.55	0.82	6.59	0.0	0.0	1	67	6.6	SW	SSW/2	59	NW
August	87.4	67.9	77.7	102	53	3.96	9.98	0.61	4.52	0.0	0.0	2	67	6.5	S	---	54	NW
September	82.0	61.9	72.0	104	39	3.46	10.89	0.02	4.74	0.0	0.0	2	62	6.8	NE	---	47	NW
October	73.1	50.3	61.7	98	24	2.69	8.33	T	5.34	0.0	0.0	2	51	7.0	NNE	NNE/4	47	NW
November	62.4	39.6	51.0	85	11	2.74	8.17	0.46	2.79	2.5	2.5	3	38	7.3	SSW	---	47	NW
December	52.5	32.4	42.5	77	2	3.44	7.41	0.43	2.87	7.5	7.5	4	31	7.4	SW	---	57	NE
Year	71.2	49.7	60.5	104	-5	42.72	12.48	T	6.59	19.3	16.5	26	48	7.5	SW	---	59	NW
Period of Record	1941-1970	1941-1970	1941-1970	1940-1980	1940-1930	1941-1970	1940-1980	1940-1980	1940-1980	1940-1980	1940-1980	1940-1980	1946-1965	1950-1980	1967-1980	1951-1960	1950-1980	1950-1980
Source	a	a	a	a	a	a	a	a	a	a	a	a	b	a	a	b	a	a

*Number of days of heavy fog (visibility equal to or less than ¼ mile)
**Speed based on fastest mile of air

Note Temperature and dew point in °F, precipitation and snow-sleet in inches (T indicates trace of precipitation), wind speed in miles per hour.

a. National Oceanic and Atmospheric Administration, Environmental Data and Information Service, National Climatic Center, "Local Climatological Data, Annual Summary with Comparative Data, 1980, Charlotte, N. C.", Washington, D. C.

b. U. S. Department of Commerce, Environmental Science Services Administration, Environmental Data Service, Climatic Atlas of the United States, Washington, D. C., 1968, pp. 57-58.

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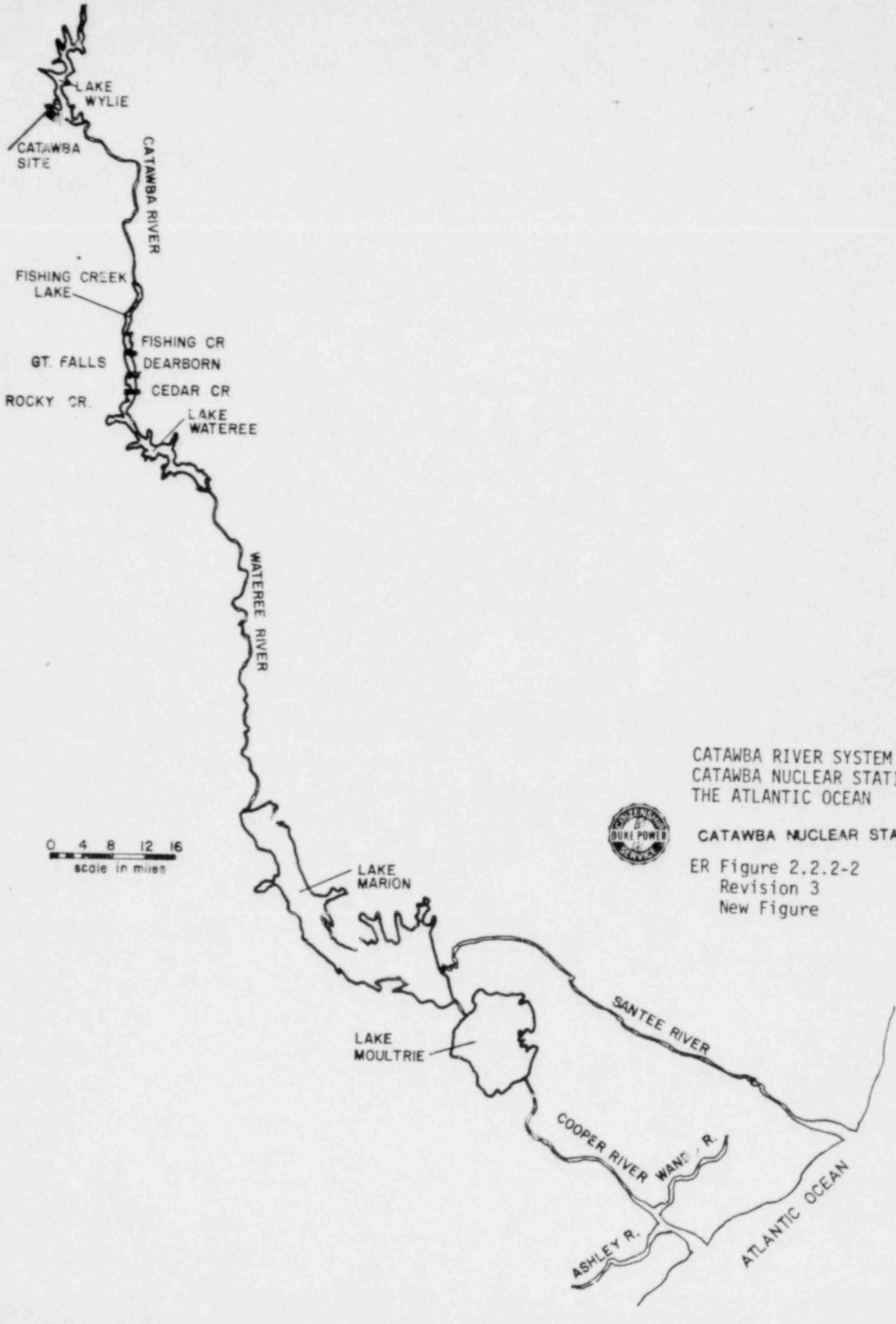
ER Table 2.3.0-1
Catawba Nuclear Station
Onsite Data
January 1, 1976 - December 31, 1977

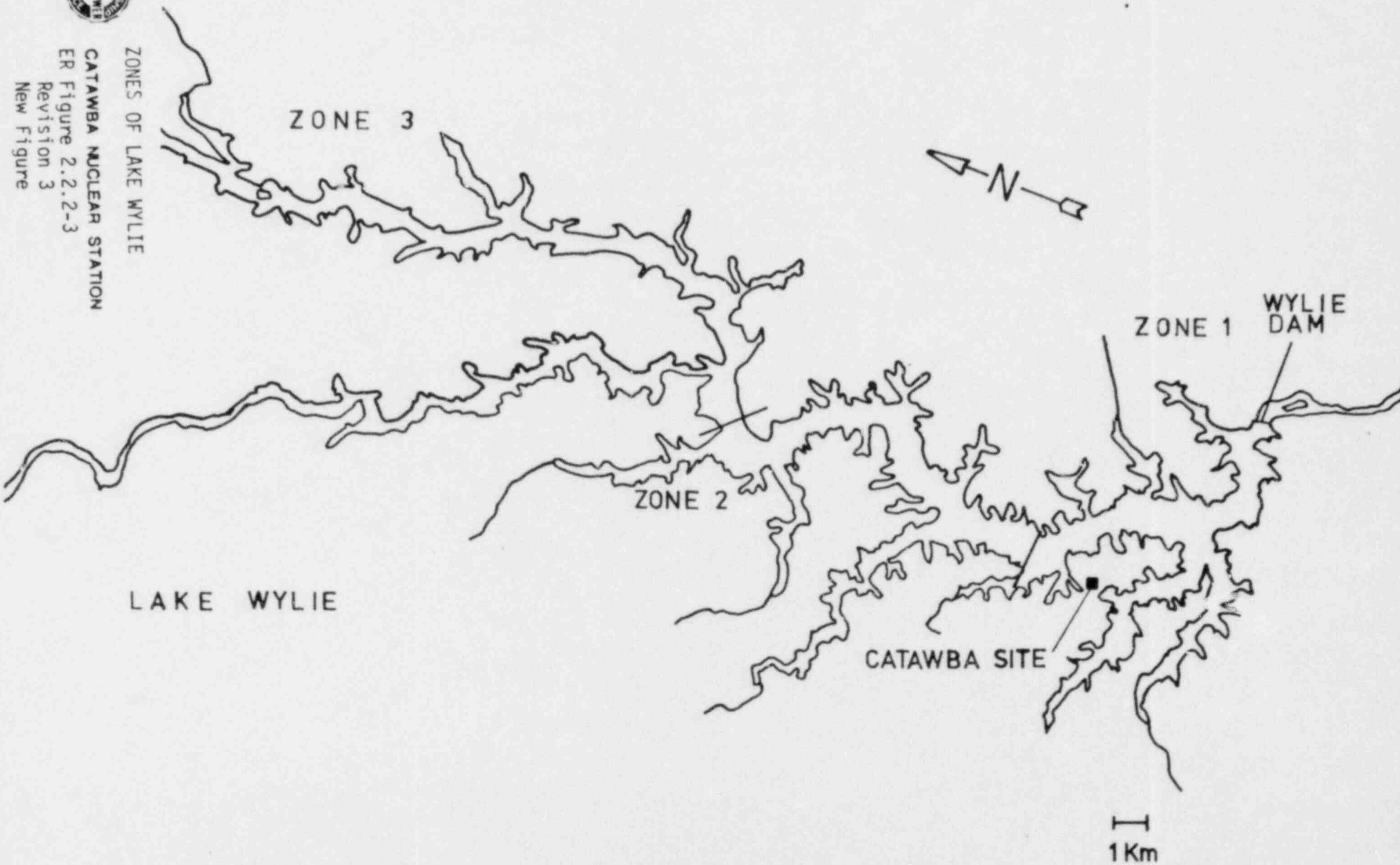
Month	Mean Temperature(°F)	% Recovery	Mean Dew Point(°F)	% Recovery	Mean Wind Speed(mph)	% Recovery
January	35	10[illegible]	23	94	5.5	84
February	47	98	30	97	6.6	86
March	56	93	43	93	6.2	97
April	63	99	46	98	5.8	93
May	68	94	56	93	5.5	100
June	73	100	63	100	5.5	84
July	79	100	66	99	4.8	91
August	77	100	66	99	5.8	98
September	71	100	62	84	4.9	100
October	57	100	45	73	6.3	100
November	49	100	38	96	5.9	99
December	41		31	99	5.2	89
Year	60	99	48	94	5.7	93



CATAWBA RIVER SYSTEM FROM CATAWBA NUCLEAR STATION TO THE ATLANTIC OCEAN

CATAWBA NUCLEAR STATION

ER Figure 2.2.2-2
Revision 3
New Figure



ZONES OF LAKE WYLIE
CATAWBA NUCLEAR STATION
ER Figure 2.2.2-3
Revision 3
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3.4 HEAT DISSIPATION SYSTEM

The Catawba is designed to convert approximately 32 percent of the thermal energy generated by nuclear fission into electrical energy. The remaining thermal energy is handled by the heat dissipation system which includes the Main Condenser Cooling Water System, Nuclear Service Water System, and Low Pressure Service Water System (including the Make-up Water System). The flow paths of all water systems within Catawba are shown schematically in Figure 3.3.0-1. The flow rates, frequency of flows, and dilution for all systems are incorporated into Figure 3.3.0-1.

3.4.1 CONDENSER COOLING WATER SYSTEM

The condenser cooling water (CCW) system includes the main steam condenser, cooling towers, pumps, valves, and piping. Figures 3.4.1-1 thru 3.4.1-4 show a schematic representation of the CCW system. The closed-cycle mechanical-draft cooling tower system has been evaluated and found environmentally acceptable (FES Section 3.4).

Table 3.4.1-1 shows temperature, pressure, and equivalent elevation at various points in the CCW system at design summer conditions with 100% load conditions. At these specified conditions the cooling towers are designed to dissipate 7.9 x 10^9 Btu/hr. (8.33 x 1012 J/hr) per unit.

The combined length of the condenser tubes for the three condenser shells is approximately 126 ft (38.4 m). There are 23,506 tubes per condenser shell. The design velocity for the water through the tubes is 8 fps (2.4 m/s).

The condenser tubes are 1 1/2 in. (3.2 cm) outside diameter, 22 gauge, 304 stainless steel. The tubes are rolled into a tube sheet on both ends of the condenser shell.

Condenser cleaning is accomplished by injecting sponge rubber balls (Amertap Balls) into the condenser inlet (see Figure 3.4.1-3). These balls are slightly larger than the condenser tube inside diameter and clean the tubes as they are forced through them by the water flow. The Balls are recaptured at the condenser outlet for reuse (see Figure 3.4.1-3).

Steel plate for the pipe shell and flanges conforms to ASTM Specification A-283, Grade C. Steel plate for pipe stiffness and for reinforcement of specials conforms to ASTM Specification A-36.

The closed-cycle mechanical draft circular cooling towers are approximately 66 ft. (20 m) tall with an outside diameter of approximately 272 ft. (83 m) (Figure 3.4.1-5). Table 10.1.1-3 (circular mechanical draft) gives other cooling tower details. Cooling tower evaporation is estimated in Table 3.4.1-2. Cooling tower drift droplet size distribution is given in Table 3.4.1-3. The cooling tower performance curve is shown in Figure 3.4.1-6. The cooling towers are constructed of concrete with PVC fill.

The cooling tower blowdown release is maintained as required to prevent dissolved solids buildup and subsequent scaling in the CCW system. Dissolved solids concentrations in the cooling water are maintained at a maximum level approximately ten times (Section 3.6.2) greater than that of makeup water.

Blowdown of the cooling water flow is extracted from the condenser cooling water pipes (Figure 3.4.1-2), and is discharged into the lake through the LPSW discharge structure. The LPSW discharge structure is located at the end of the discharge cove (Figure 2.1.1-3). The facility is designed to allow warm discharge water to float on the surface of the lake with a minimum amount of mixing. This type of discharge facilitates cooling and minimizes the affected area. Details of the discharge structure are shown on Figure 3.4.4-1.

Consumptive water use is only that portion of the CCW lost due to evaporation and drift.. Therefore, at full load maximum consumption water use would be 28,110 gpm (1.77 m^3/s).

3.4.2 LOW PRESSURE SERVICE WATER

The Low Pressure Service Water (LPSW) system supplies cooling water for various functions on the secondary side of the plant, including the main turbine oil coolers, the generator stator cooler, and the generator hydrogen cooler. The LPSW is drawn from the Catawba River arm of Lake Wylie and discharges into Allison Creek (Figure 2.1.1-3). The service water experiences an approximate temperature rise of 15 F (8.3 C) during the winter. Water quantities are shown on Figure 3.3.0-1 and Table 3.3.0-1.

The Makeup Water system replaces water that is lost in the cooling towers due to evaporation and blowdown. Average makeup water requirements are expected to be 30,915 gpm (1.95 m^3/s), operating at seven cycles of concentration.

3.4.3 INTAKE STRUCTURE

The location of the intake structure is shown on Figure 2.1.1-3. The structure is located on the east side of the intake cove and serves as a platform for supporting various pumps, trashracks, and screens. The structure was originally designed with three bays, each containing a LPSW pump traveling screen and trashrack. During the detailed design, a fourth bay was added to house the main fire pumps and an associated trashrack and pullout screen. This feature was required to meet fire protection insurance codes requiring the fire protection system to be completely independent of and isolated from the continuous source of cooling water. 290.3

The LPSW pumps are protected from debris by the trashbacks and traveling screens. The fixed racks are bars spaced 4 inches apart that prevent large objects from entering the pump bay. Each motor driven traveling screen has a group of trays that revolves in a continuous, vertical loop. As the screen revolves, debris is deposited on the 3/8 inch wire mesh covering the trays. The backwash system washes the debris from the screens and deposits it in a trough on the top of the structure where it flows by gravity into the trash basket.

The fire pumps are protected from debris by similar features. In this bay, however, the traveling screen is replaced by a stationary pullout screen. This screen must be removed and cleaned by hand.

All collected debris is transmitted to a sanitary landfill.

The intake structure is shown on Figure 3.4.3-1. The structure is designed for a maximum water velocity of 0.5 fps (0.15 m/sec) in front of the trashracks/screens at maximum drawdown. Listed below are the design velocities for the conditions and locations as noted:

Full Pond
W.S. Elev. 569.4

Area	Velocity
Gross Opening (306.0 ft^2)	0.24 fps (0.07 m/s)
Thru Trashracks (224.3 ft^2)	0.33 fps (0.10 m/s) 290.
Thru Screens (158.6 ft^2)	0.47 fps (0.14 m/s)

Maximum Drawdown
W.S. Elev. 559.4

Area	Velocity
Gross Opening (194.3 ft^2)	0.38 fps (0.12 m/s)
Thru Trashracks (141.9 ft^2)	0.53 fps (0.16 m/s)
Thru Screens (100.7 ft^2)	0.74 fps (0.23 m/s)

Since the only revision to the original intake structure concept was the addition of fire pumps, the environmental impact of the existing design is not significantly different from the environmental impact of the CP-stage design.

3.4.4 DISCHARGE STRUCTURE

The location of the LPSW discharge structure is shown on Figure 2.1.1-3. From this discharge structure the NSW, cooling tower blowdown, liquid radwaste and LPSW systems are discharged to Lake Wylie. This facility is designed to allow warm discharge water to float on the surface of the lake with a minimum amount of mixing. This type of discharge facilitates cooling and minimizes the affected area.

The CP-stage concept of four 42 inch diameter pipes was based on early preliminary information. Due to refinements in the hydraulic design for the LPSW system, the preliminary piping concept evolved into the current concept of two 290.
54 inch diameter pipes. The supporting concrete structure was appropriately changed and refined to accomodate the final piping arrangement. The discharge structure is shown in Figure 3.4.4-1.

3.4.5 NUCLEAR SERVICE WATER SYSTEM

The Nuclear Service Water (NSW) system supplies cooling water to various heat loads in both the primary and secondary portions of each unit. The NSW is drawn from the Catawba River arm of Lake Wylie and discharges into Allison Creek. The maximum flow is 68,000 gpm (4.14 m^3/s) with the average flow being 25,000 gpm (1.52 m^3/sec) (Figure 3.3.0-1 and Table 3.3.0-1).

The Standby Nuclear Service Water Pond (SNSWP) at Catawba is responsible for meeting requirements for the reliable ultimate heat sink as outlined in Regulatory Guide 1.27. The maximum flow to and from the SNSWP is 68,000 gpm (4.14 m^3/s) and the average flow is 0 gpm (0 m^3/s) since the pond is not used in normal operation.

3.6 CHEMICAL AND BIOCIDE WASTES

3.6.1 CHEMICAL EFFLUENTS

All chemical wastes are collected, treated, and the effluent discharged into Lake Wylie (Figure 3.6.1-1).

The treatment systems for all chemical wastes from Catawba are different from those described in the Construction Stage Environmental Report. Instead of a single pond for waste treatment, a new four basin Conventional Waste Water Treatment System is planned. Non-radioactive turbine building drains, water treatment system filter backwashes, and demineralizer regeneration wastes are routed through this system prior to discharge to Lake Wylie. This system utilizes a physio-chemical treatment regime rather than biological methods.

Wastes are initially directed to a concrete lined initial holdup pond where primary sedimentation occurs. This 300,000 gallon (1200 kl) capacity reservoir has a retention time of from 12 hours to 24 hours and acts as a surge tank to prevent overloading and subsequent degradation of effluent quality throughout the remainder of the system. A sludge accumulation rate of approximately 2.6 ft/yr (.79 m/yr) is in this pond and removal to an approved landfill is accomplished once every one to three years. Provisions for temporarily varying and routing of the influent and in process waste waters provides ample opportunity for sludge removal if the accumulation begins to interfere with pond performance.

The initial holdup pond is followed by parallel stream settling ponds. These two 5 million gallon (1.9E4 kl) ponds are lined with compacted clay and are equipped for recirculation. One pond is in service while the other is on standby. Coagulant aids are likely to be used in these ponds for settling lighter solids along with the pH adjustment to precipitate various chemical compounds. Holdup time for each of these basins ranges from 6 to 12 days.

The waste water then flows by gravity to the final holdup pond where it is aerated; retention time for this basin is 3 to 5 days. This final pond is used to remove any persistent oxygen demand of the wastes. Final precipitation of compounds could occur in this basin; however, it is not likely that the system would be operated in such a manner to make this a significant occurrence, since there is presently no provision for removing such precipitates from the basin prior to discharge. The pond has a capacity of 1 million gallons (3800 kl). Its contents may be pumped to the head of the settling basins or back to its own inlet for recirculation if the effluent does not meet the established discharge limits.

The system is designed to provide adequate treatment within basin holdup time, to allow intrabasin and interbasin recirculation and to be equipped with complete monitoring of effluents from each basin in the system. With these provisions built into the system, consistent effluent quality is expected with the following characteristics shown in Table 3.6.1-1.

Table 3.6.1-2 lists the expected chemical waste discharges from Catawba and the resultant downstream incremental concentrations. Annual chemical usage and disposition is given in Table 3.6.1-3.

3.6.2 COOLING TOWER BLOWDOWN

Makeup water for the cooling towers is supplied by the conventional service water system (see Figure 3.3.1-1) at a maximum rate of about 31,000 gpm (117 m^3/min). Evaporation and drift consume about 26555 gpm (100 m^3/min) of this, and the blowdown is about 3,000 gpm (11 m^3/min). Because of the concentrating effect of the evaporation, the cooling tower water and consequently the blowdown water have a dissolved solids concentration about ten times that of the intake water. Pilot studies indicate that the optimum operation for the cooling towers will result when the blowdown is approximately eight cycles of concentration. At this value chemical usage and pumping costs are balanced with water usage. Operation of cooling towers should be at a high cycle of concentration. At values greater than 10, however, it becomes difficult to maintain the proper water chemistry as the blowdown rate decreases. Operation may not always be at 10 cycles of concentration. The controlling parameter for determining cycles of concentration will be silica. Silica concentration in the cooling water will be closely monitored and compared to that of the makeup water. If the makeup water silica concentration is 10 ppm or less, then 10 cycles of concentration may be maintained. However, if the silica concentration is greater than 10 ppm in the makeup water, then the cycles of concentration will be less than 10. The silica concentration in the cooling water must not exceed 100-115 ppm since scaling of the condenser tubes will occur and the efficiency of the unit will be reduced. (The condenser cooling tubes are of stainless steel which is highly resistant to water corrosion. Therefore, no significant amounts of corrosion products are expected to be released to Lake Wylie). Based on the anticipated quality of makeup water, it is estimated that the system will average 7 cycles of concentration. Table 3.6.1-2 was, therefore, based on the anticipated long term average cycles of concentration even though operation will be maintained at as high a value as possible. 290.15

Various chemicals are added to the cooling tower circulating water system. For control of biological growth, shock clorination will be conducted on a daily basis using sodium hypoclorite generated on site. The NaOCl will initially be fed into the system at a high rate to meet the chlorine demand of the water then at a slower rate to maintain a free chlorine residual for one to two hours. Application of 600 lb. [(272 Kg) of chlorine daily per unit (1200 lb/day total (544 Kg/day)] over a period of about 1 hour will obtain a free chlorine residual corresponding to a chlorine demand of approximately 3-4 ppm. The free chlorine residual will vary depending on the season. A free residual of 1.5 ppm will be maintained in the summer and 0.5 ppm in the winter. Blowdown from the cooling towers will be halted during this period of shock chlorination and sufficient time allowed for free and total chlorine residual to decompose before discharging to Lake Wylie. The blowdown will be combined with the Low Pressure Service Water and Nuclear Service Water discharge into Lake Wylie thereby diluting any remaining free and total chlorine residual. The biocide in the combined service water to the lake will be kept below 0.1 ppm total chlorine residual (ER Table 3.6.1-3) 290.9

The amount of time required for the decay process varies according to the water quality, the air and water temperatures, the time of the year and the amount of sunlight. It is estimated to take from 2 to 4 hours to decay below 0.1 ppm in the summer and 4 to 7 hours in the winter. Combining the blowdown with the combined service water before discharge should ensure the discharge into Lake Wylie is below 0.1 ppm total chlorine residual. 290.10

To optimized chlorine effectiveness and thereby minimize chlorine usage, sulfuric acit is used to control the pH by the continuous addition of 1350 lb/unit daily (612 Kg/unit) or 2,700 lb (555 Kg) total. In conjunction with this water treatment, aminomethylenephosphonate (AMP), a dispersant formulation, may be used for deposit control. It is expected that this formulation would not be used routinely.

If chlorine-resistant organisms require control, an organic biocide may be used. At the present time no final decisions as to type, frequency, and amount of organic biocide to be used has been made. Final selection will be an GPA-approved organic biocide for the problem being experienced.

to follow the Federal Power Commission's "Guidelines for the Protection of Natural, Historic, Scenic and Recreational Values in the Design and Location of Right-of-Way and Transmission Facilities."

Historical research has been conducted to insure that no historical sites are disturbed by the Catawba transmission lines. No historic sites listed or nominated for listing in the Department of the Interior's National Park Service-National Register of Historic Places are in or along the routes of the proposed lines.

On November 6, 1972, Duke met with James D. Compton, manager of the Greater Gaffney Chamber of Commerce, to discuss any interference the proposed transmission lines might impose on historical sites in Cherokee County. Mr. Compton stated that no historical sites, other than Kings Mountain National Park, are located in or near the line routes.

On November 13, 1972, Duke met with Sam B. Mendenhall, state senator and noted historian of Rock Hill, S. C. to discuss historical sites in York County which might be affected by the Catawba lines. Mr. Mendenhall stated no historical sites are located in or near the line routes. A book entitled Survey of Historical Sites in York County, prepared by the Catawba Regional Planning Council, reveals no historical sites in York County are affected by the Catawba lines.

The University of South Carolina Institute of Archeology and Anthropology has completed an archeological reconnaissance and survey of the Catawba transmission lines and the report is included in Section 2.6.5.

The Catawba-Ripp 230 kV Line passes approximately 0.5 mi (0.7 km) south and southwest of Kings Mountain National Military Park. Careful tower placement along the undulating terrain provides adequate screening of the line from the park.

The transmission line rights-of-way out of Catawba permit many possible beneficial land uses which could be developed in the line corridors. Agricultural and pasture lands crossed by the lines can continue their present use with no interference from the lines. Land that must be cleared is planted with suitable vegetation to provide food and cover for local wildlife. Some areas along the rights-of-way have the potential for development of hiking trails, game food plots, Christmas tree cultivation, and other uses that the property owner may choose.

Section 5.5 discusses the possible electrical effects caused by operation of the transmission lines.

3.9.4 230 kV SWITCHING STATION

The Catawba 230 kV Switching Station is located about 700 ft (213.4 m) west of the powerhouse and encompasses an area of 16.3 ac (6.6 ha). Its design utilizes low profile modern rigid frame structures to enhance the overall appearance and to harmonize with the contemporary architectural concept of Catawba after completion. A pleasing symmetrical arrangement of buses and equipment as seen in Figure 3.9.4-1 is achieved in the layout utilizing the modern concept of breaker placement known as the breaker and a half arrangement. This design allows the reduction in the number of circuit breakers required in the switching station as compared to other comparable methods and is shown in Figure 3.9.4-2.

Power is transmitted from each Catawba unit on two separate overhead transmission lines connected to the 230 kV switching station. This thereby complies with regulations requiring each unit to have two connections to the offsite power system. Initially the 230 kV switching station interconnects with Duke's 230 kV network by five double circuit 230 kV overhead transmission lines as shown in Figure 3.9.4-3. The utilization of double circuit lines permits the reduction in the number of rights-of-way required by allowing the use of one tower line for two 3 phase circuits. Provisions for future installation of four additional double circuit lines are included in the design. All of these transmission lines interconnecting with the switching station are composed of stranded aluminum wire, sky gray insulators, and galvanized hardware. These colors blend well with other equipment in the switching station and most importantly the sky, thus reducing any contrast with the surrounding environment to a minimum.

Inside the switching station all supporting structures for the buses and equipment are of a tapered rigid frame design and are constructed as low as standards permit without sacrificing adequate electrical clearances. Power circuit breakers are of a low profile design as well as the switching station relay house, the only building in the switching station which is also designed for low profile appearance. The power circuit breakers use an inert, nontoxic gas for insulation and power interruption. Since there is no oil in these breakers, no source of pollution from oil fires, explosions or leaking oil exists, thereby aiding in preserving the natural environment. The gray color of the power circuit breakers blends with the galvanized station steel, the aluminum bases, the overhead lines, the powerhouse, and the surface of the switching station. The road and switchyard are covered with crushed stone of a similar grayish color. Prefabricated concrete trenches carry all the necessary power control cables throughout the station underground, eliminating these from view. The concrete covers of these trenches provide walkways inside the station.

All of these features provide the station with a low profile, subtle blend of colors, and establish an aesthetically pleasing appearance. These features also subdue the outline of the station against natural surrounding terrain as demonstrated by Figure 3.9.4-4.

ER Table 3.3.1-1
Catawba Nuclear Station
Station Water Use

290.13

Title	Average GPM	Average Liter/min	Maximum (1) GPM	Maximum (1) Liter/min
Intakes from Lake Wylie				
I. Nuclear Service Water Intake:				
Nuclear Service Water System	16,500	62,500	68,000	257,000
Nuclear Service Water Pond (Regulated)	0	0	68,000	257,000
Total	16,500	62,500	68,000	257,000
II. Low Pressure Service Water Intake:				
A. Intake Screen Backwash	0	0	560	2,100
B. Fire Protection	0	0	2,500	9,500
C. Conventional LPSW System				
1. Condenser Circulating Water System				
Cooling Tower Evaporation	26,500	100,000	28,000	106,000
Cooling Tower Drift	55	210	110	420
Cooling Tower Blowdown	4,360	16,500	28,000	106,000
Subtotal	31,000	117,000	56,000	212,000
2. Filtered Water System				
a. Pump Seals	55	210	150	570
b. Demineralized Water System	70	260	950	3,600
c. Sanitary and Potable Water	13	50	160	610
Subtotal	140	530	3,275	12,400
3. LPSW Heat Removal and Service Loads	34,900	132,000	64,700	245,000
Total for Conventional Low Pressure Service Water	66,000 (C.1+C.2+C.3)	250,000	99,000	375,000
Total for Low Pressure Service Water Intake (A+B+C)	66,000	250,000	102,000	386,000
Total for Intake From Lake Wylie (Nuclear Service Water plus Low Pressure Service Water Intakes)	~82,000	310,000	~170,000	640,000

ER Table 3.3.1-1
Catawba Nuclear Station
Station Water Use

Title	Average (GPM)	Average Liter/min	Maximum (1) (GPM)	Maximum (1) Liter/min
Discharges to Lake Wylie				
I. From LPSW and NSW Intake				
From Cooling Towers	4,360	16,500	28,000	106,000
From NWS System	16,500	62,500	68,000	157,000
From Liquid Radwaste System	10	38	100	380
From Conventional LPSW System	34,900	132,000	67,900	257,000
Subtotal	~56,000	212,000 (3)	~139,000	526,000 (4)
II. From Sewage Treatment System	12	45	35	130
III. From Final Holdup Pond	200	760	300	1,100
Total Discharges to Lake Wylie (I+II+III)	~56,000	212,000	139,000	~526,000

NOTES:

1. Maximum Flows may not occur simultaneously
2. Based on design capacity of all LPSW pumps
3. Average intake differs from discharge due to cooling tower atmospheric losses
4. Maximum intake differs from discharge due to cooling tower atmospheric losses. Also, flows from Fire Protection and Intake Screen Backwash are not included.
5. Filter system backwash flow included in subtotal

5.0 ENVIRONMENTAL EFFECTS OF STATION OPERATION

5.1 EFFECT OF OPERATION OF HEAT DISSIPATION SYSTEM

5.1.1 EFFLUENT LIMITATIONS AND WATER QUALITY STANDARDS

The South Carolina Department of Health and Environmental Control Water Classification Standards System was approved by the Environmental Protection Agency, pursuant to Section 303(a) of the Federal Water Pollution Control Act Amendments of 1972, on April 18, 1977. These standards provide for the classification of Lake Wylie located in South Carolina as Class A waters.

The applicable thermal standards for Lake Wylie are as follows:

All waters of lakes and reservoirs of the State shall not exceed a weekly average temperature of 32.2°C (90°F) after adequate mixing of heated and normal waters as a result of heated liquids, nor shall a weekly average temperature rise above natural temperatures exceed 2.8°C (5°F) as a result of the discharge of heated liquids unless an appropriate temperature criteria or mixing zone, as provided below, has been established. The water temperature at the inside boundary of the mixing zone shall not be more than 10°C (18°F) greater than that of water unaffected by the heated discharge. The appropriate temperature criteria or the size of the mixing zone will be determined on an individual project basis and will be based on biological, chemical, engineering and physical considerations. Any such determination shall assure the protection and propagation of a balanced, indigenous population of shellfish, fish and wildlife in and on a body of water to which the heated discharge is made and shall allow passage of aquatic organisms.

Duke will comply with these regulations concerning the discharge of heated liquids. This discharge will not adversely affect the quality of water in Lake Wylie located in South Carolina or waters of any other state.

5.1.2 PHYSICAL EFFECTS

Conventional Service Water (CSW) and Nuclear Service Water (NSW) for Catawba will be drawn from the Catawba River arm of Lake Wylie and discharged into the Allison Creek arm of the lake. Cooling tower blowdown will be discharged with the service water. The service water experiences a temperature rise prior to lake discharge which depends on the CSW flowrate. The CSW and NSW Systems are discussed in Section 3.4.

Thermal plume areas (Table 5.1.2-1) resulting from the combined service water and cooling tower blowdown releases are computed for the following winter and summer conditions:

Season	Discharge Flow gpm (l/s)	Temperature Rise F (C)
Winter (Oct - Mar)	19,800 (1249)	15.5 (8.6)
Summer	51,400 (3242)	8.5 (4.7)

The CSW and NSW System flows are temperature controlled, thus a variety of operating conditions are possible depending on station load, cooling water temperature, etc. Typical winter and summer release conditions were used for analysis purposes.

The near field dilution of the heated effluent is modeled using a submerged rectangular buoyant jet analysis. The discharge structure shown in Figure 3.4.4-1 consists of two adjacent 54 in (4.5 ft) diameter pipes. This configuration is approximated for modeling purposes by a rectangular discharge 9 ft x 4.5 ft whose centerline is at Elevation 555.4 ft msl. The heated plume enters the lake and entrains surrounding water as it rises to the lake surface. When the plume reaches the lake surface, the jet analysis is terminated and a simple slug flow analysis is employed. Presented below is the slug flow equation which describes exponential cooling of the heated plume over the lake surface area:

$$T_i - T_e = \exp - \frac{KA_i}{pC_vQ}$$

where: T_i = temperature of the isotherm enclosing Ai area

T_e = equilibrium temperature

T_o = discharge temperature

K = surface heat exchange coefficient

p = water density

C_v = specific heat of water

Q = plume flow

A_i = area enclosed by the T_i isotherm

The effect of the thermal plume on Lake Wylie is expressed in terms of lake area possessing a temperature higher than ambient lake temperature. Since the slug flow plume model is based on equalibrium temperature it is necessary to develope a relationship between lake ambient temperature and equilibrium temperature. Monthly average intake temperatures at the Allen Steam Station (located 11 mi (17.7 km) upstream of Catawba), representing ambient lake temperature, are compared to monthly average equilibrium temperatures computed from Charlotte's Douglas Municipal Airport meteorological data for the period 1961-1970. Following is a list of the resulting monthly average ambient temperature/ equilibrium temperature relationships:

Month	Lake Wylie Ambient Temperature
January	T_e + 7F
February	T_e + 2F
March	T_e

April	T_e
May	T_e
June	T_e
July	T_e + 1F
August	T_e + 2F
September	T_e + 5F
October	T_e + 7F
November	T_e + 7F
December	T_e + 9F

Monthly average surface heat exchange coefficients for use in the exponential cooling model are computed for a twenty-five year period (1951-1975) from Douglas Municipal Airport meteorological data. The lowest monthly average exchange coeffiecient (lowest heat transfer) computed for each month over the twenty-five year period in conjunction with a maximum lake drawdown of 10 ft (3 m) is used to compute the worst case monthly average suface temperature plumes. Average thermal plume conditions are computed using the average surface heat exchange coeffiecient in conjunction with full pond lake elevation.

Acreages, enclosed by the 5 F (2.8 C) above ambient isotherm and the 90 F (32.2 C) isotherm, with the percent of lake surface area affected are presented in Table 5.1.2-1 for average and worst conditions. Computation of the 90 F (32.2 C) isotherm area was based on the average and warmest ambient temperatures as determined from monthly average intake temperatures experienced at Allen Steam Station over a ten-year period (1961-1970).

Schematics of the 5 F (2.8 C) above ambient isotherm for the worst case winter (February), and spring (April) conditions are shown in Figures 5.1.2-1 and 5.1.2-2, respectively. Figure 5.1.2-3 shows the 90 F (32.2 C) isotherm for the worst case summer (August) conditions.

5.1.3 BIOLOGICAL EFFECTS

The biological effects of operation of the Catawba heat dissipation system can be grouped into three areas: (1) impingement of fish at the intake screens; (2) entrainment of planktonic organisms through the system; and (3) effects of the heated effluent discharged into Lake Wylie.

5.1.3.1 Fish Impingement on Intake Screens

Based on field and laboratory studies of fish impingement at steam stations (References 1 and 2) in the Piedmont Carolinas, it is unlikely that impingement at Catawba will have any significant effect on the Lake Wylie fishery. The intake is designed such that the velocity of water through the screens Subsection 3.4.3) is low enough to allow most fish to swim away from the intake structure (Reference 2). Threadfin shad (Dorosoma pentenense) are sensitive to cold water temperatures and winter die-offs can occur (References 3 and 4). This species is expected to be impinged in moderate numbers during the winter, but impingement of other species is expected to be minimal throughout the year.

5.1.3.2 Entrainment of Planktonic Organisms

Phytoplankton, zooplankton, fish eggs and fish larvae are all essentially "free-floating" organisms, and since they are small enough to pass through the intake screens, some of them will be entrained through the cooling systems at Catawba. A 100 percent mortality is expected for those organisms which are in the cooling tower make-up water (about 25 percent of total station intake flow). Organisms which are in the service water flow are subjected to physical and thermal stress, but some survival is expected. Since the total Catawba intake flow is a small fraction (about seven percent) of the average flow through Lake Wylie, the effect of entrainment on the aquatic community of Lake Wylie should be negligible.

5.1.3.3 Effects of the Heated Effluent

As described in Subsection 5.1.2, the projected acreages and percentages of Lake Wylie influenced by Catawba's heated effluent are minimal. Even under "worst case conditions", only about 105 acres (42.5 ha) or one percent of Lake Wylie is projected to be more than 5 F (2.8 C) above ambient temperature. Some species of fish will likely be attracted to the discharge area during the winter months, and some species may avoid this area for one or two months during the summer. Heat or cold shock effects on the fishes of Lake Wylie should be minimal. As mentioned above some attraction to the discharge during the winter and avoidance during part of the summer may occur but should not result in significant mortalities. Since only about one percent of the lake will be more than 5 F above ambient temperature during "worst case conditions," fish can readily migrate to and from this area as thermal preference dictates. The EPA has established guidelines for maximum weekly average temperature of plumes for various ambient temperatures (Reference 5); according to these data, plume temperatures may exceed ambient temperatures by substantially more than 5 F with no harmful effects. Overall, however, the heated effluent is not expected to have any significant effect on the biota of Lake Wylie.

5.1.4 EFFECTS OF HEAT DISSIPATION FACILITIES

The operation of closed-cycle mechanical draft cooling towers for waste heat dissipation in the condenser cooling water system at Catawba is viewed from the standpoint of condensate plume effects, humidity plume effects and tower drift effects (see Figure 3.9.4.3).

Figures 5.1.4-1 and 5.1.4-2 depict frequencies of condensate plumes by length and direction from the plant for summer and winter, respectively. Percentage occurrence is cumulative, is representative of mechanical draft towers and is without regard to height of the plume.

Frequencies are derived from 0800 LST observations of empirical data (August 1972 - July 1973) of plume length and direction for two mechanical draft cooling towers at the Duke Power Cliffside Plant, nominally a 600 MWe station 541.8 located 40 miles (64km) northwest of Catawba. Application of measured plume parameters at Cliffside Steam Station to represent plume behavior for mechanical draft cooling towers at Catawba involves: 1) the extrapolation of observed lengths at Cliffside to account for a different evaporation rate, 2) the redistribution direction-wise of length by direction frequencies to coincide with observed 130 ft (40 m) level wind directions at the Catawba site, and 3) the translation of length by direction frequencies as observed at 0800 LST to frequencies representing all hours of the day. No account is taken of increased initial dilution due to plume geometry and plume rise.

Evaporation rate is adjusted from the difference in total heat load from all towers, assuming the proportions of sensible and latent heat released are the same at both plants. Total heat load at Cliffside is approximately 820 MWt; at Catawba it is approximately 4630 MWt. A factor then of five is applied to the evaporation rate at Cliffside for estimation of the additional dilution required at Catawba in the dissipation of condensate plumes. To develop frequencies applicable to the Catawba towers for the 0800 LST observation period, extrapolation was made for this increased evaporation rate under the assumption that no significant difference exists between Cliffside and Catawba with respect to diffusion and background moisture at plume level. Since frequencies for Catawba were developed from observations at Cliffside over an annual cycle, season to season variations at plume lend are inherent in the method. From examination of synoptic influences and topographical effects, the two sites are taken as essentially subject to the same climatology regarding boundary layer conditions and turbulence and moisture through the depth of maximum mixing. Regarding similarity in conditions at plume level for the 0800 LST observation period for the respective plants, plumes in both cases are taken to penetrate nighttime surface-based inversions (Cliffside plumes observed to penetrate strong nocturnal inversions by early morning helicopter soundings). Further, 541.8
for any condition of early morning stability, differences in calculated plume rise do not suggest significant differences in diffusion or background moisture, given general similarity in low-level turbulence and moisture as postulated from synoptic and topographic bases. As a further consideration, with respect to general similarity of low-level conditions, certain average quantities are compared from nearby airports. Inferences from these comparisons only serve as a rough indicator and certainly are not taken as conslusive in and of themselves. The following annual values represent typical differences for any season:

	Mean Maximum Temperature (°F)	Mean Minimum Temperature (°F)	Mean Wind Speed (mph)
Charlotte Airport (Reference 6)	71.3	49.6	6.9
Greenville Airport (Reference 7)	70.5	51.5	8.2

	Mean Maximum Mixing Height (Meters) (Reference 8)	Mean Surface Dew Point (°F) (Reference 9)
Cliffside	1500	47
Catawba Plant	1500	48

Extrapolation of observations at Cliffside does not account for turbulence level or height above ground in each individual case. Instead, for simplicity calculation is made from the least favorable combination of stability and plume rise depending on observed plume l[illegible]ot necessarily physically consistent) where alternatives are limited to [illegible]e of either 500' or 1000' and stability conditions of either ne[illegible] very stable. A gaussian material distribution is assumed for the ins[illegible]ous plume and continuous-release diffusion coefficients are used to [illegible]mate instantaneous spread rate (Reference 10). 511.8

The redistribution of wind direction maintains the percentage breakdown of plume lengths within each sector as reported at Cliffside but changes the wind direction distribution to that at the Catawba site. This direction redistribution involves only minor changes in direction frequencies.

In translating length frequencies by direction as observed at 0800 LST to frequencies representing occurrences based on total time or all hours of the day, persistence is assumed for 24 hours following each 0800 LST observation. This leads to an overstatement of the frequency of extended plume lengths in that early morning is a favored time for long plume occurrences.

Fogging due to cooling tower operation is not expected to be a problem. For mechanical draft towers based on one year of experience from the Cliffside towers, ground contact is limited to within 0.5 mi (0.8 km) of the plant, occurring at a combined frequency of less than one percent for all temperatures and wind directions. The estimate for the extent of ground level fogging from mechanical draft cooling towers at Catawba 0.5 mi (to 0.8 km) is based on the observation of ground level fogging from the Cliffside towers. All cases of cooling tower plumes at ground level were reported to occur within 1000 ft (300 29
m) of the towers. All plumes at ground level were observed to "take off" from the ground (buoyant rise) instead of dissipating from the action of atmospheric turbulence. Consideration of the differences in tower shape (circular at Catawba with cross-sectional area approximately 13,500 ft^2 (1250 m^2)/tower; rectangular at Cliffside with maximum cross-sectional area approximately 21,000 ft^2 (1950 m^2) tower, and in heat load per tower (about 775 MWt at Catawba to 410 MWt at Cliffside) suggests some amelioration of ground-level fogging at Catawba; low pressure wake effects would be lessened while plume buoyancy would be increased. A 1000 ft (300 m) distance criterion has been used in design considerations with regard to the positioning of electrical equipment in the station yard. Since the nearest highway, S.C. 274, is approximately 1.5 mi (2.4 km) from the cooling tower yard, no effect on ground transportation is expected.

Humidity plume effects are evaluated for more or less typical conditions and for a near maximum impact set of conditions.

Calculation of ground-level absolute humidity assumes a gaussian material distribution in the plume utilizing diffusion coefficients from Smith for a neutrally stratified atmosphere (Reference 11). A point source is assumed with no correction for area of the cooling tower yard. Plume rise is from Briggs (Reference 12). The buoyancy flux parameter is derived from sensible heat transfer/tower at design conditions which is 13% (Reference 13) of the total heat rejection/tower (775 MW) or about 101 MW. This yields a buoyancy flux parameter of 3.93 x $10^2 m^4$ $sec.^{-3}$. An enhancement factor is applied, as a function of plum rise, as suggested by Briggs to account for augmented rise by virtue of the cluster effect (6 towers) (Reference 14). Evaporation rate from all towers is taken from design conditions at about 62 CFS (see Table 3.4.1-2). Maximum ground-level absolute humidity/downwind distance is determined as a function of wind speed assuming proportional growth of the plume in vertical and crosswind directions. Terrain is assumed level in these cases. Relative humidity increase is calculated as a function of absolute humidity and temperature.

For typical daytime conditions, temperatures range from about 5°C to 30°C due to seasonal variation with wind speeds on the order of 4 m/sec in the lower 2000 feet (Reference 6). This implies a maximum increase in surface relative humidity of about 5% at a downwind distance in the range 5-10 miles. Relative humidity during the day is characteristically 50-60% in winter and 60-70% in the summer (Reference 6).

Typical nighttime conditions should not give rise to appreciable increase in surface relative humidity due to stable thermal stratification in the lower layers resulting from surface radiational cooling (Reference 6). Nighttime cloudiness or moderate to high wind conditions, however, do result in relative humidity increases at the surface. For a wind speed of 8 m/sec in the lower 2000 feet, maximum surface relative humidity increases are about 5% during summer and 10% during the winter at a downwind distance of about 3-5 miles. Background relative humidity at the surface is likely to be moderately high during cloudy conditions, but in any event the comparative increases appear minimal.

Near maximum effect on relative humidity at the surface occurs in high wind conditions, a relatively infrequent phenomenon (Reference 15). An assumed wind speed of 16 m/sec in the lower 500 feet implies maximum surface relative humidity increases on the order of 15-30% at about 1-2 miles downwind for winter temperatures, the season most likely to produce sustained high winds. High winds in warmer conditions result in much less increase in surface relative humidity. Background relative humidity for high wind winter cases is likely to be moderately low, (Reference 15) again with little or no perceptible change from increases due to the cooling towers.

Tower drift effects, assessed in studies at the construction permit stage, are not significant, and therefore are not addressed in Section 5.1.4. Preoperational and postoperational terrestrial monitoring, however, is to be undertaken.

The mechanical draft cooling towers will have a certain level of noise associated with their operation. Maximum noise levels which the cooling tower manufacturer must meet are as follows:

1) The sound levels at any location on the fan deck or any cell (near field) shall not exceed 90 db when measured on the "A" scale of a standard sound level meter at slow response with all fans in operation.

2) The combined sound pressure levels measured at a distance of 250 feet from any point on the outer casing in any direction shall not exceed the following values:

Octave Band Center Frequency, Hz	63	125	250	500	1000	2000	4000	8000
SPL, db, re 0.0002 Microbars	84	77	72	69	69	65	65	65

The levels presented above are maximums; actual noise levels are expected to be considerably lower. Vegetative screening should further reduce noise levels so that offsite noise will not be a problem. Presently there are no plans to provide other than existing natural screening for the attenuation of plant generated noise. 290.16

There are no plans to make a comprehensive operation phase noise level study until such time as circumstances warrant. 290.17

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6.1 APPLICANT'S PREOPERATIONAL ENVIRONMENTAL PROGRAMS

The first year preoperational ecological study of the plant site incorporates the period September 1973 to 1974. The second year preoperational ecological study is scheduled to begin one full year prior to fuel loading. Duke's "Second Year Pre-Operational Environmental Program for Catawba Nuclear Station" complete with parameters and locations was approved by the NRC in a letter from Wm. H. Regan, Jr. of the NRC to W. H. Owen of Duke on February 7, 1977. An interim water quality monitoring program is conducted to provide continuity between the year-long studies. The second-year study is much reduced from the earlier study since Catawba is now equipped with cooling towers, which results in a large reduction of thermal effluent flows.

6.1.1 SURFACE WATER

6.1.1.1 Physical and Chemical Parameters

6.1.1.1.1 Water Quality 1973-1974 First Year Preoperational Study

The first year preoperational (baseline) study was initiated in September 1973 (Reference 1). This intensive study continued through August 1974.

Weekly vertical profile measurements were made of selected water quality variables (Table 6.1.1-1) at 20 locations in the study area (Figure 6.1.1-1; Table 6.1.1-2) and water samples were collected from 14 locations at monthly intervals and analyzed for selected chemical variables (Table 6.1.1-1). Details of the methods utilized for analyses of the chemical variables given in Table 6.1.1-1 are presented in Reference 1.

6.1.1.1.2 Water Quality Interim Study

The interim study, initiated in September 1974, is to continue until the second year preoperational study is initiated. The objectives of this study are:

A. To document any long-term trends in the temporal variability of Lake Wylie water quality;

B. To compare long-term trends in the water quality constituents immediately above and below the Catawba site.

The study objectives are met by initially monitoring selected water quality constituents (Table 6.1.1-3) at 12 locations (Figure 6.1.1-1) on Lake Wylie at the specified frequency (Table 6.1.1-3). Eight locations correspond to those locations monitored and evaluated in the 1973-1974 First Year Preoperational Study (Table 6.1 1-3). Pursuant to recommendations made in the 1974-1977 interim report to the NRC (Reference 2), eight (Table 6.1.1-4) of the original 12 locations were retained and analyses of chromium were omitted for the remainder of the interim study period. Details of the analytical methods, preservation techniques, and detection limits employed for analyses of the selected chemical parameters are presented in Reference 2.

6.1.1.1.3 Water Quality Second Year Preoperational Study

The second year preoperational study will be implemented at least one full year prior to fuel loading of Unit 1. The objectives of the study are:

A. To provide a detailed assessment of the temporal variability of the water quality for the period immediately preceding commencement of CNS operation.

B. To provide a detailed comparison of spatial and temporal variability in water quality data for the intake and discharge area, and;

C. To provide a detailed assessment of water quality in the discharge area and lower Lake Wylie.

The objectives of the study are to be accomplished by conducting monthly sampling of selected chemical variables (Table 6.1.1-5) at Locations 210.0, 215.0, and 220.0 (Figure 2.2.2-1). In situ profile measurements will be made at these locations. Depth profiles will start at 0.3 m below the surface to 1.0 m above the bottom.

Samples for laboratory analysis will be drawn at depths which will characterize the water column. All samples will be analyzed for the constituents listed in Table 6.1.1-5. The methods, preservation techniques and detection limits will be those currently accepted by the U. S. Environmental Protection Agency (40 CFR 136) or techniques which can be shown to provide results comparable to the accepted USEPA procedure. These analytical methods, detection limits and preservation techniques are subject to change as available technology improves. However, any changes implemented shall be in accordance with 40 CFR 136 or produce results comparable to those obtained by the methods given in 40 CFR 136.

6.1.1.2 Ecological Parameters

6.1.1.2.1 Phytoplankton

In the first year program (Reference 1), phytoplankton standing crop samples were collected monthly at 12 stations. Duplicate samples were collected 1 m below the surface and 1 m above the bottom. Population samples were preserved, then the phytoplankton were identified to the lowest possible taxonomic level. Permanent diatom slides were made to facilitate diatom identifications. Cell volumes were calculated using appropriate geometric formulae for each species dimensions.

Chlorophyll and primary productivity samples were collected every other month at six uplake stations in the vicinity of Plant Allen (Reference 2, Chapter 9). Cholorphyll sample aliquots were filtered and analyzed fluorometrically. Primary productivity estimates were made using the light-dark bottle C-14 method and environmental chambers for incubation.

Second Year Program

Phytoplankton standing crop samples will be collected monthly at Stations 210.0, 215.0 and 220.0 (Figure 2.2.2-1, Table 6.1.1-6), for one year prior to

Catawba Unit 1 fuel loading. Duplicate samples will be taken at discrete depths. An aliquot from each sample will be preserved for population analysis. An aliquot from each sample will also be filtered for chlorophyll extraction.

The preserved population sample will be allowed to stand undisturbed to allow settling of particulate material. The supernatant will be siphoned off and the concentrated volume resuspended in a smaller container (Reference 3). The whole process will continue until a preserved, concentrated volume of 5-10 ml is reached. Phytoplankton in the concentrate will be identified and counted. Cell volumes will be calculated with appropriate geometric formulae using average cell dimensions. Permanent diatom slides will be prepared when necessary to aid identification. Algae will be identified to the lowest practical taxon using taxonomic references and the assistance of taxonomic consultants, retained by Duke Power Company. Chlorophyll samples will be analyzed either fluorometrically or spectrophotometrically.

Data Analysis

Phytoplankton population (density and cell volume) and chlorophyll data will be evaluated statistically for station and time effects. Significant differences among means will be separated by multiple range testing.

6.1.1.2.2 Zooplankton

In the first year program (Reference 1), zooplankton samples were collected monthly at 13 locations on Lake Wylie from September 1973 to August 1974. Four replicate vertical hauls were made at all locations from 1 m above the bottom to the surface and at 7 locations from 3 m to the surface. Monthly samples were collected with an 80 μm mesh size plankton net (30 cm mouth diameter). The volume of water filtered was estimated from the depth of the water column sampled. All samples were preserved at the time of collection in 5 percent neutralized formalin.

In the laboratory, each sample was diluted or concentrated to a workable density of organisms. Random subsamples were withdrawn from the sample vials with an automatic pipette. Organisms were identified and counted in a Bogorov chamber using a stereozoom microscope at 10-70 X magnification. Subsampling continued until approximately 300 dominant organisms were counted. Organisms which could not be positively identified were removed from the chamber, mounted, and examined with a research microscope at 100-1000 X magnification. All crustaceans were identified to species with the exception of immature copepods and certain taxonomically indistinct adult forms. Rotifers were identified to genus only. Identifications were made using widely accepted zooplankton taxonomic references.

Zooplankton density (organisms/m^3), species composition, and relative abundance were determined. Data were analyzed for seasonal and spatial differences in density using accepted statistical methods.

Second Year Program

The second year preoperational study will follow the first year study with the following amendments:

Zooplankton standing crop samples will be collected monthly at Locations 210.0, 215.0, and 220.0 (Figure 2.2.2-1 and Table 6.1.1-6) for one year prior to Catawba Unit 1 start up. Triplicate vertical net hauls will be taken to characterize zooplankton located 3 m to the surface as well as below 3 m. Collections will be made with an 80 μm mesh size plankton net (50 cm mouth diameter). A flowmeter suspended in the mouth of the net will be used to estimate the volume of water filtered.

Discrete depth sampling will be conducted quarterly at Locations 210.0 and 215.0. Duplicate samples will be collected at 3 m intervals using a 30-ρ plankton trap equipped with 80 μm mesh size netting.

In the laboratory, a random subsample of sufficient volume to contain at least 100 organisms will be removed from the sample vials for enumeration. Separate counts will be performed for rotifers and crustaceans. Rotifers will be identified and counted at 80-100 X magnification using a compound microscope and crustaceans at 20-40 X magnification using a dissecting microscope.

6.1.1.2.3 Benthos

In the first year program benthic macroinvertebrates were collected at seven locations on Lake Wylie in the vicinity of Catawba Nuclear Station by Industrial BioTest Company (Reference 1). Four quantitative samples were collected at all locations with a petite Ponar grab. Locations 19, 28, 29, 31, and 32 were sampled in October and December 1973, February 1974, and April through August 1974. Locations 20 and 33, in the Catawba intake and discharge, respectively, were sampled in October 1973, and in February, June and August 1974. Sampling at Location 20 was discontinued in August due to completion of the cofferdam near the Catawba intake. Qualitative samples, which consisted of 30 minutes of collection effort with a D frame aquatic dip net or by handpicking, were collected along the shoreline and shallow areas near Locations 19 and 32. All samples were preserved in the field in 10 percent formalin. In the laboratory, the samples were washed through a U. S. Standard No. 30 sieve (595 micron mesh) and the residue was handpicked under variablepower dissecting microscopes. The organisms recovered were preserved in 70 percent ethanol, identified, and counted.

Second Year Program

The second year sampling program will begin one year prior to fuel loading of Catawba Unit 1. Benthic macroinvertebrates will be sampled monthly at four locations in the vicinity of Catawba (Figure 2.2.21, Table 6.1.16). Location 220.0 is equivalent to Locations 19 and 20 of the first year program; Location 210.0 is equivalent to Locations 28, 29, and 30, and Location 215.0 is equivalent to Locations 31, 32, and 33. Location 212.0 does not correspond to any location sampled in the first year program. Three quantitative samples will be collected at each location with a modified Petersen grab. One qualitative sample will be taken with an aquatic dip net at a depth between 0.1 m and 0.5 m immediately off the shore nearest each grab sampling location. Samples will be preserved in the field with 70 percent ethanol containing 0.25 g/l rose bengal stain, which facilitates sorting of organisms from the sediments. Sampling location, depth, bottom temperature, and substrate type will be noted in the field. In the laboratory, the samples will be washed through a U. S. Standard No. 30 sieve and organisms will be picked from the residue under a 2X illuminated magnifier. The organisms will be identified to the lowest possible taxonomic category and counted. Wet-blotted weights to the nearest 0.1 mg will be determined for the following major groups of organisms: Oligochaeta, Chironomidae, *Corbicula*, *Hexagenia*, *Chaoborus*, and the remaining taxa. For each location and date, estimates of density (No./m^2) will be made for each taxon, and estimates of standing crop (mg/m^2) will be made for the major groups indicated above. Temporal and spatial differences in density and biomass will be evaluated using standard statistical procedures.

6.1.1.2.4 Fish

In the first year program (Reference 1), four locations on Lake Wylie were sampled for adult and juvenile fishes (Figure 2.2.2-1). Each location consists of a cove off the main body of the lake. Coves similar to one another in physical characteristics and habitat type were chosen. Sampling locations in the vicinity of the Catawba site represent: a) the area of the cooling water intake (Location 220); b) the area of the blowdown and service water discharge (Location 215) and areas that would presumably be unaffected by operation of the Station (Location 217). Construction activity prevented sampling at Location 215 during August 1974.

Field Procedures

Experimental gill nets were set monthly for a period of 16 hours (overnight) at each of the four sampling areas. These nets were set from September 1973 through August 1974.

Electrofishing was conducted with a 230 volt AC boat-mounted electrofisher. Each location was sampled for a period of 20 min once each month.

Fishes collected by gill netting and electrofishing were identified to species, total length measured (mm) and weight determined (g). Scale samples and stomach samples were obtained from a representative number of individuals of selected species. Sex and stage of gonad development were noted for fish sacrificed for stomach samples. All fishes were examined for the presence of external parasites and diseases. An effort was made to release unharmed as many fishes as possible.

Two 100 ft (30 m) seine hauls were made at all locations. Seining was not conducted during December 1973 and January 1974 because of high water levels. The seine was 30 ft (9.2 m) long, 6 ft (1.8 m) deep and 0.2 in (0.6 cm) Ace mesh.

Fishes collected by seining were preserved in 10 percent formalin and taken to the laboratory for identification and measurement of total length.

Larval fish populations were sampled once in March 1974 and twice monthly from April through July 1974 with towed 1.6 ft (0.5 m), 0.02 in (571 μ) mesh cone nets. Duplicate surface and mid-depth tows were made at each of Locations 215 and 220. Ten-minute tows were made at a standard speed. A flowmeter mounted in the mouth of each net is used to determine the volume of water filtered. Larval fish are identified by Dr. Walter J. Hoagman, Virginia Institute of Marine Science.

Laboratory Procedures

Stomach samples were individually examined under a binocular dissecting scope. Food items are identified to the lowest positive taxonomic level and measured volumetrically to the nearest 0.1 ml. Scale impressions were made on plastic slides and examined using a slide microprojector.

Second Year Program

Sampling Locations

Fishes are to be sampled at four locations and ichthyoplankton sampled at three locations on Lake Wylie during the second year preoperational study (Table 6.1.1-6). Three of these areas correspond roughly to the areas that were sampled during the first year preoperational study.

Location 217 is in Big Allison Creek (Figure 2.2.2-1) just upstream of the Catawba blowdown and service water discharge, corresponding to Location 7 in the previous one year preoperational study (Reference 1). Location 215, corresponding to Location 6 of the first year study (Reference 1), is in the Catawba discharge cove within the direct influence of the blowdown and service water discharge. Location 210 is in the Big Allison Creek arm of Lake Wylie downstream of the CNS discharge cove (Figure 2.2.2-1). There is no first year study location that corresponds to Location 210. Location 220 is in the vicinity of the confluence of Beaver Dam Creek and the Catawba River near the Catawba intake (Figure 2.2.2-1). This location corresponds to Location 5 of the first year study. Sampling at these locations will begin one full year prior to fuel loading.

Field Procedures

Electrofishing samples are collected monthly using a Smith-Root Mark VI electrofisher providing pulsed DC current. Electrofishing sampling areas are located along the shoreline at Locations 210, 215, 217, and 220. The numbers and total lengths (mm) of each species of fish captured are recorded. Those fishes not used in life history studies are returned to Lake Wylie.

Gill net samples will be collected using 90 ft (27.5 m) experimental gill nets, 6 ft (1.8 m) deep, with alternating 10 ft (3.1 m) panels of 1 in (2.5 cm), 1.5 in (3.8 cm), and 2.0 in (5.0 cm) square mesh fished along the bottom perpendicular to shoreline. Nets will be set in the afternoon and picked up the following morning. Fishes collected in gill nets will be identified, lengths (mm) and weights (g) measured and recorded, and buried. Gill nets will be set quarterly (January, April, July, October) in duplicate at Locations 210, 215, 217, and 220.

Cove rotenone samples are collected annually in cooperation with South Carolina game and fish authorities and will continue until adequate data are established which characterize the fishery in the study area. Coves of approximately 3 ac (1.2 ha) are blocked off with a net and rotenone introduced with a pump and perforated hose. Fish picked up the first and second days after the rotenone application are processed and these data recorded. The fish and are identified, counted, measured, and total weight of each 1 in (2.54 cm) length class determined. This information is used to determine year class strength and to estimate species abundance, composition, and standing crop. Rotenone collections are made in a cove near Location 215.

Data concerning the abundance and species composition of larval fish is collected with an ichthyoplankton trawl. Trawling is initiated prior to the onset of fish spawning and continues on a biweekly basis through the peak spawning period. Larval samples are collected in the vicinity of Locations 210, 215, and 220.

Laboratory Procedures

Adult fishes will be identified using standard references (References 4, 5, 6, and 7). Larval fishes will be identified on the basis of taxonomic literature currently available (Reference 8).

Life history studies on sacrified fishes include age and growth and food habit analyses. Age and growth for a fish species will be calculated by standard methods (References 9 and 10). Stomach contents will be analyzed by numeric, gravimetric, and percent occurrence methods (Reference 11).

Larval fish samples will be preserved in formalin. Larval fish will be sorted, identified, and lengths (mm) measured and recorded. Larval fish abundance will be expressed as either number of individuals per unit volume or per unit surface area of Lake Wylie.

Data Analysis

Data will be analyzed for differences between locations and seasons using standard statistical procedures.

6.1.2 GROUNDWATER

To evaluate groundwater conditions at the station, observation wells with water level recorders are installed, tests are performed to determine hydrologic properties of the water-bearing materials, and water quality from core borings and private wells is analyzed.

Packer permeability tests are performed in borings to determine permeabilities of the rocks underlying the site. Figure 6.1.2-1 presents the test arrangement and description. Constant head field permeability tests are performed in selected borings to determine horizontal permeabilities of saprolite soils. Figure 6.1.2-2 presents the test arrangement and description. Vertical soil permeability is measured by laboratory tests according to ASTM D 2434 on undisturbed samples. Constant discharge pumping tests are conducted to determine average values of horizontal permeability, transmissivity, and storage coefficient of the aquifer. The layout of the pumping tests is shown in Figure 6.1.2-3. For these tests, the wells are drilled to a depth of 70 ft (21 m) and 4 in. (10 cm) PVC pipe is installed. The pipe is slotted with 0.030 in (0.076 cm) openings in the lower 65 ft (20 m) of the well. The annular space between the drilled well and the slotted pipe is filled with pea gravel. Eight observation wells of 2 in. (5 cm) PVC pipe are installed. Test well A85-TW was pumped for 168 hr at 5.0 gpm (19 l/min); well A48-TW was pumped for 145 hr at 1.5 gpm (5.7 l/min).

Groundwater elevations, made at about 60 locations in the immediate vicinity of the site, are used to make a contour map of the water pre-construction table. A water level recorder was installed in boring A-33 and then moved to boring A-62 to obtain groundwater level fluctuation data. Data are also obtained from a USGS well as described in Subdivision 2.4.4.2.

Twelve permanent groundwater wells are installed in the zoned wall filter around the perimeter of the Reactor/Auxiliary Building walls. Continuous monitoring devices will be installed in six of the twelve wells to monitor the groundwater level in the zoned wall filter. In addition to the continuous monitoring devices, each of the six wells have three points of alarm to alert the plant operator to a rise in groundwater. The remaining six wells without monitoring devices will be available to dewater the zoned wall filter in the unlikely event of a rise in groundwater. The location of the twelve groundwater wells is shown in Figure 6.1.2-4.

6.1.3 AIR

Data bases for predicting impact of the plant on the local atmospheric environment and for predicting atmospheric transport and diffusion process are taken from a cooling tower plume observation program at the Duke Power Cliffside Steam Station (August 1972 - July 1973), a nominally 600 MWe station located 40 miles (64 Km) northwest of Catawba and onsite meteorological measurements made from December 17, 1975 to December 16, 1977.

Onsite data is provided hour-by-hour on magnetic tape with substitute data for 451.1
missing hours. Subsequent data collection has been in a test mode, as site 451.12
topography remains essentially unchanged (excavation, lake level, etc.). 451.10

6.1.3.1 Meteorology

Onsite meteorological measurements include wind direction and speed, horizontal
wind direction fluctuation, temperature and vertical temperature gradient, dew
point visibility, surface water temperature, and rainfall. The instrument 451.11
shelter is environmentally controlled; that is, it is heated and air conditioned. 451.16
Relative positions of instruments with Respect to station yard are noted in 451.9
Figure 6.1.3-1. Relative elevations of both surface levels and instrument
levels are depicted in Figure 6.1.3-2. The locations of both wind measuring
systems, the resistance thermometers, and the dew point instrument are clearly
indicated. Relative positions of fog study sites with respect to the station
yard are shown in Figure 6.1.3-3.

Locations of towers for the measurement of a 10 m wind and delta-temperature at
the CP review stage also are shown on Figure 6.1.3-1. Base elevation for both 451.11
towers was 645' MSL. Additional details are available in PSAR Figures 2.3-4, 451.16
2.3-5 and 2.3-6. Comparison of 10 m wind direction frequencies for the earlier
data base with those from present measurements (see Table 2.3.0-3 and PSAR
Table 2.3-2) reveals notable shifts which are ascribed to synoptic based
variations in direction preferences.

The following information is provided regarding the present siting of meteoro-
logical instruments. Nominal distances between plant structures and the 451.11
measurements system are determined from Figure 6.1-3 as 1100' for Unit #1 451.16
Reactor Building, 700' for Unit #1 Turbine Building and 1400' for the cooling

tower yard. Heights of these structures from Figures 6.1.3-2, 3.1.0-7, and 3.4.1-5 are nominally 135' for Unit #1 Reactor Building, 100' for Unit #1 Turbine Building and 65' for the mechanical draft cooling towers. Height to distance ratios here suggest minimal interference with meteorological measurements from mechanically generated turbulence associated with these structures. Although the orientation of cooling towers with respect to measurement site for the observed distribution of wind direction yields a low occurrence of cooling tower effluent transport in the direction of meteorological instruments, little impact is otherwise expected. Typical plume rise results in transport of the condensate/humidity plume well clear of the 40 m tower. Plume centerline heights are on the order of 1000' as determined by methods used in Section 5.1.4. 451.1 Drift effects, addressed at the CP Stage were estimated to be highly 451.1 localized with affected area essentially within 1000' of the towers. Deposition rates are presented in PSAR Table 2.3-5. On balance instrument exposure appears reasonably representative of vicinity topography and an appropriate basis for plant effluent transport/diffusion estimates.

Wind measurements are made with the Packard Bell Model WS 101B Series Wind Direction - Speed System with starting thresholds of 0.7 and 0.6 miles per hour for direction and speed respectively. Temperature and delta temperature measurements are made with a Leeds and Northrup 100 Ohm Resistance Temperature Device with Packard Bell Model 327 Thermal Radiation Shields. Visibility measurements are made with the Meteorology Research, Inc. fog visometer model 1580A which has a minimum accuracy of ± 15% of reading plus ± 1% of full scale voltage. Surface water temperature measurements are taken from a Yellow Springs Instrument's thermistor which is waterproofed and placed in a shaded 451.9 location 2-3" below the water surface. Dew Point is taken from the EG&G dew point hygrometer Model 110 S-M; and rainfall is measured with the Belfort Weighing rain gage Model 5-780. Wind direction and speed are recorded in the instrument shelter on Esterline-Angus Model A 601C Strip Chart Recorders with a system accuracy of ± 5.4°F direction and ± 0.45 mph for speed. Temperature, delta temperature and dew point, surface water temperature, and visibility are recorded on the Leeds and Northrup Speedomax W Recorder with a system accuracy of ± 0.85°F for temperature at the 10 m level, and surface water temperature of ± 0.18°F for delta temperature (40 m level referenced to the 10 m level) and of ± 0.85°F for dew point at the 10 m level. Measured rainfall is accurate to ± 0.03 and ± 0.06 in. for 0 to 5 inch totals and for 5 to 10 inch totals respectively. All measurement systems comply with the recommendations of NRC Regulatory Guide 1.23.

The following calibration - maintenance schedule is extraced from the Duke Power Company manual, Schedule and Procedures for Calibration and Maintenance of Meteorological Instruments, as pertains to the care of these instruments.

Schedule for Calibration and Maintenance of Meteorological Instruments Weekly

The following field checks are to be performed each week before old charts are replaced and pens re-inked:

a. Wind Direction

(1) Recorder time accuracy

(2) Recorder zero

(3) Translator zero and full scale

b. Wind Speed

(1) Recorder time accuracy

(2) Recorder zero

(3) Translator zero

c. Temperature, Delta temperature, Dew point, Visibility, Surface water temperature, and Rainfall

(1) Recorder time accuracy

Semiannually

The following field checks are to be performed twice each year:

a. Temperature, Delta Temperature, and Surface water temperature

(1) Electronic simulation to transmitter (over total range of temperature)

b. Dew Point 451.9

(1) Dew point control unit calibration check (electronically simulated input as furnished by manufacturer)

c. Rainfall

(1) Check rain gage with manufacturer's certified weight

d. Visibility

(1) Internal optical/mechanical calibration check (operated manually at the instrument)

As Required

The following laboratory checks are to be performed as required:

a. Wind Direction

(1) Refined linearity

(2) Transmitter starting torque

b. Wind Speed

(1) Electronic Simulation to translator (over total range of speeds)

(2) Transmitter starting torque

(3) Transmitter shaft end play

All data are reduced manually and keypunched for storage on magnetic tape. Procedures for data reduction are as follows:

Wind direction and speed are averaged over 30 minute intervals preceding each hour and logged on the hour. Wind range is measured during 30 minute intervals preceding each hour and logged on the hour. Wind direction and speed are averaged with a transparent straight edge making a visual integration by equal area apportionment. Wind range is measured by counting direction intervals between extreme directions, eliminating momentary peaking. This 30 minute averaging time has been determined as the optimum recorder trace length which can be analyzed accurately by the chart readers.

Temperature, delta temperature, and surface water temperature are averaged over one hour intervals, 30 minutes before and after each hour and logged on the hour. Temperature is recorded for the low level (10 meter) sensor. Delta temperature is the difference in the reading between the low and high sensors (30 m separation).

Both temperature and delta temperature are averaged by the equal area technique employed in reduction of wind data.

Dew point is averaged over one hour intervals, 30 minutes before and after each hour and logged on the hour. Averaging again is made by the equal area technique.

Rainfall is noted for each hour (by taking the difference in total rainfall between successive hours) and logged on the hour.

Fog visiometer data are averaged over one hour intervals, 30 minutes before and 451.
after each hour, and logged on the hour. The data are averaged by the equal area technique employed in the reduction of wind and temperature data. Visibility data are read as percent of full scale to the nearest 0.5% as various definitions of visibility are available for analysis.

With respect to the Cliffside Plant cooling tower plume observation program, observations made at 0800 LST include: plume rise, length, and direction of drift to eight compass points. Rise characteristics are assessed by reference to a 150 meter stack adjacent to the cooling towers. Length and direction are estimated from an area map provided with range markers. Three helicopter flights were made at observation times during the period of record to ascertain the adequacy of ground based observations and assess other factors relating to plume behavior; e.g., effects of elevated and ground based inversions on plume dissipation.

Daily morning fog occurrence observations are taken in conjunction with the visiometer data by security personnel near the south measurement site and by personnel at Wylie Hydro Station. The observations are broken down into fog over land and fog over water and include visibility, top of fog, and fraction of fog. A sample fog observation form is shown in Fig. 6.1.3-4. Meteorologists also personally observe episodes of steam fog on Lake Wylie to identify the extent of the fog, transport of the fog off the lake, and elevation of the base of the steam fog.

6.1.3.2 Models

Long-term models were used to assess dispersion characteristics to 50 miles and to evaluate near-field dispersion for the reactor building complex area.

Average dilution factors are computed from onsite data, covering the stated period of record, for angular intervals of five degrees at ten distances to 50 miles utilizing a gaussian diffusion model which stores and accumulates successive hourly values. These estimates are assumed to represent annual conditions. Hourly values are calculated to distances of ± 20 degrees from observed wind directions. Points beyond ± 20 degrees for any one hour are assumed at zero relative concentration for that hour. Releases from the 38 meter vent stacks are considered partially elevated and partially ground level releases. The fraction of the plume material which remains elevated depends on the ratio of exit velocity to wind speed at release height. This fraction has been calculated from equations 7 and 8 of NRC Regulatory Guide 1.111, Revision 1 (Reference 13):

$$F_g = 2.58 - 1.58 \frac{W_o}{U} \qquad \text{for } 1 < \frac{W_o}{U} < 1.5$$

and

$$F_g = 0.3 - 0.06 \frac{W_o}{U} \qquad \text{for } 1.5 < \frac{W_o}{U} < 5.0$$

where F_g = fraction of the time the release is considered to occur at the ground.

W_o = exit velocity (m/sec)

U = wind speed from the 40 m sensor (m/sec)

$$F_e = 1 - F_g$$

where F_e = fraction of the time the release is considered to be elevated.

Plume height for elevated releases is calculated from Sagendorff (Reference 12). Effective stack height is determined from

$$H = h_s + h_{pr}$$

where H = effective stack height (m)

h_s = physical stack height (m)

h_{pr} = plume rise (m)

Plume rise is calculated using formulas from Briggs (Reference 15). The station is assumed to have a cold plume, so the heat emission rate is zero, and the plume rise is calculated from the momentum equations. For neutral or unstable conditions,

$$h_{pr} = 1.44 \left(\frac{W_o}{U}\right)^{2/3} \left(\frac{X}{D}\right)^{1/3} D \qquad \text{(a)}$$

where X = downwind distance (m)
D = inside stack diameter (m)

When the exit velocity is less than 1.5 times the wind speed, a correction for downwash is subtracted (Reference 14):

$$C = 3 \left(1.5 - \frac{W_o}{U}\right) D$$

where C is the value to be subtracted, and the other terms are defined above.

The result is compared with

$$h_{pr} = 3 \left(\frac{W_o}{U}\right) D \qquad \text{(b)}$$

and the more conservative value is used. For stable conditions, the results from (a) or (b) is compared with the results from the following two equations:

$$h_{pr} = 4\left(\frac{F_m}{S}\right)^{1/4}$$

$$h_{pr} = 1.5\left(\frac{F_m}{U}\right)^{1/3} S^{-1/6}$$

and the smallest value of h_{pr} is used. Above F_m is the momentum flux parameter as S is a stability parameter where:

$$F_m = W_o^2 \left(\frac{D}{2}\right)^2$$

$$S = \frac{g}{T} \frac{\partial \theta}{\partial z}$$

where g = 9.8 m sec^{-2} and T = temperature (°K)

$\frac{\partial \theta}{\partial z}$ = vertical gradient of potential temperature (°K/m)

S = 8.7×10^{-4}, 1.75×10^{-3}, and 2.45×10^{-3} for E, F, and G stabilities, respectively.

Plume rise is computed from the exit velocity (22.4 m/sec), stack diameter (2.1 m), and stack height (38 m) employing the wind speed from the 40 meter sensor. The effect of terrain on effective plume height is included according to Egan

(Reference 16). If all heights are referenced to plant grade, H is the effective plume height without terrain correction, and h_t is the height of the terrain feature; then the corrected plume height is $H - h_t/2$ above local terrain. An exception noted is that plume height is constrained to remain between H and H/2 above local terrain. The h_t values represent the highest terrain in the vicinity of the receptor within the 22.5° sector after Sagendorf (Reference 14); h_t values are taken to be equal to or greater than zero according to NRC Regulatory Guide 1.111, Revision 1 (Reference 13).

The equation employed for each hourly X/Q calculation for the ground release portion is (Reference 17):

$$(X/Q)_g = \frac{F_g}{u_{\pi} (\sigma_y \sigma_z + CA/\pi)} \exp\left[\frac{-y_1^2}{2 (\sigma_y^2 + CA/\pi)}\right] \qquad \text{Eqn. 6.1.3-1}$$

The equation employed for the elevated portion is (Reference 17):

$$(X/Q)_e = \frac{F_e}{u_2 \pi_y \sigma_z} \exp\left[\frac{-y_2^2}{2\sigma_y^2} + \frac{-H^2}{2\sigma_z^2}\right] \qquad \text{Eqn. 6.1.3-2}$$

where X/Q = normalized concentration at plume centerline (sec/m³)

σ_y = crosswind concentration distribution standard deviation (m)

σ_z = vertical concentration distribution standard deviation (m)

C = containment structure shape factor = 0.5

A = cross-sectional area of containment structure normal to the wind = 1616 m²

H = the plume height considering all corrections as discussed above (m)

F_g and F_e are the fractions of the plume which are ground level and elevated, respectively.

u_1 and u_2 are the low level and high level average wind speeds, respectively (m/sec). A minimum value of 0.45 m/sec is assumed. This minimum value derives from precendent in other licensing reviews and is taken as acceptable in view of the low incidence of wind speeds less than 0.45 m/sec. High level winds 451.14
(40m) seem to be appropriate for elevated material where momentum plume rise 451.15
tends to balance the disparity in absolute elevation of physical vent and the 40m wind system.

y_1 and y_2 are the lateral distances of the receptor from the wind direction vectors u_1 and u_2, respectively (m).

Crosswind and vertical standard deviations are those suggested by D. B. Turner (Reference 12). Stability categories are determined by vertical temperature gradient according to the following schedule:

Stability Class	Vertical Temperature Gradient
G	Greater than +2.1°F in 100 ft
F	+0.9 to +2.1°F in 100 ft
E	-0.2 to +0.8°F in 100 ft
D	-0.8 to -0.3°F in 100 ft
B-C	-1.0 to -0.9°F in 100 ft
A	less than -1.0°F in 100 ft

The factor ($\sigma_y\sigma_z$+ CA/π) is a measure of plume spread. This factor is restricted to be no greater than ($3\sigma_y\sigma_z$) as recommended in the NRC Draft Regulatory Guide 1.XXX, "Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants." The building wake factor, CA, is entered in the exponential as suggested by Davidson (Reference 17).

For annual average X/Q input to radioiodine dosage, the $(X/Q)_g$ and $(X/Q)_e$ values are modified to account for plume depletion by dry deposition of elemental radioiodine. The method employed is as recommended in Regulatory Guide 1.111, Revision 1 (Reference 13).

Output for both undepleted and depleted X/Q is summarized in terms of sector averages from the 5° grid point values.

Regulatory Guide 1.111, Revision 1 (Peference 13), suggests that long-term X/Q values be adjusted to account for variations in plume trajectory over time scales on the order of one day, which would otherwise not be considered by the straight-line trajectory models. The adjustment factor for this station is taken as 1.0; that is, no such variations are significant. This fact is demonstrated in the following analysis:

Factors which would cause an adjustment greater than 1.0 are a) systematic flow reversals, b) stagnant pooling of air, c) systematic curved trajectories such as terrain-induced channeling, and d) randomly curved trajectories under some conditions.

Flow reversals would yield higher doses because a repeated passage of the effluent would effect longer dwell times and would cause higher air concentrations by introducing contaminated background air. Nocturnal downslope flows at the plant site could be a mechanism for such recirculation. Inspection of Figure 2.3.0-3 reveals that no signification bias in wind direction during stable conditions is evident to support the existence of such a flow. Downslope wind possibilities are assessed for near vent levels in that most releases are assumed elevated by the method described in Section 6.1.3.2. 451.13

Stagnation of contaminated air would cause higher doses since the model assumes contamination only in the downwind direction. Stagnation at the plant would result from winds at stack release height which are presistently low. The frequency of winds less than 1.0 mph during any stability condition is 0.17 percent. This low frequency should not contribute to a significantly higher

annual average dose from stagnation. Wind speeds equal to or greater than 1.0 mph at the 40m level are assumed associated with individual parcel trajectories that always have an away-from-the-plant component such that time mean mass distribution in the alongwind direction is constant and equal to Q/u (g/m). 451.13
(For low wind speeds greater than 1.0 mph individual parcels certainly are expected to follow an exaggerated meandering path.) This postulated behavior precludes a pooling effect in time averages.

Systematic curved trajectories would effect higher doses in some direction if flow, induced by terrain or any other source, exposes a receptor more frequently or to higher concentrations than the straight-line trajectory assumption. Channeling of winds by the valley walls at Catawba, or pronounced drainage winds at night could cause such an underestimation by the model. It is evident that the gentle terrain variations within the valley (see Figure 2.1.1-1) do not channel the winds. Also, the absence of significant drainage is addressed above.

With respect to curvature which is random by direction, when direction frequency is inhomogeneous and dispersion conditions are homogeneous from one sector to another, the effect of course, is to reduce the annual average X/Q or D/Q value in the high frequency sector. Only when there exist severe differences in direction frequency, or a positive correlation between poor dispersion conditions and high frequency is evident, are noticable changes likely to occur in the long term X/Q or D/Q fields. Inspection of the high frequency southwest wind directions indicates neither the relative frequency of wind direction nor the relative proportion of poor dispersion conditions from one sector to another is unduly biased in the sense discussed above (see Tables 2.3.0-2 and 2.3.0-3). In the high frequency north wind directions, there is no significant bias.

In summary, there exists no apparent cause for systematic flow reversals, systematic trajectory curvature or stagnation of contaminated air; and the conditions for which random curvature is a problem do not exist at the site.

The model for annual average D/Q(m^{-2}) is described in Regulatory Guide 1.111, Revision 1 (Reference 13). The D/Q values account for terrain according to Egan as described above. Also, they consider the fractional breakdown of elevated and ground level plume contributions to D/Q, and plume rise in the same manner as in the calculation of X/Q values above. Wind direction, speed, and stability frequencies for these calculations were obtained from the high-level (40 m) joint frequency distribution of hourly onsite meteorology for the period of record (Table 2.3.0-2). These estimates are assumed to represent annual conditions. Adjustment conditions for the straight-line trajectory deposition model are identical to those addressed above for relative concentrations.

Average dilution factors are computed from onsite data covering the stated period of record, for selected intake vents on or near plant structures, utilizing a second straight-line gaussian model. Many features present in the X/Q and D/Q models above are incorporated here. In this model a crosswind integrated form of the equations is used with output in terms of a sector average (Reference 17). These estimates are assumed to represent annual conditions. The treatment of plume rise and that of partial entrainment by the building cavity are identical to those employed in the X/Q and D/Q models already discussed.

Contribution from the ground portion is taken as the higher of:

$$(X/Q)_g = \frac{F_g\,(2/\pi)^{1/2}}{R\Phi(3)^{1/2}} \sum_f \left[f \left(u_1{}^2\sigma^2 + \frac{W_o{}^2 D^2}{4} \right)^{-1/2} \right] \qquad \text{Eqn. 6.1.3-3}$$

or

$$(X/Q)_g = \frac{F_g\,(2/\pi)^{1/2}}{R\Phi} \; \underset{f}{\sigma} \left\{ f \; \left[u_1 (\sigma_z{}^2 + CA/\pi)^{1/2} \right]^{-1} \right\} \qquad \text{Eqn. 6.1.3-4}$$

Contribution from the elevated portion is taken as:

$$(X/Q)_e = \frac{F_e\,(2/\pi)^{1/2}}{R\Phi} \sum_f \left[f \left(\frac{\exp \dfrac{-H^2}{2\,[\sigma_z{}^2 + D^2/4]}}{(u_2{}^2\sigma_z{}^2 + W_o{}^2 D^2/4)^{1/2}} \right) \right] \qquad \text{Eqn. 6.1.3-5}$$

where f = the frequency of occurrence of the wind and stability category

R = the distance from the containment to the receptor (m)

Φ = the greater of 22.5° or the angle intercepted by the reactor building as seen by an observer at the receptor (for ground portion) (rad)

Φ = 22.5° (for elevated portion) (rad)

All other parameters are as previously defined.

In-stack dilution is calculated analogous to the building wake mixing (Reference 17); both are entered as suggested by Davidson (Reference 17). The limit on building wake dilution in the ground portion calculation is based on recommendations for limits on the volumetric correction of vertical plume spread in NRC Regulatory Guide 1.111 (Reference 13). The effective stack height, H, is adjusted as before by accounting for height of the terrain feature but here the correction is $H-h_t$ where h_t is now the height of the highest building near the receptor. This application is not taken to represent flow behavior in response to terrain variation as it was before, but is a means of accounting for differences in receptor height for a more or less constant H relative to an absolute frame. The summation of frequencies is for categories in Table 2.3.0-2, taken from the high-level (40 m) system. The number n of 22.5° sectors contributing to f is extracted from Figure 1 of Murphy (Reference 18) where n is a function of s/d, the ratio of containment - receptor distance to containment diameter.

6.1.4 LAND

6.1.4.1 Geology and Soils

The methodology and results of geologic studies are described in Section 2.5 of the FSAR, and in the "Final Geologic Report on Brecciated Zones" (submitted to the NRC in March, 1976).

6.1.4.2 Land Use and Demographic Surveys

Demographic and land use methodology and results are presented in Chapter 2, Subsections, 2.1.2 and 2.1.3, respectively.

6.1.4.3 Ecological Parameters

The methods used to survey the terrestrial biota during the preconstruction phase are described in "Catawba Nuclear Station, Terrestrial Studies", submitted to the NRC January 31, 1975.

6.1.5 PREOPERATIONAL RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

The preoperational phase of the Radiological Environmental Monitoring Program for Catawba provides data on the existing environmental radioactivity levels, and their variations, along the anticipated critical exposure pathways in the vicinity of the station. The results of the preoperational phase also provide a basis for evaluating the station's contribution, if any, to increases in environmental radioactivity levels in the site vicinity after the station begins operation.

The design of the Preoperational Program includes the guidance of the EPA report ORP/SID 72.2, Environmental Radioactivity Surveillance Guide, in establishing proper sampling methods and analytical procedures. The Branch Technical Position on Regulatory Guide 4.8 has provided guidance in the selection of sample types, locations, and collection and analysis frequencies. Local site characteristics, such as meteorology, hydrology, land use and population density have been examined to determine the critical exposure pathways to man and then applied to the general program criteria set forth in the Branch Technical Position. The resulting program thus establishes a reasonable and adequate level of environmental radiation surveillance in the station environs.

In general, the exposure pathways identified in the area surrounding the station are the same as those recommended in the Branch Technical Position. However, certain local conditions exist for the Catawba site which render inappropriate two types of recommended sampling media. These are ground water and food products (crops). Ground water monitoring is deemed necessary by the Branch Technical Position only when the local hydraulic gradients and recharge properties are suitable for contamination by liquid effluent releases. In the vicinity of the station, however, the hydraulic gradients, and thus ground water movements, are toward the lake (i.e., the discharge canal). Ground water recharge is by precipitation only. Sampling of local food products from any area which is irrigated by water in which liquid plant wastes have been discharged is also recommended. However, no such irrigation is found in the vicinity of the station. Therefore, since the Branch Technical Position takes these aspects into consideration, sampling of ground water and food products will not be routinely performed.

Additionally, since the I-131 dose calculated for the consumption of drinking water in the Catawba environs is less than 1 mrem per year, low level I-131 analyses of drinking water will not be performed routinely.

Table 6.1.5-1 provides a tabular summary of the Preoperational Program, listing the pathways and types of samples to be collected, sampling location criteria, collection and analysis frequencies, and the analyses to be performed on each sample. The map presented in Figure 6.1.5-1 shows the physical orientation of the sampling locations and lists each location as a function of direction and distance from the site.

It should be noted that the Preoperational Program outlined here represents a substantial change in design from the original program described in the Catawba Nuclear Station Environmental Report - Construction Permit Stage. The shift in program design criteria--from that set forth in the EPA report ORP/SID 72.2, Environmental Radioactivity Surveillance Guide, to the recommendations supplied by the Branch Technical Position on Regulatory Guide 4.8--is reflected in the current program's emphasis toward more conservative selection of sampling locations (i.e., closer to effluent release points) and the collection and analysis of only those environmental media within each critical exposure pathway which form the most direct link to human exposure. The sampling of more remote media associated with the existing pathways, such as aquatic vegetation, rain and settled dust, lake bottom sediment, soil, and raw water supplies, is thus no longer considered necessary.

The first phase of the Preoperational Program will begin at least two years prior to the commercial operation of Unit 1, with monitoring of direct radiation (TLD), fish, broad-leaf vegetation, and shoreline sediment. The remainder of the program, including air particulates, surface and drinking water, and milk will go into effect at least one year prior to commercial operation of Unit 1. Special analysis for airborne radioiodine and iodine in milk will commence at least 6 months prior to commercial operation of Unit 1.

The Operational Radiological Environmental Monitoring Program will be identical to the Preoperational Program in regard to sample media, locations and analyses. However, collection and analysis frequencies will increase for certain sample media in the operational phase as follows:

1.a) Airborne radioiodine and particulates will be sampled continuously, with weekly collection and analyses.

3.a,b) Surface and drinking water will be composited over the monthly collection period.

4.a) Milk samples will be collected and analyzed semi-monthly when animals are on pasture.

4.c) Broad-leaf vegetation will be collected and analyzed monthly.

The Operational Program will be modified as necessary, to reflect any changes in local population growth, land use or availability of samples identified as a result of preoperational experience.

Detection capabilities (analytical sensitivity) for the environmental sample analyses performed as part of the Preoperational (and Operational) Radiological Environmental Monitoring Program are expressed in terms of the Lower Limit of Detection (LLD, as defined in the Branch Technical Position). Table 6.1.5-2 lists the LLD values for various radionuclides in each sample type. The ability to achieve the above LLD values in environmental samples depends upon the available sample quantity, external background conditions, additional radionuclides present in the sample and other environmental conditions. The detection capability for direct radiation (TLD) measurements will be that specified by Regulatory Guide 4.12, Revision 1.

REFERENCES FOR SECTION 6.1

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6.2 APPLICANT'S PROPOSED OPERATIONAL MONITORING PROGRAM

The baseline studies discussed in Section 6.1 are providing initial data necessary to determine the physical, chemical, and biological variables which are likely to be affected by station construction and operation.

The proposed monitoring program to be used during station operation is outlined in this section. As station construction nears completion and operation approaches, the detailed information now being gathered will be used to more fully perfect the operational monitoring program.

6.2.1 OPERATIONAL RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

The Operational Radiological Environmental Monitoring Program provides data to support and verify the results of detailed effluent monitoring which is necessary to evaluate individual and population exposures that result from station operation.

The elements of the Operational Program are identical to those of the Preoperational Program in regard to sample media, locations, and analyses (Reference Section 6.1.5). However, collection and analysis frequencies for certain sample media will increase in the operational phase as follows:

a) Airborne radioiodine particulates will be sampled continuously, with weekly collection and analyses;

b) Surface and drinking water samples will be composited over the monthly collection period;

c) Milk samples will be collected and analyzed semi-monthly when animals are on pasture;

d) broad leaf vegetation will be collected and analyzed monthly;

e) Shoreline sediment samples will be collected and analyzed semi-annually;

f) Fish samples, particularly bass and catfish, will be collected and analyzed semi-annually;

g) The Thermoluminescent Dosimeter (TLD) monitoring program will be expanded from its present 11 instruments to now include 40 instruments. Thirty-two of the instruments will be located within the 16 compass sectors at various distances from the plant and 8 will be sited at random locations such as schools and hospitals around the site. These samples will be collected and analyzed quarterly.

Additionally, the operational phase will include an annual census to determine the location of the nearest milk animal in each of the 16 meteorological sectors within a distance of 5 miles (8 km) of the site. As provided for in the Branch Technical Position on Regulatory Guide 4.8, broad-leaf vegetation sampling will be performed at the site boundary. This sampling is in lieu of the annual garden census.

The Operational Program will be modified, as necessary, to reflect any changes required as a result of pre-operational and operational experience, local population growth, annual census data, and appropriate regulations.

6.2.2 CHEMICAL EFFLUENT MONITORING

The chemical effluent monitoring program will be established to comply with requirements of the National Pollutant Discharge Elimination System (NPDES) permit. The permit will be issued by the Environmental Protection Agency or by the State of South Carolina depending on whether the State program is approved at the time of issuance. Table 6.2.2-1 indicates the parameters of the NPDES permit and also reflects the sampling requirements that Duke proposes to monitor.

6.2.3 THERMAL EFFLUENT MONITORING

The thermal effluent monitoring program will include, as a minimum, weekly monitoring in the discharge canal of any blowdown discharged to the river. Sampling will also be conducted monthly as specified in Subsection 6.1.1.

Calculated temperature rises from the cooling tower blowdown and the affected zones are presented in Section 5.1.2 and in Table 5.1.2-1. Other thermal effects on the water quality are also addressed throughout Section 5. Modeling studies have shown that the percentage of the total lake area effected by thermal conditions is minimal. No plans have been formulated at this time to conduct thermal plume mapping within Lake Wylie. Detection of trends is the object of the continuing biological monitoring program and should unfavorable conditions develop, such conditions are not irreversible and appropriate corrective action would be taken by Duke. No such trends are expected since closed-cycle cooling towers will be used to dissipate heat for Catawba.

6.2.4 METEOROLOGICAL MONITORING

Onsite meteorological measurements for wind direction and speed, horizontal wind direction fluctuation, temperature and vertical temperature gradient, dew point, rainfall, and visibility (for the purpose of assessing the possibility of fog characteristics at the site) are monitored in a pre-operational program and will continue during the operational program. All sampling techniques, including field and laboratory procedures for the meteorological programs, are described in more detail in Subsection 6.1.3.1 and in accompanying figures and tables.

The operational meteorological monitoring program will be identical to the preoperational study prior to the start-up of Unit 1 except for two minor differences.

The first difference involves data reduction of all parameters except visibility. Prior to plant operation, a unit will be installed to provide for automatic data reduction while maintaining parallel strip chart recorders. The digital system will sample sensor signals once every 10 seconds and have an output of 15 minute averages which will be used as hourly average values.

Compliance with NRC Regulatory Guide 1.23 will be maintained. Real time average quantities will be available in the control room as well as strip chart recorder output.

The other difference involves the length of the sampling period for the visibility measurements. All other meteorological programs will be performed indefinitely. However, the establishment of onsite and near vicinity characteristics of visibility with respect to fog will be determined for at least a period of one year prior to the operation of the cooling towers and for at least a period of one year after the initial start-up and continued operation of the station and towers. The Catawba fog study is designed to assess the effects of plant heat dissipation on the frequency and intensity of ground fog. The combination of visiometer and surface water temperature measurements, fog observations, and observations made at Charlotte's Douglas Airport will be used to describe the preoperational climatology f fog around Lake Wylie. Similar data collection will resume during plant operation. Both preoperational and operational data will be normalized by a comparison of simultaneous Charlotte Airport observations with long-term climatological data. 451.9

6.2.5 ECOLOGICAL MONITORING

The operational ecological monitoring program will be as dictated by the approved technical specifications for Catawba. The proposed program will be based on critical review of the results of the programs outlined in Subsection 6.1.1. Analytical instrumentation and methodology will be constantly reviewed and updated as feasible when better techniques are available. Sample stations and frequency will be adjusted according to the findings of Subsection 6.1.1 and consideration of operating conditions. The tentative ecological program for the operational phase is the same as proposed for the second-year preoperational study (Subsection 6.1.1).

6.2.6 EFFECTS OF COOLING TOWER DRIFT ON TERRESTRIAL VEGETATION

Two permanent terrestrial monitoring areas are established near the site, within the corridors of the most frequent wind direction (Figure 2.2.1-1). The general features of these areas are described in the report, "Catawba Nuclear Station, Terrestrial Studies," submitted to the NRC in January 1975.

A series of permanent study plots is established in each area. The plots represent as many of the common species as possible. Quantitative and qualitative aspects are recorded. Data include photographic records, species counts, and visual analysis for leaf burn and discoloration. In addition, soil and leaf tissue are analyzed for Na^+ and Cl^- content if baseline studies indicate that meaningful data can be obtained. Visual observations are also made in other appropriate areas (closer to the towers) if such areas are available.

8.0 ECONOMIC AND SOCIAL EFFECTS OF PLANT CONSTRUCTION AND OPERATION

Construction and Operation of the Catawba Nuclear Station is expected to result in certain social and economic benefits and costs. There are limits to which the social and economic consequences of station construction and operation can be evaluated and measured, in meaningful terms, over the productive life of the facility.

8.1 BENEFITS

The benefits of Catawba can be categorized into direct and indirect benefits. Direct benefits are those derived from the value of the generated electricity delivered to customers. Indirect benefits include improved system reliability, and social and economic benefits: including tax or payments made in lieu of tax revenues, employment, regional product, and public education facilities.

8.1.1 DIRECT BENEFITS

The fundamental measure of benefits to be derived from Catawba is the energy generated and delivered to the customers. Expected net capacity of the proposed units when fully operational is 1145 Mwe per unit, or 2290 Mwe for the total station. The expected annual generation of the facility, assuming a 76 percent load factor, is 15,245,000 net Mwh of electrical output. The 76 percent capacity factor is an assumed capacity factor based on a mature generating station.

It is difficult to quantify the secondary effects that follow the availability of electrical energy from the Catawba units, since it is impossible to distinguish such effects from those traceable to the availability of electric power from numerous other Duke generating facilities. However, an estimate of the ultimate use of power by certain classes of Duke service area customers based on recent usage is shown in Table 8.1.1-1.

South Carolina requires, by statute, that all public utility rates must be just and reasonable and be set by the South Carolina Public Service Commission. Because Duke's rates are set by regulatory commissions serving South and North Carolina, the effects of a single generating station or unit on the electric rate cannot be estimated.

8.1.1.1 Value of Delivered Products

The generating capacity of Catawba is made available through the entire Duke service area. Assuming that revenue contributions by class of customer remain constant until the commercial operation of the Catawba units and that rates for electrical energy remain unchanged, then the approximately 15.2-billion kilowatt hours of electricity produced annually have revenues estimated at $484 million as shown in Table 8.1.1-1.

8.1.2 INDIRECT BENEFITS

Primary benefits other than electricity produced by the facility such as the sale of steam or the use of waste heat for industrial or agricultural uses are not applicable to Catawba. There are other benefits, social and economic, which will affect various political jurisdictions or interests to a greater or lesser degree.

8.1.2.1 System Reliability

The importance of Catawba in providing adequate capacity to assure reliability of the Duke system has been considered in Sections 1.1.2 and 1.1.3.

8.1.2.2 Social and Economic Benefits

8.1.2.2.1 Tax Revenues

Under present law in South Carolina, new industry is exempt from propery tax, excluding school taxes, for various periods of time depending on the size of the investment. Considering the investment in Catawba, this exemption from property taxes, except for school taxes, will continue for five years. Each year, the York County tax rate is set to bring in revenues sufficient to cover the county's budgeted expenses. In 1981, the property tax millage rate for York County District 2 was $17.81 per $100 assessed value. This millage rate, 178.1, includes 55.4 mills other than the school rate of 122.7 mills. Therefore, tax payments will amount to approximately $20.1 million annually in local taxes for the first five years and approximately $29.2 million thereafter, based on 1981 tax rates. 310.9

The investment of $2,738,351,000 (Table 8.1.2-1) in generating and transmission facilities at Catawba creates approximately $154 million annually in new tax revenues (Table 8.1.2-2). All state and local taxes other than property taxes would go to the State of South Carolina in the form of a franchise tax, power tax, income tax, and several minor taxes. Based on Federal Power Commission data, the estimated State and local taxes (after five years) would be $70.9 million annually. The estimated Federal income tax would be $82.9 million annualy.

The justification for using this method of determining taxes is that stated in the FPC publications. Experience has shown a significant correlation between the amount of plant investment and the amount of state and local taxes.

8.1.2.2.2 Employment

Duke's construction and operating experience provides the necessary background information needed to estimate the socio-economic effects associated with increased employment for Catawba.

A 1979 survey of the Catawba construction work force indicates that approximately 17 percent or 518 workers moved into York County as a result of employment at the station. Approximately 849 or 28 percent were hired from the local labor force and 1628 or 55 percent commute to the station from outside York County. Table 8.1.2-3 gives the numbers of new resident employees and the associated socio-economic impacts of this influx. A major portion of the skilled labor force at Catawba, drawn from unskilled laborers hired locally, are to be trained under Duke's in-house training program. Duke's experience in training indicates that about 44 percent of the skilled labor force at a job is locally hired and Duke trained (Section 4.1.1.2).

The estimated total construction labor cost is $506,861,000 as detailed in Table 8.1.2-1. It is anticipated that the majority of this money will be spent in the area.

Approximately 846 full-time employees including security, quality assurance, training, and maintenance personnel are expected to be needed to operate the station in 1984. The annual operating payroll is expected to be approximately $14,500,000.

The number of operating personnel is expected to decline to 737 in 1988 and continue at that level throughout commercial operation. Table 8.1.2-3 indicates the influx of new resident population into York County as a result of station operation compared to the construction work force influx. The maximum 846 operating employees were used for conservatism and the 1980 survey of Catawba Nuclear Station operating personnel is the basis for the Catawba projections. An increase in York County population due to the operation of Catawba is not projected. Results of 1980 operating survey indicate approximately 17 percent of the workforce move into York County, 40 percent commute from beyond York County and 42 percent are local hires. 310.8

Impacts on educational facilities are expected to be minimal since the number of new students due to station operation is expected to be less than the 332 construction students that have been absorbed by the York County School System. 310.8

Impacts on public water, sewage, police, fire, health and recreational facilities are expected to be negligible.

Housing demand in the areas of mobile homes and apartments should be insignificant as the demand for this type housing is less for the operating work force than for construction. The increased demand for single family houses by the operating employees may be alleviated to some extent by the decrease in construction force levels nearing the end of the construction period or by moving or building in areas of the county where the housing markets can supply the necessary facilities.

Since the number of operating personnel is considerably less than the number of construction personnel, impacts on transportation routes should decrease significantly with commercial operation of Catawba. Approximately 200 contractural workers having an annual average payroll of $2,600,000 (1984 dollars) are expected to be employed at the site during station operation. 310.8

8.1.2.2.3 Local and Regional Products

In addition to direct operating payroll costs, money is expended on services and supplies, much of which is available locally. Purchases of these goods and services is estimated to average $1,500,000 (1981 dollars) annually in the York and Mecklenburg County area. These services include orders with local vendors, service contracts, materials, and miscellaneous equipment. 310.8

During the construction period, Duke expects to spend approximately $2,000,000 a year on the average for regional and local materials, services and supplies.

8.1.2.2.4 Externalities

A number of benefits are expected to result from Catawba and the electric power generated by its operation. These benefits are expected to be shared throughout the Duke Service Area since the power generated is to be fed into the power grid. However, though these benefits may happen they can not be quantified.

Categories of environmental benefits expected include:

a. Operation of environmental control facilities. Requirements for operation of municipal waste water treatment of domestic and industrial wastes are expected to increase due to developing regulations for higher waste water quality. Increased electrical capacity will be available for this purpose.

b. Replacement of gas burning residential and commercial heating units with electric units and resultant conservation of limited gas resources will be increasingly attractive with new power capacity.

The use of electrical energy as opposed to other fuels is addressed in Section 1.1.

Because the Duke system is an integrated system, serving both North and South Carolina, from its distribution grid, and Duke's rates are set by regulatory commissions, as outlined in Subsection 8.1.1, the effects of a single generating station or unit on the electric rate cannot be estimated. However, a nuclear generating station presents the most economical source of base load.

c. Available electricity may speed the building of electric powered mass transit systems, thereby reducing the number of metropolitan automobiles and associated air pollution.

There are currently no plans for electric powered mass transit systems within Duke's service area; however, the Charlotte-Mecklenburg Planning Commission in their "Comprehensive Plan 1995" has addressed mass transit systems as follows:

> At the present time, less than three percent of internal person trips are made by mass transit. For the preferred plan, it is estimated that by 1995 seven percent of internal person trips would be mass transit...it is possible that the mass transit percentage of internal person trips could go higher than seven percent by 1995.

The Planning Commission has not addressed the type of power to be used in such a mass transit system but it is likely that energy requirements will be a major consideration in determining the power used. Eric Hirst in his paper "Pollution Control Energy Costs" notes, "mass transit is often suggested as an environmentally attractive substitute for automobiles because of its lower air pollution emissions, smaller land requirements, greater safety, and improved fuel economy." He additionally calls for a shift of ten percent of automobile transit to mass transit and states, "If the ten percent shift were entirely to electric transit, that added electricity requirements would have been 21 billion kwh for 1970, 1.5 percent of the total electricity used for that year."

d. The operation of Catawba could permit the retirement of older, less environmentally pleasing fossil-fired generating units.

As stated previously, it is Duke's intention to retire its old conventional units and combustion turbines at the earliest practicable time. Because it is not possible to schedule firm retirement dates far in the future, however, it can be stated only in general terms that construction of the Catawba units should provide sufficient capacity to permit retirement of some older units.

Categories of social benefits to be expected from the Catawba units include:

a. Assured electric power capacity to maintain essential services such as schools, police and radio will be provided.

   Duke does not have information pertaining to the fraction of its electrical production utilized by public service categories.

   The peak power usages in Duke's service area generally occur in January or February (winter peak) between eight and ten in the morning, and in July and August between four and six in the afternoon. Duke generally expects that the winter peak does include a portion for school usage, but that the summer peak when schools except for some colleges are closed, does not.

   Duke has no current knowledge pertaining to emergency power sources of police and radio stations in the service area.

b. Added power generation to the Duke system will permit the continued expansion and growth in the availability and use of comfort, convenience and leisure items. This will increase the regional portion of the Gross National Product and improve the standard of living.

c. Local and temporary benefits can be anticipated during the construction phase with an average of 2049 employees per year for a twelve year period. A portion of these employees can be expected to temporarily reside locally. Thus, increasing the local commerce and tax base.

8.2 COSTS

Catawba represents an expenditure in excess of $2.0 billion in construction costs and approximately $36.9 million annually in station operating costs. These costs will be borne by Duke and their customers. Additionally, temporary and long-term costs will be borne mainly by area residents and recreational users.

8.2.1 PRIMARY INTERNAL COSTS

The primary internal costs are those expenditures resulting from the construction, operation, and decommissioning of Catawba.

8.2.1.1 Construction Costs

Construction costs for the nuclear station and associated facilities are estimated to cost $2,067,894,000 and are detailed in Table 8.1.2-1. Construction costs for a fossil-fueled alternative are presented in Table 8.2.1-1.

8.2.1.2 Operating Costs

Duke has developed operating costs (1984 dollars) for Catawba from experience at Oconee Nuclear Station of $36.9 million.

8.2.1.3 Decommissioning Costs

Duke Power Company is conducting a decommissioning cost study (Section 5.8) of a commercial three unit PWR nuclear power station (Oconee Nuclear Station). This information is extrapolated to a two unit PWR such as Catawba. Three alternatives ranging in cost from $34 to $41 million (per unit) are selected in the study as most practical: mothballing-delayed removal/dismantling, entombing-delayed removal/dismantling, and prompt removal dismantling. However, because of the changing regulatory climate and societal pressures, it is assumed that the decommissioning alternative used is prompt removal dismantling.

Oconee is estimated to cost $41 million (1977 dollars) per unit for prompt removal dismantling. Because Oconee does not employ cooling towers and Catawba does, it is estimated $4 million (1977 dollars) per unit additional is necessary to complete decommissioning. Thus the total cost for decommissioning at Catawba are expected to be less than $100 million (1977 dollars).

8.2.1.4 Cost of Generating Electric Energy

The estimated cost of generating electric energy in mills per kilowatt-hour for Catawba and a fossil-fueled alternative station are presented in Table 8.2.1-2.

8.2.2 EXTERNAL PROJECT COSTS

8.2.2.1 Temporary External Costs

Short-term external costs with a duration paralleling construction activities have been relatively minor. The temporary external costs of the project have been insignificant in the areas of housing shortages, inflationary rentals or prices, noise and temporary aesthetic disturbances, overloading of water supply and sewage treatment facilities, crowding of local schools, hospital or other public facilities, and overtaxing of community services. No permanent residences were to moved (Catawba Section 4.4-1a).

Congestion of local streets and highways has occurred at the Catawba site at times of work shift changes, but is minimized by workers commuting in car pools. Also some road rebuilding was necessary.

8.2.2.2 Long Term External Costs

The most significant long term external cost would be the impairment of recreation values or alternatives from the Catawba site.

The impact of Catawba on the scenic and aesthetic values would be difficult to determine monetarily, but will not be a significant impact.

Catawba will employ 846 full-time employees when commercial operations begin. There will be some increase in local traffic from pre-construction levels, but this will not be a significant impact on the average daily traffic levels.

ER Table 8.2.1-1
Catawba Nuclear Station
Catawba Fossil Alternative
Internal Costs

	Estimated Cost at Commercial Operation
Land and Land Rights	$ 2,132,000
Structures and Improvements	82,758,000
Boiler Plant Equipment	378,560,000
Turbo-Generator Units	113,599,000
Accessory Electrical Equipment	41,704,000
Miscellaneous Power Plant Equipment	11,542,000
Transmission Plant Station Equipment	8,275,000
Total Material Cost	$ 638,857,000
Labor and Overhead	$ 289,989,000
Steam Production, General Office, Quality Assurance, and Engineering	69,992,000
Contingencies	122,306,000
Total Direct and Overhead Costs	$1,120,857,000
Property Taxes During Construction	0
Allowance for Funds During Construction	$ 400,597,000
Total Station Cost	$1,521,454,000
Installed Capacity (kWe)	2,290,000
Cost ($/kWe)	664
Plant Cost	$1,501,738,000
Substation Cost	19,716,000
Transmission Cost	28,087,000
Total Site-Plant Cost	$1,549,541,000
Total Cost ($/kWe)	677

Note: Based on Commercial Operation Schedule of Unit 1 in 3-84 and Unit 2 in 9-85.

ER Table 8.2.1-2
Catawba Nuclear Station
Estimated Costs of Electrical Energy Generation

	Nuclear	Fossil
Fixed Charges[1]	486,719,000	269,620,000
Costs of Operation & Maintenance[2]	36,235,000	82,076,000
Costs of Insurance[3]	4,500,000	625,000
Fuel Cycle Costs[4]	130,832,000	441,714,000
Total Annual Costs[5]	658,286,000	794,035,000
$/KW/Year	287.5	346.7
Mills/KWH	46.9	56.5

[1]Fixed charges are 17.6% of the capital cost for nuclear; 17.4% for fossil.

[2]Fossil: Assumes 1981 fixed O & M of $66.88/MW per week plus 1981 variable O & M of $3.82/MWH, both escalated to 1985.
Nuclear: Assumes 1981 fixed O & M of $162.95/MW per week plus 1981 variable O & M of $.576/MWH, both escalated to 1985.

[3]Fossil: Assumes $.27 per kilowatt per year
Nuclear: Assumes $1.97 per kilowatt per year

[4]Fossil: The ten year levelized average fossil fuel cost for the period ending 1995 (345.67¢/MBTU).
Nuclear: The ten year levelized average nuclear fuel cost for the period ending 1995 (93.17¢/MBTU).

[5]The summation of other annual costs

Note: All costs are in thousand dollars unless noted
Based on Commercial Operation Schedule of Unit 1 in 3-84 and Unit 2 in 9-85.

ER Table 9.3.2-1
Catawba Nuclear Station
Economic Benefits of Nuclear vs. Fossil Fuel at Catawba

Basic Data	Nuclear	Coal
Site-Plant Cost Per kW	1208	677
Annual Fixed Charge Rate	17.6%	17.4%
Heat Rate (BTU/kWh)	10,000	9,100
Energy (kWh/yr)	14.04×10^9	14.04×10^9
Fuel Cost ¢/MBTU	93.17	345.67
Cost Comparison		
Annual Costs/kW		
Fixed Charges	$212.54	$117.74
O & M	15.82	35.84
Fuel	57.13	192.89
Insurance	1.97	.27
TOTAL	$287.46	$346.74
Annual Savings With Nuclear Per kW	$ 59.28	
Capitalized Value of Savings At 2290 MW and 17.6% Fixed Charge Rate	$770,136	
Break Even Fossil Fuel Value ¢/MBTU		167.6

[1]Assumes high sulphur coal.

ER Table 9.4.0-1
Catawba Nuclear Station
Costs of Alternative Generation Methods

	Catawba Nuclear	Catawba Fossil
Land and Land Rights	1,967	2,132
Structures and Improvements	134,536	82,758
Reactor Plant Equipment[1]	375,366	378,560
Turbogenerator Units	123,122	113,599
Accessory Electrical Equipment	92,113	41,704
Miscellaneous Power Plant Equipment	11,108	11,542
Transmission Plant Station Equipment	12,778	8,275
TOTAL MATERIAL COST	750,990	638,857
Labor and Overheads	607,167	289,989
Steam Production, General Office, Quality Assurance, and Design Engineering	499,444	69,992
Licensing Fees	982	0
Contingencies	43,000	122,306
TOTAL DIRECT AND OVERHEAD COSTS	1,901,583	1,120,857
Property Taxes During Construction	0	0
Interest During Construction	836,768	400,597
TOTAL STATION COST	2,738,351	1,521,454
Installed Capacity (kW)	2,290,000	2,290,000
Cost ($/kW)	1,196	664
Plant Cost	2,691,758	1,501,738
Substation Cost	46,593	19,716
Transmission Cost	27,100	28,087
TOTAL SITE-PLANT COST	2,765,451	1,549,541
Cost ($/kW)	1,208	677

[1]Boiler plant equipment for fossil alternative.

Note: All costs are in thousand dollars unless noted. Based on Commerical Operation Schedule of Unit 1 in 3-84 and Unit 2 in 9-85.

ER Table 9.4.0-1
Catawba Nuclear Station
Costs of Alternative Generation Methods

	Catawba Nuclear	Catawba Fossil
Capital Expenditures		
a) Plant Cost	2,691,758	1,501,738
b) Substation Cost	46,593	19,716
c) Transmission Cost	27,100	28,087
d) Total Capital Cost	2,765,451	1,549,541
e) Cost/kW - Total ($/kW)	1,208	677
f) Cost/kW - Station ($/kW)	1,196	664
Generating Cost (Annual)		
a) Annual Generating (kWh)[1]	14.04×10^9	14.04×10^9
b) Fixed Charges[2]	486,719	269,620
c) Fuel Costs [3]	130,832	441,714
d) Insurance Cost[4]	4,500	625
e) Operating & Maintenance[5]	36,235	82,076
f) Total Generating Cost[6]	658,286	794,035
g) Cost/kW - ($/kW)[7]	287.5	346.7
h) Cost/kWh - (Mills/kWh)[8]	46.9	56.5

[1]Annual generation assumes a 70 percent station capacity factor.
[2]Fixed charges are 17.6% of the capital cost for nuclear; 17.4% for fossil.
[3]Fossil: The ten year levelized average fossil fuel cost for the period ending 1995 (345.67¢/MBTU).
Nuclear: The ten year levelized average nuclear fuel cost for the period ending 1995 (93.17¢/MBTU).
[4]Fossil: Assumes $.27 per kilowatt per year.
Nuclear: Assumes $1.97 per kilowatt per year.
[5]Fossil: Assumes 1980 fixed O & M of $66.88/MW per week plus 1980 variable O & M of $3.82/MWH, both escalated to 1984.
Nuclear: Assumes 1980 fixed O & M of $162.95/MW per week plus 1980 variable O & M of $.576/MWH, both escalated to 1984.
[6]The summation of other annual costs.
[7]Total annual cost divided by capacity.
[8]Total annual cost divided by total annual generation.

NOTE: Costs are in thousands of dollars.

UNIVERSITY OF SOUTH CAROLINA

COLUMBIA, S. C. 29208

INSTITUTE OF ARCHEOLOGY AND ANTHROPOLOGY

(803) 777-8170

May 28, 1981

Mr. Charles E. Lee
South Carolina Department
of Archives and History
P. O. Box 11669
Columbia, SC 29211

RE: Archeological Clearance for Duke Power Company's Catawba Transmission Lines

Dear Mr. Lee:

I have reviewed the enclosed report entitled, "Test Pits in the Piedmont: An Archeological Survey of Duke Power Company's Proposed Catawba Transmission Lines." I concur with the findings of this report.

Briefly, Paul Brockington conducted a field survey of the Catawba Ripp and Catawba-Newport transmission lines in 1978. Of the twenty-seven archeological sites located, one was recommended as eligible for the National Register of Historic Places. A testing program of this site, 38YK72, was conducted by Veletta ~nouts in 1979. The excavated materials provided artifact frequency, density, and compositional data for .1% of this site area. Although the information potential of this site has not been exhausted, no further investigation of the site is recommended in conjunction with the Catawba transmission line project. Even though the site will continue to sustain impacts from cultivation and possible tower or transmission line maintenance, if the site continues to be managed as it has been, sufficient data should remain available for future investigators.

I, therefore, recommend archeological clearance be granted for the project.

Sincerely yours,

Robert L. Stephenson

Robert L. Stephenson
Director and State Archeologist

RLS:dsw

Enclosure

cc: Mr. R. Andrew Cloninger ✓
Duke Power Company

TEST PITS IN THE PIEDMONT: AN ARCHEOLOGICAL SURVEY OF DUKE POWER COMPANY'S PROPOSED CATAWBA TRANSMISSION LINES

by

Paul E. Brockington, Jr.
Research Manuscript Series 152

APPENDIX

THE ARCHEOLOGICAL TESTING PROGRAM AT SITE 38YK72

by

Veletta Canouts

Prepared by the
INSTITUTE OF ARCHEOLOGY AND ANTHROPOLOGY
UNIVERSITY OF SOUTH CAROLINA
August, 1980

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ACKNOWLEDGEMENTS

Completion of this study project was made possible by the contributions and cooperation of many individuals. First, Mr. Robert A. Cloninger and Mr. Stan Berg of Duke Power Company assisted in many ways. They saved much project time by guiding us within the project areas, and they even served cheerfully as temporary archeological surveyors and test pit excavators.

Fieldwork was accomplished by the author, assisted by Ms. Claudia Wolfe, Mr. James O'Hara, and Mr. James Scurry. Laboratory cleaning, sorting, and analysis were also performed by these individuals. A number of the staff members of the Institute of Archeology and Anthropology also aided the successful completion of the project, including Mr. Darby Erd, illustrator, Mr. Gordon Brown, photographer, Mr. Kenneth Pinson, manuscript editor, Ms. Dorothy Alford, administrative assistant, and Dr. Robert L. Stephenson, Institute Director. All of these individuals are warmly thanked for their contributions.

A final word should be said about the enthusiastic cooperation of Duke Power Company in the performance of this archeological project. Although some private and public organizations and agencies are suspicious of those involved in various environmental impact review studies, and see themselves as, essentially, adversaries of the "environmentalists," this was certainly not true of Duke Power Company. All company individuals were very interested in the project and very cooperative. Detailed maps, aerial photos, and field assistance were generously supplied, aiding the project greatly. Duke Power even sent their own surveyors into the project areas to cut and mark overgrown areas so that we could be more efficient in locating our sample units. It was a welcome relief from the tedium of hacking our way through dense vegetation to come upon suddenly a recent cowbone hanging from a limb with a cryptic message inscribed: "Prehistoric Indian Joint."

All in all, Duke Power Company was concerned with protecting archeological sites and was helpful and cooperative in the accomplishment of this project. We congratulate them on their sense of responsibility and thank them for their cooperation.

ABSTRACT AND MANAGEMENT SUMMARY

Duke Power Company has proposed construction of two major electrical power transmission lines and three minor route changes for existing lines in York and Cherokee Counties, South Carolina. As part of the federally mandated consideration of the environmental impact of project construction, Duke Power Company contracted in August 1978 with the Institute of Archeology and Anthropology, University of South Carolina, to perform an inventory and assessment of cultural resources that may be impacted by the proposed construction.

Records were checked and field work completed by the Institute of Archeology and Anthropology in August of 1978. Although no archeological or historical sites were previously known for the areas under study, 27 prehistoric archeological sites were located during field work. Of these, 11 are located along the proposed right-of-way of the Catawba-Ripp transmission line, 15 are located within the proposed Catawba-Newport transmission line right-of-way, and 1 was located in a minor route change. The project areas and site locations are shown in Figs. 1, 2, and 3.

Analysis of artifacts and other data recovered was performed during the Fall of 1978 and the Spring of 1979. Assessments of the sites located were based on evaluations against criteria for inclusion in the National Register of Historic Places. Of the 27 sites located, 1 is recommended as eligible for the National Register, and 26 as not eligible (see Table 1). During December of 1979, the Institute conducted a three-day limited testing program at 38YK72 (Appendix). The site was mapped and surface and subsurface deposits sampled. These data provided estimates about the nature of the surface and subsurface artifact assemblages and information about the extractive activities that probably occurred there. With respect to this project, no further archeological work is recommended at the site.

The limited number of sites located, as well as the limited artifact inventories from each site, do not allow major substantive research contributions by the archeological project. Furthermore, detailed research studies beyond those necessary for adequate assessment of site significance are outside of the scope of work for this archeological project. The data recovered during this project, however, do confirm general patterns emerging from contemporary, larger scale, Piedmont archeological research projects (House and Ballenger 1976; Goodyear 1978, 1979; House and Wogaman 1978; Taylor and Smith 1978; Brooks n.d.). In addition, data recovered will be curated in perpetuity at the Institute of Archeology and Anthropology and will be available for study by other scholars.

A methodological contribution was made by the present study in that the efficiency of several site discovery techniques for Piedmont archeological survey was evaluated, and recommendations for future survey studies made. By using a mixed strategy and by developing

TABLE 1

Archeological Sites, Catawba Transmission Lines, Management Information

Site Number	Transmission Line	National Register Recommendation	Present Condition	Construction Impact	Mitigation Recommendation
38YK59	Catawba-Pacolet Fold-in	not eligible	highly eroded	slight	no further work
38YK60	Catawba-Newport, East	not eligible	highly eroded	slight	no further work
38YK61	Catawba-Newport, East	not eligible	highly eroded	slight	no further work
38YK62	Catawba-Newport, East	not eligible	highly eroded	slight	no further work
38YK63	Catawba-Newport, East	not eligible	highly eroded	slight	no further work
38YK64	Catawba-Newport, East	not eligible	highly eroded	slight	no further work
38YK65	Catawba-Newport, East	not eligible	highly eroded	slight	no further work
38YK66	Catawba-Newport, East	not eligible	highly eroded	slight	no further work
38YK67	Catawba-Newport, East	not eligible	highly eroded	slight	no further work
38YK68	Catawba-Newport, East	not eligible	highly eroded	slight	no further work
38YK69	Catawba-Newport, East	not eligible	highly eroded	slight	no further work
38YK70	Catawba-Newport, East	not eligible	highly eroded	slight	no further work
38YK71	Catawba-Newport, East	not eligible	highly eroded	slight	no further work
38YK72	Catawba-Newport, East*	eligible	slight erosion; well preserved	moderate	intensive controlled surface collection; small excavations at tower locations
38YK73	Catawba-Newport, East	not eligible	highly eroded	slight	no further work
38YK74	Catawba-Newport, East	not eligible	highly eroded	slight	no further work
38YK75	Catawba-Ripp	not eligible	highly eroded	slight	no further work
38YK76	Catawba-Ripp	not eligible	highly eroded	slight	no further work
38YK77	Catawba-Ripp	not eligible	highly eroded	slight	no further work
38YK78	Catawba-Ripp	not eligible	highly eroded	slight	no further work
38YK79	Catawba-Ripp	not eligible	highly eroded	slight	no further work
38YK80	Catawba-Ripp	not eligible	highly eroded	slight	no further work
38YK81	Catawba-Ripp	not eligible	highly eroded	slight	no further work
38YK82	Catawba-Ripp	not eligible	highly eroded	slight	no further work

Site Number	Transmission Line	National Register Recommendation	Present Condition	Construction Impact	Mitigation Recommendation
38YK83	Catawba-Ripp	not eligible	highly eroded	slight	no further work
38YK84	Catawba-Ripp	not eligible	highly eroded	slight	no further work
38CK50	Catawba-Ripp	not eligible	highly eroded	slight	no further work

*approximately between stations 227 & 50 and 234 & 00, and covering the entire width of the existing right-of-way.

detailed sampling methods and rigorous fie'd control, baseline data on the cost-benefit of these survey techniques was obtained. These data should be useful in future managment-oriented impact surveys, as well as in less applied research projects.

INTRODUCTION

Project Description

Duke Power Company is planning construction of two major, new electric transmission lines, as well as three minor route adjustments to existing lines, in York and Cherokee Counties, South Carolina. These transmission lines will provide for electric power distribution from, and to, the Catawba Nuclear generating station presently under construction in York County. Transmission lines are designated by their beginning and end points, and by the number of volts they normally carry.

The Catawba Nuclear-Ripp Switching Station 230 KV. line will run approximately 25 miles generally east-west from the Catawba Nuclear Station situated in eastern York County near Lake Wylie (Catawba River) to Ripp Switching Station in eastern Cherokee County (see Fig. 1). The Catawba-Ripp line will thus cross almost entirely interriverine uplands between the upper Catawba River and Broad River drainages. For the easternmost 4-5 miles the Catawba-Ripp line will parallel an existing transmission line; its remaining 20 miles will be over completely new ground. Moving west along the proposed line, the interriverine uplands become more hilly and generally rugged. More detailed physiographic data for the region are presented in a section below.

The Catawba Nuclear-Newport (East) (Newport B&W) 230 KV. line will extend approximately 5 miles in a general northeast to southwest direction from the Catawba Nuclear Station to Newport switching station (see Fig. 2). While this Catawba-Newport line also crosses primarily interriverine uplands, it is close to the Catawba River Valley and thus crosses several large tributary streams. This line parallels an existing line over its entire route.

Three minor route adjustments involving connection of existing lines to the Catawba Nuclear generating plant were also surveyed. These were proposed segments approximately one mile or less of the (1) Catawba-Allen 230 KV, (2) Catawba-Pacolet 230 KV, and (3) Catawba-Newport (Allison Creek B&W) 230 KV lines. These line segments are all located just west of the Catawba Nuclear plant (see Fig. 3).

Potential Impact to Archeological Sites

Construction and maintenance of these transmission lines may impact archeological and historical sites lying in their path. Potential impacts to archeological sites by transmission line construction have been discussed for this region by Brockington (1977).

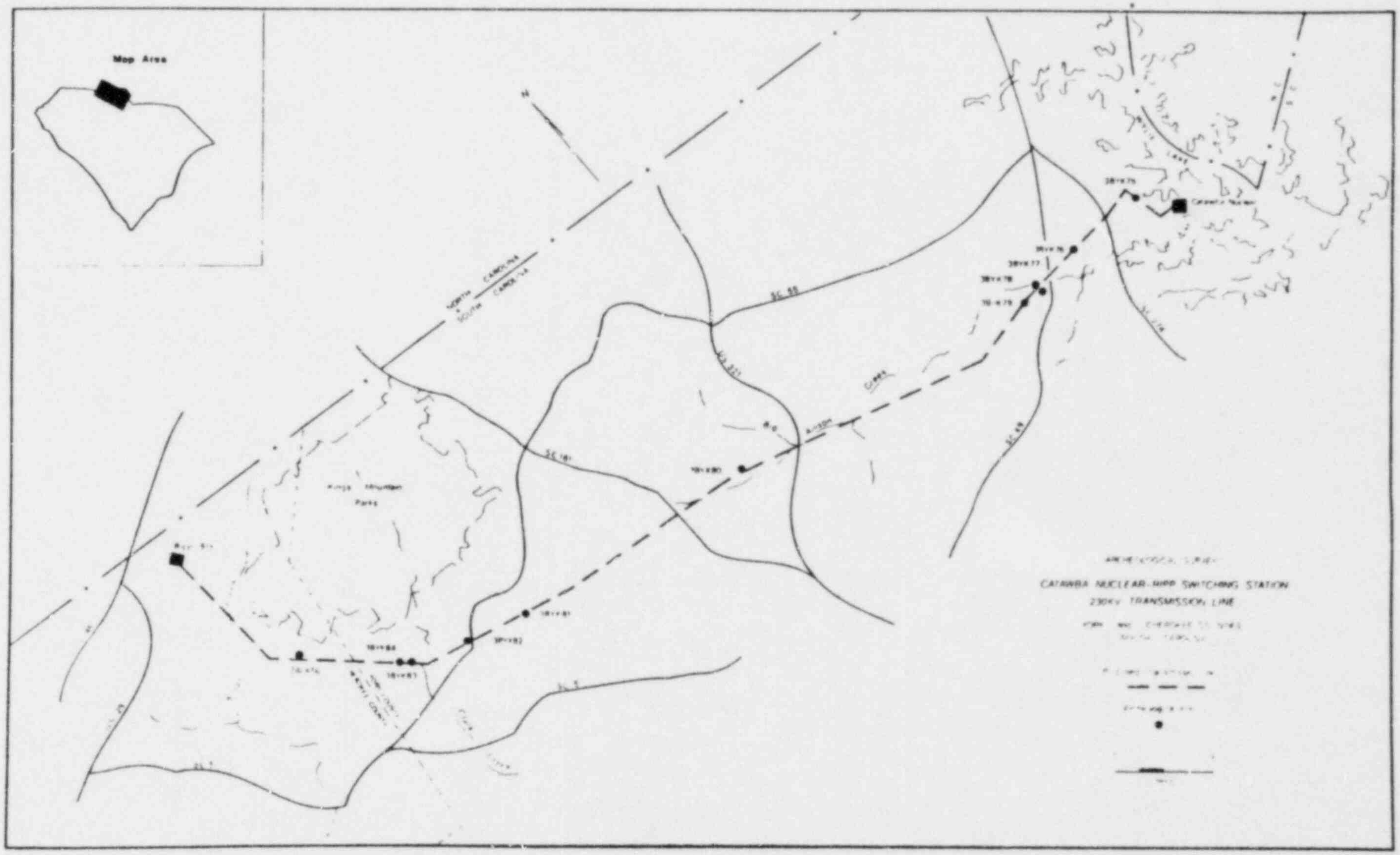

FIGURE 1: Catawba Nuclear-Ripp Switching Station transmission line, showing archeological sites recorded.

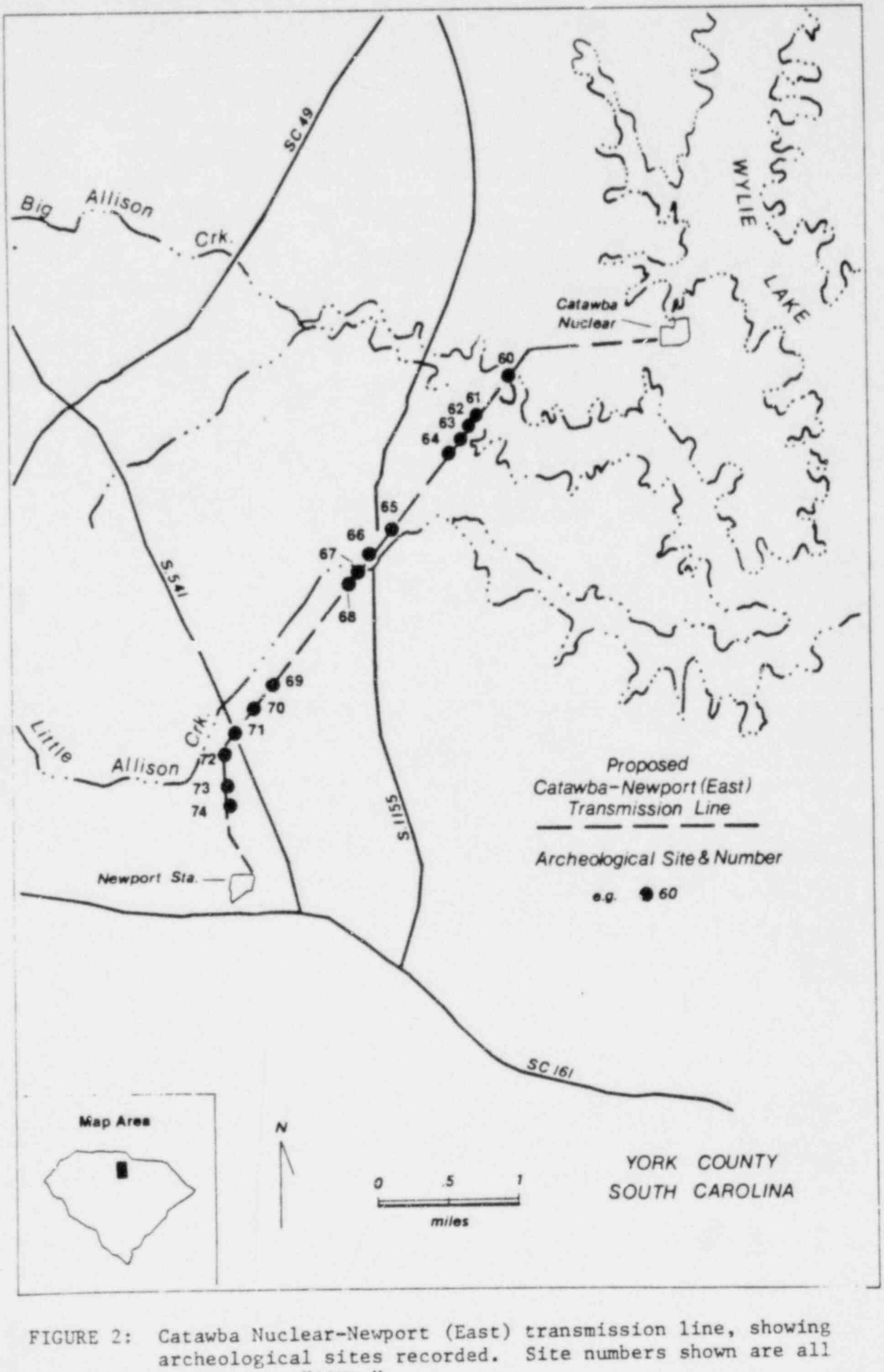

FIGURE 2: Catawba Nuclear-Newport (East) transmission line, showing archeological sites recorded. Site numbers shown are all prefaced by "38YK."

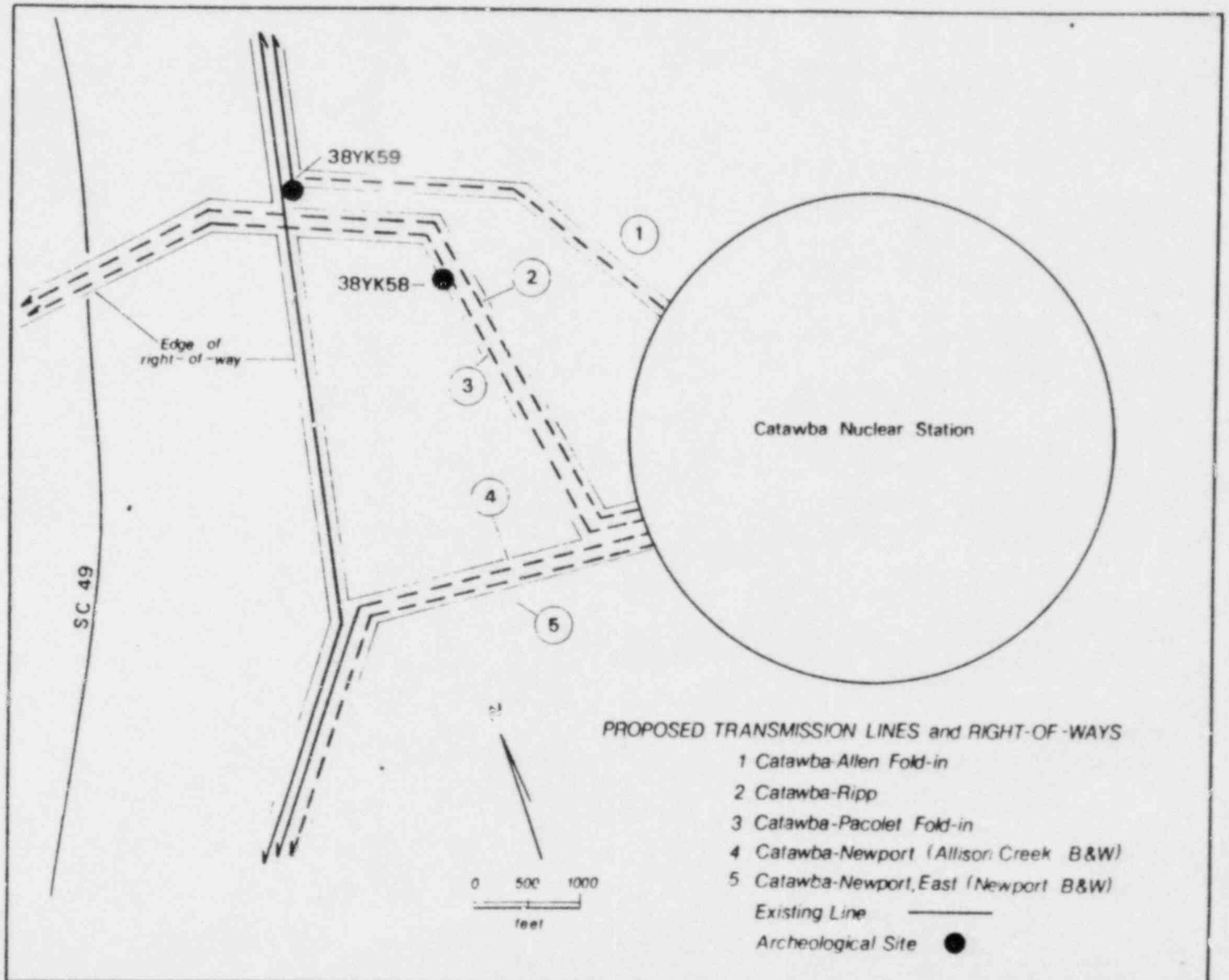

FIGURE 3: Catawba Nuclear transmission lines, showing realignments or "fold-ins."

Impacts can be direct (primary) or indirect (secondary). Direct impacts occur usually during construction and include disturbances of ground by vegetation clearing, tower construction, and movement of heavy equipment. Equipment staging areas and worker facility areas should also be considered as potential impact zones. Indirect impacts usually occur after construction and over a longer period of time. Indirect impacts may include long-term erosions, vandalism due to increased access, maintenance construction, and future industrial, housing, or recreational development.

Study Rationale

The National Environmental Policy Act of 1969 mandates environmental impact review of Federally sponsored or licensed projects. Construction of the various transmission lines described above for this project is Federally regulated and thus must be reviewed for potential impact to archeological and historic sites. Review procedures for assessing and considering impact to archeological and historic sites are outlined by various rules and regulations promulgated under authority of the National Historic Preservation Act, Executive Order 11593, as well as the National Environmental Policy Act. In addition to Federal interest and consideration of archeological sites, the state of South Carolina, under its permitting authority, also considers impact to archeological sites in its decision to grant transmission line permits.

In compliance with these authorities Duke Power Company contracted with the Institute of Archeology and Anthropology (1) to assess the potential of the project areas for containing archeological sites, (2) to search existing records for evidence of historic or archeological sites that might be present in the project areas, (3) to conduct a field survey to discover and inventory archeological sites presently unknown, (4) to assess the significance in relation to National Register criteria of sites located, and (5) to develop a plan, if necessary, to mitigate any potential impact to sites recommended as significant.

Even though the goals of this archeological study were management-oriented (to solve problems and perform services for Duke Power Company), most archeological studies can also provide information of use to the community of research scholars. Care was taken in designing this study project so that contributions could be made to ongoing archeological research without any additional cost to Duke Power Company and without any diminuation of the primary management oriented goals.

For most archeological survey projects adequate assessment of significance will provide descriptive and analytical data that in themselves contribute substantively to ongoing archeological research. Assessment of significance for this project, because of the nature of the archeological resources located, is based entirely on their potential for contribution to studies of history and prehistory. Several research problem domains for archeological studies in the South Carolina Piedmont have been advanced in recent years (House and Ballenger 1976:145-150; Taylor and Smith 1978; House and Wogaman 1978). These are summarized in the section below describing survey methods. Evaluations of sites located in the project areas in terms of their potential contribution within these problem domains showed only one site to have significant potential. The descriptions and evaluations of the various sites, however, contribute important substantive information on the nature of archeological resources in the South Carolina Piedmont.

. A major portion of the archeological research contracted for by Duke Power Company involved the development of a rigorous sampling strategy for site discovery to be executed during the fieldwork phase. This emphasis was selected for two important reasons.

First, such a strategy should allow the gathering of a representative sample of the archeological sites within the project area, reducing the time and cost of inventory activities without limiting (and perhaps increasing) assessment capabilities. In other words, if areas to be inspected were carefully chosen and inspection methods rigorously controlled, fewer areas would have to be inspected to predict site location and significance.

A second reason for developing a rigorous site discovery strategy was its usefulness for predicting time, cost, and recovery rates for future inventory and assessment projects in the Piedmont of North and South Carolina. Several other, similar, construction projects are under consideration by Duke Power Company for future development. The kinds of methods with the best cost-benefit ratio for archeological survey of those future projects need to be known. For example, should certain physiographic areas of high archeological probability be selected in the future? Are certain aspects of vegetation cover limiting for site discovery? Are test pits effective as a means of site discovery?

A mixture of site discovery methods was selected for use during fieldwork on the project. These methods were then field tested and evaluated against each other. In general it was found that rigorously developed sampling strategies for archeological survey in the North and South Carolina Piedmont are not advisable. Test excavations conducted for site discovery are not effective, except in very limited circumstances. What is effective for site discovery is close examination of the ground surface in unvegetated areas. Survey of highly vegetated areas, necessarily involving test pits for site discovery, has such high cost and low benefit that it is not advisable for general application in the Piedmont at this time. It may be necessary, however, for special, high-interest areas. Such high-interest areas may become known for a project through information gained from historical records research or from knowledgeable local persons. Such high-interest areas may also become known if future archeological studies succeed in correlating physiographic features with site locations.

Understanding the cost-effectiveness and biases of various survey methods in the Piedmont is a goal of archeologists both for pure research studies and for resource management studies. This project has thus academic as well as management oriented interests. Similarly, success of studies of the correlation of site location and physiographic features in the Piedmont has both research significance and resource management importance. Recommendations are made in this report for directions that should be taken in future studies to increase the chances of success of these studies and gain better site location and significance predictability.

ENVIRONMENTAL BACKGROUND

Introduction

For especially the past two decades archeologists have been concerned with the mechanics involved in the evolution of cultural systems rather than simple description of technology and temporal placement. Increasingly, this research orientation has been manifested in studies of cultural adaptation to regional environments. From a natural environment viewpoint, these studies emphasize the gathering of an understanding of the number, kind, and distribution of animal, plant, and mineral resources available to earlier populations. Also important are the direct influences of climate, soils, and topography on part human groups. In this section, we will outline briefly the significant aspects of the Piedmont environment in terms of available natural resources, physiography, and climate.

Archeologists are also interested in environmental processes because these processes affect the formation of sites and their alteration through time. Certain kinds of climatic activity will affect vegetation patterns, affecting (indirectly) depositional and erosive patterns. Sites might thus be covered over and preserved or eroded away and destroyed. Changes in ground water levels, for example, could act to preserve or deteriorate archeological features such as firehearths or specimens such as bone.

Probably the most significant disturbing factor in the Piedmont has been the erosion of the uplands and the concomitant sedimentation of the stream valleys in historic times. These processes are associated with original European-African settlement in the 18th and 19th centuries. Extensive timberlands were cleared and farmed with very poor soil conservation practices. The result was severe erosion of upland areas and destruction of many sites there. Archeological sites in the stream and river valleys were often covered with several feet of this upland-derived material and are now extremely difficult to locate and to study.

Present Environment of the Project Area

The project area lies within the Piedmont Province as defined by Fenneman (1938). The Piedmont Province is an area of narrow river valleys and broad interriverine zones deeply dissected by numerous small streams and intermittent drainages. Elevations near the project area range from about 550 feet in the stream valleys to 850 feet above sea level on the ridge tops. Rocks of the area include mostly gneiss, schists, argillite, and granite. Other rocks are represented in minor quantities, including veins of quartz exploitable by prehistoric human groups.

Soils in the project area have been grouped into several distinct associations; these are, for the most part, deep, well-drained, sandy and silty loams with clay subsoils (United States Department of Agriculture 1967). These soils have a high erosion potential and have in the past been subject to significant erosion. Soils are generally moderate to high in fertility and are suited to cotton, corn, grain and legume agriculture.

The watershed area is today dominated by a mixed pine-hardwood forest, although the potential dominant vegetation of the area is oak-hickory forest, with some mixing of pine (Shelford 1963). A great variety of herbaceous plants is also present, especially in recently cleared or disturbed areas.

Fauna in the watershed area include most species of eastern mammals, birds, and reptiles (Shelford 1963). Trout were once abundant in streams and rivers of the area, as were perch, bass, catfish and others.

The project area has a generally mild climate with a mean annual temperature of 62°F. The average growing season is 221 days, with annual precipitation of 44.8 inches (United States Department of Agriculture 1967).

In general, the present environment of the project area is rich in resources exploitable by prehistoric and historic groups. Useful stone is available for prehistoric tool manufacture and for historic building. The oak-hickory forest present in prehistoric times produced a variety of wild plant resources, including, especially, nuts and acorns, although herbaceous plants, berries, and seeds were also probably intensively exploited for food by early groups. Soils are conducive to agriculture both by late prehistoric and historic Indian groups and by early European settlers and later peoples. Fauna were probably abundant in the area in prehistoric and early historic times; most important were probably deer, raccoon, beaver, bear, rabbit, fox squirrel, turkey and various species of fish. Fur bearing mammals were important for their hides as well as their food value, and animal bones were probably frequently fashioned into tools by prehistoric groups.

Past Environments

The general picture of the environment of the project area indicates resources and constraints present today and in the recent past. Climatic change over the last 25,000 years, however, has been shown to have occurred, and to have resulted in environments significantly different than that of the present day (Watts 1971; Whitehead 1973; Carbone 1974). Following, in general, Olafson (1971) and Bryson, Baerreis, and Wendlund (1970), 4 major climatic episodes can be defined for the Southeast covering the last 25,000 years.

These are (1) the full-glacial from 23,000 to 13,000 B.C., (2) the late-glacial from 13,000 to 8,000 B.C., (3) the post-glacial from 8,000 to 3,000 B.C., and (4) the recent period from 3,000 B.C. to the present.

During the full-glacial period temperatures were much lower than today, especially in winter, with relatively more precipitation. Vegetation in the project area was probably more boreal, with pine, spruce, and fir species dominant, although there appear to have been open areas within the forest with extensive herbaceous growth. Faunal biomass was probably considerably lower than today.

The late-glacial episode shows evidence for a shift from a boreal forest type to a general northern hardwood forest. Oak and hickory were dominant by the end of the period. Pleistocene megafauna became extinct during this episode and present day faunal communities began to dominate.

From about 8,000 to 3,000 B.C., oak-hickory forests reached their maximum development in the Piedmont. Higher temperature and lower precipitation than today are hypothesized to characterize this period, but data from the Southeast in particular are lacking. Present-day faunal communities became dominant early in this episode.

The recent climatic episode is hypothesized to be characterized by a general increase in precipitation and decrease in temperature. It is also thought to have witnessed a general shrinkage in oak-hickory forest and a resultant slight loss of floral and faunal resource productivity, especially in the Piedmont uplands.

This brief summary of environmental variables and their changes through time provides a basis for correlation with changes in the demographic, settlement, and subsistence patterns of human groups occupying the project region. Such correlations represent attempts to look for causes of social and economic change in human populations and to analyze and understand general evolutionary processes. Of particular importance at the present time is the understanding of hypothesized differential utilization, with shifts through time, of the major environmental zones of the South Carolina Piedmont: the riverine and inter-riverine regions. These questions will be addressed in more detail in the following section.

PREHISTORIC AND HISTORIC BACKGROUND

Prehistory

Earliest evidence of human occupation of the Piedmont region indicates that man was present by at least 10,000 B.C. (Williams and Stoltman 1965; Michie 1977). The environment during this late glacial period would have been more boreal than today, with pine forest dominant and a much lower biomass available for human exploitation. Indications are that the general Piedmont area was sparsely occupied during this time (Michie 1977).

Beginning soon after transition to the post-glacial period, human occupation of the Piedmont became more intense, especially in the interriverine zone where recent archeological studies have been accomplished (House and Ballenger 1976; Goodyear 1978; Taylor and Smith 1978; Kelly 1972). Sites from this period appear to be primarily small, hunting and gathering camps in the uplands. Their appearance coincides with the trend toward dominance of oak-hickory forest in the region. In addition, most sites in this general climatic period seem to fall in the hypothesized maximum oak-hickory expansion of 5,000 to 3,000 B.C.

Sites dating after 3,000 B.C., in the recent climatic period, are fewer in number and appear to be restricted more to the major river valleys within the Piedmont. It is thought that during this period there is a general trend toward increasing sedentism, larger populations, and more labor intensive food producing strategies, including, after about A.D. 500, increasing reliance on corn agriculture (Coe 1964).

The detailed development and testing of these generalized patterns depend on future problem-oriented research in the region. Presentation of such generalized hypotheses, however, allows the development of preliminary criteria of site significance and the formulation of a basic fieldwork and analytic plan.

A general cultural-historical sequence has been formulated for prehistoric eastern North America (Griffin 1967). This general sequence has been refined and developed in more detail for the southeastern Piedmont by Coe (1964), Phelps (1964) and Wauchope (1966). Table 2, following Coe (1964) and others, presents this basic sequence as it might be expected to occur in the project area along with brief descriptions of general characteristics. Current research has focused not so much on further refinement of this cultural sequence as on determining the settlement-subsistence systems operative, particularly the nature of exploitation of the interriverine Piedmont during the long Archaic period (House and Ballenger 1976; Goodyear 1978; Taylor and Smith 1978; Cable, Cantley and Sexton 1978; Brooks n.d.; House and Wogaman 1978).

TABLE 2

Archeological Sequence Expected in the Project Area
(after Coe 1964 and Keel 1976)

Date	Period	Phase	Characteristics
A.D. 1900			Replacement by European-American homesteads and farms
A.D. 1820	Euro-American Protohistoric		Europeanization of native technology, economy and settlement patterns
A.D. 1650	Mississippian		Distinctive stone tools; distinctive pottery; sedentary villages; platform mounds; maize, beans, squash agriculture with hunting and gathering.
A.D. 1000		Uwharrie	Distinctive projectile points; ground stone tools; soapstone vessels; distinctive ceramics; sedentism more evident; hunting, gathering, and some horticulture.
A.D. 300	Woodland	Yadkin	
200 B.C.		Badin	
800 B.C.		Otarre Savannah River	Distinctive projectile points; ground stone tools; soapstone vessels; hunting and gathering.
2000 B.C.	Archaic	Guilford Morrow Mountain	Distinctive projectile points; hunting and gathering; large increase in number of sites.
6000 B.C.		Stanly Kirk Palmer Hardaway	Distinctive projectile points; hunting and gathering.
10000 B.C.	Paleo-Indian	Clovis	Fluted projectile points; nomadic hunting (possibly of now-extinct animals) and gathering of wild plants.

House and Ballenger (1976: 84-87) postulate three different extractive strategies that may have been operative in the interriverine Piedmont during the Archaic. These include fall-winter deer hunting and nut collecting (both in the upland hardwood forest), and fishing and plant gathering (along stream bottomlands). House and Ballenger also hypothesize that the stream bottoms may have been used as base camps for extractive journeys into the uplands in search of deer and nuts in the fall and winter. In addition, House and Ballenger (1976: 117) see a general movement of people, during the Middle and Late Archaic especially, out of the interriverine zone during the late winter, spring, and summer to residences along major rivers to take advantage of migratory fish and floodplain plant resources. Further research has generally upheld this basic settlement-subsistence model, although data are meager, especially for the Early Archaic (Goodyear 1978; Taylor and Smith 1978; Cable, Cantley and Sexton 1978; Brooks n.d.; House and Wogaman 1978).

Data concerning Woodland and Mississippian period occupation of the Piedmont are sparse. Present indications are, however, that resource extraction continued in the interriverine zone, probably concentrated in the fall and early winter, although base camps were restricted to the major river valleys (House and Ballenger 1976; Goodyear 1978; Taylor and Smith 1978; Kelly 1972). During the Woodland and Mississippian periods there was apparently a trend toward increasing sedentism, larger population, and more labor intensive exploitation of the floodplains of major rivers.

It may be noted that, in postulating general Piedmont settlement-subsistence systems for the Archaic, researchers suffer from a lack of good data concerning occupation of major river valleys. Most research has focused on the interriverine zone, and recent work in river valleys has not been reported in detail (see Taylor and Smith 1978; Brockington 1977). In addition, general survey data from major river valleys are most probably biased because of difficulty in detecting the probably deeply-buried archeological sites there. This problem will be discussed in more detail in a later section.

Ethnohistory

The Ethnohistoric period refers to the time between first contacts and influence of Europeans and the ultimate destruction or removal of native Indian groups. In the South Carolina Piedmont the Ethnohistoric period generally extends from the sixteenth century through the nineteenth century. The major Indian group near the project area was the Catawba Nation. Detailed ethnohistoric studies of the Catawba have been recently presented by Brown (1966) and Baker (1975).

Earliest contact by Eureopeans with the Catawba may have been by the DeSoto expedition in 1540. The DeSoto chronicles describe, in particular, the Province of Cofitachiqui (Swanton 1952), apparently a thriving, pristine Mississippian society. There is evidence that Cofitachiqui was located on the upper Wateree-Catawba River, just south of the project area (Baker 1975). Indian groups of the area were also contacted by the Spanish Juan Pardo expedition in 1566 and 1567 (Brown 1966; Baker 1975). After this, contact was apparently at a minimum for about 100 years when trade began to develop with Europeans operating out of Virginia, and later, South Carolina. An early account of the Indians of the South Carolina Piedmont is presented by Lawson (1952) in his diary of travels during 1700-1701. Speck (1946) presents an account of Catawba hunting, fishing and trapping techniques based on his interviews with elderly informants in the early twentieth century.

As detailed by Brown (1966), the Catawba Nation has a complex history of trading, wars, alliances and amalgamation with other groups. Most of these groups were Souian-speaking, and the Catawba were thus set apart from the more numerous Iroquoian-speaking Cherokee to the northwest and the Muskogean groups to the south and west. Early accounts generally indicate that the South Carolina Piedmont, except for the Catawba and several smaller groups, was sparsely occupied during most of the Ethnohistoric period, and was reserved as communal hunting territory for the groups inhabiting its margins and perhaps several of the major river valleys.

Early European History

Trade in deer and other skins provided the first continuing contact by Europeans with Indian groups of the South Carolina Piedmont. This trade began early in the eighteenth century and, although there was early competition with traders from Virginia, Charleston soon dominated. By the mid-1700's, the value of deerskin exports from Charleston exceeded all other exports and provided enormous profits (Brown 1966: 109). Such trade necessarily put strong pressure on traditional economic pursuits of Indian groups and may have led to dramatic changes in their economy, demography and social organization. Through the early 1700's most Carolina traders came from Charleston by way of Congaree Fort near present-day Columbia, then eastward up the Wateree-Catawba system. No early trading centers near the proposed transmission lines are known.

European settlement of the central Piedmont area began in the 1730's along major rivers. The first settlement near the project area was at present-day Camden. These early settlers included farmers, merchants, craftspeople, and Indian traders. A major influx of settlers into the Piedmont began in the late 1750's as Scotch-Irish refugees moved into the area from settlements in Virginia and Pennsylvania because of attacks by Indians there during the French and Indian War (Oliphant 1964: 125). Scotch-Irish farms became dominant in the area by the late 1700's. Their major cash crop was tobacco, which was shipped overland to merchants in Virginia.

The introduction of new varieties of cotton and the development of the cotton gin at the end of the eighteenth century had dramatic effects on the economy of the Piedmont. Cotton agriculture was extremely productive and large areas of Piedmont forest were cleared for the first time. The plantation system became dominant over the family farm, emphasis on cotton replaced that on tobacco and diversified farming, and large numbers of African slaves were imported into the region (Oliphant 1964: 216-217; McMaster 1946: 36-37).

This cotton agriculture system was ecologically disastrous and self-destructive (Oliphant 1964: 216-217; Trimble 1974). Massive forest clearing and poorly designed tillage and conservation methods soon caused severe soil depletion and erosion. Cotton profits were so large, however, that plantation owners were able to make up for this loss by greatly expanding their holdings and their operations, first in adjacent lands in the Carolina Piedmont and then by wholesale migrations in the mid-1800's to new lands to the west, particularly Mississippi. Even though yields and profits continued to decline, new owners, sharecroppers, and tenant farmers were locked into the cotten system because of extremely low prices of other crops. Not until the first quarter of the twentieth century, with increased prices for legume crops, cattle and livestock and timber, and with the increased importance of manufacturing, did the cotton monoculture system change. The Piedmont today has a low population density and consists mostly of forest regrowth, pine plantations and scattered patches of farmland and pasture.

Impacts to Archeology of Historic Land Use

The cotton agricultural system employed in the Piedmont in the nineteenth and early twentieth centuries resulted in tremendous erosion (see Trimble 1974). Cotton was planted in rows generally running down slopes to obtain better drainage necessary because of the clay substrate underlying the top 8-10 inches of soil. The heavy and sudden rains characteristic of the South Carolina Piedmont resulted after just a few years in complete loss of soil and formation of large gullies on the gentle hillslopes. Investment in terracing and contour farming was not profitable because of the high value of cotton in relation to the low value of land during the early 1800's. In addition, other crops, such as legumes which could have reduced erosion and allowed replenishing of soil nutrients brought such low prices that it was not economical to plant them. It was more profitable to farm an area intensively until the soil was exhausted or eroded and then buy, clear and plant new land. Abandoned land continued to erode.

Erosion of upland soils quickly clogged the streams and rivers of the Piedmont with large sediment loads. Large rainstorms quickly produced great runoff and major flooding occurred. This flooding, combined with direct hillslope erosion, covered the rich soils of the stream and river bottoms with up to several feet of silt with low productivity. Increased sediment loads caused the streams and rivers of the Piedmont to aggrade, aggravating the flooding problem and causing a dramatic rise in the water table in stream valleys. Swamps were created in many of these stream valleys. Figure 4, after Trimble (1974), shows this development in a typical Piedmont stream valley.

The erosion of the uplands and sedimentation of the streams and river bottoms had dramatic effects not only on the agricultural productivity of the region as discussed in the preceding section, but also on the archeological record. This archeological record had been preserved in the soil for at least 10,000 years with minimal disturbance. During the 1800's, however, upland erosion dislocated and deflated artifacts and destroyed features indicative of past construction and other activities. Sedimentation of stream bottomlands covered over archeological deposits with up to several feet of silt and slopewash. While this sedimentation blanket may protect archeological deposits, it biases our understanding of them because it makes sites extremely difficult to detect, or to study if discovered.

Changes in agricultural practices and a shift to livestock and timber production as well as manufacturing have greatly decreased erosion in the Piedmont since the early 1900's and the region is recovering economically. The damage, however, and biases introduced to the archeological record cannot be changed. It is incumbent upon the archeologist, therefore, to search for areas within the Piedmont where erosion was not so dramatic and where effects on the archeological record are minimal. Such minimally affected areas, and the archeological sites within them, are thus extremely significant in understanding the cultural heritage of the region.

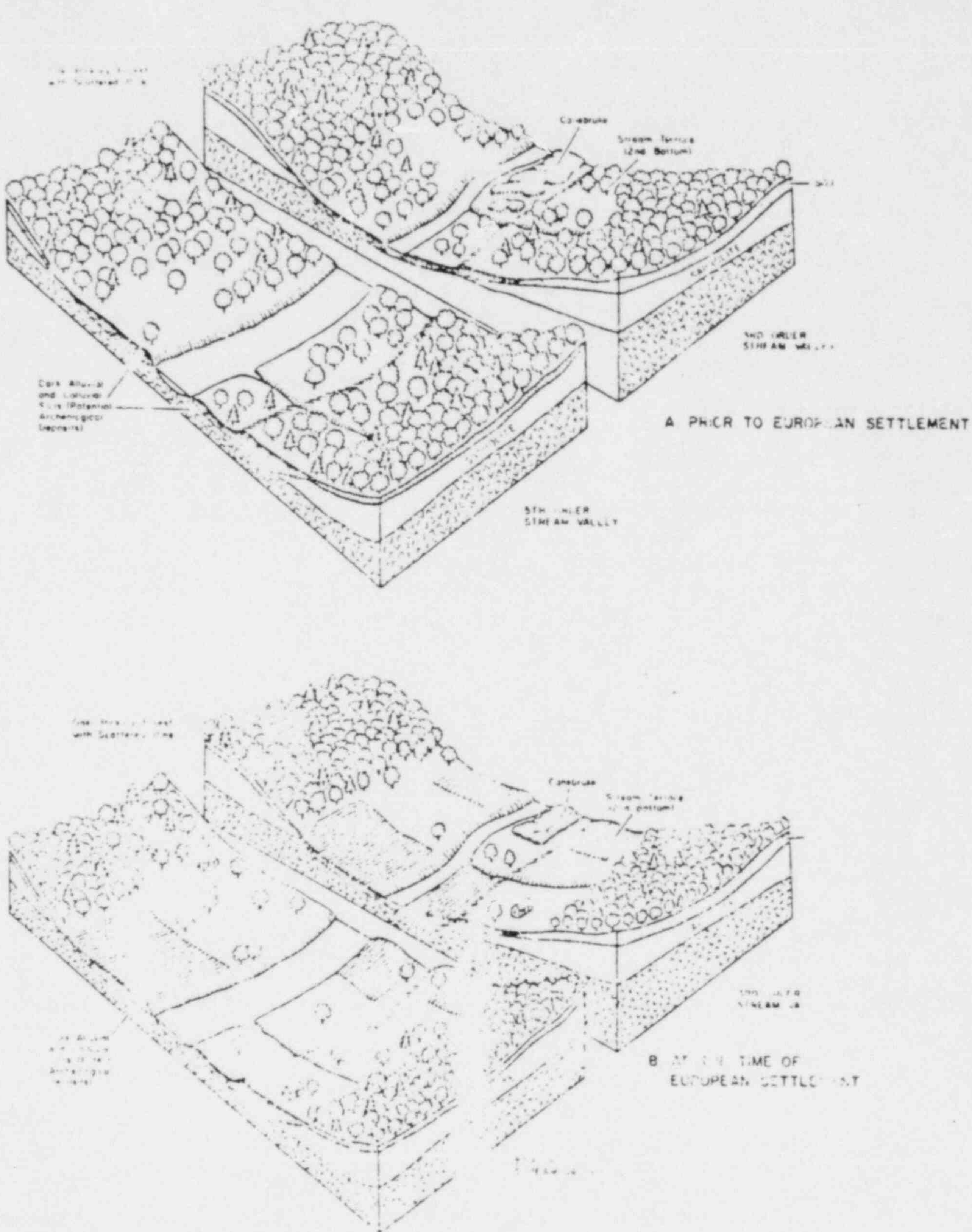

FIGURE 4: Erosion and sedimentation sequence in a Piedmont valley (after Trimble 1974).

Research Design

The research design for this study project was determined in large part by the management-oriented goals of (1) discovery and location of all or of a representative sample of the cultural resources present, and (2) assessment of the significance of these resources. Descriptive and analytical data recovered and produced in such a location and evaluation study would be of direct use to those involved in ongoing archeological research.

Although some archeological sites may derive significance because of their association with historically important persons, events, or movements, or because they exhibit unique styles of craftsmanship or architecture, evaluation of significance of most sites involves assessment of their potential contribution to ongoing research about past cultural systems. House and Ballenger (1976: 145-150) have recently suggested several research problem areas for which data from South Carolina Piedmont archeological sites are needed. These problem domains cover most archeological research questions in the region and pertain directly to the project areas under study here. They are summarized and discussed below.

Culture-History

Deep, stratified sites would be very useful in refining the prehistoric sequence established by Coe (1964) and others for the region. Such sites are probably most likely to occur in large river valleys because of periodic flooding and deposition, although smaller stream valleys could also yield stratified sites. Non-stratified sites with potential for independent dating (e.g., with charcoal for radiocarbon analysis) would also be significant for culture-history questions. Sites with large samples of stylistically diagnostic artifacts may be dated indirectly (e.g., through seriation studies) and may contribute importantly to our understanding of the range of variability of stylistic variables.

Activity Analysis

Previous research in the Carolina Piedmont (House and Ballenger 1976) has shown that many prehistoric sites exhibit artifact patterning indicative of past activities performed there. To attempt reconstructions and comparisons of past cultural systems, detailed knowledge is necessary of the range and character of prehistoric activities.

Lithic Procurement and Technology

Understanding stone utilization and procurement forms a basis for exploring many other questions because of the relationship, in non-metal using societies, between lithic technology and other basic economic and social variables. Sites with a large number of stone tools and manufacturing waste could contribute greatly within this problem domain.

Settlement-Subsistence Patterns

Individual sites can contribute to our knowledge of the functional differentiation of settlements hypothesized especially for the Archaic prehistoric period in the Piedmont. Activity analysis, in combination with direct subsistence data (bones, seeds, pollen) and information inferred because of site location near exploitable natural resources, can lead to an understanding of the character and variability through time of broad settlement-subsistence patterns.

Adaptational Change and Anthropological Theory

Most of human existence of the last several million years is represented by adaptations involving hunting and gathering of natural, wild resources. Hunting and gathering groups existing today are limited in number and live in "marginal" environments, e.g., deserts, tropical forests, ice-covered areas. Archeological evidence indicates that modern hunting and gathering groups do not exhibit the range of economic, social, and ideological complexity of hunters and gatherers existing in the past in highly productive temperate forests. Detailed study of environmental diversity and change within the temperate forest habitat, in combination with further detailed study of human adaptations in the form of settlement-subsistence patterning and social, political, and ideological organization, may lead to solutions to cultural evolutionary research problems of world-wide significance. Certain sites, or series of sites, may contain data crucial to understanding the processes involved in broad economic, social, and ideological transitions.

Historical Archeology

South (1977) has recently argued for more consideration of patterns in the study of historical sites and has called attention to the potential of historical sites for reconstructing past lifeways and for investigating evolutionary processes operating on historic populations. Such potential research is illustrated by Lewis (1976) in his use of historical period archeological data near Camden, South Carolina, to test aspects of a "frontier model" of expansion of British colonial society. An additional scientific problem domain in historical archeology is indicated by Carrillo (1976; n.d.) in his demonstration of potential correlation between refuse disposal patterns and ethnic identification at several eighteenth-nineteenth century house sites in South Carolina.

Refinement of Survey Methodology

Detailed study of certain sites may be justified by what it can tell us of the adequacy of survey methods. Survey information on the character and distribution of sites can itself make a substantive contribution, as long as such information is shown by more detailed studies to be representative.

The above problem domains will be used to evaluate the significance of sites located in the project areas. Thus, the problem domains form the basis for the research design by asking a variety of relatively specific questions about the sites, the data they contain, the environmental data they are related to, and the methods used to discover them.

Archival and Library Research

The first phase in the study project involved library and records research to identify presently known and recorded data and to estimate, in general, the potential for archeological and historic sites. The State Site Inventory files, maintained by the Institute of Archeology and Anthropology, were checked first. No sites were recorded for the project areas, although several sites were on file for York and Cherokee Counties. Contact with the staff of the South Carolina State Historic Preservation Officer indicated that no sites within or near the project areas were on, or under consideration for, the National Register of Historic Places.

The potential for discovering presently unknown sites was judged, however, to be high. Small prehistoric campsites are commonly found in areas of the Piedmont similar to the project areas (see House and Ballenger 1976; Taylor and Smith 1978; Goodyear 1978). The actual density, topographical distribution, and degree of preservation, however, could not be estimated for these potential sites. Field survey was necessary.

Library research also indicated that it would probably be difficult to locate sites in much of the project area. Dense ground surface cover, in the form of forest, scrub, and grass, was predominant in areas to be surveyed, with plowed fields and other open areas at a minimum. Previous Piedmont survey under such low surface visibility conditions had relied on exploratory excavation of small test pits over wide areas in an attempt to locate sites. This approach has produced mixed results. House and Ballenger (1976) and Taylor and Smith (1978) reported that relatively few sites were located by exploratory subsurface test pits. Sites have been found with this approach, however, especially on small survey projects where test pits have been closely spaced (see, for example, Brockington 1978).

This test pit approach, however, has not been systematically evaluated as a discovery technique. Taylor and Smith (1978) abandoned initial attempts to use discovery test pits in surveying Russell Reservoir because of the low productivity in relation to the time and labor cost. Much of the cost for Taylor and Smith, however, was due to logistics problems relating to the accurate on-the-ground location and mapping of the test pits so that their distribution would conform to the sampling plan designed. Such logistics problems may not be great in surveys of the systematic, linear project areas represented by transmission lines.

House and Ballenger (1976) also used systematically placed test pits in their survey of the proposed Interstate 77 highway corridor. Again, the location and mapping of the test pits themselves was a high cost, and the approach resulted in few sites being discovered. House and Ballenger spaced their test pits widely and used relatively few of them. This could be seen to increase their logistics problems in the field relative to the discovery potential.

Library research thus indicated problems with using test pits to discover the typically low artifact density sites of the Piedmont. Review of previous large scale studies, however, left unresolved the efficiency of the approach if logistics-related costs could be reduced. Such cost reductions might generally be possible when working within long, narrow corridors typical of transmission line projects. In addition, library research indicated few recommended alternatives to the test pit approach for vegetated areas. Systematic clearing of small areas using a rake to remove surface vegetation has been attempted, but with largely unproductive results (Glen Hanson, personal communication; Pat Garrow, personal communication). Large scale Piedmont survey projects have relied primarily on inspection of small, eroded dirt roads or timbered areas and the relatively few cultivated fields that may be present in a survey area (Goodyear 1978; Taylor and Smith 1978; House and Ballenger 1976).

Such reliance on open areas, however, poses severe problems for environmental impact related archeological survey projects because of the typical small size and arbitrary boundaries of the projects. The areas actually inspected may often be too limited to assess adequately the archeological resources that may be present. In addition, it becomes extremely difficult to conduct problem oriented research and make meaningful substantive contributions with reliance on such a discovery approach because of the difficulties of fitting such open areas into a scientifically meaningful sampling plan.

The following section represents an attempt to overcome some of these sampling problems, while maintaining a rigorous and meaningful overall plan. The sampling design was also developed specifically to allow evaluation of the efficiency of the discovery test pit approach in comparison with other methods.

Sampling Plan

The overall plan structuring the sampling was to provide a mixed strategy of surface observation and exploratory test pits to meet the goals of (1) providing for adequate survey coverage, (2) substantive research results, and (3) methodological evaluation. Test pits would be used under tightly controlled conditions so that their cost-benefit as a discovery technique could be carefully evaluated. It was also decided to attempt to minimize the cost of the test pit approach as much as possible while maintaining a system of numerous, closely spaced pits.

A one-day reconnaissance of the project areas and inspection of aerial photos provided by Duke Power Company were very useful in designing the sampling plan. These early investigations allowed us to estimate ground cover conditions in different parts of the project area.

Ground surface visibility was highest for the Catawba-Newport East (Newport B&W) and the 3 short "fold-ins," Catawba-Allen, Catawba-Pacolet, and Catawba-Newport (Allison Creek B&W). This surface visibility was primarily the result of small patches of eroded areas associated with the existing transmission lines paralleling the proposed routes. These small eroded patches were most often the result of highway roadcuts across the project corridor and of small dirt access roads built within the existing corridors for maintenance purposes. Several small plowed areas existed within the project corridors in addition. The total percentage of ground surface that was visible for inspection was difficult to estimate accurately, but probably represented 7-10% of the project area.

Ground surface visibility was very low, however, for the Catawba-Ripp line. There were no plowed fields intercepted over its entire 25 mile route, and open areas without heavy grass or forest were very limited. Visible ground surface over the route was estimated to be less than 1% of the Catawba-Ripp project area.

It was noted during the short reconnaissance of the project areas that few, if any, areas of mature forest existed. The area was dominated by scrub forest, thick undergrowth, and dense pasture grass. These conditions would make difficult or impossible the use of a raking approach to clear leaf and needle mold and examine the ground surface.

It was decided to use opportunistic surface inspection to survey the Catawba-Newport East (Newport B&W) line and the three short fold-ins. A team of 2 surveyors would walk over the corridor (of variable width, but usually 100 feet) searching for areas where the surface of the ground was visible. These areas would then be carefully examined for artifacts. If artifacts could be found, they would all be collected and the site's size, shape, and artifact density recorded. A test pit would be excavated to record subsurface deposits and stratigraphy. Notes would also be taken on the environmental conditions at the site.

For the Catawba-Ripp line, surface observation would also be used whenever possible, but, because of the limited nature of surface visibility, the main emphasis would be on exploratory test pits. To be successful, such test pits would have to be numerous and relatively closely spaced. The test pit approach, however, is relatively labor intensive, and thus costly as a survey technique. Such a high cost makes sampling of the area necessary. With the use of a sampling plan with enough rigor to provide a representative estimate of the entire area, logistics problems greatly increase because of the difficulty of traversing the area, accurately measuring distance traveled, and finding the test pit location designated by the sampling plan. The need is thus for a sampling plan that can be quickly and easily implemented in the field while maintaining enough rigor to produce a scientifically adequate sample.

Correlation of site location with environmental features is not well developed in Piedmont archeology. Certain environmental features only, such as hilltops, for example, could not be selected and surveyed intensively. All environmental settings would have to be included within the sample. For an adequate sample, these microenvironments should be selected in proportion to their total presence within the project area.

Such a strategy, however, is not without difficulty. It is very difficult to characterize interriverine Piedmont microenvironments. Ideal types, such as hilltop, valley bottom, and hillside slope can be described, but on-the-ground breaks between these types are difficult to make. The situation becomes even more complex when attempting to include finer, but perhaps more meaningful types such as ridgetop, ridgenose, ridgeslopes, bluff, knoll, saddle (see Taylor and Smith 1978: 163). To implement a sampling strategy based on such a typology, features within a large area surrounding the project corridors would have to be typed, their proportions estimated, and then these proportions used in selecting microenvironments for study within the corridor.

After examining topographic maps of the project region and attempting to type landforms, it was decided that such a system was too subjective to be meaningful. We had no confidence in the utility of most of our distinctions, for example, among ridgetop, ridgenose, and saddle. Furthermore, it was felt that these distinctions would be even more difficult to make in the field, especially as the project corridor may intercept the landform types in a variety of different ways. Such difficulty in the field would also compound logistics problems involved in using the test pit approach to site discovery.

It was therefore decided to divide the project corridor for the Catawba-Ripp line into a number of logistically manageable units, take environmental data on these units, stratify the population of units on the basis of this data, and then sample within each stratum. It was thought that a 15-20% sample of the project area would be of sufficient size to recover an adequate sample of sites and their value ranges for ecological and cultural variables. That size sample should also be sufficient to test the usefulness of the test pit approach. If the approach was judged extremely useful, perhaps additional sampling or complete survey would be warranted. If the approach was judged to be relatively useless, perhaps another form of survey would be indicated.

Our procedure was as follows. We divided the 24.49 mile long corridor into 258 segments each 500 feet long. English system measures were used rather than metric so as to fit with topographic survey information recorded for the corridor by Duke Power Company. The corridor and the unit segments were drawn on U.S.G.S. 7.5 minute quadrangle maps for the project area, and environmental data were recorded for each unit. The variable list for each unit was as follows:

- Study unit identification number. A sequential number from 1 to 258. Engineering survey station numbers, used by Duke Power Company, were also recorded. These station numbers were obtained from detailed plan and profile drawings prepared by Duke Power Company.

- Major drainage. The major river drainage within which the study unit occurred, either the Catawba River or Broad River.

- Major soil unit. Four broad soil associations were mapped for the region by The Soil Conservation Service, U.S. Department of Agriculture.

- Present vegetation. Forested or non-forested.

- Direction of slope facing. East, northeast, north, etc.

- Change in elevation along the corridor centerline. The difference in feet between the beginning and end points of each 500-foot long study unit.

- Change in elevation perpendicular to the corridor centerline. Elevation change in feet, measured perpendicular to the corridor centerline, for 250 feet on each side of the study unit's midpoint.

- Distance from unit midpoint to nearest water. Measured in feet to nearest permanent stream or spring.

- Number of streams within 1/2 mile.

- Number of streams within 1 mile.

- Distance to major river (Catawba or Broad), in miles.

- Elevation above sea level of unit midpoint.

Using available U.S.G.S. quadrangle maps, as well as aerial photos and plan and profile drawings provided by Duke Power Company, values for these variables were recorded for each study unit. These were then keypunched and standard histograms produced for each variable. These histograms were carefully examined for obvious distribution breaks that could indicate points for sample stratification. No major breaks were observed. The variables with 2 or more qualitative states showed relatively smooth distributions. These distributions were not normal, however, but were skewed to various degrees as expected.

The next set of experiments involved inspections of distributions and sample statistics for groups of study units. The study units were grouped according to their values for a certain variable, and then these groups were compared in terms of their values on all the other variables. For example, the study units were divided into 2 groups, one within the Broad River Drainage and one within the Catawba River Drainage. These two groups were then compared for their values on all the other variables. Each of our study unit variables was analyzed in this manner.

The purpose of this analysis was to gain a subjective understanding of the interrelationships of the variables measured. More objective statistical methods, e.g., chi-square analysis, analysis of variance, correlation analysis, were not considered appropriate or very useful. First, we did not have a detailed understanding of the meaning of each variable and, in some cases, were unsure of the reliability of our measurements. Second, detailed statistical tests and analyses assumed certain distribution characteristics such as normality. Although transformations could perhaps have helped in meeting these assumptions, we were hesitant to manipulate such a limited data set so heavily. Third, our mixture of nominal, ordinal, interval, and ratio data would not have allowed statistical comparisons even in the best of conditions.

Comparisons of groups of study units did not produce any outstanding insights. Several of the variables were obviously interrelated, e.g., number of streams within 1/2 and 1 mile, while others appeared to be independent, e.g., slope direction. In general, we were able to conclude that there were no major differences among any of the study unit groups we created, e.g., between east facing and west facing slopes, for the variables we were measuring. We noticed that the Broad River drainage (to the west of the study area) was generally more rugged, with greater elevation changes within study units, and with greater percentage of forest cover.

As this preliminary analysis provided no real clues as to how to stratify our population of study units, we selected, based on intuitive grounds only, measures of elevation change within study units as our major stratifying variable. The reasoning behind this was that, in the absence of other indications, degree of slope was felt to have perhaps been the major variable for site selection by prehistoric groups. Water was generally available throughout the project area, reducing its probable importance as a site selection factor. Soil types, while probably very important in site selection because of the vegetation control, and thus faunal control, they exert, were extremely difficult to measure for our study units. We had little confidence in their accuracy. Attempts to use broad soil groups for our analysis were not rewarding because of the limited variability of these over the project area. In addition, we had little confidence in the ability of present-day soil types to indicate prehistoric soil types for this heavily eroded area.

We first divided our study units into 2 groups: those in the Broad River drainage and those in the Catawba River drainage. This was done to increase our overall sample dispersion in accordance, particularly, with our management-oriented goals and the general distinction we had noticed in ruggedness between the two drainages.

Within each of these groups we first added together, for each study unit, the values of Change in Elevation Along Corridor Centerline and Change in Elevation Perpendicular to Corridor Centerline. This sum was interpreted by us as a general measure of the amount of slope in each study unit. Lower sums would indicate more "flatness" and higher sums more slope within each unit. In general, we expected to find archeological sites association with "flatness".

We next divided the Broad and Catawba drainage groups into subgroups based on increments of 10 feet in the above sum. For example, 0-9 feet, 10-19 feet, 20-29 feet, etc., of total slope defined the subgroups of study units. A 20% random sample was then drawn from each subgroup. Because all fractions were evaluated as the next highest whole number, we ended up with a 26.7% total sample, 69 of the total 258 study units.

For each of these 69 study units selected we planned to excavate 6 exploratory test pits, each 30 cm square. These test pits would be placed on the corridor centerline exactly 100 feet apart. All the dirt fill of each pit would be carefully examined with a small hand trowel for the presence of artifacts. In addition, notes on the vegetation, soil, degree and direction of slope, and other environmental features would be recorded for each study unit.

This method of exploratory test pitting allowed us to locate study units by survey station numbers marked on wooden stakes by Duke Power Company engineers. Duke Power Company aided us tremendously by sending their survey engineers back into the field ahead of our party to locate precisely our study units within the corridor and to re-stake and re-mark them as necessary. We planned to locate a study unit, excavate a test pit at its origin, move 100 feet along the corridor and excavate a second test pit. We would continue this spacing until we reached the end of the study unit and excavated our sixth test pit. When 2 study units occurred together, the last test pit of one would serve also as the first test pit of the other.

This method would allow us to map exactly the locations of all our test pits, while at the same time would keep logistics problems to a minimum. Of course, our efficiency was greatly increased by the re-surveying performed by Duke Power Company, as well as by the accompaniment at all times in the field by Duke Power Company staff familiar with the area.

In addition to test pits excavated in this manner, we planned to excavate others in order to test areas perceived in the field as having high potential. Also, we planned to examine carefully any cleared or plowed areas we discovered while surveying the corridor. Several possibly open areas were recorded from study of aerial photos, and these were listed as places to check for surface examination.

Fieldwork

Fieldwork proceeded almost exactly according to plan. A total of 8 working days with a four-person crew was necessary to complete the designed survey. In addition, a one-day reconnaissance preceded the survey, and one day of photography and test pit excavation at selected sites was spent after completion of the field survey.

Actual field procedures did not deviate from those detailed in our research design. Three days were spent examining the short "fold-in" transmission line segments and the Catawba-Newport (East) line. Sixteen sites were found in these proposed right-of-way, all of which were discovered in eroded or cultivated areas. Intensive collections were made at these sites, in an attempt to gather all artifacts observable. For all sites, however, ground cover restricted visibility, and prevented complete collection. Even though the collections are probably incomplete, we are confident that as representative sample as possible was collected. In addition, we are confident that no large or high-artifact-density sites were missed along the proposed Catawba-Newport (East) line, or the Catawba-Allen, Catawba-Pacolet, and Catawba-Newport (Allison Creek B&W) realignment segments. Small eroded areas, dirt access roads, and patches of cultivation were numerous and relatively closely spaced over the corridors. We do not recommend further discovery-related survey for these lines.

Five working days with a four-person crew were spent in surveying the proposed Catawba-Ripp line. This involved excavation as planned of 393 test pits, each 30 cm square, for the 69 study units selected for our initial sampling. In addition, we carefully examined the entire corridor for areas in cultivation, eroded areas, and other areas of surface visibility. These open areas were very limited within the proposed corridor, but contained all 11 sites found. Not a single artifact was encountered in any of the 393 test pits, even when a "surface" site was present nearby. These results were very disappointing and force us to reconsider the utility of such an approach for general Piedmont survey. It is highly probably that many sites are present in the corridor but simply could not be located by us.

Even though subsurface testing was ineffective, we do not feel that complete reliance on surface examination was adequate for this proposed corridor, or will be adequate for future projects in the region with similar ground cover conditions. New procedures must be developed. Possible alternatives are discussed in a concluding section of this report.

Laboratory Work

Laboratory work on the artifacts and other data recorded during the field survey was carried out intermittently during the Fall of 1978 and the Spring of 1978. Artifacts were cleaned, sorted, and catalogued, and prepared for permanent curation. Site records were completed and placed on file, and photography and drafting were accomplished as necessary for completion of permanent curation requirements and for use in the analysis and report preparation. Detailed comparisons of artifacts recovered were made with those from other collections and with those discussed and illustrated in archeological research literature concerning the region. Significance assessments for the sites were made on the basis of this study, and a plan was developed to mitigate impact to the one significant site located and to the undiscovered sites that may exist in the Catawba-Ripp corridor. Site descriptive data, significance assessments, and recommendations are presented in the following section.

RESULTS AND RECOMMENDATIONS

Site Data and Assessments

All of the 27 sites located during the field survey were discovered in unvegetated areas, and all artifacts collected were found on the ground surface. In general, the sites were monotonously similar, most consisting of a few quartz or slate flakes and fewer bifacial/unifacial tools (if these latter were present at all). All but one of the 27 sites were located in severely eroded areas, with no preservation of archeological deposits. The one exception, 38YK72, has suffered moderate erosion in some areas, but has potential for containing subsurface deposits. Its size and its preservation from complete erosion make it an exceptional site for the interriverine Piedmont.

Table 3 presents data concerning the 27 sites located during the study project. The sites can be classified into 3 major categories: (1) small scatters of flakes, and perhaps a few tools, with no artifacts present that are diagnostic of cultural-historical periods, (2) small scatters of flakes and a few tools, one or several of which are diagnostic of a cultural-historical period, and (3) larger, more dense flake and tool scatters.

Of the 27 sites found in the study areas, 15 contained no artifacts diagnostic of a defined cultural-historical period. These sites were small, and only one contained more than 17 total artifacts. All 15 of these sites are located in badly eroded areas with no archeological deposits preserved. The effects of past agriculture, timbering, and other disturbances on these sites has been so great as to limit greatly their research potential. No further work is recommended at any of these sites and none of them is recommended as eligible for the National Register.

Sites with artifacts diagnostic of particular cultural-historical periods have more research value because, as a group, they can provide data on changes through time in demography, technology, and settlement-subsistence patterns. Twelve sites with at least one temporally diagnostic artifact were found. Of these, 9 were small and contained fewer than 25 total artifacts. All of these 9 are located in severely eroded and disturbed areas and suffer the same limits on research potential as described above for the undiagnostic sites. Data already collected from these 9 sites may have utility for future synthetic studies of Piedmont archeology, but gathering of additional field data would not be cost-effective, and no further work is recommended. These 9 sites are recommended as not eligible for the National Register.

Three sites located during the survey contained significantly larger numbers of artifacts, indicating great intensity of occupation

TABLE 3. Siteand artifact data for the 27 sites located during the study project.

Site Number	Culture-History Assignment	Total Artifacts	Total Lithic Tools	Quartz Artifacts	Slate Artifacts	Pottery	Site Size	Possible Preservation of Deposits	National Register Recommendation	Mitigation Recommendation	Transmission Line
38YK59	--	82[5]	2	40	41	0	2500	no	not eligible	no further work	Catawba-Pacolet Fold-in
38YK60	Guilford	160	14	109	51	0	5626	no	not eligible	no further work	Catawba-Newport, East
38YK61	Palmer, Guilford Otarre	153	13	145	8	0	2500	no	not eligible	no further work	Catawba-Newport, East
38YK62	--	17	0	17	0	0	900	no	not eligible	no further work	Catawba-Newport, East
38YK63	Savannah River (Otarre)	5[6]	1	3	0	0	900	no	not eligible	no further work	Catawba-Newport, East
38YK64	Savannah River (Otarre)	22	3	13	9	0	2500	no	not eligible	no further work	Catawba-Newport, East
38YK65	--	5	0	5	0	0	400	no	not eligible	no further work	Catawba-Newport, East
38YK66	Halifax[7]	25	1	24	1	0	2500	no	not eligible	no further work	Catawba-Newport, East
38YK67	--	3	0	2	1	0	400	no	not eligible	no further work	Catawba-Newport, East
38YK68	--	12	0	12	0	0	400	no	not eligible	no further work	Catawba-Newport, East
38YK69	--	8	1	8	0	0	400	no	not eligible	no further work	Catawba-Newport, East
38YK70	--	8	0	8	0	0	400	no	not eligible	no further work	Catawba-Newport, East
38YK71	--	7	2	7	0	0	2500	no	not eligible	no further work	Catawba-Newport, East
38YK72	Guilford, Savannah River, Otarre, Woodland	228	26	188	22	3[8]	15000	yes	eligible	intensive, controlled surface collection; excavation in tower locs.	Catawba-Newport, East
38YK73	--	11	0	7	4	0	900	no	not eligible	no further work	Catawba-Newport, East
38YK74	Guilford, Woodland	24	1	18	4	2[9]	2500	no	not eligible	no further work	Catawba-Newport, East
38YK75	--	17	1	17	0	0	2500	no	not eligible	no further work	Catawba-Ripp
38YK76	--	7	0	5	2	0	2500				
38YK77	Woodland	3	2	3	0	0	400	no	not eligible	no further work	Catawba-Ripp
38YK78	Savannah River	1	1	0	1	0	1[10]	no	not eligible	no further work	Catawba-Ripp
38YK79	Otarre	1	1	1	0	0	1[10]	no	not eligible	no further work	Catawba-Ripp
38YK80	Woodland	23	4	12	9	2[11]	3600	no	not eligible	no further work	Catawba-Ripp
38YK81	--	6	0	6	0	0	900	no	not eligible	no further work	Catawba-Ripp
38YK82	--	5	0	1	4	0	400	no	not eligible	no further work	Catawba-Ripp
38YK83	--	12	2	12	0	0	900		not eligible	no further work	Catawba-Ripp
38YK84	--	8	2	8	0	0	400		not eligible	no further work	Catwaba-Ripp
38CK50	Guilford	6	1	6	0	0	400		not eligible	no further work	Catawba-Ripp

Notes:
1. See Table 2 above
2. "Total artifacts" is the sum of "Lithic Tools", "Pottery", and lithic flakes (not listed separately).
3. "Slate artifacts" is a catchall category for various local Piedmont, igneous-metamorphic materials, e.g., rhyolite, argilite, banded slate.
4. Site size expressed in square meters; this is an estimate based on surface scatter of artifacts.
5. Includes one Coastal Plain Chert flake of bificial retouch.
6. Includes one Ridge and Valley Chert flake of bificial retouch.
7. Halifax phase dates between Guilford and Savannah River phases; and has been dated at 3884 B.C. (Coe 1964:123).
8. All small, badly worn, grit tempered.
9. Both small, badly worn, grit tempered.
10. Single find.
11. One small, badly worn, grit tempered, and one small, simple stamped, grit tempered.

and perhaps better preservation of the archeological deposits. Two of the 3 sites, 38YK60 and 38YK61, are located on opposite bluffs overlooking Big Allison Creek (now part of Lake Wylie) (see Figure 5). While both of these sites produced large artifact collections, and 38YK61 contained artifacts representative of Early, Middle and Late Archaic subperiods, both sites are severely eroded and disturbed. No soil remains at either site, probably as a result of intensive cotton agriculture in the 19th and early 20th centuries. While erosion has now been checked, the effects of previous agriculture, timbering, and soil movement greatly limit further investigation potential. Artifact collections already recovered constitute a sample for future study of the sites; additional investigation would add only limited information. No further work is recommended for 38YK60 or 38YK61, and neither is recommended as eligible for the National Register.

One site, 38YK72, is recommended as eligible for the National Register on the basis of its potential to yield important information. 38YK72 is located on a broad terrace and slope overlooking Little Allison Creek to the west; it covers approximately 15,000 square meters of a large soybean field (see Figure 6). The site is unique among those discovered in this study project in that it still has soil present on its surface; this characteristic is rare for interriverine Piedmont sites. Test pits excavated at the site indicated that sub-plow zone deposits may remain at least partially intact. Thus, features may be present. At the very least, horizontal stratification (differential placement over the surface) is probably not greatly disturbed, allowing for isolation of temporal components and activity areas and comparisons of these among themselves and with other sites.

Site 38YK72 has the potential for answering questions within several of the problem domains listed above as determining the overall research design. These problem domains are culture-history, activity analysis, lithic procurement and technology, settlement-subsistence patterns, and adaptational change. The multiple components (temporal) present, the moderate artifact density, and, above all, the preservation at the site, all contribute to the evaluation of high research potential for 38YK72. A plan to mitigate effects of transmission line construction to the site is presented in the section below.

Recommendations

Mitigation of Impact to 38YK72

Construction of the Catawba-Newport (East) 230 KV. transmission line will not totally destroy site 38YK72, even if the most destructive construction procedures were to be followed. Duke Power Company can take steps to reduce this impact further. If towers supporting the transmission lines can be placed outside the site, and heavy machinery routed so as to avoid passing over the site, impact will be minimal. Long-term, indirect impacts to the site should not be a problem. The

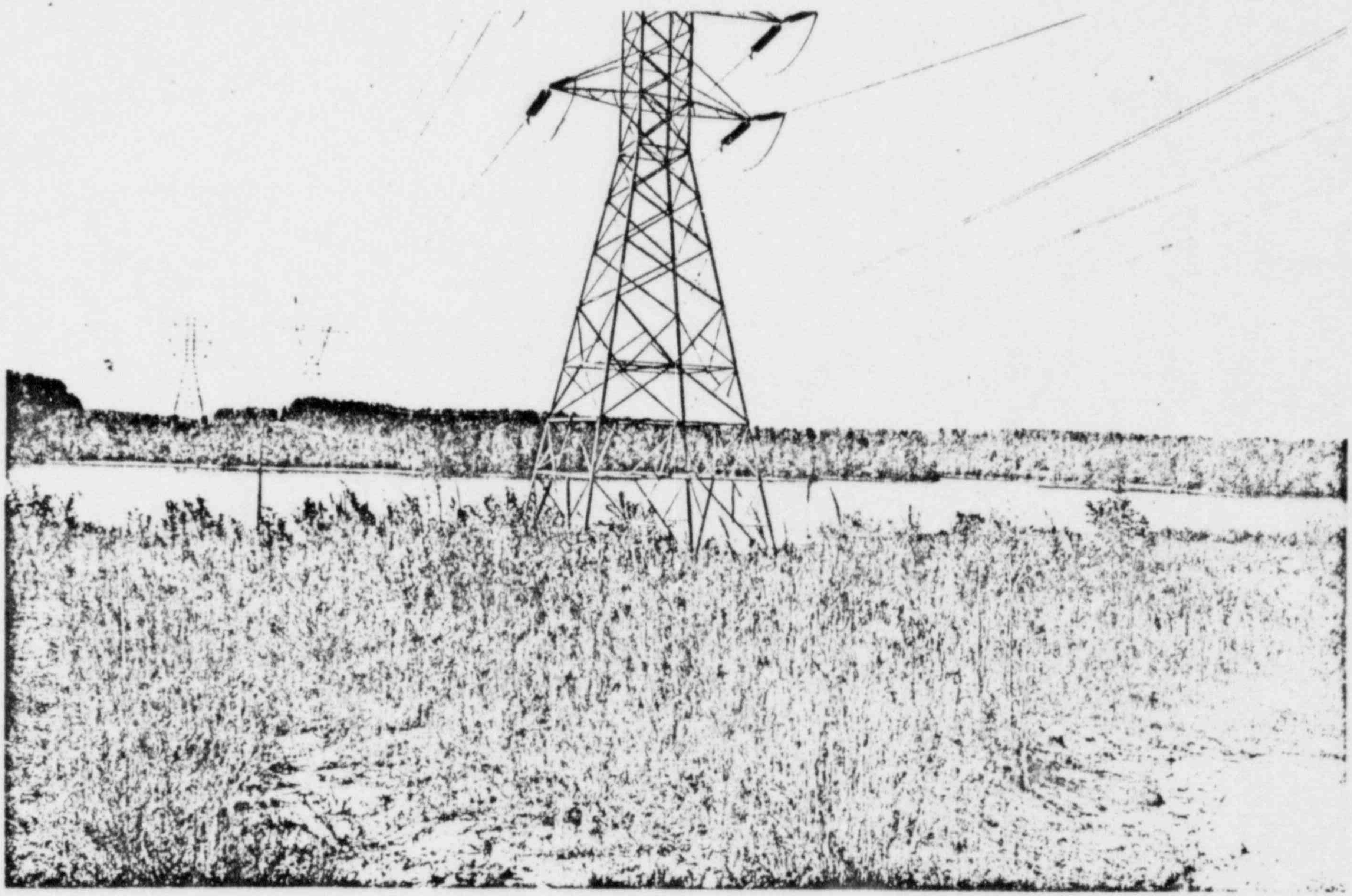

FIGURE 5. View of proposed Catawba-Newport (East) transmission line corridor, facing south. Tower and line construction will be in existing corridor to the east (left) of the two transmission lines shown. Site 38YK60 is in foreground, and site 38YK61 is on top of bluff across Big Allison Creek (now Lake Wylie).

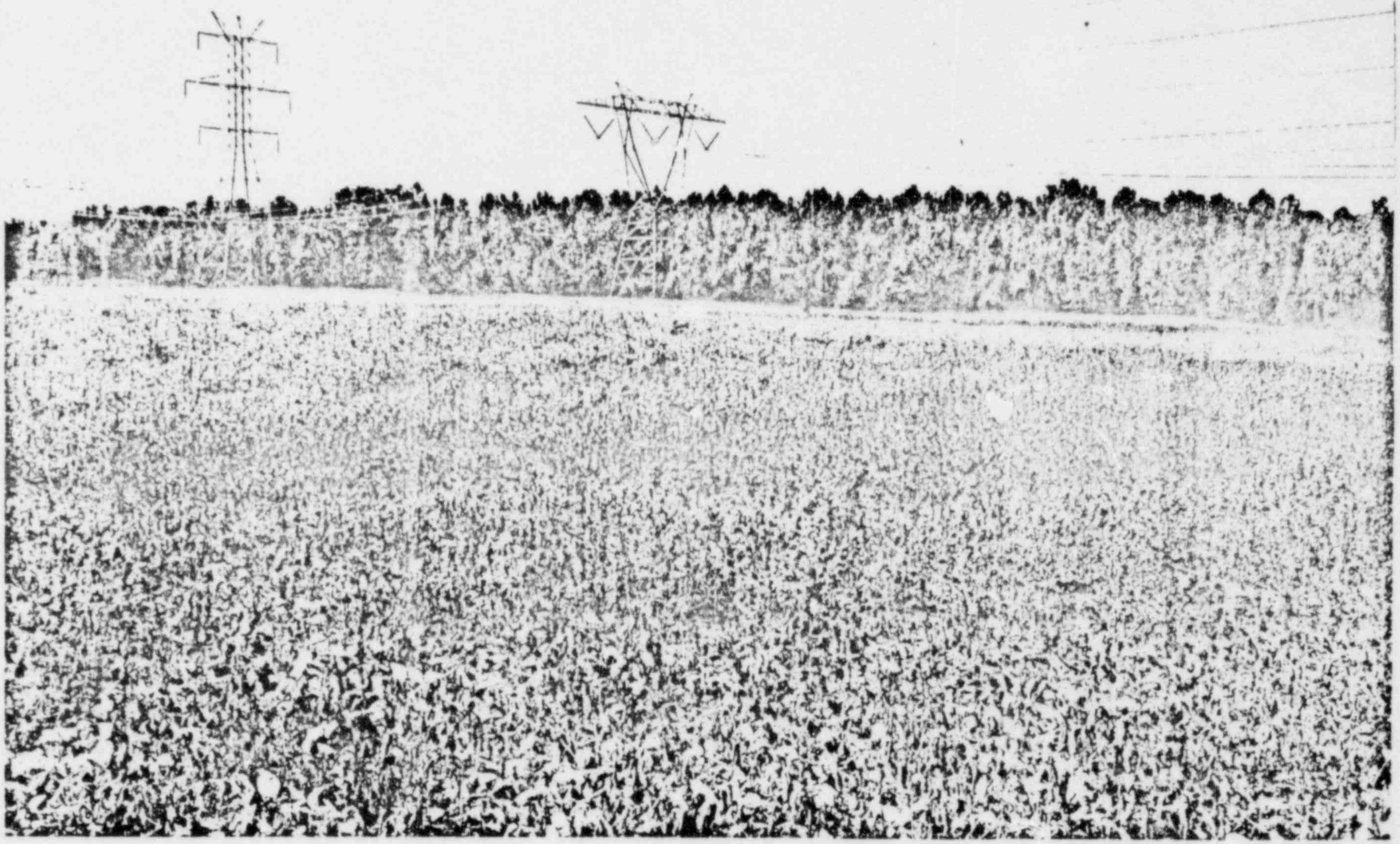

FIGURE 6. View of 38BK72 facing southwest. Site covers a large area presently under cultivation on a terrace and slope overlooking Little Allison Creek.

site is already cleared and is maintained as an agricultural field. Vandalism, erosion, and new construction should be limited because of the farmer's interest in the site area.

Location of towers to avoid 38YK72 may be impossible, however, because of the necessity for an angle, or turn, in the transmission line near the site. In the event tower construction and some heavy equipment movement cannot avoid the site a five-point study program to recover data is recommended to mitigate their effects:

1. Prepare a detailed topographic map of the site area, especially showing its relation to Little Allison Creek to the west.

2. Conduct an intensive, systematic surface collection of the site area to evaluate presence and preservation of historical stratigraphy.

3. Conduct small, limited excavations at proposed tower locations to recover data that would be lost during construction.

4. Perform a detailed study of the data recovered.

5. Make available a report of the study to interested researchers.

Such a study program should not be time-consuming or expensive. A two-person crew could complete a detailed topographic map in 2-3 days, including drafting time. Intensive, systematic surface collection would take a crew of four persons 1-2 days. This surface collection should be done in a period of maximum surface visibility at the site, e.g., after agricultural disking and a heavy rain, but before grass, weeds, or crops begin to grow. Small excavations at tower locations should take a crew of 4 about 1 week. Study of data recovered and preparation of a research report should involve 1-2 persons for about 1 month.

Consideration of Undiscovered Sites along the Ripp Corridor

Although no significant archeological sites were found in the proposed Catawba-Ripp corridor, it is expected that many sites exist there which could not be discovered because of dense vegetation and the inadequacy of current archeological survey methods for such situations. Additional survey under present ground cover conditions is not recommended. It is extremely doubtful if such additional survey, because of its necessary reliance on small, scattered test pits to penetrate the vegetation cover, would result in the discovery of any additional sites.

Numerous small prehistoric sites are expected to still exist in the corridor, but because of their limited size and artifact content, and especially their generally poor preservation, few would probably have enough research significance to qualify them for the National Register. On the other hand, the small amount of data from each of these numerous sites contributes to a pool of information concerning a large area.

Such a pool of information usually results from a survey project with the scope of the present study and provides important data concerning general patterns within a region. This pool of information can be construed to provide for mitigation of impact to the numerous, small sites that may be destroyed as a result of a construction project. It is unfortunate that such a pool of information did not emerge from the present study. Few sites were located, and, because of our lack of confidence in discovery methods, we are uncertain as to the representativeness of this small sample. Thus, substantive contributions to research by the survey project itself are very limited.

It may be possible, however, to solve this problem and, in doing so, test an approach to solving more general problems involved with methods of archeological survey in the Piedmont. Duke Power Company, in constructing the transmission line, will proceed in 3 major steps: (1) forest clearing, (2) disking and seeding the right-of-way with erosion-preventing grass, and (3) tower construction and line placement. Ideal conditions for observation of surface artifacts would occur after disking and before growth of grass cover and tower construction. There will, of course, be impact to the presently unknown archeological sites in the corridor by the forest clearing and disking, but no other feasible means exists for their discovery.

An examination of the corridor after disking would have several great benefits. First, probably all of the sites, rather than just a small, unrepresentative sample, would be recorded. This should allow much progress to be made toward development of a predictive model for site location in the interriverine Piedmont. In addition, it should provide data for a definitive evaluation of survey methods in the Piedmont--archeologists will see for the first time exactly what they are missing by relying on opportunistic surface inspection and test pitting.

Larger collections of artifacts from each site should result from inspection of the freshly disked corridor, allowing for better estimates of the original artifact density and site size. Larger and more representative artifact samples will also give archeologists better information on the range of technology of manufacture and use of stone tools and other implements; such samples could possibly allow better characterization and understanding of the more usual, small, and probably unrepresentative artifact samples.

Recording sites within the disked corridor and collecting artifact samples from them would also have the benefit of providing after-the-fact mitigation of impact to the corridor as a whole. Data recovered would be available to researchers working on a variety of archeological problems. No other approach could provide such data.

Recording of sites within the disked corridor would also have the very useful benefit of allowing more detailed assessment of the destructive impact to archeological sites in the interriverine Piedmont of transmission corridor clearing and disking. Although a great amount of impact is currently assumed, such may not be the case. The intensive cultivation, severe erosion, and prior timbering episodes over most of the interriverine Piedmont may have so disturbed archeological sites present that construction of transmission lines has little further impact. If this is so, future archeological impact survey for transmission lines might concentrate on proposed tower locations as being the only areas of further impact.

For these reasons it is recommended that the Catawba-Ripp corridor be examined for archeological sites immediately after disking. Such a project should not involve extensive time or cost. A crew of 4 persons should be able to walk the corridor and record data in less than 2 weeks. As impact to any sites recorded would have already occurred, there would be no strict schedule necessary for study of the materials and preparation of a report. Such a report, however, should be prepared within a reasonable time to provide the results to those persons attempting related projects. As a follow-up to the present study, such a report would provide unique and much-needed data for those involved in management of Piedmont archeological sites, as well as for scholars interested in studies of the prehistory of the region.

Considerations for Future Archeological Surveys of Transmission Line Corridors in the Interriverine Piedmont

Given the nature of archeological sites in the interriverine Piedmont, i.e., small, with low artifact density, the history of destructive land use practices, and the present heavy vegetation cover over much of the region, it is very difficult to locate sites during archeological impact surveys. Archeologists are in a poor position to predict locations of sites because of inadequate samples from previous studies. Research strategies are also greatly limited by these inadequate samples, and conclusions based on such data may be specious.

Another problem, especially for archeologists involved in culture resource management studies, is the lack of follow-up studies for projects that are not totally destructive of the resources. Archeological studies are usually done in advance of construction, with no monitoring during construction or follow-up inspections after construction. Although such an approach is definitely necessary and may be the only approach feasible for certain totally destructive projects, archeologists should be aware that a more flexible procedure may provide additional, much needed data, especially for projects where impact is not total. One data set that should emerge from the addition of monitoring and/or follow-up phases to a project is that concerning more detailed assessment of construction and maintenance impacts to the archeological resources. Such assessments may allow for much more efficiency in future projects, as well as provide for a flexible and long-term management of the resources remaining after project construction is complete. Benefits of such monitoring and follow-up study phases also accrue to more problem-oriented archeological research because of the additional data that would be generated.

To allow for and to justify properly such monitoring and follow-up studies, archeologists, government regulators, and development agencies and industries may need to become more flexible in their interpretation of what constitutes adequate survey coverage, what should be the unit of significance assessment, and especially, what may constitute mitigation. The 3-step procedure of inventory, assessment, and data recovery (mitigation) in advance of construction may be too limited to accomplish the goal of adequate historic preservation. Monitoring and follow-up studies may be necessary for such preservation, and perhaps should be thought of as mitigating measures themselves. Emphasis on the site as the unit of study for assessment of significance and development of data recovery plans may not be appropriate for all areas or projects. An alternative would be development of mitigation plans based on the overall potential of the impact area. Actual data recovery could then be accomplished before, during, and after construction.

In view of the above comments a program for survey of future transmission line projects in the Piedmont is presented below. First, existing archeological site inventories, archives, and local libraries should be consulted to locate known sites and areas of high potential or interest. If possible, predictions of sites and high interest areas should be made based on topographic features and their established correlation with known archeological sites. Attempts should be made to contact local persons who are artifact collectors, amateur historians, or who otherwise may help in the location of sites. Such contact may include personal interviews, requests for assistance through the media, or presentations to local organizations. A second phase would involve identification of areas where surface visibility is good and a high survey efficiency would be possible. This identification should be made through study of detailed maps and aerial photos, a brief reconnaissance of the area, and, perhaps, an overflight.

A third phase would involve actual field survey of selected areas. Those areas with high surface visibility would be inspected, and areas of high interest or site potential would be tested, probably with subsurface excavations. A fourth phase would involve study of data collected and preparation of an interim management-oriented report. Such a report would assess sites known by that time, as well as additional project area potential, and recommend mitigation measures as necessary. Mitigation measures, if necessary, would require additional phases involving excavation/data recovery, monitoring and additional site recording during construction, follow-up studies after construction, and preparation of a final project report.

Of great interest in Piedmont transmission line studies is the potential of monitoring and follow-up studies for providing after-the-fact mitigation as well as useful information for future research projects. If significance can be construed as applying to the potential, undiscovered sites in a project area, then the only feasible mitigation of construction impact to this resource potential is, in many cases, through monitoring and follow-up studies.

The addition of monitoring and follow-up study phases to an archeological impact project should actually reduce the overall project cost. Each phase would be more efficient in that it would be targeted toward activities with a highly favorable cost-benefit ratio. Trudging through the forest, blindly excavating subsurface test pits in highly eroded areas, as was done in the present project, would be eliminated. In addition to eliminating such unproductive activity and thereby increasing efficiency, monitoring and follow-up studies should greatly increase the available data with a minimum effort. This would act also to increase the project efficiency.

The greatest benefit to adding monitoring and follow-up studies to archeological surveys in the Piedmont would be the long term increase in the archeological data base. Perhaps no other approach offers a way out of the problems of inadequate samples now faced by archeologists studing the prehistory of the region.

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APPENDIX

THE ARCHEOLOGICAL TESTING PROGRAM
at Site 38YK72

by

Veletta Canouts

INTRODUCTION

The site of 38YK72 was first recorded in August of 1978 during an archeological survey for Duke Power's Catawba Nuclear-Newport (East) 230 kV transmission line. Situated on a slight rise, 30 m north of an intermittent drainage and 150 m east of Little Allison Creek, the site yielded a wide variety of lithic tool forms and raw materials. At least six temporal components have been defined through diagnostic bifaces and the presence of pottery. Paul Brockington identified Guilford, Savannah River, Otarre, and Woodland affiliations. Veletta Canouts and William Marquardt from the Institute of Archeology and Anthropology, accompanied by Andrew Cloninger from the Duke Power Company, visited the site in November of 1979 and recovered a Palmer basal fragment from an earlier Archaic component. A Morrow Mountain biface was recovered from the site during the testing phase in December of 1979.

The site locational data from the survey show that archeological materials occur commonly on top of ridge systems that parallel the higher ranked drainages or creeks in the Piedmont. Although Site 38YK72 is but one of many occurrences, it has a higher density and greater variety of materials than other sites located in the transmission line corridor. In addition, the archeological record at this locus apparently has a greater integrity than many Piedmont sites since the topsoil has not been eroded away completely.

Because of the density of Archaic materials relative to other inter-riverine Piedmont sites, the presence of a later ceramic component which might signal features, and limited soil disturbance which might permit observations of artifact associations, the site was considered potentially eligible for nomination to the National Register of Historic Places. In the event that the proposed construction could not avoid the site, Brockington recommended a five-point study program to document the site more fully. Because this site was the only one selected for testing, it assumes a unique significance relative to understanding the archeological record of the area.

No archeological testing ensued prior to the construction of a transmission tower at the southern edge of the site area in the fall of 1979. Up to that point, site disturbance had been confined to the cultivation of soybeans and probably some indirect impact, in the form of vehicular and pedestrian traffic, from the construction of two transmission lines on the western boundary of the site, nearer Little Allison Creek. Some studies of the effects of plow disturbance on archeological materials have been undertaken recently (e.g., Talmage et al. 1977; Roper 1976). They reach the conclusion that although materials are mixed and dragged laterally, their relative positions, that is artifact concentrations and associations, appear to reflect the original site patterning. Few, if any, such studies have been undertaken to record the impact of transmission line construction on archeological sites.

In order to begin to document the impact of transmission line construction on archeological sites, the Institute of Archeology and Anthropology conducted a limited testing program for three days in December of 1979 after tower construction had been completed. Twenty-five one-meter square collection units were randomly located within the transmission line right-of-way, north of Tower #27. Five of the units were then excavated to sterile soil. A discussion of the testing program follows. With respect to the Catawba-Newport transmission line project, no further archeological work is recommended at this site.

Methodological Problems

Because the site was only cursorily collected on the initial survey and not formally tested, it is not possible to quantify, or even qualify with any reasonable certainty, the condition of the present artifactual materials and their distributions relative to their condition and distribution prior to tower placement. This information is necessary in order to understand and recognize those changes actually attributable to the short-term, direct impact of transmission line construction.

The construction variables may be reconstructed with some degree of confidence. The four tower pods were sunk to a depth of eight feet. The crane used to set the tower was transported on wide, balloon tires. After construction, the area around the excavation was smoothed and planted with millet to control erosion. Andrew Cloninger furnished this information and ventured to guess that these activities occurred during a dry period in the fall of 1978. Briefly, the site would seem to have been affected by surface disturbance due to machine traffic, perhaps some compression due to heavy loads (although wide, balloon tires would tend to equalize this pressure), disturbance of artifacts lying in the first 20 cm below the surface during construction of the tower pods, and the possible collection of diagnostic artifacts by crew members.

Impact to archeological sites by transmission line construction has been described as limited and minor relative to other developmental projects. Intensive collection and post-holing or small-scale excavation are believed to provide adequate means for sampling the information potential of Piedmont surface sites and for satisfying mitigative requirements in most cases (Brockington 1977a: 4,7). However, before the results of such sampling strategies can be substantiated, better information about the data potential of the sites before (and after) project impact is required. Two problem areas are extremely important: lateral displacement of artifacts and the relationship of surface to subsurface materials.

Lateral Displacement

Artifact assemblages of surface sites situated in the Piedmont have been displaced laterally by deforestation, cultivation, and soil erosion, to mention a few agents. What then is the data potential of these sites prior to project impact? For example, 38YK72 has been plowed and is still under cultivation. As mentioned earlier, studies have begun to ask questions about the effects of discing in dragging and breaking artifacts. But to interpolate information from these general studies to conditions at a particular site in the South Carolina Piedmont is very questionable. More studies are needed in order to contend with regional and local variability with reference to soil type, type of cultivation, type of machinery, length of cultivation, etc. (James Michie, personal communication).

To address this problem at Site 38YK72, a portion of the site needed to be disced and materials plotted before and after discing. For purposes of comparison, a similarly controlled experiment to measure vehicular and pedestrian traffic on a site should be conducted, preferably just prior to tower construction elsewhere in this or a similar area. Unfortunately, poor weather conditions stayed plowing at 38YK72, and these data still need to be collected and quantified in other testing programs.

Relationship of Surface to Subsurface Materials

The investigation of mixed deposits may be better considered with respect to the relationship between surface and subsurface deposits. Leaving aside until later the issue of in situ archeological deposits, the first question addressed is whether the composition of the surface assemblage is an accurate representation of the subsurface assemblage and the total assemblage. The next question to follow is whether the surface patterning, with reference to density, artifact associations, and spatial isolates, reflects the subsurface patterning. This question bears directly on feature or provenience data from undisturbed subsurface deposits.

These are important questions that relate to the amount of information that can be retrieved from surface data. Subsurface testing is a very labor intensive proposition. The degree to which it is to be employed depends upon the nature of the site, the research problem under investigation, and in cultural resource management studies, the effects of project impact on the site. The latter is of major concern in this study.

Investigations into these relationships are just beginning in the South Carolina Piedmont and elsewhere. The I-77 investigations offer a starting point (House and Ballenger 1976; House and Wogaman 1978). In a preliminary testing phase, Winthrop College students under the direction of Veletta Canouts (1976) excavated Site 38YK25A and there made an attempt to identify and deal with the horizontal and vertical vectors of disturbance. Preliminary results indicated a close correspondence between the content of the surface and subsurface assemblages -- that is, a similar range and proportion of artifacts. Furthermore, the area of greatest artifact concentration on the surface also turned out to have the greatest amount of subsurface materials.

A more thorough testing program was initiated at the Windy Ridge site, 38FA118 (House and Wogaman 1978). This study suggests that there is indeed spatial patterning in subsurface deposits that have been disturbed. In this case, disturbance was limited to a possible tree fall and plowing which took place 30 to 40 years ago. An intact sandy loam zone was discovered below the plow zone and above the subsoil (House and Wogaman 1978: 36).

Although the investigations were conducted in two stages, to attempt to maximize the potential for isolating activity sets, the time constraints did not allow the analysis interval needed to recognize distributional patterns. The Stage I and Stage II results produced some information on sampling biases, however. For example, Morrow Mountain bifaces seemed to cluster in Stage I but in opening the Stage II block excavation outside the cluster area, a high number of Morrow Mountain bifaces was recovered. The suggestion is that both data sets may indicate a concentration of bifaces further east, a "tip of the iceberg" effect (House and Wogaman 1978: 122).

As interesting as these results are, they cannot be related back to a controlled surface collection, especially a plowed surface. Contour maps of controlled surface collections of plowed sites have produced spatial patterns (see Goodyear 1975: 18-19). But few studies have compared surface and subsurface data. Many such studies are needed before a generalizing (quantifiable) stage is reached in which the surface occurrences will help predict subsurface occurrences (see Goodyear 1975 for a discussion outlining long-term investigation and integration of information retrieved from discrete sites).

If it should be ascertained that transmission line construction and maintenance activities do not cause very severe impact and if disturbance factors can be controlled and surface data relied upon to indicate the nature of the subsurface remains, the extent of archeological testing (or mitigation) can be circumscribed. Surface data are more readily accessible both in survey reconnaissance and intensive survey.

FIELD STRATEGY

The Institute of Archeology and Anthropology planned a three-day testing program for Site 38YK72. Under the direction of Veletta Canouts, assisted by Michael Harmon from the Institute and Andrew Cloninger and Stan Berg from Duke Power, field investigations were conducted from December 19 through December 21, 1979. A total of 70 person hours was spent in the field, mapping the site and sampling the surface and subsurface deposits.

The site of 38YK72 is located on a second rank drainage, Little Allison Creek which now flows into Lake Wylie, an artificial lake produced by the Wylie Dam across the Catawba River. The site itself occupies some 25,000 square meters of a broad sloping terrace. Artifacts appear on the surface for a distance of 125 m east of Little Allison Creek to the base of a small knoll and from an intermittent drainage just south of Tower #27, 200 m north to an east-west running fence (Fig. 7). The depth of the topsoil suggested the possibility of sub-plow zone features to Paul Brockington (p. 34). Soil probes, during a visit to the site in November 1979, revealed sandy loam deposits, 20-30 cm in depth.

At that time, the soybean staff had been plowed under. Tower #27 was in place at the southern edge of the site, and the tower pods were surrounded by grass planted to control erosion. Erosional gullies occurred downslope along the western edge of the 230 kV transmission line right-of-way. Stony, depleted soils lay underneath the 500 kV transmission line paralleling the project line further downslope. A relatively high number of artifacts were visible there. While their number may have been due to slope wash, the same area yielded a high number of artifacts during the first survey when the fields were in soybeans.

Because of the limited testing program, activities were confined to the right-of-way near the tower pod, as it was the primary area of impact. Without plowing, which ground conditions did not permit, surface visibility was rather disparate. No plowing meant also that controlled data on artifact movement could not be gathered. Therefore, the field strategy focused on the relationship between surface and subsurface assemblages at a ratio of 25 surface collection 1x1 m squares to 5 subsurface 1x1 m excavation units. Cold weather and stony, wet ground interfered with the efficiency of the testing program.

A datum was first set up near the northwest corner of Tower #27 (Fig. 8). The southwest corner of 15 collection squares was located north of the tower using a table of random numbers to determine vectors and distance. The coordinates were chosen to conform to the right-of-way boundaries, approximately 23 m either side of the centerline. The extra help provided by the Duke Power representatives facilitated the operations, and a second datum was set up approximately 60 m north of Datum 1; both datums had a 180° sweep and a 50 m radius.

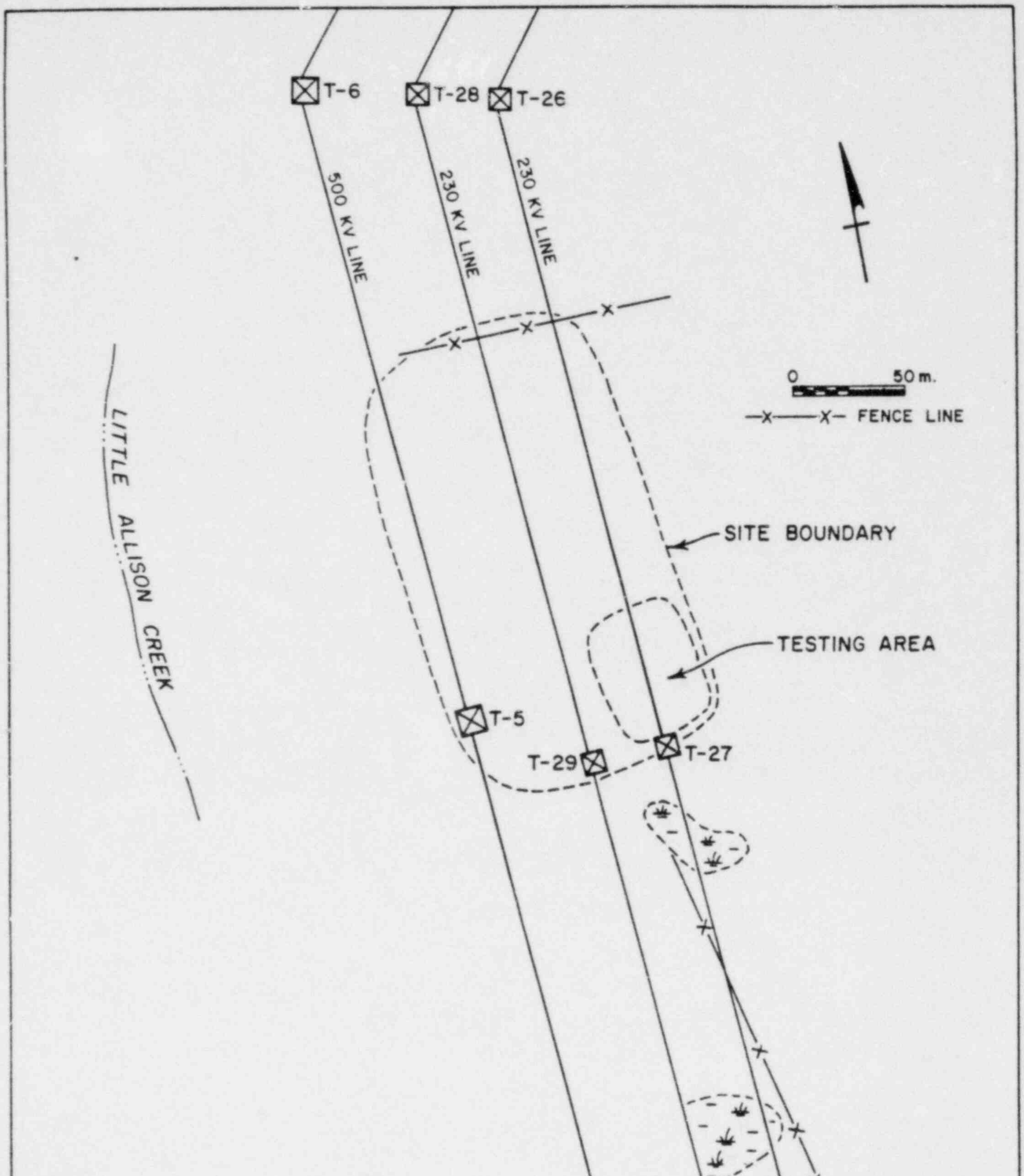

FIGURE 7: Catawba-Newport (East) Transmission line: 38YK72.

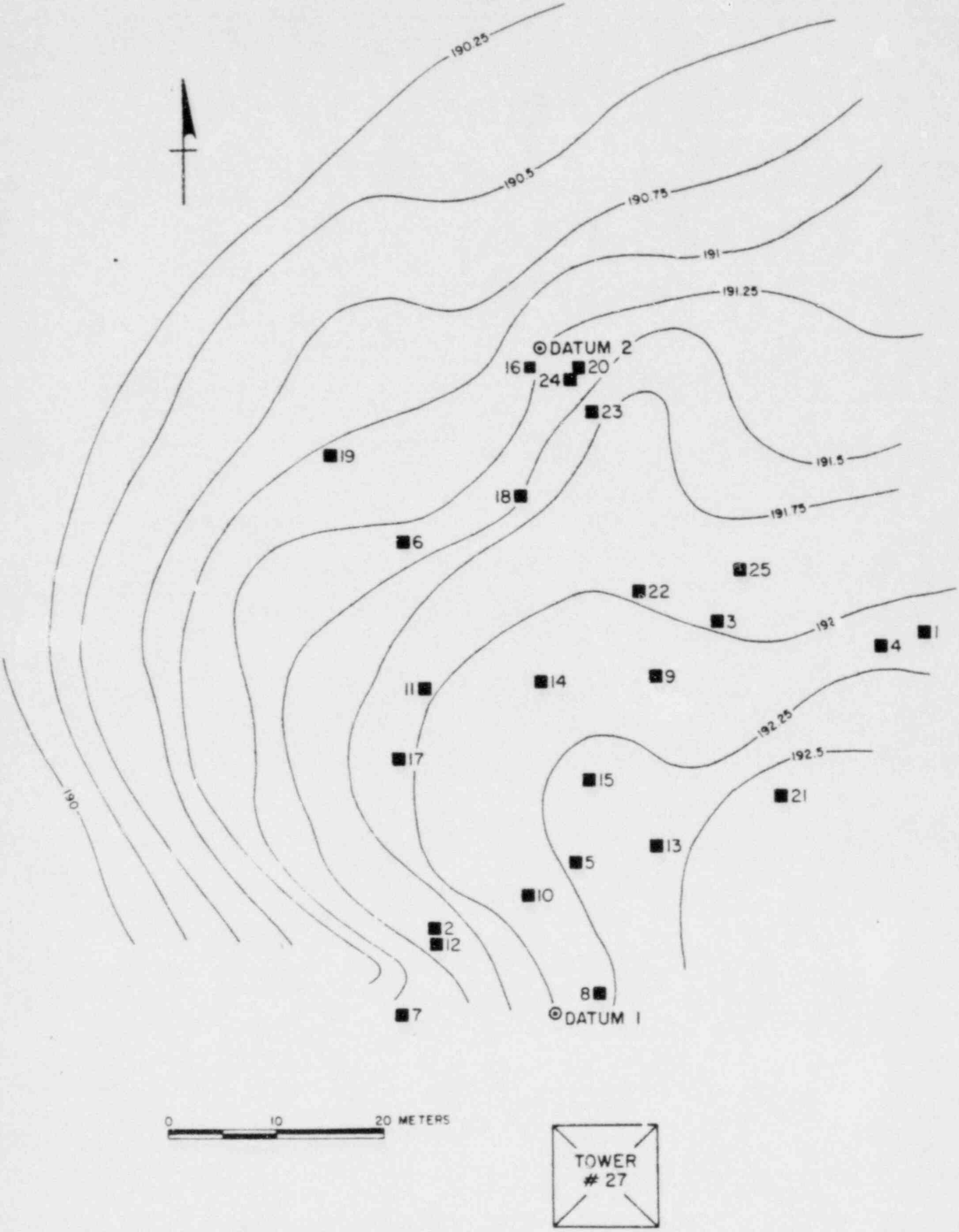

FIGURE 8: Testing Area at 38YK72.

Ten more squares were located south of Datum 2.

Thus, the squares were randomly located over a 2750 square meter area within the southeast quadrant of the site, approximately a .9% sample, or about .1% of the total site area. A stratified, unaligned sample would have insured better dispersion over the area. However, the efficiency of this method may not have been realized with such a small sample. The simple random sample was faster and easier to employ under the circumstances.

Each 1x1 m square was cleared of vegetation, and except where noted, a 100% collection was made of all surface materials. Clearing effected between 25% and 100% surface visibility, with half the squares exhibiting 90% or better visibility and three-fourths, 50% or better. Points for a contour map were recorded while the surface collection was underway: 20°/10 m intervals around Datum 1 and 40°/10 m intervals around Datum 2 (Fig. 2).

Based on a curscry field examination of the collections, the squares were stratified according to potential artifact counts and location: Group 1 - 16, 20, 23, 24; Group 2 - 14; Group 3 - 7, 12; Group 4 - 1, 3, 4, 5, 8, 9, 13, 15, 21, 22, 25; and Group 5 - 2, 6, 10, 11, 17, 18, 19. One square (underlined) was selected from each of these groups, using a table of random numbers were appropriate. One and one-half days were spent excavating these units. The deposits were screened (¼" mesh) with a power sifter. The rocky matrix in Sample Squares #2 and #7 and the wet clay encountered in the remaining squares caused difficulty. In order to clean the screen and keep it operating, much more of the matrix than originally anticipated had to be sacked and returned to the laboratory. Water screening to facilitate the initial sorting of these materials was conducted at the Institute in Columbia, South Carolina, during the first part of January.

Each excavated unit displayed a unique soil profile. There are few Piedmont site excavations to aid in assessing their archeological potential (cf. Cable and Michie 1977; House and Wogaman 1978; Canouts 1976). Most Piedmont soils have been heavily deflated and exhibit truncated soil profiles. The typical Cecil sandy clay loam, which comprises the testing area, exhibits the following horizons: 1) A horizon,, 0-15 cm of dark brown, sandy loam; 2) B horizon, 15-35 cm of yellowish-red, friable clay loam; and 3) C horizon, 35+ cm red, firm clay (U.S. Department of Agriculture 1965: 16).

All five excavated units contained between 10-15 cm of the fine, brown loamy topsoil. As expected from its slope position and nearby erosional gullies, Sample Square #7 had the least amount of topsoil. A transitional coarse grained clay strata containing mineral stains, probably manganese oxides, which occurred in Sample Square #7, was absent from the adjacent Sample Square #2. Similar mineral stains were observed in Sample Square #25 on the eastern edge of the site where the topsoil was once again shallow.

Sample Squares #14 and #24, located midfield, had by far the greater topsoil depth of 15 cm. No clay was encountered below the tilled soil in Sample Square #14. Instead, the excavators shoveled easily through a decomposing, granitic matrix. The parent soils derive from amphibolite, minor schists, and gneiss (Butler 1966: Plate 1). The higher elevation on which the square was located results from the underlying geologic formation which gives the illusion of, and even substance to, a greater soil depth.

Only in Sample Square #24 were there a few centimeters below the brown loamy tilled horizon A and above a stained, brown clay horizon C where subsurface features might have remained partially intact (Fig. 9). However, no soil changes were observed. The extent of this stratum is impossible to predict since the soil profiles appear to be so highly variable.

One anomolous feature was noted in the south profile of Sample Square #25. A moderately compact, mottled clay-filled half circle appeared at the bottom of the excavation. The top of the feature began 18 cm below the surface and widened to 40 cm in diameter, 40 cm below the surface. Although the fill was more mottled and slightly less compact than the surrounding clay matrix, the texture was remarkably similar. Another faint stain appeared in a quarter circle at the base of the southwest corner. As no cultural or organic associations were noted and as neither feature originated at the surface, some kind of naturally decomposing geologic feature is suggested. There is a very slight possibility that they may be culturally derived from earlier historic activities indicated by a few late nineteenth and early twentieth century items occurring in the area.

In all, about 1.5 cubic meters of soil were excavated. Fifty centimeter square units were excavated to between 20 to 35 cm into subsoil, once the bottom of the A and B horizons had been reached. All the artifacts were recovered in the A horizon or plow zone, in the first 10 to 15 cm. Except for Sample Squares #7 (1 level) and #24 (3 levels), the plow zone was removed in two levels, which have been collapsed into one for the analysis of the surface to subsurface artifact ratios.

Testing Results

The testing results emphasize the diversity of the artifacts from 38YK72: their number, type, and raw material. These data will contribute to a discussion of the vertical relationship between surface and subsurface cultural deposits. Distributional data which might indicate horizontal differences relative to occupational density or activity loci could not be quantitatively generated from the limited surface collection and even more limited subsurface excavation. In an effort to supplement the data base, the uncontrolled surface collections from the survey and testing phases are included.

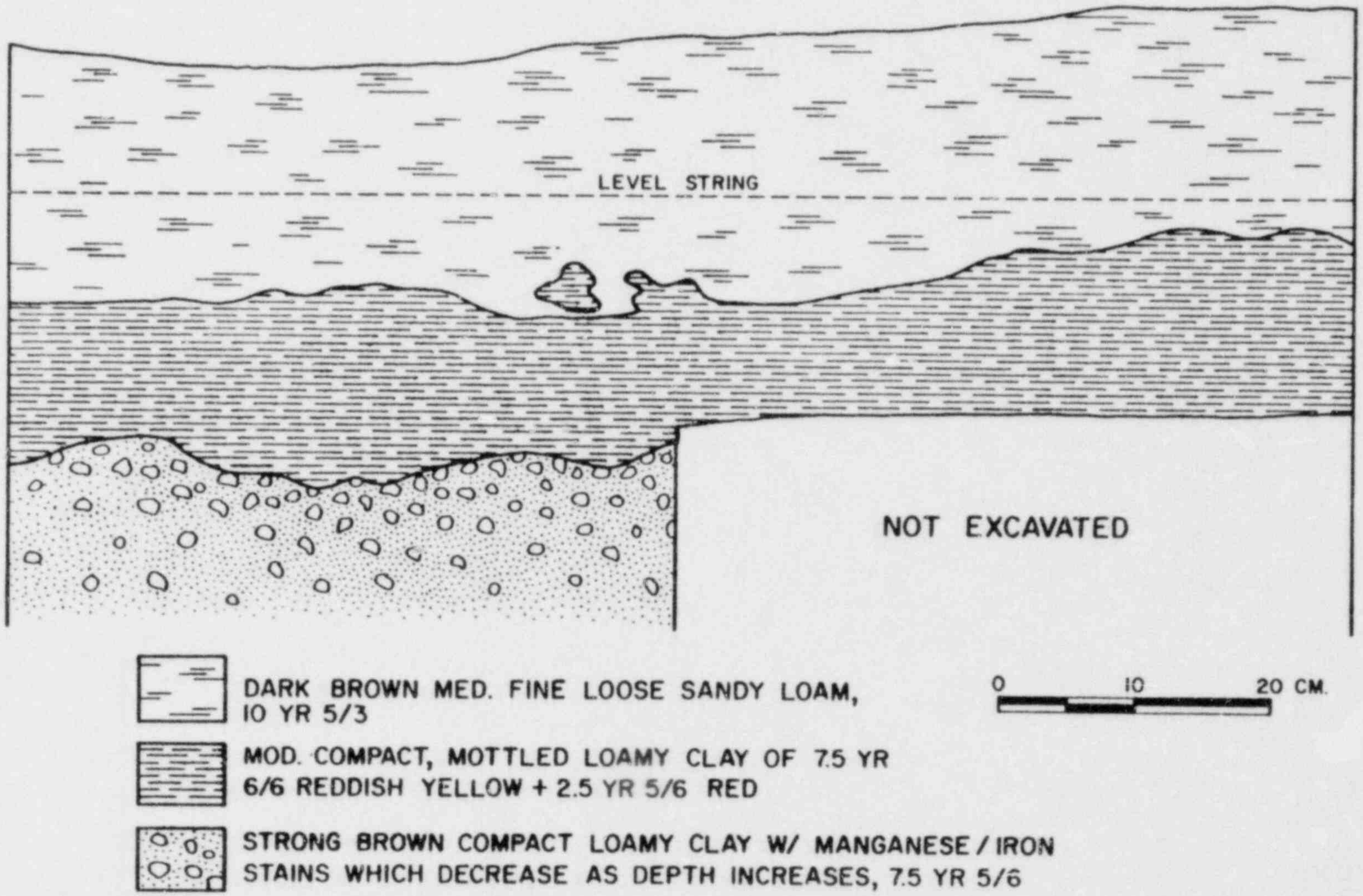

FIGURE 9: Profile of Sample Square #24.

TABLE 4

SURFACE COLLECTION: FLAKED STONE

RAW MATERIAL	Chunks	Bifacially Worked Chunks	Primary Flakes	Secondary Flakes	Biface Thinning Flakes	Utilized Flakes	Bifaces	TOTALS
Quartz (qtz)	16	4	9	129	25		26	209
Rhyolite (rhy)	2		3	21	13	3	2	44
Felsic Tuff				4	1		1	6
Basalt (bst)				3				3
Chert					3		1	3
Argillite (arg)				1				1
TOTALS	18	4	12	158	41	3	30	266

The general surface collection introduces some artifact diversity. A total of 272 artifacts was collected: flaked stone tools, utilized flakes, debitage, and stone and pottery sherds (Tables 4 - 6). Six temporal periods were identified by diagnostic bifaces (Table 6, see Table 2). Table 4 provides a comparison of flaked stone to type of raw material. Raw material identification follows the description of lithic types by Novick (1979). The major discrepancy between Novick and the discussion by House and Wogaman (1978: 53-57) concerns the identification of "Carolina Slate." Although the debate is not over, the more generally acceptable typology assigns a volcanic origin to the "Carolina Slate" (Derting 1980). As used here, banded and unbanded varieties of rhyolite are comparable to what has been called "Carolina Slate."

Ubiquitous quartz has the greatest representation, on the order of five times the second ranked rhyolite. The remaining lithic types might be considered almost rare. But all are available locally. The most exotic, non-local type is the Tennessee Ridge-and-Valley chert which was manufactured into a Palmer biface. The other two gray chert specimens may have been imported from further north, as well (Novick 1979: 432).

TABLE 5
SURFACE COLLECTION: STONE AND POTTERY FRAGMENTS

NUMBER	DESCRIPTION
5	Plain, coarse quartz tempered sherds (1 with a blackened interior)
1	Worked steatite sherd
3	Unworked schist fragments
1	Unworked, weathered rhyolite fragment
1	Unworked small quartz cobble
1	Unidentified, weathered green fragment
12	

The descriptive typology used to analyze the debitage conforms basically to that employed by House and Wogaman (1978: 58-60) with the following modifications. A bifacially worked chunk category has been added. Apparently, the number of bifacially worked chunks recognized at Site 38YK72 is the result of working with variable quality quartz. These quartz chunks have had several flakes removed but have not been reduced to a blank or preform stage. Their bifacial reduction pattern eliminates their consideration as cores.

TABLE 6

HAFTED BIFACES FROM THE SURFACE OF 38YK72

TYPE	RAW MATERIAL	TL	HL	BW	HW	THICKNESS	WEIGHT	COMMENTS
Palmer	chert	21.1	8.9	24(?)	22.2	8.2	14.1	broken blade
Morrow Mt	quartz	41.6	13.7	22.6	17.7	10.6	7.7	broken tip
Guilford	quartz	44.9		TW 20.3		12.3	10.6	broken tip
Guilford	quartz	49.1		TW 20.6		9.4	9.9	broken tip
Guilford	quartz	43.3		TW 22.2		8.5	7.7	concave base
Savannah R	quartz river cobble	53.1	14.9	42.7	24.6	13.7	35.0	broken tip
Savannah R	banded rhyolite	49.0	14.5	20.8	50.5	9.4	24.8	broken tip, one side corner notched
Savannah R	quartz	50.1	9.9	33.8	19.6	11.8	19.3	broken tip and broken corner of base
Savannah R	quartz	55.9	12.8	44.7	20.0	19.0	47.0	broken tip
Savannah R	quartz	38.2	9.8	32.2	19.8	14.9	19.1	broken tip
Savannah R	quartz	54.8	12.3(?)	39.1	18.7(?)	11.8	21.4	broken base and tip
Savannah R	quartz	58.8	12.5	27.6	15.6	10.9	18.0	whole
Savannah R	quartz	60.5	9.7	35.6	18.4	15.5	27.6	whole
Otarre	quartz	44.0	11.8	32.1	15.5	8.6	14.0	broken tip
Otarre	quartz	43.0	10.2	28.5	18.2	10.5	13.7	broken tip
Unnamed Woodland stammed	rhyolite	30.1		TW 26.5		8.3	7.2	broken base and tip
Unnamed stemmed (MM?)	quartz	25.4		TW 27.1		8.5	5.3	broken base

KEY: TL Total Length HL Haft Length BW Blade Width (TW Total Width) HW Haft Width (after House and Wogaman 1978: 63).
All measurements in mm and gr

House and Wogaman's (1978: 59) flake category encompasses primary, secondary, and biface thinning flakes. Primary flakes are decortication flakes which exhibit an outer cortex. Secondary flakes correspond to the other flake category and are interior or intermediate reduction stage flakes. Biface thinning flakes or flakes of bifacial retouch result from the last stages of manufacture and resharpening. The model of a biface reduction system was originally presented in House and Ballenger (1976: Fig. 15). In the analysis, flakes which had questionable thinning flake attributes were assigned to the secondary flake category.

The high correlation that holds between off-site raw materials acquisition and smaller flake size is readily apparent from Table 4 (e.g., House and Ballenger 1976: 131). In contrast, all stages of biface reduction are represented by quartz. The amount of on-site quartz was quite high. Over 100 kg of quartz rock from Sample Squares #2 and #7 were discarded in the laboratory. One Savannah River biface was manufactured from a quartz cobble, and at least one quartz cobble, which would have been extracted from a stream bed, was collected on the surface. However, most quartz artifacts were derived from quartz-veined bedrock. Although no on-site rhyolite source was observed, one unworked fragment found on the site and the number of debitage classes represented suggest a complete manufacturing sequence. Indeed, the rhyolite is more locally available than was recognized when this material was identified as "Carolina Slate" (House and Ballenger 1976: 126; House and Wogaman 1978: 54-55). The greater ratio of biface thinning flakes to other flakes probably relates to the better technological qualities of rhyolite, and as a consequence, better morphological attributes exhibited by the biface thinning flakes.

The general surface collection was a biased sample, and these data patterns are only suggestive. Comparison of the surface and subsurface assemblages incorporates the quantitative data from the Sample Squares. The nature of the general surface assemblage is quite different, in analytical terms, than the controlled surface and subsurface assemblages. That is, general surface collections often consist of only those materials which are unquestionably cultural artifacts. Quartz artifacts present a special case in such collective policies. Quartz is not a good medium on which to distinguish cultural use patterns and natural fractures. Plowing quartz artifacts and natural quartz rock together obscures the distinction even further. To compensate, the analysis of quartz artifacts from the Sample Squares allowed a greater range of variability. This decision was prompted by the fact that the wide dispersal of the Sample Squares did not permit an evaluation of continuous or even concentrated artifact distributions and by the fact that evidence of continued occupation suggested a high incidence of cultural remains relative to natural deposits.

A rather high percentage of Sample Squares yielded no surface artifacts (Table 7). It is encouraging to note that a few artifacts were recovered in the subsurface excavation of one of these squares, Sample Square #25 (Table 8). Frequency estimates based on 28 prehistoric artifacts for a 25 square meter area is approximately one artifact

TABLE 7

SAMPLE SQUARES: SURFACE ASSEMBLAGE

Provenience	Chunks	Bifacially Worked Chunks	Primary Flakes	Secondary Flakes	Biface Thinning Flakes	Historic Artifacts	Comments
1				1 qtz	1 arg		
					1 qtz	1 brick frag.	
2	1 qtz	1 qtz					
3							no artifacts
4							no artifacts
5			1 qtz				
6							no artifacts
7	2 qtz	1 qtz		3 qtz			
8						1 clear glass	
9							no artifacts
10				1 qtz	1 rhy		
11	1 qtz						
12	2 qtz	1 qtz		1 qtz	1 rhy		
13							no artifacts
14		1 qtz					
15					1 qtz		
16				1 qtz	1 qtz		
17				1 qtz			
18					1 qtz		
19							no artifacts
20							no artifacts
21							no artifacts
22				1 qtz			
23							no artifacts
24	1 qtz						
25							no artifacts
TOTALS	7	4	1	9	7	2	10

TABLE 8

SAMPLE SQUARES: SUBSURFACE ASSEMBLAGES

Provenience	Chunks	Bifacially Worked Chunks	Primary Flakes	Secondary Flakes	Biface Thinning Flakes	Other Stone	Pottery	Historic Artifacts
2	2 qtz	1 qtz		1 bst 3 rhy 7 qtz	1 qtz	1 steatite sherd 1 unworked steatite fragment		1 iron, round-headed nail 1 clear glass fragment
7	1 qtz			1 rhy 7 qtz	1 qtz	2 unworked steatite fragments		1 green glass fragment
14	3 qtz			2 rhy 7 qtz				
24	1 qtz	1 qtz		8 qtz	1 qtz	2 steatite fragments (one side worked?)		1 albany glazed stoneware fragment
25	2 qtz						1 plain, coarse sand tempered sherd	1 alkaline glazed stoneware fragment
TOTALS	9	2	0	36	3	6	1	5

per square meter. Density estimates based on cubic meters, given five squares each measuring 1x1x(ca).13 m by volume is 57 prehistoric artifacts per .65 cubic meters, or almost 90 prehistoric artifacts per cubic meter. As some of the squares were selected on the basis of their high artifact potential and as the identification included questionable flakes, a lower estimate would be more reasonable. Two immediate influencing factors to consider are the effects of long-term artifact collecting on the site and the different spatial densities. With regard to the latter, the testing area was confined to the southeast quadrant of the site which exhibited a fair amount of surface material.

The assemblage diversity or range of artifact types decreases as the sampling fraction decreases: the biface and utilized flake categories of the general surface assemblage were missing from the controlled surface assemblage and the primary flake category was missing from the subsurface assemblage. Of the range of raw materials, felsic tuff and chert were missing from the controlled Sample Squares. Table 9 shows the proportional differences between the flaked stone debitage of the three assemblages. Interestingly enough, the controlled surface collection does not correspond very closely to either the general surface or subsurface assemblages. This lack of correspondence is probably due to the small sample size, for when the Sample Squares are combined, the match is much better.

In summary, specific reference is made to the numerical relationship between surface and subsurface assemblages in the five excavated units (Table 10). The comparison is limited to the number of flaked stone artifacts, as these were the only prehistoric artifacts recovered in the controlled surface collections. The surface to subsurface artifact ratio for these five sample units is 1:5. However, the variability is such that at a 95% confidence level it ranges from as low as 1:13 to as high as 1:3. Additional studies along similar lines should help reduce this variability if other site variables such as site depth and spatial differences relating to temporal period and activity loci can be controlled as well.

TABLE 9

COMPARISON OF THE FLAKED STONE DEBITAGE

DEBITAGE ASSEMBLAGE	Chunks	Primary Flakes	Secondary Flakes	Biface Thinning Flakes	TOTALS
General Surface	18	12	158	41	229
Controlled Surface	7	1	9	7	24
Controlled Subsurface	9	0	36	3	48
TOTALS	34	13	203	51	301
General Surface	8%	5%	69%	18%	100%
Controlled Surface	29%	4%	38%	29%	100%
Controlled Subsurface	19%	-0-	75%	6%	100%
General Surface	8%	5%	69%	18%	100%
Sample Squares	22%	1%	63%	14%	100%

TABLE 10

SURFACE TO SUBSURFACE ARTIFACT RATIO:
PREHISTORIC FLAKED STONE

SAMPLE SQUARE #	SURFACE ARTIFACTS (y)	SUBSURFACE ARTIFACTS (x)
2	2	15
7	6	10
14	1	12
24	1	11
25	0	2
n = 5	$\bar{y} = 10$	$\bar{x} = 50$
	$\bar{y} = 2.0$	$\bar{x} = 10.0$
	$s_y = 2.35$	$s_x = 4.85$

$$\hat{R} = y/x = .20$$

$$s^2_{\hat{R}} = \hat{R}^2 (1 - f) \frac{(V_x^2 + V_y^2 - 2\rho V_x V_y)}{n}$$

Hanson, Hurwitz, and Madow 1953: 163

where V = Coefficients of Variation
ρ = Coefficients of Correlation
f = Sampling percent at .002
y = Number of Surface Artifacts
x = Number of Subsurface Artifacts

Computation form for standard deviation for calculator:

$$s_{\hat{R}} = \frac{\sqrt{1 - f}}{\sqrt{n}\ \bar{x}} \sqrt{\frac{\Sigma y^2 \quad 2\hat{R}\Sigma yx + \hat{R}^2\Sigma x^2}{n - 1}}$$

Cochran 1963: 31

$$s_{\hat{R}} = .10$$

THE STRUCTURAL POSE AT 38YK72

Up to this point, the analytical discussion has been confined to the methodological problems concerning the representativeness of the various assemblages. Before these relationships can be extended to other sites, the underlying structural pose must be considered. A structural pose is simply "the way a simple human society (is) appropriately organized at a particular moment for a particular purpose" (Gearing 1962: 15). Following Wilmsen's (1970) lead in archeology (cf. House and Wogaman 1978: 126 ff.), the assemblage and spatial patterning exhibited at this site will be discussed in terms of "structural poses," that is, the activity sets. Archeological identification of activity sets depends upon a functional analysis of the assemblages, the spatial distributions of the artifacts and features, and their temporal placement, all of which are difficult to assess at Site 38YK72.

The multicomponent nature of the site contributes to the high spatial and artifactual heterogeneity. The data base is the product of a number of distinct, perhaps continuous, occupational episodes. Some 7,000 years are represented by the diagnostic artifacts. Even though the primary adaptive strategy during that long period of time relied on hunting and gathering, use of the same space for the same purpose cannot be assumed. Archeologists have recently suggested that different occupational episodes can be spatially isolated. The characterization of the different artifact assemblages according to exploitative strategies and temporal periods, which is also receiving new emphasis, should help further to define these areas.

Although the controlled surface collections were not extensive enough to provide spatially discrete results, the general surface collection suggests possible spatial differences. The artifacts are scattered over a larger area than initially calculated during the survey when the field was covered with soybeans. The scatter is not uniform and becomes very sparse at the peripheries of the site. At least two broad areas of concentration have been recognized: Area 1- an area of relatively flat relief north of Tower #27 where the testing phase occurred; and Area 2- another relatively flat area underneath the 500 kV transmission line adjacent to Tower #5 (Fig. 7). Whether these level surfaces are natural or the result of transmission line construction is difficult to say. Some differences are reflected in the artifacts. In the first area, quartz artifacts predominate. The majority of the Savannah River bifaces were collected there as were all the steatite specimens. Area 2 contained more non-quartz artifacts. Since the topsoil is almost completely eroded from this area, the non-quartz artifacts may just be more visible. These data are far from conclusive.

For temporal placement, the only diagnostic artifacts distinguishing 6,000 years of Archaic occupation are the diagnostic bifaces which account for just over 5% of the surface flaked stone assemblage. The steatite and pottery sherds which generally signify Late Archaic and Woodland respectively add little information to the identity of these periods. If Savannah River and Otarre bifaces and steatite sherds are added together, they account for about 55% (15/27) of the diagnostic artifacts, or about 5% (16/356) of the total (surface and subsurface) prehistoric assemblage. This frequency is higher than the remaining periods added together and suggests a greater intensity of Late Archaic occupation, either by a larger group or through greater repetition of activities.

Site activities which cause site variability have been outlined in House and Wogaman's (1978: 126 ff.) discussion of inter-riverine Piedmont archeological sites. The two major hypotheses relate to the degree of habitation: whether the site was used for intensive settlement or used as a hunting and gathering camp. From an evaluation of the test implications for Windy Ridge (38FA118, a Piedmont ridgetop site located in Fairfield County, northeast of Winnsboro, South Carolina), House and Wogaman concluded that the site was a hunting-butchering camp for procurement of white-tailed deer. Since many test implications depended upon relative measures, Site 38YK72 will be compared, whenever possible, to Site 38FA118.

Unlike Site 38FA118, Site 38YK72 is located in a favorable habitative setting adjacent to a permanent creek. Like 38FA118, it displayed no structural or subsurface features, but 38YK72 did contain more ceramic and steatite sherds relative to the amount of surface survey and subsurface excavation which occurred at both sites. The remaining test implications characterize the flaked tool assemblage.

The debitage classes relate to the production of bifaces. To differentiate early stage biface reduction stages found at quarry and workshop sites from resharpening stages which would indicate maintenance activities, House (House and Ballenger 1976: 96-98) developed two indices: one of manufacture, ER = # of chunks + other flakes/ # of thinning flakes; and one of use, BD = # of bifaces/ # of other flakes. Treating the surface data as a single component yields the following results: ER = 4.59 and BD = .14 (excluding the bifacially worked chunks). The ER index of 38FA118 was .8; the BD index, .20. The ER index reflects primarily the quartz flaked stone as it comprises over 75% of the lithic assemblage at 38YK72. As House (House and Ballenger 1976: 99) noted, veined quartz may not be quarried but worked on an ad hoc basis at many extractive sites. Such a behavioral pattern would give a relatively high index of primary reduction. Furthermore, the number of broken bifaces at 38YK72 indicates a high rate of discard through use.

The range of tools at 38YK72 is fairly narrow: 3 utilized flakes; 20 hafted bifaces and biface fragments; and 10 other bifaces, including 1 knife and 2 blanks. All of the utilized flakes were of rhyolite.

One rhyolite thinning flake exhibited three utilized edges. Twenty-six bifaces were of quartz. While a decision not to conduct an edge wear analysis on these bifaces was based on the limited scope of work, quartz does not lend itself well to edge wear analysis because, depending on the grade of quartz, the edges usually exhibit a broken or crushed appearance rather than good concoidal fractures (Baker 1976; Dickson 1977).

A few preliminary observations were recorded, however. Only six of the bifaces were complete or almost complete. The remainder were broken stems, tips, or mid-sections. Interestingly, several bifaces displayed diagonal breaks across the blade between one-third and one-half of the way down from the estimate tip. Of the six broken Savannah River stemmed bifaces, three exhibited diagonal breaks, whereas only one was broken straight across. The Guilford bifaces and Morrow Mountain biface had their very tips broken. The other pronounced diagonal break found on the Palmer biface does not appear to be a use break (Keith Derting, personal communication). A slight imperfection in the chert probably caused it to break t e when it was damaged by a fire or a plow. The use breakage patterns of the Savannah River bifaces do suggest heavy pressure such as would be exerted in butchering tasks.

In summary, the general tool assemblage manifested at 38YK72 compares favorably with that at 38FA118. The data fit best the expectation of a hunting and butchering camp for the procurement of game animals; that is, the "artifact assemblage is dominated by the outputs of manufacture (of locally-available raw materials), use, resharpening, breakage and discard of stone butchering tools" (House and Wogaman 1978: 130-131). The site appears to have been most intensively occupied during the Late Archaic period. Its position next to Little Allison Creek, the presence of steatite and pottery vessels, and the early stage biface reduction debitage suggest a temporary campsite with associated support activities, such as cooking and tool manufacture and replacement.

CONCLUSIONS

The artifact data gathered at Site 38YK72 contributed significant information concerning prehistoric adaptation in the South Carolina Piedmont. An analysis of the assemblages and their spatial distributions reveals that 38YK72 was in all likelihood a Late Archaic campsite where animals (possibly white-tailed deer) were butchered. A more intensive settlement is not indicated due to the narrow range of artifact types and uses and the lack of features. Despite the number of temporal components found on the site, the general assemblage was remarkably homogeneous, which suggests that earlier and later occupants were performing a limited set of activities, probably also associated with game procurement. This site, then, comprises only one small structural unit within a larger subsistence-settlement framework. Other adaptive stances in the framework would include basecamps, plant collecting stations, fishing areas, etc. necessary to complete the full range of subsistence activities occurring on a yearround basis. Although white-tail deer were hunted primarily in the fall and early winter by later historic and protohistoric Indians Smith 1975; Canouts 1971), there is no evidence to suggest that deer procurement was such an exclusive seasonal event in the Archaic period (House and Wogaman 1978: 22).

Very few archeological sites are recorded for York County; a total of 44 prehistoric sites was listed by Taylor (1979: 74). This site is the second open lithic scatter to be tested (Canouts 1976). Both sites were tested because construction activities threatened to impact the integrity of the sites. In the case of 38YK72, a tower for the 230 kV Catawba Nuclear-Newport (East) transmission line was erected on the southeast edge of the site (Fig. 7). As the site was not tested before tower placement, its direct impact on the condition and distribution of the artifacts could not be monitored.

This site is but one of many which will ultimately contribute information concerning artifact displacement and the reliability of surface evidence to predict the total site variability. Such information will, in turn, aid in assessing the degree of impact from this and similar projects. The present data set provides artifact frequency, density, and compositional measures for .1% of the total site area. In no way has the information potential of this site been fully recorded. However, no further investigation of this site is recommended in conjunction with the Catawba transmission line project. Although the site will continue to sustain impacts from cultivation and possible tower or transmission line maintenance, if the site continues to be managed as it has been, sufficient data should remain for future investigations.

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REQUEST FOR ADDITIONAL INFORMATION

240.1 The description of low flow periods on the Catawba River at Lake Wylie does not give an adequate picture of the effects of droughts on plant operation. Provide analysis of droughts, including at least the drought of record, showing the effects on water levels in Lake Wylie in relation to minimum required levels at the intake structures. The analyses should include both the frequency and duration of shutdowns of the plant due to inadequate water supply or low water levels. (Refer also to Section 3.3.2)

Response: Section 2.4.1.1

240.2 Provide your estimate of the frequency of the assumed drought for the SNSWP. Also, Section 2.4.1.1 seems to indicate that an intake from Lake Wylie to the SNSWP is provided, but Section 2.4.3 does not discuss this. Please clarify and if makeup can be provided, provide this range of water levels at which the intake can operate.

Response: Section 2.4.3

240.3-a Provide descriptions of the floodplains (as defined in Executive Order 11988) of all water bodies, including intermittent water courses; within or adjacent to the site. On a suitable scale map, provide delineations of those areas that will be flooded during the one-percent chance flood in the absence of plant effects (i.e., pre-construction floodplain).

Response: Section 2.4.1.1

240.3-b Provide details of the methods used to determine the floodplains in response to a. above. Include your assumptions of and bases for the pertinent parameters used in the computations of the one-percent flood flow and water elevation. If studies approved by Flood Insurance Administration (FIA), Housing and Urban Development (HUD), or the Corps of Engineers are available for the site or adjoining area, the details of analysis need not be supplied. You can instead provide the reports from which you obtained the floodplain information.

Response: Section 2.4.1.1

240.3-c Identify, locate on a map, and describe all structures, construction activities, and topographic alterations in the floodplains. Indicate the status of each such structure, construction activity and topographic alteration (in terms of start and completion dates) and work presently completed.

Response: Section 2.4.1.1

240.3-d Discuss the hydrologic effects of all items identified in c. above. Discuss the potential for altered flood flows and levels, both upstream and downstream. Include the potential effects of debris accumulating on the plant structures. Additionally, discuss the effects of debris generated from the site on downstream facilities.

Response: Section 2.4.1.1

240.3-e Provide the details of your analysis used in response to d. above. The level of detail is similar to that identified in item b. above.

Response: Section 2.4.1.1

240.3-f Identify non-floodplain, alternatives for each of the items (structures, construction activities and topographic alternations) identified in c. above. Alternately, justify why a specific item must be in the floodplain.

Response: Section 2.4.1.1

240.3-g For each item in f. above that cannot be justified as having to be in the floodplain either show that all non-floodplain alternatives are not practicable or commit to relocating the structures, construction activity or topographic alternation out of the floodplain.

Response: Section 2.4.1.1

240.4 Calculate the radiological consequences of a liquid pathway release from a postulated core melt accident. The analysis should assume, unless otherwise justified, that there has been a penetration of the reactor basemat by the molten core mass, and that a substantial portion of radioactively contaminated sump water was released to the ground. Doses should be compared to those calculated for the Liquid Pathway Generic Study (NUREG-0440, 1978) small riversite. Provide a summary of your analysis procedures and the values of parameters used (such as permeabilities, gradients, population affected, water use). It is suggested that meetings with the Staff of our Hydrologics Engineering Section be arranged so that we may share with you the body of information necessary to perform this analysis.

Response: To be submitted in subsequent revisions.

290.1 Provide a short narrative describing the present status of the application of renewal for the NPDES permit filed with the S. C. Department of Health and Environmental Control on June 11, 1979.

Response: Table 12.3.0-1

290.2 Make available for examination during the site visit one copy of aerial photographs used to determine forest and land use types along the Catawba transmission corridors.

Response: Photos were made available at time of site visit.

290.3 The intake structure has been significantly redesigned since issuance of the CP-EIS. Provide the intake bay cross sectional area under both full pond and maximum drawdown conditions, the size mesh of the traveling screens, a description of traveling screen operation and the purpose and functioning of the pullout screen bay. Discuss impact of new design relative to impact of CP stage design.

Response: Section 3.4.3

290.4 The discharge structure has been significantly redesigned since issuance of the CP-EIS. Provide a description of and purpose of the proposed design change.

Response: Section 3.4.4

290.5 In addition to other requested information, provide a summary and brief discussion in table form, by section, of differences between currently projected environmental effects (including those that would degrade, and those that would enhance environmental conditions) and the effects discussed in the environmental report submitted at the construction permit stage.

Response: Table I-1

290.6 Provide an estimate of the maximum probable yearly recreational harvest of finfish, shellfish and molluscs harvested from waters downstream of the station to the Atlantic Ocean that potentially could be contaminated by radionuclides due to a maximum probable accident. The harvest estimates should be summarized by species and location of capture (water body segment) and provide an explanation of how the estimate was obtained.

Response: Section 2.2.2, Tables 2.2.2-12 through 2.2.2-14, Figures 2.2.2-2 and 2.2.2-3

290.7 Using data from the last 5 years from the National Marine Fisheries Service provide an estimate of the maximum probable of yearly commercial harvest of finfish, shellfish, and molluscs harvested from waters downstream of the station that potentially could be contaminated by radionuclides due to a maximum probable accident. The harvest estimates should be summarized by species and location of capture (water body segment). Provide a generalized explanation of how the estimate was made.

Response: Section 2.2.2, Tables 2.2.2-15 through 2.2.2-17, Figures 2.2.2-2 and 2.2.2-3

290.8 Provide a copy of the following references from Section 2.2; 2, 7, 21, 59.

Response: Copies were made available at site visit.

290.9 (ER-OL Sec. 3.6.2) Discuss the plant operational practices or plant design features that will result in planned 0.1 mg/liter maximum total residual chlorine concentration in plant blowdown discharge.

Response: Section 3.6.2

290.10 (ER-OL Sec. 3.6.2) Estimate the time duration that residual chlorine will be present in the plant discharge (for other than sanitary waste discharge) after each application to the cooling towers.

Response: Section 3.6.2

290.11 (ER-OL Sec. 3.6.2) Provide additional information on the type, amount, and frequency of use of the organic biocide control of chlorine resistant organisms. Identify changes in planned usage from that evaluated at the CP Stage.

Response: Section 3.6.2

290.12 (ER-OL Sec. 3.7.1) Indicate on a diagram of the site the location of the outfalls from the temporary and permanent sewage treatment systems into Lake Wylie.

Response: Figure 2.1.1-5 Section 3.7.2

290.13 (Table 3.3-1) The average flows cited for station water use do not add up to the total withdrawal cited for the intake from Lake Wylie. Also, a source of the average flow values in the table (e.g., LPSW intake, sanitary and potable water) do not coincide with those shown in Figure 3.3.1-1. Please clarify these discrepancies.

Response: Table 3.3.1-1

290.14 (Table 3.6.1-1) Indicate the source of the limits cited in the table.

Response: Table 3.6.1-1

290.15 (Table 3.6.1-2) The average chemical concentration values cited in the table are based on 7 cycles of concentration. It is stated in the text that the plant will operate at 10 cycles of concentrations but that optimum value is 8. Indicate the basis for the determination that 8 cycles is the optimum value. Resolve the discrepancy between the table and text values, based on your projected actual operating mode and revise table 3.6.1-2 to reflect the anticipated cycles of concentration.

Response: Section 3.6.2

290.16 (ER-OL Sec. 5.1) Indicate whether and where vegetative screening will be used on-site for alteration of plant generated noise.

Response: Section 5.1.4

290.17 (ER-OL Sec. 5.1) Identify and provide a discussion of the operational phase noise levels and expected impacts on nearby noise sensitive lands and sampling locations, identified in Sec. 2.7.

Response: Section 5.1.4

320.1 Please provide production cost analysis which show system operating cost associated with both the availability and unavailability of the proposed nuclear facility costs resulting from this type of analysis generally represent the variable or incremental expenditures (fuel, operation, and maintenance) necessary to supply system load. If, in your analysis, other factors influence the cost of energy production, explain in detail.

a. The analyses should assume electrical energy grows at (1) the system's latest forecasted growth rate, and (2) zero growth from the latest annual energy load experience.

b. The analysis should provide results on an annual basis covering the period from initial operation of the first unit through five full years of operation of the last unit.

c. For each year (and for each growth rate scenario), the following results should be clearly stated: (1) system production costs with the proposed nuclear addition available as scheduled; (2) system production costs without the proposed nuclear addition; (3) the average fuel cost and variable O&M for the nuclear addition and the sources of replacement energy (by fuel type) - both expressed in mills per kwh; and (4) the proposition of replacment energy assumed to be provided by coal, oil, gas, etc.

d. Where more than one utility shares ownership in the proposed nuclear addition, the analysis should include results for the aggregate of all participants.

e. All underlying assumptions should be explicitly identified and explained.

Response: Section 1.3

451.1-a To expedite the meteorological review, provide hour-by-hour meteorological data from the onsite measurements program for the period 1975-1977 on magnetic tape using the enclosed guidance on format and tape attributes. Additional data collected since 1977 should also be included if available.

Response: Section 6.1.3

451.1-b One year of hour-by-hour meteorological data are necessary for evaluating the environmental consequences of Class 9 accidents. From the period of record of hour-by-hour meteorological data provided on magnetic tape, select a representative continuous one-year period where data recovery for wind direction, wind speed, atmospheric stability indicator, and precipitation are high. (All missing data should be properly identified on the magnetic tape.) Substitutions are necessary for each of the four parameters missing for any hour during the selected one year period. Substituted data should not be incorporated into the magnetic tape, but rather provided as a separate listing. The listing of substituted data should identify the date, time and the value of the parameter to be substituted. Also identify the source of the substituted data, and provide a brief description of the bases for selecting the substituted data. In the selection of substitutions for long periods of missing data, the diurnal and synoptic cycles should be considered.

Response: Section 6.1.3

451.2 Explain the statement made on page 2.3-2 that "changes in the numerical values of X/Q and D/Q estimates result from the correction of a coefficient in the calculation of stable plume rise pertaining to the respective codes used for these purposes", what X/Q and D/Q values have changed? What computer codes were previously incorrect?

Response: Section 2.3

451.3 Identify the sources and periods of record of the data presented in Table 2.3.0-1. Update extreme values as appropriate to reflect meteorological events occurring since 1960.

Response: Section 2.3

451.4 Tables 2.3.0-2 and 2.3.0-3 are somewhat misleading. Although the tables are entitled "1975-1977" wind occurrences" for the 40 m and 10 m levels, respectively, implying 3 years of data, examination of the tables indicates the data are for just 2 years. Identify the period of record for Tables 2.3.0-2 and 2.3.0-3.

Response: Tables 2.3.0-2 and 2.3.0-3, Section 2.3

451.5 Table 2.3.0-3 indicates that wind speed less than 5.5 mph occur about 58% of the time at the 10 m level; however, only about 0.7% apparently can be classified as "calm". Define the threshold for calm winds and indicate the reasonableness of such a small fraction of calm conditions.

Response: Section 2.3

451.6 The first part of Table 2.3.0-6 identifies annual average X/Q values at various intake vents around the site. Provide the distance and direction from the release points to each intake for distances less than 100 m, describe how appropriate σ_z values were determined.

Response: Section 2.3

451.7 The second part of Table 2.3.0-6 identifies a single population X/Q value to 50 miles from the plant. Explain the significance of such a single value of X/Q to represent are directions out to a distance of 50 miles. Provide arrays of annual average X/Q and D/Q values by distance and direction out to 50 miles from the plant for use in determining population exposure from routine releases of radioactive material to the atmosphere.

Response: Section 2.3

451.8 The analyses of atmospheric effects of the mechanical draft cooling towers at Catawba are apparently based solely on empirical data from "a mechanical draft cooling tower at the Duke Cliffside Plant" (p. 5.1-4)

a. Discuss the validity of extrapolating from observations of the operation of one tower to six considering differences in number of tower units, tower shape, orientation, topography, meteorology, heat load and evaporation.

Response: Section 5.1.4

b. Figures 5.1.4-1 and 5.1.4-2 depict frequencies of visible plumes estimated in the vicinity of the Catawba site for summer and winter. Annual mean values at meteorological parameters considered representative of the Cliffside and Catawba facilities are presented on pages 5.1-5 and 5.1-6. Discuss seasonal variation in meteorological conditions at the Cliffside and Catawba facilities, and indicate how seasonal differences were considered in developing Figures 5.1.4-1 and 5.1.4-2.

Response: Section 5.1.4

451.9 An inconsistency appears to exist between the preoperational meteorological measurement program described in Section 6.1.3 and the preoperational program described in Section 6.1.3 and the preoperational program described in Section 6.2.4 "which will continue during the operational program" (page 6.2-2) with respect to monitoring of visibility. Describe the preoperational program designed to provide "baseline" measurements of meteorological conditions affected by operation of the mechanical draft cooling towers, and describe the operational program to assess the affects of the cooling towers. Identify the type(s) and locations of visibility monitoring equipment, data reduction procedures, and calibration and maintenance schedules.

Response: Section 6.2.4

451.10 Describe the status of the onsite meteorological measurements program since December, 1977.

Response: Section 6.1.3

451.11 Assuming that meteorological measrements are made on or near the microwave tower identified in Figure 6.1.3-1, the measurements are made at a distance of about 700 feet from the Western edge of Unit 1 Turbine Building, about 1100 feet from the Southwestern edge of the Unit 1 Reactor Building, and about 1400 feet West of the Mechanical draft cooling tower complex. Provide the heights of these structures and discuss possible building influence on meteorological measurements. Also, discuss the possible effects of the condensate plume, humidity plume, and drift from the cooling towers on meteorological sensors and data recovery.

Response: Section 6.1.3.1

451.12 Provide the percent recovery for each of the following parameters for the period December 17, 1975 to December 16, 1977: wind speed at the 40 and 10 m levels; wind direction at the 40 m and 10 m levels delta temperature (10 m and 40 m); dry bulb temperature and dew point temperature at 10 m; and precipitation.

Response: Sections 2.3, 6.1.3

451.13 The discussion of the rationale for not adjusting the straightline Gaussian dispersion model to consider spatral and temporal variations in airflow (page 6.1-14) requires further elaboration: a) Explain how measurements made at an elevation 90 feet above Lake Wylie and 70 feet above plant grade on nearly the highest elevation near the plan can be expected to identify nocturnal downslope airflow, b) The definition of stagnation (i.e., winds less than 1 mph) appears to be unnecessarily restrictive. Stagnation conditions can be accompanied by wind speeds considerably higher than 1 mph. Wind speeds less than 5.5 mph occur nearly 60% of the time at the 10 m level of the onsite meteorological measurement program. Discuss the behavior of effluent plumes in the vicinity of the Catawba site during conditions with wind speeds less than 5.5 mph, and indicate if "recirculation" of the plume is possible during these conditions.

Response: Section 6.1.3

451.14 The starting threshold for the wind direction and wind speed sensors are 0.7 mph and 0.6 mph, respectively (page 6.1-8). However, in the discussion of minimum wind speed to be used in dispersion calculations, a value of 0.45 m/sec (1.0 mph) is selected. Discuss this inconsistency.

Response: Section 6.1.3.2

451.15 Discuss the rationale for using meteorological data from the 40 m level (762' elevation) in the calculation of annual average atmospheric dispersion conditions when the height of the station vent is at an elevation of 719 feet.

Response: Section 6.1.3.2

451.16 The onsite meteorological measurements program used to provide data for the Construction Permit Review was apparently in a different location than the present program. Identify on Figure 6.1.3-1 the location (including base elevation) of the meteorological towers used to provide data for the CP review, and compare data from the period 7/71-6/72 with more recent data from the present measurements program. Data from the earlier period showed strong secondary airflow from the northeast which is not discernable from data presented in the ER. Discuss the rationale for siting the current meteorological measurements system in its present location, and discuss the representativeness of the data collected at this location.

Response: Figure 6.1.3-1, Section 6.1.3

470.1 Although Table 5.2.4-1 of the ER compares the estimated doses from the Catawba Station with the Appendix I dose design objectives, it does not compare the estimated quantities of non-tritium liquid effluents and I-131 airborne releases with the curie limits contained in the Annex to 10CFR50 Appendix I. If a cost benefit analysis is not going to be performed, then the estimated quantities of the preceeding effluents should be compared with the curie limits in the Annex to 10CFR50 Appendix I.

Response: Table 5.2.4-1

470.2 Section 5.2.4.4.1 of the ER discusses population doses from ingestion of drinking water. However, the population data used in § 5.2.4.4.1 is not consistent with the population data in ER Table 2.1.3-5. For example, Table 2.1.3-5 lists 330,000 persons using the Catawba River as a drinking water site, whereas § 5.2.4.4.1 lists only 210,000 persons for all populations served by Lake Wylie and the Catawba River. Resolve this apparent discrepancy and provide the population size ingesting water from the major sources of water.

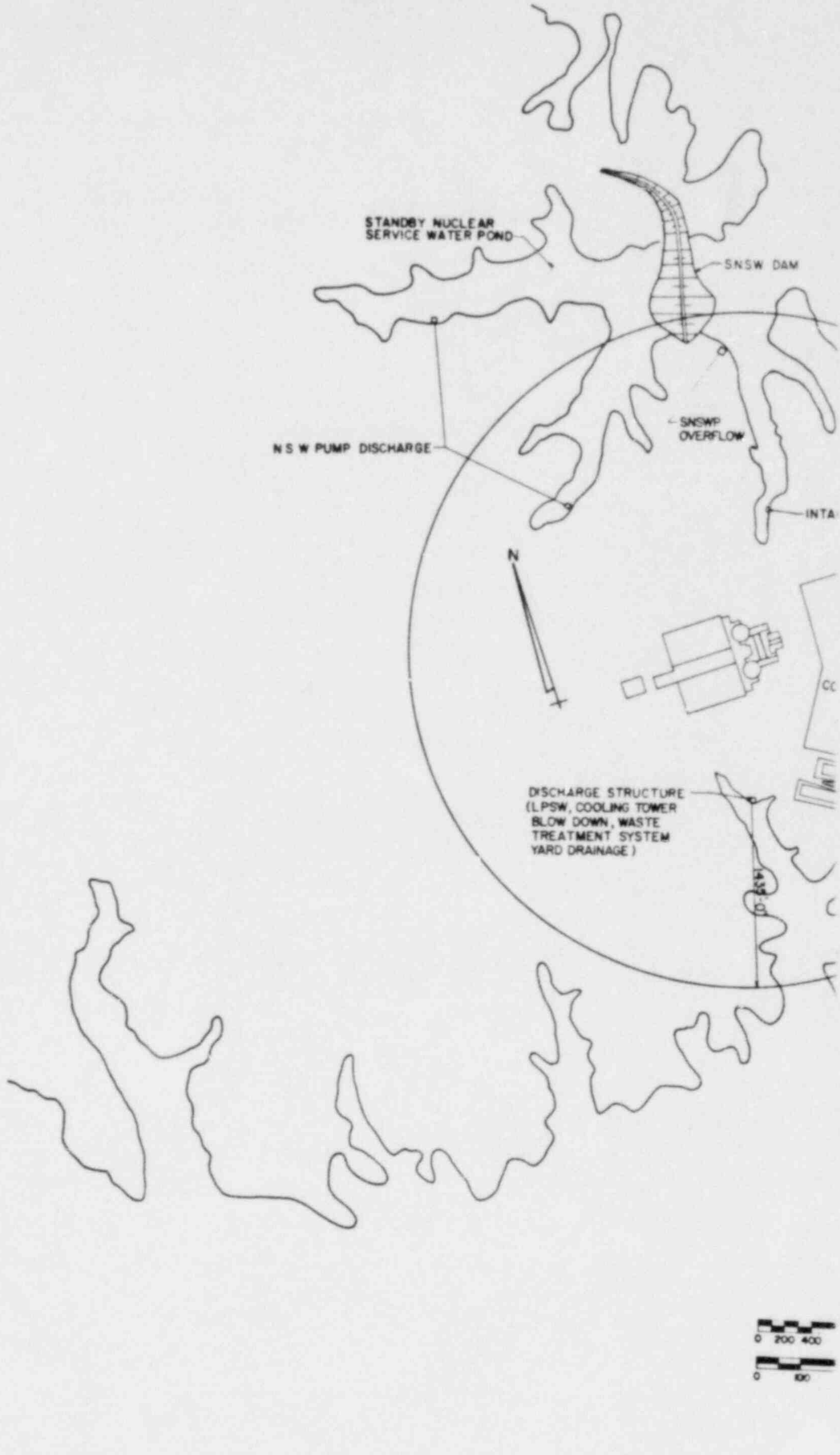
Response: Table 2.1.3-5, Section 5.2.4.4.1

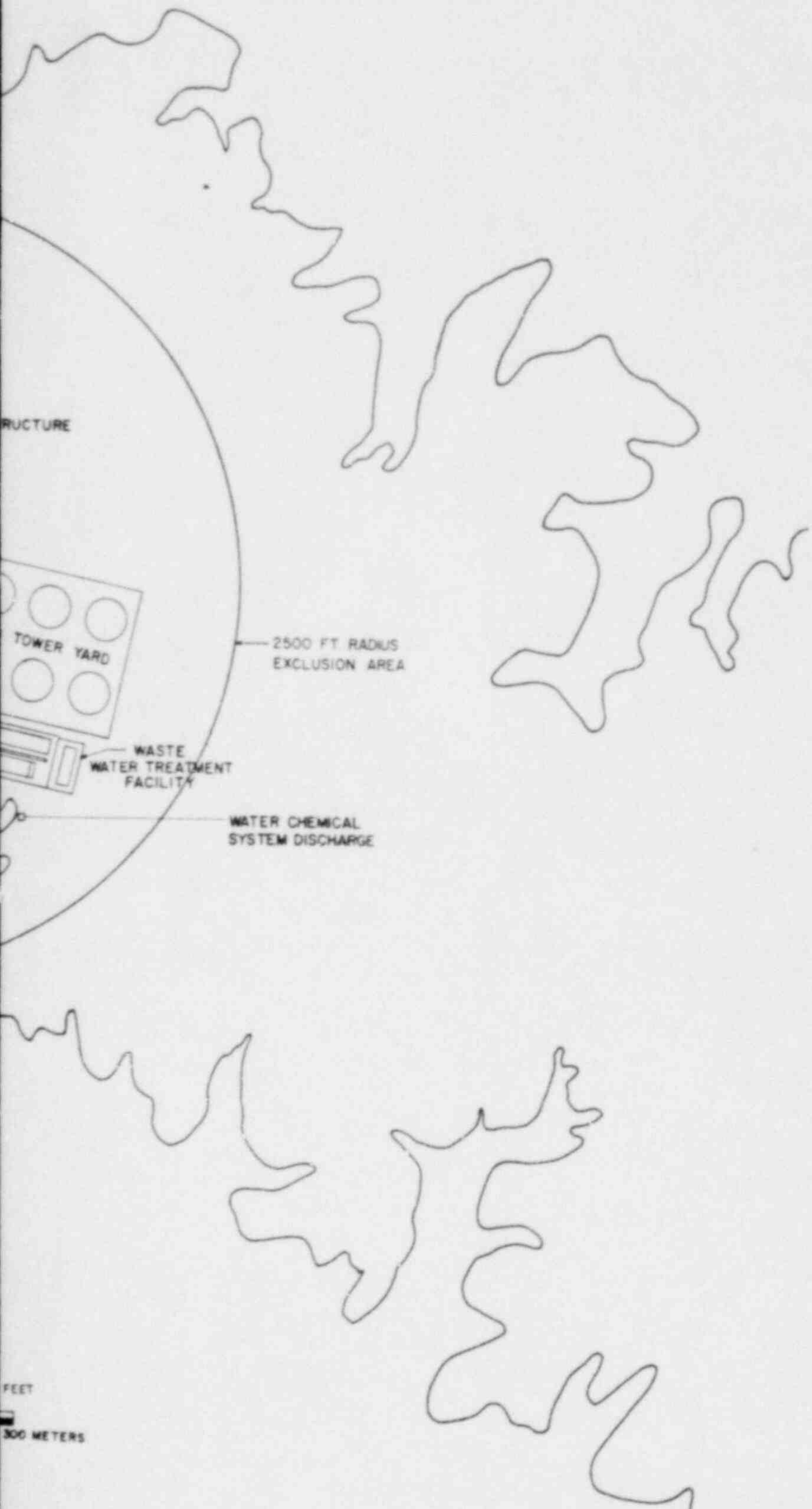
470.3 On p. 5.2-10 of the ER, it is stated that the GASPAR and LADTAP computer codes were used to estimate doses from exposure to radioactive effluents. Provide a listing of input parameters that were used in the GASPAR and LADTAP computer runs.

Response: Parameters were provided at site visit

470.4 ER Table 2.1.3-5 lists the locations of surface water users in terms of river distance miles. Please provide the location of the plant discharge point in river distance miles.

Response: Table 2.1.3-5


STANDBY NUCLEAR SERVICE WATER POND
SNSW DAM
SNSWP OVERFLOW
N S W PUMP DISCHARGE
N
DISCHARGE STRUCTURE (LPSW, COOLING TOWER BLOW DOWN, WASTE TREATMENT SYSTEM YARD DRAINAGE)
0 200 400
0 100



NON-RADIOLOGICAL
RELEASE POINTS

CATAWBA NUCLEAR STATION

ER Figure 2.1.1-5
Revision 3